Compliance Report 2020-2021

Kooragang Island Waste Emplacement Facility, Area 2 Closure Works

EPBC 2016/7670

Revision 1

10 November 2021

Document history and status

Revision	Date	Description	By	Checked	Approved
A	16 Oct 2021	Draft	G. Moylan	M. Bardsley	M. Bardsley
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NSW GOVERNMENT
Hunter & Central Coast Development Corporation

Declaration of Accuracy

In making this declaration, I am aware that sections 490 and 491 of the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) make it an offence in certain circumstances to knowingly provide false or misleading information or documents. The offence is punishable on conviction by imprisonment or a fine, or both. I declare that all the information and documentation supporting this compliance report is true and correct in every particular. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed	
Full name (please print)	Michael Bardsley
Position (please print)	Environmental Manager
Organisation	Hunter & Central Coast Development Corporation ABN 94 688 782 063
Date	10 November 2021

Hunter & Central Coast Development Corporation

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1. Purpose of the Report

The Kooragang Island Waste Emplacement Facility (KIWEF) Area 2 Closure Works Project was undertaken by Daracon Contractors Pty Ltd (Daracon) between August 2019 and July 2020. The Hunter and Central Coast Development Corporation (HCCDC) was acting as the agent of the New South Wales (NSW) Government for the closure of KIWEF, a former landfill site that received waste from the former Broken Hill Proprietary (BHP) Company Limited Mayfield steelworks and associated operations.

KIWEF is a 179-hectare site located on the western portion of Kooragang Island, approximately 7km north west of Newcastle's city centre. The site is bounded by Newcastle Coal Infrastructure Group to the south, the Port Waratah Coal Services – Kooragang Coal Terminal railway line to the west and north and adjacent industrial land consisting of third part waste facilities to the east. The action involves the closure of a 32-hectare portion of referred to as Area 2, shown on Figure 1.

In 2019, HCCDC completed an assessment of impact to matters of national environmental significance (MNES) under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. The Department of Agriculture, Water and Environment (DAWE, previously Department of Environment and Energy) granted approval for the project (EPBC 2016/7670) under sections 130(1) and 133(1) of the EPBC Act, on 22 March 2019.

The Area 2 closure works consisted of the construction of an engineered cap over the former landfill. The site is complicated by presence of MNES including Wetlands of International Importance and listed threatened species including the *Litoria aurea*, Green and Golden Bell Frogs (GGBF) and migratory wading birds.

This report documents HCCDC's compliance with the conditions of the approval issued under the EPBC Act for the action (EPBC 2016/7670) and to satisfy Condition 15 of that approval, which states:

Annual compliance reporting

15. The approval holder must prepare a compliance report for each 12 month period following the date of the commencement of the proposed action, or as otherwise agreed to in writing by the Minister. The approval holder must:

- *a) publish each compliance report on the website within 60 business days following the relevant 12 month period;*
- *b) notify the Department by email that a compliance report has been published on the website within five business days of the date of publication;*
- *c) keep all compliance reports publicly available on the website until this approval expires;*
- *d) exclude or redact sensitive ecological data from compliance reports published on the website; and*
- *e) where any sensitive ecological data has been excluded from the version published, submit the full compliance report to the Department within five business days of publication.*

Note: The first compliance report may report a period less than 12 months so that it and subsequent compliance reports align with the similar requirement under state approval. Compliance reports may be published on the Department's website.

The action was commenced on 21 August 2019 and works on site were completed within a single reporting period. **Section 2** provides further detail on the activities completed within the current reporting period (nominally between September 2020 and August 2021). **Section 3** demonstrates the sites compliance throughout the current maintenance period, against the conditions granted under EPBC 2016/7670.

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Figure 1: Project Locality

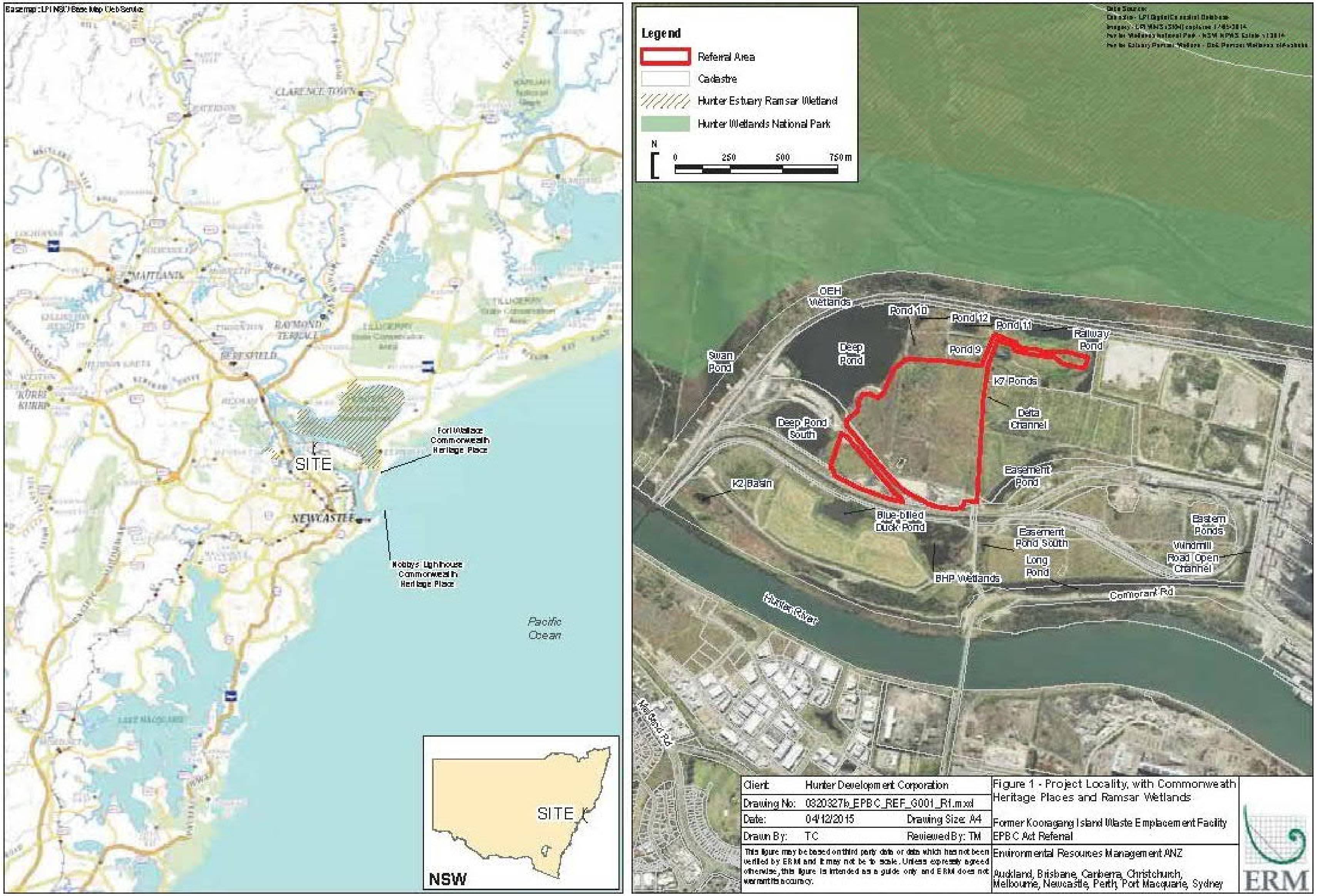

Figure 2: Footprint of the Action area

2. Description of Activities

Civil works for the controlled activity were completed on 10 July 2020. Since then, the site has been managed under a maintenance phase where the contractor (Daracon) were responsible for establishment of vegetation, removal of weeds or vegetative species that could damage the capping layer and repair any damage caused by stormwater erosion.

A breakdown of works undertaken within Area 2 during the current period are summarised below in Table 1.

Table 1: 2020-2021 Activities

Works Undertaken	Date of Works
Biannual Cap Inspection – Daracon and HCCDC conducted an inspection of Area 2 at the end of the Post-Construction Maintenance phase. The inspection aimed to identify any areas of damage to the cap and the establishment of vegetation. The site was confirmed to have minor surface defects requiring routine maintenance	October 2020
Annual GGBF Monitoring – A team of amphibian researchers from the University of Newcastle (UoN) undertook three rounds of ecological surveys across 2020/2021 summer season as required by the KIWEF GGBF Management Plan and condition 3 of the EPBC 2016/7670. The monitoring program includes (but is not limited to) the survey of 80 ponds (and their surrounds) across the KIWEF site and adjacent national park areas, for the following: • Presence/absence of GGBF (and other frog species); • GGBF distribution; • Habitat utilisation; • GGBF behaviour; • GGBF size, age and gender; • Tagging/recapturing of GGBF to track movement patterns; • Presence/absence of predators including *Gambusia holbrooki*.	September 2020 to May 2021
Biannual Surface Water Datalogger Download – HCCDC's consultants (Robert Carr and Associates) undertook the first round of Continuous Datalogging as required by the Water Quality Management Plan and condition 6 of EPBC 2016/7670. The network of 13 continuous dataloggers installed within surface water bodies around the KIWEF were downloaded and the resultant data was compared to the established salinity threshold levels for chytrid protection.	December 2020
KIWEF Annual Water Quality Monitoring – HCCDC's consultants (Hazmat Services) undertook the Annual Water Quality Monitoring as required by the Water Quality Management Plan and condition 6 of EPBC 2016/7670. The network of 50 groundwater monitoring locations and 5 surface water monitoring locations were sampled and analysed for a variety of parameters and pollutants as specified by the NSW EPA issued Surrender Notice.	June 2021
Biannual Surface Water Datalogger Download – HCCDC's consultants (Robert Carr and Associates) undertook the second round of Continuous Datalogging as required by the Water Quality Management Plan and condition 6 of EPBC 2016/7670. The network of 13 continuous dataloggers installed within surface water bodies around the KIWEF were downloaded and the resultant data was compared to the established salinity threshold levels for chytrid protection.	June 2021

Works Undertaken	Date of Works
Biannual Cap Inspection – HCCDC conducted a site walkover to inspect capped areas for signs that the cap has eroded, degraded or slumped. The inspection identified several items requiring rectification including: • The growth of vegetation with root systems that can damage the capping layer; • Some areas identified with low density vegetation regrowth; • Small areas with signs of ponded water (outside of constructed basins); • Erosion at the inlet a drainage line into one of the constructed basins.	Main Area –June 2021 Wedge – July 2021
Annual Cap Maintenance – HCCDC's contractors (Daracon) commenced the rectification issues identified by the HCCDC Biannual inspection. These works involved: • Removal of targeted vegetation species with roots that can impact capping layer. This was mechanical where possible; otherwise removed individually by hand cutting and sprayed by hand directly to the freshly cut stump. • Additional topsoil placed to areas with low density vegetation regrowth; and reseeded. • Recontour of localised areas to avoid further ponding. • Reinstate eroded areas, install geofabric and larger ballast rock to slow water movement and reduce potential for erosion.	July to August 2021

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3. Approval Compliance

An assessment of the action's compliance with the conditions of the Commonwealth Approval under the EPBC Act (EPBC Ref: 2016/7670) during the 2020-2021 period is summarised in Table 2.

Table 2: Approval Conditions Compliance Table

Condition Ref	Condition	Compliance	Evidence/Comments
PART A – CONDITIONS SPECIFIC TO THE ACTION			
1.	The action must only be undertaken within the footprint.	Compliant	During the current period the only works that have disturbed the footprint of Area 2 is the cap rectification works. As the works were limited to the extent of the cap installed during the construction phase, they are known to be within the footprint shown in Figure 2.
2.	The person taking the action must implement the Green and Golden Bell Frog Management Plan to avoid and mitigate impacts on the Green and Golden Bell Frog (Litoria aurea) (GGBF) population.	Compliant	The GGBF Management Plan was implemented through the reporting period. This included monitoring of the GGBF population by the University of Newcastle (UoN) researchers and preparation of the 2020/21 Island Wide Survey (IWS) report (Appendix C). In addition, during the rectification works, Daracon were also required to have an ecologist present to conduct ecological clearances prior to undertaking and activities that could create a disturbance. Ecological clearance reports are provided as Appendix G.
3.	GGBF monitoring must be undertaken in accordance with the Green and Golden Bell Frog Management Plan within the KIWEF Site, including the temporary basins, aligned with NCIG monitoring program.	Compliant	As described in Section 2, the annual monitoring of GGBF in accordance with the GGBF Management Plan (refer to Appendix B) was undertaken by the University of Newcastle through the spring – summer period. A copy of the 2020/21 Island Wide Survey report is provided in Appendix C.
4.	GGBF monitoring data must be analysed following each round of monitoring to identify any changes to the GGBF population, as compared to the baseline data described in the Green and Golden Bell Frog Management Plan. Should a decline in population be attributed to the action, response measures must be developed and implemented in accordance with the Green and Golden Bell Frog Management Plan.	Compliant	The UoN Island Wide Survey results (refer to Appendix C) have observed that after a decrease in the previous (2019-20) season, the population estimate for the GGBF population on Kooragang Island increased back toward the levels seen in 2018-19 (refer to the below chart, non-CHEMP wetlands). The population decrease in the 2019-20 season is thought to have been a result of the prolonged dry period up to February 2020. The drought period was broken by heavy rains through February and March 2020 which resulted in a mass GGBF breeding event. The young frogs that survived the winter were too small at the start of the 2020-21 monitoring season to be included within the initial population estimates but had grown enough by the end of summer 2021 to be marked and therefore counted within the current 2020-21 population estimates.

Condition Ref	Condition	Compliance	Evidence/Comments
			Over the course of the 2020-21 monitoring season the GGBF population was observed to increase 5-fold, as the young cohort entered the population estimates; and by the end of the season the GGBF population appears to have largely recovered from the decrease experienced in the drought of 2019. During the current period there were no observations of population decline that were attributable to the construction of the Area 2 Closure Works. The decline previously observed during 2019-20 season is a result of the prolonged drought conditions, a bush fire through the area and natural variabilities of a population. The linked image cannot be displayed. The file may have been moved, renamed, or deleted. Verify that the link points to the correct file and location.
5.	The person taking the action must revegetate the area marked in yellow and identified as 'Area 2 Closure works' on Map 2 at Attachment A to restore Green and Golden Bell Frog habitat	Compliant	At the completion of the Area 2 Closure Works, the site was topsoiled and seeded in accordance with the Revegetation Management Plan. However, the recent Cap Inspections identified several areas where vegetation growth was low. Rectification works

Condition Ref	Condition	Compliance	Evidence/Comments
	in accordance with the Revegetation Management Plan.		conducted in July/August included the placement of additional topsoil and reseeding of the area; consistent with the requirements of the Revegetation Plan. The below aerial image from Nearmap in October 2021 shows the revegetation of the majority of the capped area with further revegetation work in progress. 
6.	The person taking the action must undertake water quality monitoring for groundwater and surface water at the KIWEF Site in accordance with the Water Quality Management Plan.	Compliant	The continuous datalogging network were downloaded in December 2020 and June 2021. A copy of the December 2020 report and comparison against salinity threshold levels is provided in Appendix D; and the June 2021 report is provided as Appendix E. The Annual Groundwater and Surface Water monitoring program was completed in June 2020 a copy of the report is provided in Appendix F.
7.	At the completion of the project works, the approval holder must ensure:	-	-

Condition Ref	Condition	Compliance	Evidence/Comments
i.	no increased distribution of Gambusia holbrooki due to the project works, within the area identified as 'Potential GGBF foraging or breeding habitat' as identified on Map 2 at Attachment A, and	Compliant	The UoN IWS report for 2020/21 (refer to Appendix C) provides the current distribution of *Gambusia holbrooki* across KIWEF. The report notes that the repeated and incremental cycles of drying and recharging of wetlands has gradually removed Gambusia from much of the system since 2016. Across Kooragang Island, the number of wetlands with Gambusia present has declined from 65 in March 2016 to seven in March 2020. However, the arrival of a La Niña event in 2020-21 saw higher than average rainfall, which has reduced the number of wetlands that have dried this season. In the Industrial Zone, Gambusia were detected in 10 wetlands by the end of the current season. Further, the newly constructed ponds onsite are reported to be Gambusia free and are expected to remain so as they are hydraulically isolated (upgradient) from the surrounding pond networks.
ii.	no net loss of GGBF foraging or breeding habitat as an impact of the project works.	Compliant	Foraging habitat within the works footprint was temporarily reduced during the construction activities, however the site is being revegetated in accordance with the Revegetation Management Plan following construction completion. The Biannual Inspection identified several areas with sparse vegetation coverage. As part of the cap maintenance works additional topsoil was spread across these areas and they were reseeded in accordance with the contingency measures specified in the Revegetation Management Plan. The below picture shows an area of sparse vegetation coverage prior to the rectification works. 

Condition Ref	Condition	Compliance	Evidence/Comments
			The below picture was taken following completion of the topsoil placement and reseeding. Seed strike and regrowth is in progress 
8.	The approval holder must implement the KIWEF Site EMP.	Compliant	The Post Construction elements of the Construction Environmental Management Framework (CEMF, provided as Appendix A) including the preparation of the Construction Validation Report and Independent Auditors Report of the construction works have been completed and submitted to the NSW EPA in accordance with the requirements of the CEMF and Surrender Notice. The site has continued to implement the requirements of the GGBF Management Plan (Appendix B) throughout the Post-Construction period including the IWS monitoring (Appendix C) and ecological pre-clearance surveys (Appendix G) prior to any ground disturbing activities. The Post-Completion Water Monitoring has also been conducted in accordance with the requirements of the CEMF (Appendix D to Appendix F)

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Condition Ref	Condition	Compliance	Evidence/Comments
PART B – STANDARD ADMINISTRATIVE CONDITIONS			
Notification of date of commencement of the proposed action			
9.	The approval holder must notify the Department in writing of the date of commencement of the action within 10 business days after the date of commencement of the action.	Compliant	HCCDC issued notification to the DAWE on commencement of works during the previous period on 4 September 2019, which confirmed earthworks had commenced on 21 August 2019
10.	If the commencement of the action does not occur within 5 years from the date of this approval, then the approval holder must not commence the action without the prior written agreement of the Minister.	Not Applicable	HCCDC commenced within one year of the approval being issued.
Compliance records			
11.	The approval holder must maintain accurate and complete compliance records.	Compliant	Reporting and analysis of groundwater, surface water, GGBF monitoring and cap inspection reports are maintained by HCCDC.
12.	If the Department makes a request in writing, the approval holder must provide electronic copies of compliance records to the Department within the timeframe specified in the request.	Not Applicable	No request has been made by the Department for compliance records to be provided
Note: Compliance records may be subject to audit by the Department or an independent auditor in accordance with section 458 of the EPBC Act, and or used to verify compliance with the conditions. Summaries of the result of an audit may be published on the Department's website or through the general media.			
Preparation and publication of plans			
13.	The approval holder must:	-	-
a.	publish all plans associated with the action on the approval holder's website within 30 business days of the date of approval of the action;	Compliant	Commonwealth and State approval documents/plans were uploaded to the HCCDC website: https://www.hccdc.nsw.gov.au/kooragang-island-waste-emplacement-facility
b.	exclude or redact sensitive ecological data from plans published on the website or provided to a member of the public; and	Not Applicable	No sensitive ecological data was required to be redacted from the documents.
c.	keep plans published on the website until the end date of this approval	Compliant	HCCDC will continue to maintain the project plans on the website until completion of the closure works and the approval is transferred to Port of Newcastle.
			Port of Newcastle will then be responsible for uploading project plans on their website when approval transfers.

Condition Ref	Condition	Compliance	Evidence/Comments
14.	The approval holder must ensure that any monitoring data (including sensitive ecological data), surveys, maps, and other spatial and metadata required under a plan, is prepared in accordance with the Department's Guidelines for biological survey and mapped data (2018) and submitted electronically to the Department in accordance with the requirements of the plan.	Compliant	Data from 2019-20 monitoring season compliant with the Department Guidelines were submitted to the Department in December 2020. The data for the current 2020-21 monitoring season compliant with the Department Guidelines is ready to be submitted to the Department once the compliance report has been issued.
Annual compliance reporting			
15.	The approval holder must prepare a compliance report for each 12 month period following the date of the commencement of the proposed action, or as otherwise agreed to in writing by the Minister. The approval holder must:	Compliant	During the construction phase, HCCDC engaged independent firm Ramboll to audit HCCDC and its Contractor Daracon's compliance with the requirements of the EPBC Approval throughout the construction phase. Ramboll prepared the Compliance Report for the 2019/20 period on behalf of HCCDC as an independent observer and the report was uploaded to the HCCDC website on 12 November 2020. HCCDC has been prepared this report for the maintenance phase, to comply with this condition for the 2020/21 period.
a.	publish each compliance report on the website within 60 business days following the relevant 12 month period;	Compliant	The 2019/20 Compliance Report was published on the HCCDC website on 12 November 2020. The 2020/21 Compliance Report is to be published on the website before 12 November 2021.
b.	notify the Department by email that a compliance report has been published on the website within five business days of the date of publication;	Compliant	HCCDC notified DAWE via email on the 13 November 2020 that the 2019/20 Compliance report had been published on the HCCDC website for the Area 2 Closure Works. It is expected that HCCDC will notify DAWE by 19 November 2021 that the 2020/21 Compliance report has been published on the website.
c.	keep all compliance reports publicly available on the website until this approval expires;	Compliant	The 2019/20 and 2020/21 Compliance Reports will remain on the HCCDC website until the site and Commonwealth Approval are transferred to the Port of Newcastle at Completion. Port of Newcastle will be responsible for uploading project plans on their website when approval transfers.
d.	exclude or redact sensitive ecological data from compliance reports published on the website; and	Not Applicable	No sensitive ecological data was required to be redacted from the documents.

Condition Ref	Condition	Compliance	Evidence/Comments
e.	where any sensitive ecological data has been excluded from the version published, submit the full compliance report to the Department within five business days of publication.	Not Applicable	No sensitive ecological data was required to be redacted from the documents.
Note: The first compliance report may report a period less than 12 months so that it and subsequent compliance reports align with the similar requirement under state approval. Compliance reports may be published on the Department's website.			
Reporting non-compliance			
16.	The approval holder must notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in plans. The notification must be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance. The notification must specify:	Not Applicable	There were no non-compliances during the current period; and a notification to the Department was therefore not required.
a.	the condition which is or may be in breach; and	-	-
b.	a short description of the incident and/or non-compliance.	-	-
17.	The approval holder must provide to the Department the details of any incident or non-compliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying:	Not Applicable	There were no incidents or on-compliances during the current period; and a notification to the Department was therefore not required.
a.	any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future;	-	-
b.	the potential impacts of the incident or non-compliance; and	-	-

Condition Ref	Condition	Compliance	Evidence/Comments
c.	the method and timing of any remedial action that will be undertaken by the approval holder.	-	-
Independent audit			
18.	The approval holder must ensure that independent audits of compliance with the conditions are conducted:		
i.	Following the completion of onsite construction works and prior to the completion of the project works period;	Not Applicable	An Independent Audit of records will be undertaken prior to completion of the project approval (before the transfer of the Approval) 21 August 2022.
ii.	Within a 12month period from the completion of the action;	Not Applicable	Port of Newcastle to undertake Independent Audit at the completion of the project action (post-transfer of the Approval) 31 December 2030.
iii.	or as requested in writing by the Minister.	Not Applicable	No independent audit has been requested
19.	For each independent audit, the approval holder must:	Not Applicable	An independent audit is not required and therefore has not been completed during the current period.
a.	provide the name and qualifications of the independent auditor and the draft audit criteria to the Department;		-
b.	only commence the independent audit once the audit criteria have been approved in writing by the Department; and		-
c.	submit an audit report to the Department within the timeframe specified in the approved audit criteria.		-
20.	The approval holder must publish the audit report on the website within 10 business days of receiving the Department's approval of the audit report and keep the audit report published on the website until the end date of this approval.	Not Applicable	-
Completion of the action			

Condition Ref	Condition	Compliance	Evidence/Comments
21.	Within 30 days after the completion of the action, the approval holder must notify the Department in writing and provide completion data.	Not Applicable	Port of Newcastle will notify the Department of the completion of the action in 2030 following completion of the monitoring required under the Green and Golden Bell Frog Management Plan

4. Conclusion

This report has been prepared to assess compliance with the conditions of the approval issued under the EPBC Act for the action (EPBC 2016/7670) and to satisfy Condition 15 of that approval. The undertaking of the action during the reporting period has been assessed to be compliant with the conditions of EPBC 2016/7670. No non-compliance issues were identified.

Onsite construction works were completed in July 2020. As such completion of the project works (defined as two years following completion of onsite construction works) will occur in August 2022.

Appendix A – Construction Environmental Management Framework (Jacobs, 2019)

Kooragang Island Waste Emplacement Facility Area 2 Closure

Hunter and Central Coast Development Corporation

Construction Environmental Management Framework

IA192100_02 | Final

16 April 2019

HDC369

Kooragang Island Waste Emplacement Facility Area 2 Closure

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Contents

1. Introduction

1.1 Purpose and Scope

This Construction Environmental Management Framework (CEMF) sets out the environmental, stakeholder and community management requirements in relation to the Kooragang Island Waste Emplacement Facility (KIWEF) Area 2 Closure Works. The CEMF provides a link between the environmental and planning regulatory documentation and the construction environmental management documentation to be developed by the Principal Contractors relevant to their scope of works. The Principal Contractors will be required to implement and adhere to the requirements of this CEMF. The requirements of this CEMF will be included as a contract document in all design and construction contracts.

1.2 Project Overview

The endorsed approach to the closure of KIWEF is to implement minimal change in site processes by maintaining similar site hydrology, vegetation and surface soils while further isolating potential contaminants. The isolation of contaminants is to be achieved though the reduction of surface water infiltration resulting from the installation of capping with reduced permeability and a moderation of site surface gradients.

The basic principles of the closure works are to reduce surface water infiltration into the groundwater by the following means:

- Re-grading of the site to a minimum 1% grade to prevent ponding of surface waters;
- Drainage improvements;
- Provision of a 0.5 metre (m) thick, low permeability cap; and
- Rehabilitation using existing topsoil and alternative low nutrient and Chytrid free imported growth medium.

These closure works are to be undertaken within a sensitive and complex environmental context. In particular, the works need to be delivered in a manner which:

- Complies with regulatory requirements;
- Avoids direct impacts to Matters of National Environmental Significance (MNES) in particular Green and Golden Bell Frogs (GGBF) but also migratory wading birds;
- Carefully manages indirect impacts to MNES through avoidance of spread of chytrid fungus and predatory aquatic species and through avoiding impacts to water quality of surrounding waterbodies; and
- Manages fill material such that higher risk materials are appropriately isolated from surface waters.

The closure works area is relatively isolated from sensitive human receptors and standard, reasonable and feasible mitigation measures are also to be deployed to minimise environmental impacts.

1.3 Background

Extensive background information has been prepared in relation to the Project and in the first instance the Contractor should refer to the Tender Specifications. The following background is provided for environmental context only.

KIWEF is a former industrial waste disposal area located off Cormorant Road, Kooragang Island, Newcastle New South Wales (NSW). KIWEF ceased operation in 1999 and until this time was used by Broken Hill Proprietary Company Limited (BHP) as a landfill for disposal of waste from their Mayfield steelworks and associated operations. KIWEF was subject to Environment Protection Licence (EPL) 6437 issued under the

Protection of the Environment Operations Act 1997 (PoEO Act) for the scheduled action of "Waste disposal by application to land" first issued in 1999 to BHP and subsequently transferred to Regional Land Management Corporation Pty Ltd in May 2003 and then Hunter and Central Coast Development Corporation (HCCDC (also referred to as HDC in quoted text and reports commissioned by HCCDC prior to the merger of the Hunter Development Corporation with the Central Coast Development Corporation) in January 2008.

HCCDC surrendered EPL 6437 on 8 December 2010 and the NSW Environment Protection Authority (EPA) issued a conditional Surrender Notice 1111840 with subsequent variation notices being issued on 2 May 2013 (notice number 1510956) and 17 April 2014 (notice number 1520063) collectively referred to as the Surrender Notice for the remainder of this report. The Surrender Notice conditions relate primarily to the closure process, and describe the capping that is required across much of the area, and cross reference the GHD (2009) Revised Final Landform and Capping Strategy (the Capping Strategy).

HCCDC are the NSW Public Authority currently assigned responsibility for the closure of KIWEF on behalf of the NSW Government (the State). The land on which KIWEF is located (the closure works area) is owned by the Port of Newcastle Lessor (a NSW Government entity) who has contracted HCCDC as an agent of the State, to complete the KIWEF remedial works in accordance with a Binding Terms of Agreement.

For the purposes of closure, KIWEF has been divided into three areas with Area 2 being the subject of this CEMF while Areas 1 and 3 closure have been completed. Area 2 is further divided into sub areas K3 to K8 with some sub-areas further divided into specific disposal cells.

1.4 Delivery Mechanism

1.4.1 Closure Works

The closure works are to be delivered as a Construction only contract. As such the Contractor is to refer to the Tender Specifications and Design information provided by HCCDC which incorporates and supersedes any design information provided in this CEMF and supporting environmental assessment and management documentation.

1.4.2 Wedge and Peninsular Access

The access track to the Wedge and Peninsular Borrow Pit will be delivered as a design and construct contract so that the Contractor can design the access to cater to their specific equipment access requirements. In addition to complying with the specific environmental performance expectations and mitigation measures contained in this CEMF, the Wedge and Peninsular access will be required to be designed, constructed and used to the satisfaction of ARTC as the owner of the land accommodating the access track.

2. Regulatory Requirements

The key environmental obligations for the closure works arise under the following legislation:

- *Protection of the Environment Operations Act 1997* (POEO Act);
- *Environmental Planning and Assessment Act 1979* (EP&A Act); and
- *Environmental Protection and Biodiversity Conservation Act 2000* (EPBC Act).

Various environmental assessments and management plans have been prepared under these Acts as follows:

- **POEO Act** - NSW EPA (2010), Approval of the Surrender of a Licence – License 6437, (Ref: 1111840, and as varied by notice number 1510956 and 1520063) and associated documents including:
  - Golders (2011), KIWEF Closure Works, Green and Golden Bell Frog Management Plan;
  - GHD (2009), Report on KIWEF, Revised Final Landform and Capping Strategy; and
  - RCA (2012) Materials Management Plan – Kooragang Island Waste Emplacement Facility.
- **EP&A Act** – Hunter Development Corporation Determination under Division 5.1 of the EP&A Act and associated assessment documentation including:
  - ERM (2016), Review of Environmental Factors, KIWEF Area 2 Closure Works; and
  - Jacobs (2018) Addendum Review of Environmental Factors, KIWEF Areas 2 Closure Works.
- **EPBC Act** – Notice of determination of referral number 2016/7670 dated 22 March 2019 and associated documentation including:
  - ERM (2015), KIWEF Area 2 Closure Works, EPBC Referral;
  - ERM (2016), Response to Request for Information, KIWEF Area 2 Closure Works; and
  - Ramboll (2018), EPBC Referral, Preliminary Documentation Package – KIWEF Area 2 Closure Works.

The conditions and commitments of these documents are consolidated in the attached sub-plans.

The Closure Works design has been prepared to comply with these requirements and the Contractor is responsible for implementing these designs. Where departures are proposed by the Contractor, it is the Contractors obligation to demonstrate how compliance with all applicable environment regulations is achieved.

The Peninsular access track is to be designed and constructed by the Contractor to accommodate safe access for the Contractor’s equipment, in a manner that achieves the general environmental performance expectations within this CEMF and to the satisfaction of ARTC.

Various other environmental legislation and requirements apply to the site as documented in Appendix A and their requirements are generally captured in the attached sub-plans.

3. General Environmental Management Requirements

3.1 Environmental and Sustainability Management System

The Contractor is required to have a corporate Environmental Management System certified under AS/NZS ISO 14001:2015.

3.2 Environmental Training

All Contractor personnel and sub-contractors will undergo environmental training before commencing works on site. Training will be undertaken in the following forms:

- Project Induction; and
- Regular (daily) pre-start discussions on environmental topics.

Records of induction and training will be kept on the Contractor's database including the topic of the training carried out, dates, names and trainer details. Inductees will be required to sign-off that they have been informed of the environmental issues and that they understand their responsibilities.

3.2.1 Induction

Prior to working on site, the Contractor will ensure that all staff and sub-contractors working on site are appropriately inducted. The Contractors induction must communicate the environmental performance expectations of this CEMF and the specific mitigation measures to achieve these expectations as documented in the Contractors CEMP. Induction content is expected to include:

- Legal and regulatory requirements including duty of care and potential consequences of infringements;
- Environmental responsibilities with detailed training on the implementation of hygiene protocols and the importance of GGBF;
- Identification of sensitive areas including threatened species habitat, waterways, asbestos impacted waste and other hazardous waste;
- Identification of boundaries for vegetation clearing, washing, refuelling and maintenance areas for vehicles, plant and equipment;
- Environmental management techniques for noise, air, surface and ground water, waste generation, contaminated land etc;
- Emergency plans and incident management including the use of spill kits;
- Reporting processes for environmental harm or environmental incidents;
- Roles and responsibilities in achieving conformance with environmental policies and requirements, including emergency preparedness and response requirements; and
- Identification and management of non-conformances.

3.2.2 Daily pre-start talks

Pre-start talks will help to ensure that timely and relevant information is communicated to the workforce and that feedback can be provided on issues of interest or concern. Pre-start talks should address weather forecasts with implications for daily site environmental management (dust or rainfall response requirements) as a minimum, and where necessary, should be used to provide refresher information on the environmental induction topics and associated environmental procedures.

In the event of environmental near misses or incidents, or changes to procedures that could result in changed levels of environmental risks, pre-start talks may be used to deliver updates.

3.3 Emergency Contacts and Response

An emergency response plan would be prepared and implemented during the Project by the Contractor. The emergency response plan should document the contractor’s approach to managing potential hazards and risks, incidents and emergencies. In undertaking planning for emergencies, learning from past incidents, applying risk assessments and training methods should be documented.

3.3.1 Emergency Preparedness

The key to effective prevention of environmental incidents involves selecting the right personnel and subcontractors, promoting a positive attitude to the importance of environmental issues, training, controls, monitoring, and surveillance. During construction activities, inspections and preventative action should include:

- Daily inspections of active work sites;
- Completion of routine environmental checklists;
- Issue and timely and effective close-out of maintenance and non-compliance notices;
- Maintenance of constant supervision on site;
- On-going environmental training; and
- Environmental audits of work sites, subcontractors and compliance issues.

Environmental and safety information on hazardous substances (e.g. safety data sheets) should be made available at the main site office and near to where such substances are stored and used. These locations will be communicated to all personnel.

Testing of and training in environmental response procedures should be conducted in areas where a pollution risk is present, such as on site and near re-fuelling areas for spill awareness, or worksites near environmentally sensitive areas. Personnel involved in emergency response activities should be provided with specific training.

An up-to-date list of emergency response personnel and organisations should be developed and maintained at the Contractor’s main project office.

4. Implementation

4.1 Risk Assessment

The consideration of potential environmental risks has been undertaken through the Environmental Impact Assessment Process. This process has drawn on a significant volume of information. As a minimum, the Contractor is required to have read and understood the documents listed in Chapter 2 such that they have an adequate understanding of the environmental context and management expectations for the Closure Works. In preparing the Contractor's Construction Environmental Management Plan, the Contractor is required to undertake any additional risk assessment they deem necessary to manage environmental risks, such that the performance expectations of the CEMF are achieved when implementing their nominated construction methodology.

Based on HCCDC's understanding of the site, the following priority environmental factors and aspects were identified:

- Flora and Fauna Management;
- Erosion and Sediment Control, and Water Management;
- Contaminated Materials Management; and
- Rehabilitation.

In addition to the above priority environmental management requirements, suggested mitigation measures for environmental risks including traffic, air quality, lighting, noise, waste, rehabilitation and heritage are addressed in the attached sub-plans and are to be incorporated into the Contractor's work methods.

4.2 Environmental Management Activities and Controls

The documents listed in Chapter 2 identify environmental management and monitoring measures that apply to the Closure Works. These documents include:

- Hunter Development Corporation - Report on KIWEF - Revised Final Landform and Capping Strategy - August 2009 - Revision 2, prepared by GHD (the Capping Strategy);
- 'Green and Golden Bell Frog Management Plan – Kooragang Island Waste Emplacement Facility Closure Works' dated 19 April 2011 and prepared by Golder Associates;
- 'Materials Management Plan - Kooragang Island Waste Emplacement Facility' dated November 2012 prepared by RCA Australia; and
- 'EPBC Referral Preliminary Documentation Package – KIWEF Area 2 Closure Works' June 2018 prepared by Ramboll (the PDP).

The Surrender Notice also requires that the implementation of these plans and strategies to be validated through a report provided to the NSW EPA to allow the lifting of the Surrender Notice obligations. The summary of the measures required to be implemented and when are presented in Appendix B.

Further detail on the above documents has been incorporated into sub-plans prepared as part of this CEMF. These have been prepared based on requirements of the Surrender Notice, EPBC Act Referral outcome, Review of Environmental Factors, previously completed capping works and current industry practice to provide guidance on how to manage certain aspects of environmental management during construction.

The suite of action plans addressing priority environmental aspects includes the following:

- Appendix C. Materials Management Plan
- Appendix D. Flora and Fauna Management Plan

- Appendix E. Revegetation Management Plan
- Appendix F. Water Quality Management Plan
- Appendix G. Traffic Management
- Appendix H. Air Quality Management
- Appendix I. Noise Management
- Appendix J. Heritage management

The Contractor is expected to be fully aware of the requirements of these sub-plans in preparing their tender and program and to be prepared such that extensive clearing and bulk excavation works on site do not commence prior to all required environment controls being in place for any given works area.

4.3 Environmental Control Plans or Maps

A Preliminary Environmental Control Map, reproduces Constraints Map prepared by SMEC, is provided below. This Preliminary Environmental Control Map is to be updated by the Contractor to address Contractor's specific work methods. The Environmental Control Map is to be specific to the site and outline the location of protection measures, monitoring requirements and environmentally sensitive areas. The Environmental Control Map forms the practical application of the proposed control measures contained within this CEMF.

The Environmental Control Map is to be used in project inductions, work site set-up, reviewing ongoing environmental performance and be included as information in tender documents to subcontractors where applicable.

The project Environmental Control Map is to be updated to include:

- The worksite layout and boundary, including entry/exit points and internal roads and clearing limits;
- Location of adjoining land-use and nearest noise sensitive receivers;
- Location and type of sediment and erosion control measures, including size / capacity of detention basins and wheel wash facilities;
- Location and type of fauna exclusion fences;
- Location of site offices;
- Location of spill containment and clean-up equipment;
- Location of worksite waste management facilities;
- Hours of work applicable to the worksite (including specific time windows for deliveries and any restrictions on high noise generating activities).
- Location of environmentally sensitive areas (e.g. threatened species, critical habitat, known contaminated areas, etc)
- Vegetation and trees to be protected;
- Location of stormwater drainage and watercourses leading to / from the worksite; and
- Summary of specific environmental management requirements from licenses, approvals or permit conditions.

The provisions of this plan apply in addition to any erosion and sediment control plans or other documentation that specify the location of environmental controls on site.

LEGEND

- AREA 2 - KIWEF SURRENDER NOTICE BOUNDARY
- AREA 2 - (POTENTIAL BORROW)
- AREA 2 - COMMONWEALTH APPROVAL BOUNDARY (REFER NOTE 1 - PLAN 0004)
- T4 SEPARATION LINE (2016#)
- T4 SEPARATION LINE WITH BUFFER (2016#)

(#) OBTAINED FROM IMAGE FILE - INDICATIVE ONLY

- SURVEY BOUNDARIES / LEASE BOUNDARY
- EXISTING BUND WALL LOCATIONS (INDICATIVE ONLY)
- K5 6N — KI WELLS (GROUND WATER MONITORING)
- BOS AREA — BOS AREA (GHD 2010)
- HYDRO CARBON IMPACT — HYDRO CARBON IMPACT AREA (DP 2011)
- PAH IMPACT — PAH IMPACT BOUNDARY (GHD 2011)
- POND 5 — POND 5 BOUNDARY (GHD 2010)
- LIME — LIME; LEADED DUST — LEADED DUST: WASTE CLASSIFICATION (DAMES & MOORE 1991)
- GREEN & GOLDEN BELL FROG (GGBF) KNOWN AND POTENTIAL HABITAT AREAS (GHD-2010)
- EXISTING CAP OR DRAIN - DO NOT DISTURB

NOTE: HABITAT AREA EXTENDED TO INCLUDE ALL WETLANDS IN THIS AREA

REFER INSET

150 mm ON ORIGINAL

A1

DRAWING FILE LOCATION / NAME
D:\SMEC\30011921_KIWEF\CAD\DWG\0006_D.dwg

PLOT DATE 16 Dec 2018 TIME 16:51:10

EXTERNAL REFERENCE FILES
X_AH_Kooragang Image
x_Newc_a1_30011034
x_SMEC MASTER BDY
x_SMEC MASTER HABITAT
x_SMEC MASTER GEO
x_M&P_Survey 160477A_0

REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
A1	27.09.18	ISSUED FOR 90% PROGRESS REVIEW	-	-
A2	5.10.18	ISSUED FOR 90% REVIEW	-	-
B	13.11.18	ISSUED FOR 100% REVIEW	-	-
C	28.11.18	ISSUED FOR PRE-TENDER ESTIMATE	-	-
D	17.12.18	ISSUED FOR TENDER	001	EW

TITLE	NAME
DRAFTER	MLC
DRAFTING CHECK	EW
DESIGNER	MLC
DESIGN CHECK	JH
PROJECT MANAGER	EW
PROJECT DIRECTOR	JK

SCALES AT A1 SIZE DRAWING
0 20 40 60 80 100m
SCALE 1:2000 AT ORIGINAL SIZE

DESIGNER
SMEC
SMEC AUSTRALIA PTY LTD
© ABN 47 065 475 149
74 HUNTER STREET
NEWCASTLE NSW 2300
PH +61 2 4925 9600 FAX +61 2 4925 3888

CLIENT
NSW GOVERNMENT
Hunter & Central Coast Development Corporation

TITLE
KOORAGANG ISLAND WASTE EMPLACEMENT FACILITY
STAGE 5 CLOSURE WORKS AREA 2 (K3/K5/K7) CONTRACT HCCDC 18/04
SEPARABLE PORTIONS 1 and 2 - GENERAL

CONSTRAINTS PLAN

SCALE	PHASE	PROJECT / DRAWING No.	REVISION
1: 2000	TENDER	0006	D

4.4 Environmental Schedules

The Environmental Schedules set out below represent the records likely to be required to be kept during the Project.

- Weekly and post rainfall site inspection checklist;
- Daily materials tracking forms;
- Level 2 and Level 3 notification forms;
- Notified materials tracking register;
- Water quality monitoring results register;
- Dewatering form;
- Waste Register;
- Induction record;
- Internal Audit Register;
- Non-Conformance Register;
- Complaint Form; and
- Complaint Register.

The form and content of the Environmental Schedules is to be provided by the Contractor in accordance with their Environmental Management System.

5. Monitoring, Reporting and Review

5.1 Environmental Monitoring

As part of the overall environmental management of the site, during the landfill closure works, the Contractor is to conduct at least weekly inspections of all mitigation measures. The results of these inspections will be recorded on a weekly environmental inspection record. Should non-conformances be identified, the Contractor is required to undertake corrective action to address the issue.

The following construction monitoring is required:

- Daily prestart checks on amphibian-disease hygiene station functioning and supplies, and weather forecast noting predicted wind and rain;
- Real-time classification of materials to nominated thresholds in accordance with the Materials Management Plan decision matrix;
- Post rainfall checks of sediment dam water level and water quality, and erosion and sediment control functioning;
- Inspection covering sediment dam water levels and water quality, erosion and sediment control structures, frog fences, fuel and chemical storage, stockpile bunding and covers;
- Sediment basin discharge or dewatering water quality sampling and analysis suitable to demonstrate pollution of water has/will not occur;
- noise monitoring of any out of hours construction works in accordance with Interim Construction Noise Guidelines;
- visual observations of visible dust levels to confirm no off site dust impacts; and
- post capping defects and liabilities monitoring including revegetation success monitoring.

Where recommended actions are suggested, priorities should be set against these actions for site implementation. The list of actions should be distributed to the responsible personnel. A close out system must be included.

The defects and liabilities period is linked to a demonstration of performance against parameters to be negotiated with the HCCDC. These are likely to include revegetation success and surface water quality.

In accordance with notice of determination condition 11 and 12, accurate and complete compliance records are required to be maintained and provided to the Department of Environment and Energy on request.

5.1.1 Construction Water Quality Monitoring

The closure works are required to comply with the general duty not to pollute waters under section 120 of the POEO Act. The contractor will be required to take adequate precautions to ensure either that discharge/or dewatering is not required, or otherwise undertake sampling and analysis to demonstrate that pollution of water has or will not occur associated with water releases from sediment basins.

In the absence of an EPL, to avoid causing pollution and breaches of section 120, any water discharged from site must be of the same quality, or better, than the quality of the receiving waters (at the time of discharge) or able to be demonstrated to not have caused water pollution.

It is noted that water pollution or pollution of waters means:

- placing in or on, or otherwise introducing into or onto, waters (whether through an act or omission) any matter, whether solid, liquid or gaseous, so that the physical, chemical or biological condition of the waters is changed, or
- placing in or on, or otherwise introducing into or onto, the waters (whether through an act or omission) any refuse, litter, debris or other matter, whether solid or liquid or gaseous, so that the change in the condition of the waters or the refuse, litter, debris or other matter, either alone or together with any other refuse, litter, debris or matter present in the waters makes, or is likely to make, the waters unclean, noxious, poisonous or impure, detrimental to the health, safety, welfare or property of persons, undrinkable for farm animals, poisonous or harmful to aquatic life, animals, birds or fish in or around the waters or unsuitable for use in irrigation, or obstructs or interferes with, or is likely to obstruct or interfere with persons in the exercise or enjoyment of any right in relation to the waters, or
- placing in or on, or otherwise introducing into or onto, the waters (whether through an act or omission) any matter, whether solid, liquid or gaseous, that is of a prescribed nature, description or class or that does not comply with any standard prescribed in respect of that matter.

A summary of water quality monitoring including sample results is required to be submitted to the HCCDC following any dewatering or discharge event demonstrating that the Contractor has complied with the above obligations.

5.1.2 Environmental Auditing

Internal and external environmental audits should be undertaken throughout the construction process to ensure that the project environmental requirements and Contractors CEMP are implemented appropriately.

The auditing process should be designed to identify any non-conformances, providing an opportunity to apply corrective and / or preventative action where appropriate. The Audit schedule is to include:

- Internal environmental audit by the Contractor’s Environmental Manager on a three monthly basis during construction;
- Regular attendance at the site by the KIWEF Area 2 Closure Works Independent Auditor; and
- Independent audit of compliance with the notice of determination conditions following the completion of onsite construction works and prior to completion of the project works period.

5.2 Reporting

The implementation of the Closure Strategy and contract requires the following reporting on environmental performance:

- Daily record of material management including notification of identification of potential Level 2, Level 3 or otherwise hazardous materials;
- Monthly progress reporting;
- Validation reporting following practical completion; and
- Annual compliance reporting against the notice of determination.

Detailed requirements of these reports are included in the Tender Specifications. The following summarises the expected content of each level of reporting.

5.2.1 Daily Record of Material Management

The daily record of material management is required to summarise material interaction for the day and include:

- Description of earthworks activity undertaken;

- Description of cut to fill or cut to stockpile activities including locations;
- Notification of HCCDC of suspected contaminated or otherwise hazardous material encountered and description of handling, current location, further assessment required; and
- Summary of any handling of previously notified material including update on current location.

All notifications are also to be tracked through a notifications register to record final disposal location.

5.2.2 Monthly Progress Reporting

Monthly Progress Reporting is to include details of the implementation environmental management requirements including:

- Update on any environmental risks and opportunities, and significant environmental impacts associated with the work;
- Progress against environmental objectives, targets and measures of performance; and
- Management actions, including environmental controls, training, inspections and testing.

Specifically, the environmental monthly reporting is to include such items as:

- Characterisation, site management and fate of contaminated material, collated materials tracking information;
- Quality assurance on placed material;
- Non-compliances and corrective actions;
- Environmental monitoring requirements; and
- Monthly logs and photographs and other records of the progressive compilation of information that will be integrated into the Validation Report on completion.

5.2.3 Validation Report

The Validation Report is required to satisfy Condition 4h of the Surrender Notice which requires that there is written confirmation that the cap was established in accordance with relevant specifications as follows:

“Within three months of completion of the installation of the final cap, the licensee must provide the EPA with a written Validation Report that includes:

> *i) Advice that the final cap has been installed;*
>
> *ii) Advice from a suitably qualified and experienced person as to whether or not the cap was installed in accordance with Chapter 7 of the Landform and Capping Strategy and relevant conditions of this Notice, or future variations to this Notice;*
>
> *iii) Provision of the results of all relevant test results to validate that the permeability of the final capping layer is less than or equal to $K = 1 \times 10^{-7}$m/s. Permeability testing must be taken of the sealing layer material at a rate of not less than 1 per 2000T (or 1250m^3);*
>
> *iv) Provision of information that establishes the thickness of the installed sealing and revegetation layers in the format of either:*
>
> > *(i) As constructed drawings, including cross sections, of the surfaces of the coal washery reject layer; and*
> >
> > *(ii) The results of surveys undertaken for each capping layer by a registered surveyor”.*

The Contractor is to allow for all effort necessary to assemble adequate validation evidence throughout the implementation of the Closure Works and for the preparation of the validation report. For the avoidance of doubt, the Contractor is required to validate that the Closure works have been delivered in accordance with the design and Tender Specification in relation to capping parameters and the Materials Management Plan in relation to materials handling and tracking. The environmental performance expectations within this CEMF must be achieved as part of the Contract but are not required to be incorporated into the Validation Report. Evidence of compliance is to be available on request by HCCDC.

5.2.4 Annual compliance reporting

During the performance of the contract, and as a condition of satisfaction of the care and maintenance obligations, the Contractor will be responsible for the preparation of an annual compliance report against the conditions of the notice of determination.

5.3 Corrective Action

Non-compliance may be identified through routine weekly site inspections, impromptu site inspections, via the CEMF or CEMP review or audit process or be incident based.

Environmental non-conformance include:

- non-compliance with environmental management controls or mitigation measures specified within the CEMP;
- environmental incidents not threatening material harm to the environment; and
- environmental emergencies threatening material harm to the environment.

Corrective actions may be triggered by any of the above and will include immediate steps taken to control event, investigation and development additional controls to prevent recurrence. Corrective actions will be developed in consultation with the HCCDC and will be assigned to the appropriate staff for close out. All corrective actions will be tracked through to completion through the non-conformance tracking register.

All environmental non-conformances with project approvals, this EMP or Contractor procedures is to be recorded as an incident, investigated and closed out by the Contractor. Close-out is required to include Construction supervisor sign-off that corrective actions have been implemented or alternative solutions substituted. A summary of all non-conformances and associated corrective actions is to be provided to the HCCDC.

In addition to the above, incidents causing or threatening material harm to the environment are regulated under the POEO Act, which defines material harm under section 147, as follows:

(1a) harm to the environment is material if

(i) it involves actual or potential harm to the health or safety of human beings or to ecosystems that is not trivial, or

(ii) it results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000 (or such other amount as is prescribed by the regulations), and

(1b) loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment;

(2a) it does not matter that harm to the environment is caused only in the premises where the pollution incident occurs.

The POEO Act requires incidents causing or threatening material harm to the environment to immediately notify the relevant authorities, which include:

- the EPA;
- Newcastle Council;
- the Ministry of Health;
- the WorkCover Authority; and
- Fire and Rescue NSW.

The POEO Act outlines responsibilities down to an individual level to notify incidents threatening material harm to the environment immediately. In general terms all individuals are responsible for reporting such incidents to the Construction Project Manager who in turn will inform HCCDC. HCCDC would then notify relevant authorities. It also requires that an individual notify the incident where they cannot make contact with their employer. Relevant authority contact details are included in the table below and should be displayed where all site workers can access them easily in the event of a notifiable incident occurring.

Table 1 Relevant Authority Contact Details

Contact	Phone Number
The EPA Environment Line	131 555
The Ministry of Health via the Public Health Unit	1300 066 055
SafeWork NSW	13 10 50
Newcastle City Council	02 4974 2000
Fire and Rescue NSW	000

Environmental incidents relating to the *Environmental Protection and Biodiversity Conservation Act 1999* must be notified to the Secretary of the Department of the Environment and Energy. Specifically, conditions 16 and 17 of the Notice of determination require the following:

16. The approval holder must notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in plans. The notification must be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance. The notification must specify:

a. the condition which is or may be in breach; and

b. a short description of the incident and/or non-compliance.

17. The approval holder must provide to the Department the details of any incident or non-compliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying:

a. any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future;

b. the potential impacts of the incident or non-compliance; and

c. the method and timing of any remedial action that will be undertaken by the approval holder.

5.4 CEMF Review

This CEMF forms the basis on which the contractor's CEMP should be prepared and as such is to be reviewed/adapted or superseded based on the contractor's specific work methods and approach to environmental management. The Contractor's CEMP should be reviewed in accordance with the requirements of their environmental management system but should also be reviewed during implementation as and when required, including when the following situations arise:

- Client recommendations for changes (particularly following initial review);
- Opportunities for improvement or deficiencies in the project system are identified; or
- Following an audit of the system or the occurrence of significant incidents and non-conformances.

Appendix A. Legislative requirements

Legislation and administering authority	Requirement	Application to Closure Works
Environment Protection and Biodiversity Conservation Act 1999 Commonwealth Department of the Environment and Energy	The relevant objective of the Act is to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance. A project may be defined as a controlled action under the Act due to impacts on matters of national environmental significance.	The Project was determined to be a Controlled Action due to potential impacts to the identified key population of Green and Golden Bell Frogs and associated impacts to the ecology of the Hunter Estuary Ramsar wetland should this population be threatened. The project was approved by the Commonwealth on 22 March 2019 on the basis of the preliminary documentation provided by HCCDC. Conditions of determination have been issued and are incorporated into this CEMF. Notwithstanding anything else within this CEMF and the contract documents, the Contractor is responsible for understanding and complying with the Conditions of determination.
Environmental Planning and Assessment Act 1979 Department of Planning and Environment	Encourages proper environmental impact assessment and management of development areas for the purpose of promoting the social and economic welfare of the community and a better environment.	The Project was assessed and determined under the former Part 5 (now referred to as Division 5.1) of the EP&A Act and found unlikely to significantly impact the environment subject to the implementation of a range of mitigation measures contained within the assessment documentation. These mitigation measures have been incorporated into this CEMF.
Protection of the Environment Operations Act 1997 Environment Protection Authority (EPA)	The relevant objective of the Act is to prevent environmental pollution.	The Project is regulated under the POEO Act through the Surrender Notice but does hold a current Environment Protection Licence (for activities listed under Schedule 1). In addition to complying with the conditions of the surrender notice the general duties to prevent air/ noise/ water pollution and manage waste correctly do apply. It is the contractor's obligation to undertake works in accordance with the surrender notice and in a manner that prevents pollution. Further, the Contractor is the occupant of the site under the POEO Act (as per HCCDC18/04 contract).
Contaminated Land Management Act 1997 NSW EPA	The Act provides a process for the investigation and remediation of land where contamination presents a significant risk of harm to human health or some other aspect of the environment.	While the site is known to contain contamination it is not currently regulated under this Act as it is regulated by the EPA through the POEO Act and it is not the intention of the EPA to regulate the same site under both Acts concurrently. It is the contractor's obligation to manage contaminated materials in accordance with the

Legislation and administering authority	Requirement	Application to Closure Works
		Materials Management Plan such that contaminated materials encountered is appropriately managed to avoid exacerbation and such that the fate of such material is documented.
Dangerous Goods (Road and Rail Transport) Act 2008 EPA / SafeWork NSW	A licence is required for the storage (SafeWork NSW) and /or transport (EPA) of prescribed quantities of dangerous goods.	The Contractor is required to ensure that the transport and storage of dangerous goods exceeding licensable quantities is lawfully undertaken.
Environmentally Hazardous Chemicals Act 1985 EPA	Management of Environmentally Hazardous Chemicals.	Should any material generated or encountered at the site contain chemicals that are the subject of NSW's five (5) current Chemical Control Orders (CCO), then the material will need to be managed in accordance with that CCO. Current CCO include: · Chemical control order in relation to aluminium smelter wastes containing fluoride and/or cyanide (1986) · Chemical control order in relation to dioxin-contaminated waste materials (1986) · Organotin waste materials chemical control order 1989 · Polychlorinated biphenyl (PCB) chemical control order 1997 · Scheduled chemical wastes chemical control order 2004.
Heritage Act 1977 NSW Office of Environment and Heritage (OEH)	The Act aims to encourage the conservation of the State's heritage and provides for the identification and registration of items of State heritage significance.	Not expected to impact any items on the State Heritage Register (SHR). Should the project unexpectedly find any heritage artefacts, the relevant notifications and management actions may need to be taken.
National Parks and Wildlife Act 1974 OEH	The objectives of the Act are for the conservation of nature and the conservation of objects, places or features (including biological diversity) of cultural value within the landscape.	The proposal would not affect any area declared as a National Park, historic site, nature reserve or Aboriginal area nor would it impact any historic Aboriginal object or place, threatened species, population or endangered ecological community. The potential exists for unexpected objects to be found of significance to Aboriginal people. The Chief Executive of the OEH is the authority responsible for the protection of all Aboriginal objects and places in NSW, whether they are on national park estate or not.

Legislation and administering authority	Requirement	Application to Closure Works
Threatened Species Conservation Act 1995 OEH	Provides for the protection of any threatened species on-site.	Impacts to Threatened Species are assessed through the REF and mitigation measures to prevent significant impacts are incorporated into this EMP. Any unexpected species encountered during construction may require further assessment.
Biodiversity Conservation Act 2016 OEH	The purpose of this Act is to maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development. The BC Act commenced on 25 August 2017 repealing the *Threatened Species Conservation Act 1995* (TSC Act).	The proposal would be considered a pending Part 5 assessment if it commences within 18 months of August 2017. Under Clause 29 of the BC (ST) Regulations, the former planning provisions continue to apply (and Part 7 of the new Act does not apply) to a pending Part 5 assessment, with the former planning provisions defined as the provisions of the EP&A Act that would be in force if that Act had not been amended by the BC Act and which call-up guidelines established under the TSC Act.
Biosecurity Act 2015 OEH	The primary object of this Act is to provide a framework for the prevention, elimination and minimisation of biosecurity risks which includes the management of plant and animal pests.	The following pests are known to be present on site and will require appropriate management · Bitou Bush (Chrysanthemoides monilifera subsp rotundata), · Crofton Weed (Ageratina adenophora); · Pampas Grass (Cortaderia selloana). · African Olive (Olea europaea), · Lantana (Lantana camara); and · Groundsel Bush (Baccharis halimifolia). In accordance with the Act all plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable. Surrounding ponds are also populated by Mosquito Fish (*Gambusia Holbrooki*) and the works are required to avoid any transfer or connection of water bodies that could lead to their spread.
Water Management Act 2000 Department of Lands - Water	The relevant objective of the Act is to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality.	Clause 38 or the Water Management (General) Regulation 2011 provides that a public authority is exempt from section 91E (1) of the WM Act in relation to all controlled activities that it carries out in, on or under waterfront land. As such a

Legislation and administering authority	Requirement	Application to Closure Works
		controlled activity approval is not required for the proposed activity. The water within the fill aquifer is not considered to occur naturally, no use of water in surface water bodies is proposed and no use of other naturally occurring water sources is proposed and as such a water use approval is not deemed necessary. The proposed works do not include aquifer interference and it is understood that the Aquifer interference requirements of the Act are yet to commence and as such aquifer interference approval is not deemed necessary.
State Environmental Planning Policy (Three Ports) 2013 Department of Planning and Environment	The aim of this Policy is to provide a consistent planning regime for the development and delivery of infrastructure on land in Port Botany, Port Kembla and the Port of Newcastle.	The closure works are within the land application area and Lease Area and Environmental Management Works / Environmental Protection works are permissible without consent in the Three Ports Lease Area. The Project has been assessed under the former Part 5 (Division 5.1) of the EP&A Act (refer above).
State Environmental Planning Policy 55 Department of Planning and Environment / Council	The object of this Policy is to provide for a Statewide planning approach to the remediation of contaminated land.	While the closure works also meet the definition of remediation works under this policy, the Three Ports SEPP prevails to the extent of any inconsistency. Clause 8 (4) requires that a person who carries out a remediation work must ensure that the Council notification requirements of clause 16, 17 and 18 are complied with in relation to the work. Notification of Council required 30 days in advance of commencement of Category 2 remediation. Notification of Council following completion.
State Environmental Planning Policy (Coastal Management) 2018	The aim of this Policy is to promote an integrated and co-ordinated approach to land use planning in the coastal zone in a manner consistent with the objects of the Coastal Management Act 2016, including the management objectives for each coastal management area, by: · managing development in the coastal zone and protecting the environmental assets of the coast, and	The closure works area is surrounded by, but does not include, land mapped as coastal wetlands. Parts of the closure works area are mapped as proximity area for Coastal Wetlands, Coastal Environment Area and Coastal Use Area. Importantly, the closure works area is within the Lease Area under the Three Ports SEPP and the Coastal Management SEPP does not apply through the workings of Clause 7 of the Coastal Management SEPP.

Legislation and administering authority	Requirement	Application to Closure Works
	· establishing a framework for land use planning to guide decision-making in the coastal zone, and · mapping the 4 coastal management areas that comprise the NSW coastal zone for the purpose of the definitions in the Coastal Management Act 2016.	
Newcastle Local Environment Plan Newcastle Council	This Plan aims to make local environmental planning provisions for land in the City of Newcastle in accordance with the relevant standard environmental planning instrument under the EP&A Act.	While located within the Newcastle Local Government Area the site is not located on land to which the *Newcastle Local Environmental Plan 2012* (NLEP) applies.

Appendix B. Environmental Obligation Interface

Sequence of Work Activities	Controls/Mitigation Measures	Primary Responsible
Tender and award	· Establish all required approvals under EPBC Act and EPA Act. · Finalise Closure Works design to comply with approvals. · Integrate above requirements into CEMF and Tender Specifications. · Scheduling works to the extent possible to occur outside of the core GGBF breeding period (that is, September to March), especially in areas adjacent to known and potential breeding habitat.	State. Contractor responsible for review of approvals in place and obtaining any additional necessary approvals.
Peninsular / Wedge Access	· Complete access upgrade design to accommodate Contractor equipment in agreement with ARTC.	Contractor in consultation with ARTC
Pre-earthworks monitoring and ongoing EPL Surrender Notice monitoring.	· Update relevant GGBF abundance survey data and water level and salinity logger data. · Undertake annual surface and groundwater monitoring as per EPL Surrender notice.	State Contractor to facilitate access through Closure Works Area as required.
Auditor oversight	· Undertake all necessary site inspections, provide input into materials management decision making to allow auditor sign-off of Closure Works completion.	State to appoint auditor. Contractor to facilitate access and provide validation information as requested by Auditor.
Site Establishment	· Implement hygiene protocol as required for the closure works area (NSW Threatened Species Management Information Circular No.6 (April 2008)). · Establish any controls necessary to prevent works from occurring outside the referral boundary. · Temporary frog exclusion fencing to surround the Closure Works site and ensure GGBF habitat protected from unauthorised access prior to works commencing in those works areas or their parts. · Conduct pre-clearance surveys by a qualified ecologist in week prior to works commencing in works areas or their parts. · Apply erosion and sediment controls as per sensitive environments (Managing Urban Stormwater – Soils and Construction (Landcom 2004)) and complete and line permanent basins as per designs provided by the State.	Contractor

Sequence of Work Activities	Controls/Mitigation Measures	Primary Responsible
	· Prepare stockpile area with adequate space for 'topsoil' level 1, 2 and 3 material and erosion and sediment controls as per ESCP and Materials Management Plan (RCA Australia 2012). · Level 2 and level 3 stockpile areas are to be lined in accordance with materials management plan (RCA Australia 2012) as necessary. · Store all hazardous liquids and chemicals in covered, bunded areas with capacity to retain 110% of largest container in the event of a spill. Proprietary available spill mats, drip trays and pallets can be used as appropriate. · Provide fully stocked spill kit/s and ensure that operators are aware of the location of these kits and are trained in their use.	
Bulk earthworks	· Undertake weed management in advance of broad scale clearing and bulk earthworks. · Win and transport site derived capping and land forming materials. · Use of imported capping material assessed as having a low risk of containing Chytrid Fungus. · Use of revegetation medium materials demonstrated to be low in nutrients and assessed as having a low risk of containing Chytrid Fungus. · Works are to be staged to reduce area of exposure and minimise dust, infiltration and sediment laden run-off. · Qualified ecologist to be available on call during earthworks in the event that any GGBF individuals are encountered during works, the ecologist must be called in to capture and relocate the individuals. · Materials will be managed in accordance with the approved Materials Management Plan and GGBF management plan within each area and no transport of fill, capping or topsoil between areas is to occur. · Strip topsoil to a minimum of 100mm following material management plan decision matrix for suitability for re-use. · Topsoil to be stored separately in prepared stockpile areas as per detailed design documentation. · Stockpiles to be stored for long periods are to be wrapped, covered, re-seeded or wet to minimise dust generation. · Cut to base of excavations as per detailed design documentation insuring minimum 1% grade. Cut material to be used as fill and capping in accordance with materials management plan decision matrix. · The final surface of both capped and uncapped areas will be protected by a vegetative layer. The extent of the revegetation will depend on the proposed site use (i.e. undeveloped, commercial development or habitat areas).	Contractor

Sequence of Work Activities	Controls/Mitigation Measures	Primary Responsible
	· The use of imported topsoil is to be avoided where possible. · Upon completion of the works, the works areas must be rehabilitated in accordance with Rehabilitation Management Plan. · Dispose of materials unsuitable for reuse in accordance with materials management plan. · All waste to be removed upon completion. · Upon completion, site facilities, frog exclusion fencing and security fencing shall be removed as necessary. · Non-permanent erosion and sediment controls are to remain in place until they are no-longer required. · Sediment basins and drains will remain in place as landscape features until they are no longer required. · Refuelling is not to occur in the vicinity of sediment dams, drainage lines or water bodies. · Refuel plant using drip trays/spill mats and other spill containment devices. · Store all hazardous liquids and chemicals in covered, bunded areas with capacity to retain 110% of largest container in the event of a spill. Proprietary available spill mats, drip trays and pallets can be used as appropriate. · Do not leave chemical containers open outside or inside of the bunded areas. · Provide fully stocked spill kit/s and ensure that operators are aware of the location of these kits and are trained in their use. · Spills are to be immediately contained and absorbed using materials provided in the spill kit. · All personnel are to be trained in the appropriate use and disposal of spill kit materials.	
Construction Monitoring	· Daily prestart checks on amphibian disease hygiene station functioning and supplies and weather forecast noting predicted wind and rain. · Real-time classification of soils to nominated thresholds in accordance with the Materials Management Plan decision matrix. · Post rainfall checks of sediment dam water level and water quality and erosion and sediment control functioning.	Contractor

Sequence of Work Activities	Controls/Mitigation Measures	Primary Responsible
	· Weekly site inspection checklist covering sediment dam water levels and water quality, erosion and sediment control structures, frog fences, fuel and chemical storage, stockpile bunding and covers. · Pre-discharge physical water quality condition (temperature; dissolved oxygen; pH; electrical conductivity (EC)) and chemical water quality condition in sediment dams. · Noise monitoring of any out of hours construction works in accordance with interim construction noise guidelines. · Reference to available PWCS/NCIG dust monitoring results to determine off site dust levels.	
Defect Liability period	· Check and maintain the erosion and sediment controls regularly, especially after rainfall, to ensure that they remain effective including: o Collected sediment is to be removed from the controls as necessary to ensure they remain effective. o Collected sediment is to be combined with planting medium for reuse on the site – if appropriate. o All vehicle wheels, tracks and undercarriages must be cleaned prior to exiting the site and travelling on public roads. · Three month vegetation maintenance program to include, watering, weeding as appropriate but excluding the use of fertilisers and pesticides and herbicides. · Pre and post discharge surface water monitoring in sediment dams and receiving waters. · Revegetation monitoring and maintenance to ensure adequate cover. · Preparation of an annual compliance report against the conditions of the notice of determination.	Contractor

Appendix C. Materials Management Plan

Hazardous / Contaminated Material	
Objective	To comply with legislative requirements and ensure that hazardous / contaminated material from construction activities does not cause an environmental nuisance / harm and is handled, categorised, tracked and placed in accordance with the RCA (2012) Materials Management Plan.
Targets	No exacerbation of contamination during construction No environmental incidences involving contaminated/ hazardous materials No pollution events of the surrounding environmental and water ways by contaminated material The movement and ultimate fate of materials is fully tracked
Key Documents	**State Documents** NSW EPA (2010), Approval of the Surrender of a Licence – License 6437, (Ref: 1111840, and as varied by notice number 1510956 and 1520063) GHD (2009), Report on KIWEF, Revised Final Landform and Capping Strategy (Ref: 22/14371/85882 R4) RCA (2012) 'Materials Management Plan - Kooragang Island Waste Emplacement Facility' dated November 2012.
Material Classification	**Level 1** material is any material not exhibiting characteristics indicative of other categories. **Level 2** material is identified as material with any of the following characteristics: strong hydrocarbon odour, ammonia odour, asbestos containing material, evidence of PCB impact (dark staining and phenolic odour), materials with an average concentration of >2,000 mg/kg PAH or material represented by individual PAH concentration >2,500 mg/kg. **Level 3** material is material containing Separate Phase Hydrocarbons.
Mitigation Measures and Controls	The following is generally reproduced from RCA (2012).
Contaminated material identification and management	The Contractors Materials Management Plan is to be adequate to ensure that material management is undertaken in accordance with RCA (2012) in addition to meeting the performance expectations of the Contract Specifications and this CEMF. The Contractors Materials Management Plan is to incorporate a protocol for identification and management of Contaminated Materials that is to include the following: · Appropriate resourcing for real-time supervision of all ground disturbance activities by a suitably qualified and environmental practitioner;

Hazardous / Contaminated Material	
	· Stop work requirements (localised) if any soils are encountered which have distinguishing Level 2 or Level 3 characteristics. · Characterising and delineated Level 2 and Level 3 materials in-situ or at the place of storage following excavation including input from occupational hygienist or other appropriately qualified specialist (Contractor's Specialist) to identify the substance. · Consultation with third party advisors, the State and the auditor to confirm management expectations. All contaminated material encountered during the landfill closure works will be assessed and categorised in accordance with RCA (2012). All material is to be adequately tracked such the that the composition and location of all Level 2, Level 3 and asbestos waste fate is documented and able to be validated. Uncovering of suspected level 2, level 3 or otherwise hazardous material requires the following steps to be undertaken: · Immediately cease work and contact the Site Supervisor · Demarcate the 'unexpected find' to prevent access and install appropriate environmental and safety controls. · Follow the management steps specified below in relation to each material classification; and · If substance is assessed as level 1 material not presenting an unacceptable risk to human health the Site Supervisor to remove controls and continue work.
Level 1 Material management	There is no specific management required for Level 1 material on the site and Level 1 material has unrestricted onsite re-use classification (Section 5.6.1 of RCA 2012). Level 1 material may be used for: · Topsoil where sourced from top 100mm of existing landform; · General land forming; · Buffer material to be placed above Level 2 and Level 3 Material; · Interim bunding for stockpiled material; and · Site capping material. Level 1 material properties are to be validated in accordance with the Tender Specifications for testing and analysis.
Level 2 Material management	Level 2 material is designated as having restricted site use and where encountered is to be managed as follows: · Where suspected Level 2 soils are encountered then the nature and extent of the materials should be validated by laboratory testing to assess whether the materials are still to be classified as Level 2 or Level 3 materials. · If Level 2 material is encountered but is to remain in place and will have sufficient cap (ie >500mm), the vertical extent does not need to be validated.

Hazardous / Contaminated Material	
	· The Contractor is to develop a notification detailing material type, location, estimated quantity and potential contaminants. · The Contractor is to notify the State or its representative within 24 hours of encountering Level 2 material. · Level 2 material may be relocated to a lined and covered short-term stockpiling or skip-bin for further quantification, characterisation and categorisation. · Confirmed Level 2 contaminated material is to be isolated by covering with at least 500mm of Level 1 material, plus 500 mm of cap with preference for material to be left in situ provided there is no immediate risk to the environment or community or otherwise be relocated to an on-site location.
Level 3 Material Management	Level 3 material is designated as having restricted site use and must managed as follows: · The Contractor is to develop a notification detailing material type, location, quantity and potential contaminants. · The contractor is to notify the HCCDC as soon as possible and on the day the material is encountered. · HCCDC will then notify the EPA; · Level 3 material may be relocated to a lined and covered stockpile or skip bin for further characterisation and categorisation and while a decision is made by HCCDC on the preferred manner of ultimate disposal. The HCCDC will provide direction as to the required treatment of Confirmed Level 3 contaminated material which may include: · Isolated by covering with at least 1000mm of Level 1 material, plus 500mm of cap with preference for material to be left in situ provided there is no immediate danger to the environment or community or otherwise be relocated to an on-site location with the area having appropriate controls in place; or · Transported off-site for disposed in a legal manner.
Asbestos Management	Asbestos materials (and ACM) should be managed generally as follows as specified in RCA MMP (2012): · Where at all possible, materials containing bonded asbestos wastes would be fully delineated, be assessed to be at least 1m below final capping, and remain as undisturbed materials managed by in-situ containment; · Should any fill materials containing bonded asbestos wastes require excavation as they are not in-situ more than 1m from the final cap in the earthworks, then consideration would be given to removing the materials and emplaced at a depth of 1m; · Friable asbestos would be assessed and considered for emplacement at a depth of 2.5m below the underside of the capping layer within a purpose built excavation at a location to be agreed with HCCDC; · Final location of any asbestos discovered shall be thoroughly documented including accurate survey of the emplacement area;

Hazardous / Contaminated Material	
	· Where asbestos waste is found in fill that also contains volatile organic compounds or separate phase hydrocarbons, appropriate treatment for recorded contaminants will be required; and · All asbestos is to be managed and handled in accordance with the recommendations of an appropriately licensed Asbestos Assessor/handler. The use of in-situ or ex-situ treatment approach for any materials containing bonded and friable asbestos wastes will be assessed on a case by case basis in relation to volume and risk to human health.
Other waste management	Minimal volumes of material requiring off-site disposal have been encountered in previous stages of KIWEF closure works. In the event that such material is encountered it will be classified in accordance with the Waste Classification Guidelines (2015) and disposed of to a landfill legally able to accept the waste. Wastes generated in completing the capping works are also required to disposed of off-site. All other contaminated materials will be managed on site in accordance with the Materials Management Plan. Waste management measures to be implemented include: · Licensed waste contractors will be utilised to remove waste. · All waste is to be disposed of at a lawful facility (Note: A lawful facility includes one that has the appropriate Development Consent, Environment Protection Licence or is complying with EPA approved conditions and requirements). · Waste must be classified prior to disposal – refer to NSW EPA Waste Classification Guidelines (2015). · Records of the quantity and final locations of all on and offsite waste will be maintained · Provision of skip bins (or equivalent) to be used to collect all general wastes generated during the works. · Provide an adequate number of skip bins on site to contain all general waste generated throughout the works. · Provide bins to enable waste segregation · Provide recycling services (e.g. Paper, Concrete, Steel, Cardboard, Timber). · Ensure housekeeping is maintained and waste is disposed of to the appropriate bin. · Retain waste disposal permits and figures on the amount of waste that has been removed from site.
Monitoring & Reporting	**Real-time Supervision -** Real-time observation of all ground disturbances by a suitably qualified environmental practitioner to identify and manage suspected contaminated material. **Sampling and analysis** of material properties for categorisation and validation purposes in accordance with the tender specifications. The **daily record of material management** is required to summarise material interaction for the day and include: · Description of earthworks activity undertaken;

Hazardous / Contaminated Material	
	· Description of cut to fill or cut to stockpile activities including locations; · Notification to HCCDC of suspected contaminated or otherwise hazardous material encountered and description of handling, current location, further assessment required; and · Summary of any handling of previously notified material including update on current location. All notifications are also to be tracked through a notifications register to record final disposal location. **Monthly Progress Reporting** is to include details of the implementation environmental management requirements including: · Update on any environmental risks and opportunities, and significant environmental impacts associated with the work; · Progress against environmental objectives, targets and measures of performance; and · Management actions, including environmental controls, training, inspections and testing. Specifically, the environmental monthly reporting is to include such items as: · Characterisation, site management and fate of contaminated material, collated materials tracking information; · Quality assurance on placed material; · non-compliances and corrective actions; · environmental monitoring requirements; and · monthly logs and photographs and other records of the progressive compilation of information that will be integrated into the Validation Report on completion. A **Validation Report** is required to satisfy Condition 4h of the Surrender Notice which requires that there is written confirmation the cap was established in accordance with relevant specifications.
Actions	The Contractor's CEMP is to include specific procedure for monitoring, management and documentation of materials management suitable for implementation to achieve the intent of the Materials Management Plan and Surrender Notice under the Contractors specific construction methodology.
Responsibilities	The Contractor is to ensure that appropriate resources and processes are in place and that appropriate records are kept to allow validation that materials have been managed in accordance with the Surrender Notice.
Timeframe	Duration of site activities where works may encounter potentially contaminated fill materials.

Appendix D. Flora and Fauna Management Plan

Flora and Fauna	
Objective	To comply with contractual and legislative requirements and ensure that native fauna and flora are protected from construction activities.
Targets	No death or injury to fauna including the Green and Golden Bell Frog No unapproved destruction of flora
Legal, Contractual & Other Requirements	*Environmental Protection and Biodiversity Conservation Act 1999* *Threatened Species Conservation Act 1995 (repealed)* *Biodiversity Conservation Act 2016 (Transitional Arrangements).*
Site specific planning / approval conditions / licence conditions	**State Documents** NSW EPA (2010), Approval of the Surrender of a Licence – License 6437, (Ref: 1111840, and as varied by notice number 1510956 and 1520063) Golders (2011), KIWEF Closure Works, Green and Golden Bell Frog Management Plan (Ref: 117623029-001-R-Rev0) Jacobs (2018) Addendum Review of Environmental Factors, KIWEF Area 2 Closure Works **Commonwealth Documents** Ramboll (2018), EPBC Referral, Preliminary Documentation Package – KIWEF Area 2 Closure Works (Ref: 318000395)
General Flora and Fauna Mitigation Measures and Controls	General mitigation measures to be considered include: · Adequate run-off, erosion and sedimentation controls should be in place during construction, particularly in areas where run-off has the potential to impact on nearby waterways, surrounding native vegetation, EEC regrowth, and existing drainage line and dam areas. · Care should be taken that any noxious weeds occurring on the site are not further dispersed as a result of the Proposal. A follow up Weed Control Program may be necessary to control the encroachment of these species into surrounding areas. The landowner has a legal responsibility to control and suppress these species on their property under the *Noxious Weeds Act 1995*. The Weed Control Program should be remove weeds by physical means and avoid the use of herbicides. · Stockpiling of soil that may contain seeds of exotic species shall be stockpiled away from adjacent vegetation or drainage lines where they could be spread during rainfall events. · Placement of soil stockpiles away from vegetated areas. · Utilising existing disturbed corridors such as cleared areas, roads, tracks and existing easements, where possible for set up of equipment, stockpile areas and site facilities.

Flora and Fauna	
	· Noxious weeds to be managed in accordance with the expectations under the *Biosecurity Act 2018*. It is recommended that the plants be removed by physical removal, as herbicides may impact GGBFs and their habitat. · Open excavations and storage areas to be inspected regularly for the presence of fauna species. · Plant and equipment brought on to site must be cleaned and free of deleterious material, mud and other material that may harbour weed seeds · Proposed hours of construction are to be maintained to restrict noise and light impacts on nocturnal fauna. · Utilise an onsite ecologist during construction to re-locate any native fauna which may be displaced. · Avoid rubbish and other waste build up to deter feral animals. · Habitat features such as woody debris that may be utilised by fauna within the construction area would be retained and set-aside during the construction period for reinstatement at completion of works. · Any water required for dust suppression will be drawn from ponds established for the purpose. No water for dust suppression will be drawn from existing ponds on the site. The establishment of dedicated dust suppression ponds will be undertaken to prevent the potential spread of Plague Minnow into ponds currently free of this species. The location and procedure for those dedicated dust suppression ponds will be communicated during the site induction and training. · No night works are permitted without additional assessment of potential noise and light impacts. · Lighting of site compounds, if required for safety and security, will avoid light spill outside of the construction works footprint and will be undertaken in accordance with *Australian Standard 4282—1997 Control of the obtrusive effects of outdoor lighting.*
GGBF Management	GGBF impact avoidance is to be based on the following: · Establishment and use of Chytrid Hygiene procedures such that the Chytrid fungus is not brought to site or transferred between areas of the site; · Appropriate levels of GGBF pre-clearance/disturbance surveys and relocation to ensure to the extent possible that direct disturbance areas are free of GGBF on commencement of works in each area; · Establishment of GGBF exclusion fencing such that the risk of GGBF re-entering surveyed areas is prevented; · Establishment of clear boundaries of works areas such that unnecessary disturbance is avoided, particularly adjacent to existing ponds; · Establishment of appropriate erosions and sediment controls to prevent sedimentation and pollution of waters; · Implementation of GGBF risk consideration to all decision making such that unintended consequences to GGBF can be avoided. This includes in considering suitability of imported materials from a Chytrid risk and nutrient perspective and use of chemicals including flocculants, herbicides and pesticides; and · Rehabilitation using species preferred by GGBF (refer to rehabilitation management plan).

Flora and Fauna	
Chytrid Fungus hygiene protocol	A Chytrid Hygiene procedure in accordance with the NSW Threatened Species Management Information Circular No.6 – Service Hygiene Protocol for the Control of Disease in Frogs (April (2008) or most recent revision of that document, must be implemented on the Closure Works site during all works and any other activities undertaken as part of the action. This procedure is to include: · Dedicated disinfection bays established at site entry and all vehicles required to enter via this bay; · All disinfection processes will be monitored and controlled at the Closure Works entry point; · The location of these disinfection bays, and the obligations of disinfection, will be communicated during the site induction and training; · Cleaning and disinfection of workers boots upon entry and exit from the site; · Procedures will be implemented to inspect mobile plant entering the Project site during construction activities to control soil and/or organic matter and to disinfect tyres and wheels of vehicles entering the Project site; and · Vehicles arriving at site muddy will be sent away for more intensive cleaning prior to disinfection.
Chytrid Fungus Risk Assessment Process	The contractor is to demonstrate that suitable risk assessment has been undertaken by an appropriately qualified and experienced ecologist on all imported capping and revegetation materials to demonstrate that it contains a low risk of containing Chytrid. Risk assessment should consider as a minimum: · Material not sourced from known, suspected or likely amphibian habitat areas; · Material unlikely to have had contact with amphibians and no amphibians present in material; and · Material are not to be stored in, or come in contact with material sourced from, areas of known, suspected or likely amphibian habitat prior to transport.
Pre-clearance survey design and clearance methodology.	The Contractor will be responsible for developing a pre-clearance survey and clearing methodology suitable for implementation with the contractors specific construction methods that minimises potential harm to GGBF species. The survey methodology should give consideration to the following factors: · Level of effort warranted in different areas and habitats; · Seasonal factors on GGBF use of habitat; and · Need for night time surveys. · Survey effort required is likely to include: o Targeted active searches of potential GGBF habitat located within the disturbance footprint; o Conducted to minimise disruption of breeding activities: relocated tadpoles or metamorphs; · Be conducted in accordance with hygiene protocol;

Flora and Fauna	
	· Habitat resources including all wet areas as well as rocks, logs, tussock forming vegetation, and other cover will be searched during diurnal visual inspections. · A nocturnal habitat search including visual search, spotlighting and call playback may be conducted to assess nocturnal use (breeding/calling) in the habitat supported in disturbance area, if the surveys are conducted during core breeding season (spring/summer); · Any GGBF observed within the disturbance footprint will be relocated in accordance with relocation procedure provided in the GGBF Management Plan prior to commencement of disturbance; and · The survey methodology implemented should allow the qualified and experienced ecologist to confirm that the risk of GGBF mortality has been reduced to the extent reasonable and feasible for the applicable habitat type/area. The clearing methodology should include the following: · Consideration of most appropriate time to install frog exclusion fences; · Presence of an appropriately qualified and experienced ecologists during clearing; · Gradual degradation of higher risk habitat areas progressing from areas furthest away from pond towards areas of refuge; · Relocation of cleared vegetation to areas away from immediate works that allow remaining amphibians to escape; and · Ability to open amphibian fences during clearing at key times to allow fauna to escape.
Amphibian Relocation	If any frog specimens thought to be a GGBF are observed and are within project disturbance area the following relocation procedure will be implemented: · Observer to notify Site supervisor who in turn is to notify the HCCDC, a suitably qualified ecologist, and the Contractor's supervisor of the frog's location immediately; · Contractor supervisor to halt work in the immediate vicinity to prevent accidental interaction with the frog; · The ecologist or HCCDC's environmental representative will determine whether the frog is likely to be harmed by works or is likely to migrate to an area that it could be harmed; · If likely to be harmed by works the GGBF will be captured by the ecologist or suitably trained frog handler following GGBF handling and Hygiene procedures; · A one frog per bag policy will be observed with disinfection of all equipment undertaken immediately following any contact with frogs of any description; · If healthy the frog will be held in a cool, dark, moist place until nightfall before being released to a suitable location in the immediate vicinity of capture but outside the disturbance footprint;

Flora and Fauna	
	· GGBF showing Chytrid symptoms and deemed unlikely to survive transportation will be euthanized and preserved prior to dispatch to a designated sick or dead frog recipient in accordance with Appendix 2 of the National Parks and Wildlife Service's Hygiene protocol for the control of disease in frogs (NPWS, 2008); · If deemed likely to survive transportation GGBF will be placed in a damp cloth bag or partially inflated plastic bag with leaf litter; · Dead frogs will be preserved in accordance with the approved GGBF management plan including cutting open stomach and preserving in 10 times the volume of the specimen of 65% ethonol or 10% buffered formalin · The designated sick or dead frog recipient will be contacted prior to transport to confirm appropriate procedures; · Containers used for storing frogs will be labelled with date, location and species if known; and · A standardised collection form must be completed and a copy sent with the specimen.
Actions	The contractors CEMP is required to establish the actual pre-clearance and clearance methodology, exclusion fence designs and Chytrid Risk assessment and documentation proposed.
Responsibilities	Contractor's Ecologist is responsible for ensuring risks to Fauna is minimised to the extent reasonable and feasible. Contractor's Project Manager is responsible for allowing sufficient time within program to conduct pre-clearance and clearance in a manner that maximises survival of GGBF and other fauna following the advice of the Ecologist. Contractor is responsible for notifying the Principal of any sick or dead GGBF. All personnel are responsible for ensuring that the clearing limits are addressed and native flora and fauna species are protected. All site personnel to undertake toolbox talks in relation to the reporting process for injury/ death to fauna or clearing of flora occurring beyond the required limits for construction.
Timeframe	Duration of the works.
Monitoring & Reporting	Daily visually monitoring by site supervisors for obvious signs of fauna and the functioning of controls including fences and Chytrid hygiene stations. Weekly inspections to be documented on a Weekly Environmental Inspection Checklist. Outcomes of pre-clearance surveys are to be documented and provided to the HCCDC. Observed sick or dead GGBF are to be notified to the Principal immediately.

Appendix E. Revegetation Management Plan

Revegetation Management Plan	
Objective	To comply with State and Commonwealth approvals requirements and related conditions. To provide a post construction environment that is revegetated to stabilise the capping surface; and planted with species known to be favoured by GGBF.
Targets	The capped surface is stabilised and vegetated within 12 months of construction completion. Provide a revegetated capped surface that includes species of flora known to be favoured by GGBF.
Key Documents	**State Documents** NSW EPA (2010), Approval of the Surrender of a Licence – License 6437, (Ref: 1111840, and as varied by notice number 1510956 and 1520063) Golders (2011), KIWEF Closure Works, Green and Golden Bell Frog Management Plan (Ref: 117623029-001-R-Rev0) GHD (2009), Report on KIWEF, Revised Final Landform and Capping Strategy (Ref: 22/14371/85882 R4) Jacobs (2018) Addendum Review of Environmental Factors, KIWEF Area 2 Closure Works **Commonwealth Documents** Ramboll (2018), EPBC Referral, Preliminary Documentation Package – KIWEF Area 2 Closure Works (Ref: 318000395)
Mitigation Measures and Controls	General mitigation measures to be considered include: · Care should be taken that any noxious weeds occurring on the site are not further dispersed as a result of the Proposal. A follow up Weed Control Program may be necessary to control the encroachment of these species into surrounding areas. The landowner has a legal responsibility to control and suppress these species on their property under the *Noxious Weeds Act 1995*. The Weed Control Program should be remove weeds by physical means and avoid the use of herbicides · Stockpiling of soil that may contain seeds of exotic species shall be stockpiled away from adjacent vegetation or drainage lines where they could be spread during rainfall events. · Placement of soil stockpiles away from vegetated areas. · Utilising existing disturbed corridors such as cleared areas, roads, tracks and existing easements, where possible for set up of equipment, stockpile areas and site facilities · Bitou Bush and Crofton Weed would be managed by following the Local Noxious Weed Control Plans (NCC 2006). It is recommended that the plants be removed by physical removal, as herbicides may impact GGBFs and their habitat.

Revegetation Management Plan	
	· Plant and equipment brought on to site must be cleaned and free of deleterious material, mud and other material that may harbour weed seeds · Works associated with the closure of the KIWEF must only occur within the closure works area (project footprint); and must be restricted to the extent required to satisfy the Surrender Notice requirements. · All disturbed surfaces will be revegetated within 1 month of final land forming and in compliance with the landscaping plans. · Any capping materials that are imported from outside the KIWEF facility must be sourced from an area that is assessed as having a low risk of containing Chytrid Fungus. The Chytrid Assessment Process will follow the below procedure: · The contractor is to demonstrate that suitable risk assessment has been undertaken by an appropriately qualified and experienced ecologist on all imported capping and revegetation materials to demonstrate that it contains a low risk of containing chytrid. Risk assessment should consider as a minimum: o Material not sourced from known, suspected or likely amphibian habitat areas; o Material unlikely to have had contact with amphibians and no amphibians present in material; and o Material stored in a dry location prior to transport. · Topsoil to be used for surface layers must be sourced from within KIWEF to the extent possible and will otherwise be assessed as low in nutrients and having a low risk of containing Chytrid Fungus to be protective of adjacent MNES habitat. · Upon completion of works, the works area will be rehabilitated with vegetation species known to be favoured by GGBF. · Open stormwater infrastructure across the KWIEF site will be planted with species known to be favoured by GGBF. This revegetation and rehabilitation strategy will include a 2m wide buffer on either side of the stormwater drains. The intention is to provide movement corridors for GGBF across the site. · Drainage culverts will, where practicable, be vegetated and lined with rocks and objects that may provide temporary frog refuge, in the event that a frog seeks to traverse the future capped area of KIWEF. · Habitat features such as woody debris that may be utilised by fauna within the construction area would be retained and set-aside during the construction period for reinstatement at completion of works. · Prior to the Construction Completion dates the Contractor is required to seed the vegetation layer above the capping layer and reseed areas where sparse vegetation coverage is achieved by the end of the care and maintenance period.
Species Mix	<u>Aquatic vegetation:</u> · Selection of reeds that provide good habitat cover such as Typha, Bolboshoenus, Phragmites, and Juncus; · A mixed community is preferable to single species stands;

Revegetation Management Plan	
	· GGBF prefer wetlands with sections of open water. Water depth should be deep enough to prevent Typha spreading across the entire pond area; the reeds should be mainly at the edge of ponds; Substrate at edges should be suitable for reed growth (i.e. not too many pebbles, sandbags, etc.); · Areas of low blanketing vegetation are also desirable for GGBF breeding, for example, Paspalum grass and Shoenoplectus rush; · Establishing aquatic plants with planting after Closure Works: will maximise structural suitability of wetland to immigrating GGBF as soon as construction is completed. Terrestrial vegetation: · Stabilise new works with sterile millet (or other suitable cover crop); · Retain seed bank in fill taken from site (to be reused); · Avoid large tree species (as roots may potentially compromise the cap); Allow terrestrial species to re-colonise Drainage culverts will, where practicable, be vegetated and lined with rocks and objects that may provide temporary frog refuge, in the event that a frog seeks to traverse the future capped area of KIWEF.
Performance Criteria	Establish adequate vegetation coverage across the closure area. Where vegetation regrowth is sparse (ie less than 50% growth) in areas of greater than $10m^2$, the performance criteria will be considered to have failed and contingency measures are required. No deep-rooted vegetation (ie large shrubs or trees) on top of capped surface
Contingency Measures	Where Vegetation Coverage has been identified to be insufficient, the area will be reseeded. Where deep-rooted vegetation is identified on top of capped surface. The vegetation will be removed (mechanically where possible).
Responsibilities	The Contractor is responsible for undertaking the work, monitoring and maintenance of all elements of the revegetation management plan, until the completion of the construction maintenance period (indicatively 3 months post construction completion). The State (or its agent) is responsible for the monitoring and maintenance of all elements of the revegetation management plan and any rectification works, following the completion of the construction maintenance period.
Timeframe	For the duration of the construction works; and the construction maintenance period.
Monitoring & Reporting	Vegetation establishment will be visually monitored monthly during the construction works and construction maintenance period to identify any areas where vegetation is failing to establish. Should vegetation not establish within the construction maintenance period then targeted seeding and/or planting would be undertaken.

Appendix F. Water Quality Management Plan

Water Quality Management Plan	
Objective	To comply with State and Federal approval requirements. To prevent water discharges from construction works area to the extent possible. To manage water discharged to avoid impact to receiving waters.
Targets	No sediment or water quality impacts to the surrounding environment and waterways from the construction works.
Key Documents	**State Documents** NSW EPA (2010), Approval of the Surrender of a Licence – Licence 6437, (Ref: 1111840, and as varied by notice number 1510956 and 1520063). GHD (2009), Report on KIWEF, Revised Final Landform and Capping Strategy (Ref: 22/14371/85882 R4) **Commonwealth Documents** Ramboll (2018), EPBC Referral, Preliminary Documentation Package – KIWEF Area 2 Closure Works (Ref: 318000395)
Controls	Erosion and sediment control will be designed, installed and managed as follows: · Progressive erosion and sediment control plans (ESCPs) will be developed by the Contractor and implemented prior to the commencement of topsoil stripping and earthworks. · The for construction design for permanent sediment basins is to be in accordance with the environmental protection standards for sensitive environments based on Managing Urban Stormwater - Soils and Construction, (Landcom, 2004), as well as documents from other States and internationally (such as “International Erosion Control Association – Australasia”). · The Contractor is required to install the permanent sediment basins as per the for construction design and any necessary temporary erosion and sediment control measures in advance of bulk-earthworks reporting to each basin. · Alternative arrangements proposed by the Contractor are also required to be in accordance with these standards. · Erosion and sediment control structures are to be regularly inspected and maintained, particularly in advance of and following significant rainfall events. · Any water discharges are required to be managed to avoid pollution of waters having regard to the sensitivity of the receiving environment. In particular, any flocculants are to be demonstrated as being both effective and safe for amphibians prior to use. · Top soil/mulch stockpiles to be not greater than 2.0m in height. All stockpiles will be located clear of watercourses and drainage works. · Wastewater management facilities shall only be provided through proprietary storage and pump out systems. · All disturbed surfaces will be revegetated as soon as possible.

Water Quality Management Plan	
	· All temporary ESC works will be removed immediately prior to final completion and all surfaces will be returned to pre-existing condition. · Provision of shaker grids or rumble strip at site egress points. · if contaminated materials are encountered, they are to be managed in accordance with Materials Management Plan, and as a minimum isolated and covered to avoid runoff.
Performance Criteria	Discharge quality must comply with Performance Criteria: · TSS: < 50mg/Lt (~Turbidity 30NTU). · pH: Between 6.5 and 8.5. · Otherwise able to be demonstrated not to have caused pollution of waters.
Contingency Measures	If Water Quality performance criteria is not suitable for discharge, other management measures must be implemented prior to discharge. These may include such things as: · the trapped sediment laden water may be treated with flocculants at a rate demonstrated in advance to be effective on the local material properties and using substances safe for amphibians; · Dosing with appropriate buffers to neutralise water; · Other mitigation measures deemed appropriate which may include a purpose constructed soak-away where HCCDC advices a suitable location such that contamination in fill is not likely to be mobilised.
Responsibilities	The Contractor is responsible for undertaking the work, monitoring and maintenance of all elements of the water quality management plan until the completion of the construction maintenance period (indicatively 3 months post construction completion). The State (or its agent) is responsible for the monitoring described under the KIWEF Annual Water Monitoring and the KIWEF Continuous Data Logging.
Timeframe	Construction Water Quality and Erosion Sediment Controls will be maintained and monitored throughout the duration of site works.
Monitoring and Reporting	Daily visual monitoring by site supervisors. Documented post rainfall checks of sediment basin water level and water quality and erosion and sediment control functioning. Weekly documented inspections. Maintenance activities for ESCPs shall be documented. Sediment basin discharge or dewatering water quality sampling and analysis suitable to demonstrate pollution of water has/will not occur. All water quality data including quantity, quality and dates of water release will be maintained within the project records.

Appendix G. Traffic Management

Traffic Management	
Objective	To ensure that additional traffic from construction activities does not cause an environmental nuisance.
Targets	No valid complaints resulting from congestion from construction traffic Comply with traffic management standards
Legal, Contractual and Other Requirements	*Protection of the Environment Operations Act 1997* *Roads Act 1993* RTA Traffic Control at Worksites Roads (General) Regulation 2000 *Local Government Act 1993*
Site specific planning / approval conditions / licence conditions	Not applicable.
Controls (means and resources)	The Contractor is required to develop a Traffic Management Plan detailing the route to the site, times of activity, types of machinery, signage, traffic control measures, once the source of any imported materials has been identified. The following traffic management control measures to be implemented are to be detailed in Construction Traffic Management Procedures (CTMP): · Traffic will be required to adhere to routes and speed limits designated by the Contractor, in consultation with the HCCDC, ARTC, NCIG and RMS and the RMS Contractor for the Tourle Street / Cormorant Road upgrade works (if ongoing); · Worksite speed limits will be determined for areas of the site based on road type, road condition and adjacent work activity; · Normal road rules apply unless specifically stated otherwise; · Barrier systems may be used at the discretion of the Contractor to define the designated routes; · All project personnel will be required to undertake the site induction that will specify appropriate traffic practices on site; · Site staff with responsibilities for control of construction activities will perform site inspections aimed at maintaining traffic at determined worksite speed limits; · Following site surface stabilisation/ rehabilitation works to control erosion, foot and vehicular traffic will be avoided on recently stabilised areas wherever practical; · Water spraying (where appropriate) will be used to minimise the generation of dust from roadway surfaces; · An inspection system will be established by the Contractor to assess effectiveness of traffic control measures. The assessments will determine if any modification is required to practices on site or the CTMP; and · An incident management procedure for emergencies relating to traffic management for the project works.

Traffic Management	
Actions	Contractor to incorporate the above traffic management measures into Contractor’s Traffic Management Plans.
Responsibilities	The Contractor is responsible for ensuring traffic management plans are developed, approved and implemented.
Timeframe	Duration of site works.
Monitoring and Reporting	Daily inspection, checks and regular maintenance to be completed for traffic control measures.

Appendix H. Air Quality Management

Dust and Air Quality	
Objective	To ensure that dust and other air emissions from construction activities do not cause impacts on sensitive receivers and equipment.
Targets	No visible dust (or offensive odours) leaving site and reaching: · Identified or potential GGBF habitat, particularly water bodies and fringing vegetation; and · Cormorant Road or neighbouring coal loader operations.
Legal, Contractual and Other Requirements	Contract specification Review of Environmental Factors Kooragang Island Waste Emplacement Facility Area 2 Closure Works (ERM 2016) *Protection of the Environment Operations Act 1997* *Protection of the Environment Operations (Clean Air) Regulation 2002*
Site specific planning / approval conditions / licence conditions	All activities associated with the closure, capping, rehabilitation and post-closure maintenance and monitoring at the premises must be carried out in a manner that will minimise the emission of dust from the premises.
Controls (means and resources)	Mitigation measures include amending the nature of work in the event that construction works do not meet the above Objective. Operation of all facilities and equipment on the site will be performed so as to minimise reduce the emission of dust, odour and other air impurities including: · Use of water sprays to reduce dust emission from trafficable areas, work areas, stockpiles and other exposed areas but not to draw water from existing ponds as per the flora and fauna management plan; · Where necessary, stabilisation of long term stockpiles; · Reduce the number and extent of disturbed areas at a given time during the remediation activity on site; · Control of haul loading vehicles, whereby the load will not exceed the height of the haul boards and tailboards on the vehicles; · The vehicle speed shall be restricted along the haul roads on site to minimise dust generation and potential spilling of hauled material; · Cleaning/maintenance of the access and haul roads where they interface with public roads to prevent sediment tracking; · Loads of soil or contaminated material entering and leaving site will be covered. Internal material transport will also require a cover if material is likely to or observed to be generating dust; · Any excavated material likely to generate odours will be covered; · Maintenance and servicing of plant and vehicles to minimise reduce emission of air pollutants; · Observations of prevailing (and forecast) weather conditions, to program site activities in order to minimise air quality issues;

Dust and Air Quality	
	· Modify work practices during dry and windy conditions; · Progressively stabilise and/or revegetate as areas of works as completed; · Provide shaker grids or rumble strip at site egress points and where aggregate is used, minimum size is 150mm; · Remove mud from haul vehicles prior to entering public roads; · Remove spilt mud by construction equipment or vehicles on public roads; and · Provide awareness training in the need to minimise dust during site inductions and toolbox talks.
Actions	Contractor to implement reasonable and feasible measures from the above to achieve air quality goal.
Responsibilities	Contractor
Timeframe	Duration of site works. Water tankers and other measures available at the commencement of earthworks. Spilt mud and sediment to be removed from public roads as soon as practicable, and at least prior to the end of each shift.
Monitoring and Reporting	Daily observations of dust generation, mud tracking, vehicle emissions, site generated odours and weather conditions (wind direction and strength). Weekly inspect to record functioning of air quality controls.

Appendix I. Noise Management

Noise and Vibration	
Objective	To ensure that noise and vibration from construction activities does not cause environmental nuisance or unnecessarily disturb fauna.
Targets	No valid noise / vibration complaints resulting from construction works. No unreasonable noise or vibration. No noise and vibration impacts on external receptors.
Legal, Contractual and Other Requirements	Works are to be undertaken in accordance with the Interim Construction Noise Guidelines with works to be restricted to: · 7 am to 6 pm Monday – Friday · 8 am to 1 pm Saturdays No work outside of these hours without HCCDC's approval (except for emergency situations). *Protection of the Environment Operations Act 1997* *Protection of the Environment Operations (Noise Control) Regulation 2000*
Site specific planning / approval conditions / licence conditions	All activities associated with the closure, capping, rehabilitation and post-closure maintenance and monitoring at the premises must be carried out in a competent manner. This includes: · The processing, handling, movement and storage of materials and substances used at the premises; and · The treatment, storage, processing, reprocessing, transport and disposal of any waste generated by the activity. All plant and equipment installed at the premises or used in connection with the closure, capping, rehabilitation and post-closure maintenance and monitoring activities at the premises must be: · Maintained in a proper and efficient condition; and · Operated in a proper and efficient manner.

Noise and Vibration	
Controls (means and resources)	No work will be undertaken outside of the agreed hours without prior approval (except in an emergency situation). Delivery operations or other noise generating activities at compound and storage areas will take place during the designated construction hours nominated above, unless specifically required by Police or RTA requirements. Reasonable and feasible mitigation measures to be considered as required include: · Avoiding where practical the use of noisy plant simultaneously close together or adjacent to sensitive receptors; · All plant will be maintained in accordance with the manufacturer's requirements; · Stationary noise generating equipment to be orientated away from sensitive areas; · Undertaking loading and unloading activities away from sensitive areas and during designated construction hours; · Selection of the most appropriate plant and equipment to minimise noise generation and include where necessary screening and enclosures; · Regular checks are to be undertaken to ensure all equipment and vehicles are in good working order and are operated correctly; and · Awareness training and information will be provided to project personnel in relation to the vibration requirements on the project and the need to minimise vibration when in close proximity to operational areas (rail corridor).
Responsibilities	Contractor
Timeframe	Duration of site works.
Monitoring and Reporting	Vehicle inspections to be recorded on daily vehicle pre-start checks.

Appendix J. Heritage management

Heritage Management Archaeology and Heritage	
Objective	To ensure that undiscovered heritage and archaeological items are protected from construction activities.
Targets	Unknown or undocumented heritage sites are not knowingly destroyed, defaced or damaged. Identify and protect any new artefacts or heritage sites before any harm can take place.
Legal, Contractual & Other Requirements	*Heritage Act 1977* *National Parks and Wildlife Act 1974*
Controls (means & resources)	No known heritage items or areas have been identified within the project site or surrounds. As such, heritage mitigation measures are limited to restricting access beyond the project boundary and the implementation of the following 'chance find' protocol: · In the event that potential Aboriginal and Historic heritage items are discovered, STOP ALL WORK in the vicinity of the find and immediately notify the relevant Construction Supervisor and Environmental Manager; · Contact HCCDC to notify of the find as soon as they receive notification; · In the event of uncovering remains that are potentially human, the NSW Police are also to be contacted immediately; · Record the details and take non-intrusive photos of the find and relay information to HCCDC; · HCCDC will contact a qualified archaeologist to get advice regarding the nature and potential significance of the find; · If the qualified archaeologist advises that the find is not a potential heritage item, work will recommence in consultation with HCCDC; · If the qualified archaeologist advises that the find is a potential heritage item HCCDC will contact and notify the relevant authority; and · Work is not to recommence in the area of the identified find until clearance is received from HCCDC.
Responsibilities	All persons are responsible for reporting items of potential cultural or heritage value. Contractor's representative will ensure the implementation of the above chance finds protocol in the event that items of potential cultural or heritage value are uncovered.
Timeframe	Duration of site works
Monitoring & Reporting	Ongoing visual observations for previously unidentified items. Reporting of any chance finds in accordance with the above protocol.

Appendix B – Green and Golden Bell Frog Management Plan (Golder Associates, 2011)

REPORT

19 April 2011

GREEN AND GOLDEN BELL FROG MANAGEMENT PLAN

Kooragang Island Waste Emplacement Facility Closure Works

Submitted to:
Hunter Development Corporation
Suite B, Level 5
PricewaterhouseCoopers Centre
26 Honeysuckle Drive
Newcastle, New South Wales 2300

Report Number. 117623029-001-R-Rev0

Executive Summary

The Kooragang Island Waste Emplacement Facility (KIWEF) is located on land owned by the New South Wales (NSW) State Property Authority, which is managed under delegated-authority by the Newcastle Port Corporation (NPC).

The KIWEF contains various wastes from the former BHP steelworks at Mayfield. Hunter Development Corporation (HDC) is in the process of closing the KIWEF via implementing certain landfill closure works, which include land-forming of waste emplacement cells and construction of a capping layer over much of the KIWEF site.

Historically, HDC was the holder of an Environment Protection Licence (EPL) over the site for the former BHP Solid Waste facility (refer to Figure 1). That EPL has now been surrendered, subject to the implementation of landfill closure works required by the NSW Office of Environment and Heritage (OEH) (formerly the NSW Department of Environment, Climate Change and Water (DECCW)). HDC, as the Agents for the Crown, are undertaking those necessary landfill closure works, on lands administered by NPC, which encompass the KIWEF (Figure 1).

The KIWEF site supports known populations and habitat of the Green and Golden Bell Frog (*Litoria aurea*). A flora and fauna impact assessment (GHD, 2010a) of the proposed landfill closure works concluded that the works are "*designed to minimise the direct and indirect impacts on biodiversity of the locality, especially in relation to the Green and Gold Bell Frog... The Proposal also addresses the risks posed from the prior disposal of BHP waste on the site*" and is unlikely to result in "*long-term decrease in the size of a population, reduce the area of occupancy of species, fragment an existing population, adversely affect habitat critical to the survival of a species, disrupt the breeding cycle of a population, modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that a species is likely to decline, result in invasive species that are harmful to an endangered species becoming established in the endangered habitat, or interfere with the recovery of any threatened species*".

Overall, the flora and fauna impact assessment (GHD, 2010a) reported that the proposed capping strategy is unlikely to impact significantly on Green and Golden Bell Frogs, provided the works are managed through an appropriate environmental management plan.

In order to assist in minimising impacts of the landfill closure works, HDC engaged Golder Associates Pty Ltd (Golder) to develop this Green and Golden Bell Frog Management Plan (the GGBF Management Plan). HDC intend to incorporate this GGBF Management Plan into the detailed design documentation currently being developed for the landfill closure works. An Action Plan has been developed by Golder in conjunction with this GBBF Management Plan and is reported to HDC separately (Golder, 2011).

The Green and Golden Bell Frog is listed as 'endangered' under the NSW *Threatened Species Conservation Act 1995*, and 'vulnerable' under the federal *Environmental Protection and Biodiversity Conservation Act 1999*. Historically, this species was widespread across much of the Hunter Valley; however, it is now believed to be restricted to four key populations, including a large population on Kooragang Island (including the KIWEF site).

The Green and Golden Bell Frog is a relatively large species and is usually green, most often with irregular large gold spots and/or stripes. The Green and Golden Bell Frog can be regarded as somewhat of a habitat generalist, dispersing widely and maturing early. It is known to inhabit marshes, dams and stream sides and appears to prefer those water bodies where Bulrushes (*Typha* spp.) or Spikerushes (*Eleocharis* spp.) grow (NPWS, 1999). Green and Golden Bell Frogs are also known to inhabit highly disturbed sites (NPWS, 1999), such as the KIWEF site. The Green and Golden Bell Frog is known to travel significant distances across often seemingly inhospitable habitat. Distances of up to 1.5 km day/night are not unknown, particularly associated with significant rain events.

Frog Chytrid Fungus (FCF) has been identified as a key threatening process, at both the state and national level, for the Green and Golden Bell Frog (DSEWPC, 2009). FCF is widespread on Kooragang Island and Hexham Swamp, the other key Green and Golden Bell Frog population in the Newcastle area (DECC, 2007).

Section 3 of this document details the management procedures to be implemented, including identification and delineation of disturbance areas, pre-work surveys, identification of relocation areas, relocation procedures and rehabilitation of disturbed habitat, environmental induction training and site hygiene management for Chytrid fungus.

Section 4 of this document outlines the proposed monitoring programme for Green and Golden Bell Frogs at the KIWEF site. The monitoring programme includes annual review of publicly available baseline and ongoing data from other surveys including frog populations (such as that being undertaken by NCIG across the KIWEF site). An Annual Environmental Monitoring Report (AEMR) discussing the results of analysis of monitoring data will be presented to OEH.

Section 5 of this document identifies specific management and mitigation measures for disturbed areas and triggers for the development of response criteria in the unlikely event that the landfill closure works have an impact on the Green and Golden Bell Frogs. If the results of the monitoring programme indicate a decline in Green and Golden Bell Frog numbers across the site, which cannot be attributed to natural population fluctuations and variability, and is potentially a direct result of the landfill closure works, specific response criteria will be developed by HDC in consultation with the OEH.

Section 6 of this document outlines proposed review and reporting actions. HDC will report to OEH annually for 5 years following completion of the landfill closure works, unless analysis shows that Green and Golden Bell Frog populations are being impacted, then further reporting will be undertaken until a time agreed with OEH.

In accordance with the *Approval of Surrender of Licence Number 6437*, the Director-General will be notified of any incident with actual or potential significant off-site impacts on people or the biophysical environment, as soon as practicable after the occurrence of the incident. The Director-General will be provided with written details of the incident within seven days of the date on which the incident occurred.

The AEMR will be distributed to relevant government agencies and stakeholders, and copies provided to other interested parties, if requested.

In accordance with the *Approval of Surrender of Licence Number 6437*, this Management Plan will be made available on the HDC website.

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APPENDICES

1.0 INTRODUCTION

1.1 BACKGROUND

The Kooragang Island Waste Emplacement Facility (KIWEF) is located on land owned by the New South Wales (NSW) State Property Authority, which is managed under delegated-authority by the Newcastle Port Corporation (NPC).

The KIWEF contains various wastes from the former BHP steelworks at Mayfield. Hunter Development Corporation (HDC) is in the process of closing the KIWEF via implementing certain landfill closure works, which include land-forming of waste emplacement cells and construction of a capping layer over much of the KIWEF site.

Historically, HDC was the holder of an Environment Protection Licence (EPL) over the site for the former BHP Solid Waste facility (refer to Figure 1). That EPL has now been surrendered, subject to the implementation of landfill closure works required by the NSW Office of Environment and Heritage (OEH) (formerly the NSW Department of Environment, Climate Change and Water (DECCW)). HDC, as the Agents for the Crown, are undertaking those necessary landfill closure works, on lands administered by NPC, which encompass the KIWEF (Figure 1).

The KIWEF site supports known populations and habitat of the Green and Golden Bell Frog (*Litoria aurea*). A flora and fauna impact assessment (GHD, 2010a) of the proposed landfill closure works concluded that the works are "*designed to minimise the direct and indirect impacts on biodiversity of the locality, especially in relation to the Green and Gold Bell Frog... The Proposal also addresses the risks posed from the prior disposal of BHP waste on the site*" and is unlikely to result in "*long-term decrease in the size of a population, reduce the area of occupancy of species, fragment an existing population, adversely affect habitat critical to the survival of a species, disrupt the breeding cycle of a population, modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that a species is likely to decline, result in invasive species that are harmful to an endangered species becoming established in the endangered habitat, or interfere with the recovery of any threatened species*".

Overall, the flora and fauna impact assessment (GHD, 2010a) reported that the proposed capping strategy is unlikely to impact significantly on Green and Golden Bell Frogs, provided the works are managed through an appropriate environmental management plan.

In order to assist in minimising impacts of the landfill closure works, HDC engaged Golder Associates Pty Ltd (Golder) to develop this Green and Golden Bell Frog management plan (the GGBF Management Plan) to support the landfill closure works. HDC intend to incorporate this GGBF Management Plan into the detailed design documentation currently being developed by HDC for the landfill closure works.

This GGBF Management Plan has been prepared in accordance with HDC's Request for Tender No. 141 ("Green & Golden Bell Frog Management Plan and Action Plan for K26/32 Ponds: KIWEF"), dated February 2011, and Golder's responding proposal, dated 28 February 2011 as accepted via a letter from HDC emailed to Golder on 16 March 2011. This Management Plan has been prepared via review of documentation provided by HDC to Golder on 22 March 2011, a visual site visit by Golder personnel and written commentary from HDC.

An Action Plan for the K26/K32 Ponds has been developed by Golder in conjunction with this GBBF Management Plan and is reported to HDC in a separate document (Golder, 2011).

1.2 A SUMMARY OF WORKS COMPLETED TO DATE

A range of studies have been completed by others in relation to the Green and Golden Bell Frogs on the KIWEF site since its hand over to the Crown in 2002. The most recent relevant studies are listed in the following. It is noted that other previous studies are summarised in these works, and, therefore, are not identified here.

- Revised Capping Strategy, Flora and Fauna Impact Assessment, Rev 3 (GHD, 2010a).
- March 2011 Green and Golden Bell Frog (Litoria aurea) Survey at the Kooragang Island Waste Emplacement Facility (Umwelt, 2011).
- Revised Final Landform and Capping Strategy, Rev 4, (GHD, 2010b).

The key findings of those reports, as relevant to the ongoing management of Green and Golden Bell Frogs on the KIWEF site, are presented below.

1.2.1 Flora and Fauna Impact Assessment

The flora and fauna impact assessment of the revised capping strategy was undertaken as part of the EPL surrender, which the then DECCW required to identify any impacts resulting from the implementation of the final capping strategy on Green and Golden Bell Frogs (and other threatened species). The assessment was also required to identify associated mitigation measures for those species and their habitats.

Key Findings

The key findings of the flora and fauna impact assessment (GHD, 2010a) comprised the following:

- The assessment identified areas of known and potential Green and Golden Bell Frog Habitat (as indicated on Figure 1), and determined the presence, relative abundance and distribution of Green and Golden Bell Frogs on the KIWEF site, and the adjacent Ash Island. A summary of the locations and numbers of Green and Golden Bell Frogs recorded on the KIWEF site is presented in Figure 1. During the assessment (that is February and March 2009), 59 Green and Golden Bell Frogs were recorded from the KIWEF and surrounding area; 38 individuals were recorded on the KIWEF site.
- Two important factors to note, as identified in the report, are:
  - The Green and Golden Bell Frog's ongoing survival on Kooragang Island, and the KIWEF site, may be related to the protection that the brackish wetland habitat provides from the Chytrid fungus (Stockwell, pers. comm., in GHD, 2010a).
  - The terrestrial habitats and ephemeral water bodies supported on the KIWEF site and the larger Kooragang Island may provide important movement corridor refuges for Green and Golden Bell Frogs (Hamer *et al.*, 2008, in GHD, 2010a).
- Potential changes to water quality, especially salinity, may adversely affect the Green and Golden Bell Frogs on the KIWEF site.
- The *in situ* contaminated materials present across the KIWEF site will be addressed by the capping strategy. There is, therefore, the potential for water quality in, and adjacent to, the capped location to remain similar or improve.
- The capping strategy was designed to minimise changes to hydrology. As noted, however, the construction of the NCIG rail loop has impacted on the known Green and Golden Bell Frog habitat supported in the K26 and K32 cells, and potentially already altered the hydrology of these ponds.
- Where the proposed capping strategy would impact on streamside vegetation and banks, and, hence, potential Green and Golden Bell Frog habitat, that vegetation would be reinstated immediately following capping works to a state as close as possible to the original.
- Plague Minnow (*Gambusia holbrooki*), a known predator of Green and Golden Bell Frog tadpoles, was recorded in ponds across the KIWEF site.
- The assessment considered that the capping strategy would result in minimal fragmentation or isolation of currently interconnecting areas of Green and Golden Bell Frog habitat. The capping strategy would

leave areas of appropriate habitat in areas within the KIWEF site and the adjacent Hunter Estuary National Park.

- That vegetation that may be cleared or capped is considered unlikely to constitute key foraging habitat for Green and Golden Bell Frogs.
- The potential cumulative impacts on Green and Golden Bell frogs and their habitat across the local area from other proposals, is unknown; particularly impacts on potential movement between populations north and south. Furthermore, inference is made that competition for resources, required by the species, may have potentially increased because of the translocation of individuals into suitable areas on the KIWEF site from areas impacted by other proposals. However, the proposed "*capping strategy aims to avoid increasing these pressures while dealing with the potentially harmful pollutants on site*" and "*is unlikely to add to these previous impacts or add to cumulative adverse impacts on threatened species at the KIWEF site*".
- Overall, the assessment reports that the proposed capping strategy is unlikely to impact significantly on Green and Golden Bell Frogs, provided the works are managed through an appropriate environmental management plan. Those assessments of significance were undertaken in accordance with the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the NSW *Environmental Planning and Assessment Act 1979* (EPA Act).

Mitigation Measures

The following mitigation measures were recommended in the flora and fauna impact assessment:

- A 30 m buffer zone is proposed around fresh and brackish water wetlands, ponds, and identified areas of Green and Golden Bell Frog habitat.
- If it is identified that works will occur in Green and Golden Bell Frog habitat (such as the fringing habitat near Deep Pond), one week prior to those works commencing, a pre-clearance survey is required to be conducted by a qualified ecologist. In the event that any Green and Golden Bell Frogs are identified, they will be relocated (using appropriate amphibian hygiene protocols).
- Once works are complete, the restoration and rehabilitation of that habitat should be undertaken.
- Control of noxious weeds on the site should be undertaken limiting the use of herbicides, which may be detrimental to Green and Golden Bell Frogs.
- Maintenance of the current hydrological and water chemistry regimes; in particular, low levels of salinity in the brackish wetlands, which may protect amphibian species from the Chytrid fungus. The maintenance of runoff volumes into these areas may help conserve appropriate salinity levels.
- Similarly, general erosion and sediment control should be implemented to limit the transport of other contaminants across the KIWEF site.
- Capping and grading activities should be conducted outside of the Green and Golden Bell Frog's core breeding period (that is, September to March). If works need to be undertaken during this time, they should be limited to areas outside of recognised breeding habitat. For the purposes of this GGBF Management Plan, breeding habitat is defined as areas within or immediately adjacent to emergent, aquatic macrophytes.
- Standing water should not be transferred between waterbodies, to prevent the spread and establishment of the Plague Minnow.
- Suitable hygiene protocols must be developed and adhered to for all plant and personnel entering the KIWEF site to avoid the spread of Chytrid fungus.

- Compensatory habitat for the Green and Golden Bell Frog may be considered as part of the capping strategy. For example, the capping works may facilitate rehabilitation of suitable Green and Golden Bell Frog habitat. However, HDC has indicated that it is not intending to create artificial habitat, interfere with existing habitat, nor are seeking to modify frog population numbers or habitat.

- Ongoing, long-term monitoring of the Green and Golden Bell Frog population across the entire KIWEF site, and adjacent areas, such as the NCIG facility, should be undertaken seasonally. This data will help identify if any adverse impacts have affected the Green and Golden Bell Frog population and habitat across Kooragang Island.

1.2.2 March 2011 Survey

The March 2011 survey of GGBF (Umwelt, 2011) targeted the rail loop area, including K26 and K32 Ponds (as well as K24 and K31 Ponds). Overall, this survey was suitable for its purpose. However, the following comments are made in relation to the survey scope and its findings. Those comments were used to assist in the development of the Action Plan for the K26/K32 Ponds (Golder, 2011).

- No detailed surface water quality data have been collected and analysed for the standing water in the Ponds.

- It is known that some contaminants are detrimental to frog embryos and development, as well as known to lead to malformations in frogs for example, Abbasi and Soni, 1984; Anon., 1999, Arrieta *et al.*, 2004, Guillermo *et al.*, 2000; Marquis *et al.*, 2006; Rice *et al.*, 2002; Stabenau *et al.*, 2006; Wang and Jia, 2008). Some surface water chemistry data are available (see NCIG, 2008, in GHD, 2010b) that indicate values exceeding ANZECC trigger values for aquatic ecosystems; however, these are limited. In the absence of detailed water chemistry data, there is no baseline to compare for the long-term monitoring of the water quality, correlated with the frog populations. This represents a significant data gap.

- Data on the periodicity of the standing water in the cells has not been collected. Such data would assist in the understanding of the impacts of changes in local hydrology, such as may have occurred during construction of the NCIG rail loop.

- The mere presence of calling males may not be a useful indicator of successful breeding in the ponds. This, to some extent, has been alluded to in both the GHD (2010) and the Umwelt (2011) studies in that no tadpoles were recorded in the cells during either of those studies.

- The presence of juveniles may be a valid indicator of a sustainable population as this species is known to emigrate over large distances. Therefore, it would be useful to confirm that there has been effective breeding over one or more seasons, with tadpoles that survive to adulthood.

- The baseline comparison that the Umwelt (2011) report makes with the GHD (2010) results, in particular, that “There is no substantial change in the numbers recorded from 2009 to 2011.” (page 8) needs to be further qualified. A stable number of frogs each year over a relatively short time frame could result from a variety of factors (such as low mortality or in-migration) and is not necessarily confirmation of sustainable breeding.

To meet HDC’s requirements regarding management of contamination and frog habitat at the Ponds it is recommended that these data gaps are addressed by HDC.

1.2.3 Capping Strategy

The objectives of the capping strategy were to “*reduce risks to the environment associated with migration of contaminated groundwater and to prevent the risk of biological harm associated with contaminated soil and groundwater*” (GHD, 2010b). This objective had the associated objectives of preserving and maintaining habitat for shorebirds and other threatened species, and endangered ecological communities.

The strategy assessed the KIWEF based on sub-areas, with each sub-area assessed for the requirement for capping, and the effects that capping may have on the ecology. The locations of those sub-areas are presented on Figure 1. In terms of impacts to ecology, in particular the ecology of the Green and Golden Bell Frog, the following sub-areas were important:

- K1 – This sub-area presents a low risk to the surrounding environment from contamination. Capping of this area would have a significant impact on the ecology of the area.
- K2 – This sub-area presents a low to moderate risk to the surrounding environment from contamination. Capping of this area could impact on Green and Golden Bell Frog habitat.
- K3 – This sub-area presents a low to moderate risk to the surrounding environment from contamination. Capping of the fringing areas of this sub-area may have an impact on Green and Golden Bell Frog habitat. Therefore, capping is suggested only up to within 30 m of that habitat, with the exception of the area located near K3/1W.
- K4 (deep pond) – Contamination in this sub-area presents a low risk to the environment. However, filling and capping of this sub-area will have a significant impact on Green and Golden Bell Frog habitat, and the overall ecology of the area.
- K6 – This sub-area presents a low risk from contamination. However, capping of this sub-area will have a significant impact on the ecology of the area.
- K7 – The sub-area presents a low to moderate risk to the environment from contamination. Capping of the edges of the site will significantly impact on Green and Golden Bell Frog habitat.
- K26/K32 cells – These cells present a high risk to the environment. However, they also support Green and Golden Bell Frog habitat. Capping is not recommended, but rather a monitoring and risk assessment be completed. Details of recommended actions for the K26/K32 Ponds are presented in an Action Plan (Golder, 2011).

Based on the above assessment, a capping strategy was developed that minimised the impacts to Green and Golden Bell Frog habitat. A brief summary of the other sub-areas, suggested for capping, is provided below.

- K5 (excluding pond 5) – This sub-area presents a low to moderate risk to the environment from contamination. There is no significant Green and Golden Bell Frog habitat in this area; therefore, capping is an option.
- Pond 5 – Migration of contaminants from this sub-area may impact the estuarine aquifer. This sub-area does not support significant Green and Golden Bell Frog habitat. Therefore, capping is an option.
- K10 (excluding K26/K32) – The sub-area presents a low to moderate risk to the environment from contamination. The BOS area presents a moderate risk to the environment. Capping is suggested for this area.

1.3 Other Relevant Management Plans and Guidelines

This GGBF Management Plan should be read and in conjunction with the following management plans and guidelines, which are relevant to the Green and Golden Bell Frog population on Kooragang Island and the KIWEF:

- *Coal Export Terminal Green and Golden Bell Frog Management Plan* (Newcastle Coal Infrastructure Group (NCIG) (Document No. GGBFMP-R01-E.DOC, 2007)) (the NCIG management plan)
- *Draft Management Plan for the Green and Golden Bell Frog Key Population in the Lower Hunter* (Department of Environment and Climate Change (DECC) (NSW) 2007) (the Lower Hunter management plan)
- *Significant impact guidelines for the vulnerable Green and Golden Bell Frog (*Litoria aurea*)* (Department of Sustainability, Environment, Water, Populations and Communities (DSEWPC), Nationally threatened species and ecological communities; Background paper to the EPBC Act policy statement 3.19, 2009)
- *Best practice guidelines: Green and Golden Bell Frog habitat* (DECC, 2008)
- *Protecting and restoring Green and Golden Bell Frog habitat* (DECC, 2008)
- *Draft Recovery Plan for the Green and Golden Bell Frog (*Litoria aurea*)*. (DECC, 2005)
- *Threatened Species Management Information Circular No.6, Hygiene Protocol for the Control of Disease in Frogs* (NPWS, 2001) (the hygiene protocol) (Appendix A).

1.4 Project Approval

This GGBF Management Plan has been developed in order to partly address the KIWEF site's *Approval of Surrender of Licence Number 6437*, dated 8 December 2010, Condition 5.b), which requires the following:

b) The licensee shall prepare and submit a Green and Golden Bell Frog Management Plan to the EPA for approval by 13 April 2011. The Plan shall encompass the entire premises occupied by the licensee and include, but not be limited to:

i) Management measures to be undertaken to minimise the spread of the amphibian Chytrid fungus including:

> *(i) the training of project personnel in site hygiene management; and*
>
> *(ii) site hygiene procedures for project personal, mobile plant and equipment, in accordance with the NPWS Hygiene Protocol for the Control of Disease in Frogs 2001; and*

ii) Measures to maintain, restore and enhance Green and Golden Bell Frog habitat, including movement corridors across the site.

Additionally, obligations exist under the DSEWPC's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as to the protection of this nationally threatened species. These obligations are detailed in the EPBC Act policy statement 3.19 (see above for reference), as well as the significant impact criteria set out in the NSW *Threatened Species Conservation Act 1995* (TSC Act).

1.5 Objectives of this Plan

In relation to Green and Golden Bell Frogs on the KIWEF site, one of the overall aims of the KIWEF landfill closure works is to manage those works in a manner that does not impact threatened species and their habitat, and to restore small areas of temporary disturbance to their original (or better) condition. To that end, the objectives of this GGBF Management Plan are:

1) To maintain the existing Green and Golden Bell Frog populations supported on the KIWEF site.

2) To reduce the spread of the amphibian Chytrid fungus (*Batrachochytrium dendrobatidis*).

3) To protect the existing Green and Golden Bell Frog habitat on the KIWEF site.

4) To increase connectivity between the existing areas of Green and Golden Bell Frog habitat on the KIWEF site.

5) To restore Green and Golden Bell Frog habitat that may be disturbed during the landfill closure works to a condition as-good or better than prior to the works.

Hence, this GGBF Management Plan aims to assist HDC in the implementation of appropriate environmental management measures during the KIWEF closure works.

1.6 Scope and Use of this Plan

The scope of this GGBF Management Plan covers that area known as the KIWEF (Figure 1), before, during and after landfill closure works.

This GGBF Management Plan has been prepared in accordance with the relevant state guidelines as identified in Section 1.3.

This GGBF Management Plan will be reviewed and updated by those responsible for undertaking the detailed design and associated documentation to ensure that it is current at the time that the landfill closure works are tendered. Once tendered, the Contractor will incorporate the revised GGBF Management Plan into their Environmental Management Plans (EMP). Where there is any conflict between the provisions of this GGBF Management Plan and Contractors' obligations under their respective contracts, including the various statutory requirements (that is, licences, permits, project approval conditions and relevant laws), the contract and statutory requirements are to take precedence. In the case of any real or perceived ambiguity between elements of this GGBF Management Plan and the above statutory requirements, the Contractor shall first gain clarification from HDC, prior to implementing that element of this GGBF Management Plan over which the ambiguity is identified.

It is intended that this GGBF Management Plan should complement those studies identified in Section 1.2. To that end, this management plan should be supplemented by publicly available monitoring results collected by others for projects on Kooragang Island. For example, it is understood that the NCIG plan requires monitoring to occur on an annual basis until 2020, as outlined in the EPBC Act Particular Matter conditions for that project. The NCIG monitoring data will be useful input into management of Green and Golden Bell Frogs on the KIWEF site.

1.7 Structure of this Plan

The structure of this GGBF Management Plan is provided below. This structure has been adopted to address the requirements as specified in the HDC brief (document number HDC141), and be in accordance with required guidelines.

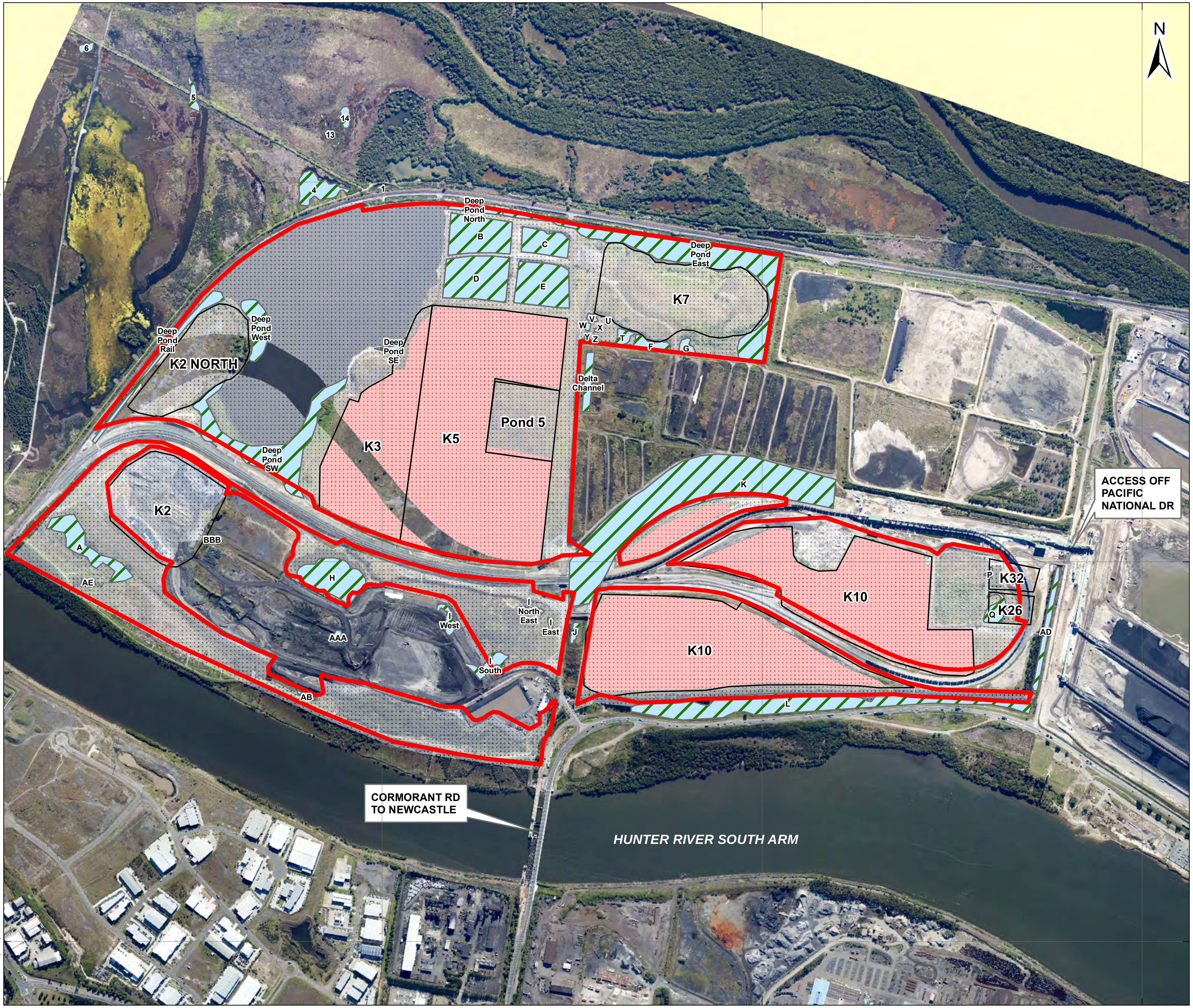
- Section 2: Provides a profile of the Green and Golden Bell Frog, including its key identifying features in the field, similar species on the KIWEF site, general ecology relevant to the KIWEF site, its conservation status and distribution on the KIWEF site.

- Section 3: Details the management procedures to be implemented, including identification and delineation of disturbance areas, pre-work surveys, identification of relocation areas, relocation procedures and rehabilitation of disturbed habitat, environmental induction training and site hygiene management for Chytrid fungus.

- Section 4: Outlines the monitoring programme for the KIWEF site.

- Section 5: Response criteria and mitigation measures, including comparison with previous data collected at the site, and procedures to be followed if a decline in the Green and Golden Bell Frog population is detected.

- Section 6: Lists the reporting and review requirements of this management plan.
- Section 7: Lists references cited in this Green and Golden Bell Frog Management Plan and other supporting information.



GREEN AND GOLDEN BELL FROG MANAGEMENT PLAN

HUNTER DEVELOPMENT CORPORATION

SITE LOCATION

LEGEND

- Kooragang Island Waste Emplacement Facility License Area
- Known and Potential Habitat Areas (GHD, 2010)
- Capping Extent Landfill Closure Works
- HDC Closure Area 2010

NOTES

Imagery provided by The Hunter Development Corporation 16/03/2011
Data digitised from Land & Property Management Authority Request for Tender - RFT No. HDC141, February 2011 Appendix A - Site and Access Map

0 40 80 160 240 320 400 metres

SCALE (at A3) 1:10,000

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117623029**
DATE: **18/04/2011**
DRAWN: **AJW**
CHECKED: **TC**

FIGURE 1

Golder Associates

2.0 SPECIES PROFILE – GREEN AND GOLDEN BELL FROG (*LITORIA AUREA*)

2.1 Conservation Status

2.1.1 Listing

The Green and Golden Bell Frog's conservation status is listed as follows:

- **Endangered** under the NSW *Threatened Species Conservation Act 1995*
- **Vulnerable** under the federal *Environmental Protection and Biodiversity Conservation Act 1999*.

2.1.2 Known Populations

The Green and Golden Bell Frog is estimated to have disappeared from 90% of its former range within NSW over the last 30 years (Pyke and White, 1996; DECC, 2007), although populations in Victoria are believed to be secure (Gillespie, 1996).

There are about 45 known populations of Green and Golden Bell Frog within NSW (DECC, 2007). Of these, only a few occur in conservation reserves; Kooragang Island Nature Reserve supports the closest protected population to the KIWEF site (DECC, 2007). Historically, this species was widespread across much of the Hunter Valley; however, it is now believed to be restricted to four key populations:

- a large population on Kooragang Island (including the KIWEF site)
- small, isolated populations at Sandgate on the margins of Hexham Swamp
- a meta-population in the Gillieston Heights/East Maitland, Ravensdale areas (also including Wentworth Swamp)
- a meta-population in the Ravensworth/Liddell/Bayswater area.

2.1.3 Management and Recovery Plans

To "ensure that the Lower Hunter population is successfully managed and monitored such that the species continues to persist in the Lower Hunter and that 'measures' of the two populations' viability are maintained or improved over time", the following key documents are important:

- *Draft Management Plan for the Green and Golden Bell Frog Key Population in the Lower Hunter* (Department of Environment and Climate Change (DECC) (NSW) 2007) (the Lower Hunter management plan)
- *Draft Recovery Plan for the Green and Golden Bell Frog (*Litoria aurea*)*(DECC, 2005).

2.2 Key Distinguishing Features

The following provides some key diagnostic features that are important for quick and easy field-identification of this species.

2.2.1 Adult Frogs

- Relatively large, muscular species with robust body form and smooth skin compared to other species known to inhabit the KIWEF site (Barker *et al.*, 1995).
- The background colouration is usually green, most often with irregular large spots and/or stripes of gold (Barker *et al.*, 1995), refer to Figure 2. It should be noted that adults can vary considerably in pattern; however, the background colouration will always be green.

- Males vary in size from 60 to 70 mm (snout to vent length (SVL)); females vary from 65 to 110 m SVL (Tyler and Knight, 2009). Typically, most individuals being in the range of 60 to 80 mm SVL (DEC, 2005).
- A white or cream stripe extends from above the nostril, over the eye and ear (tympanum) and continues as a fold down the side (Robinson, 1998). There is usually a darker stripe below the white stripe, and another pale stripe from below the eye, extending to the base of the forearm (Robinson, 1998).
- The groin area, and behind the thighs, is usually pale blue or bluish-green, particularly in breeding males (Tyler and Knight, 2009). Mature males may also have a yellowish darkening of the throat area (DEC, 2005).
- The tympanum is usually brown (Tyler and Knight, 2009).
- The belly is usually creamish-white (DEC, 2005); the lower sides of the body are adorned with raised glandular, creamish-coloured spots of irregular size.
- The eye has a horizontally elliptical pupil and a golden yellow iris. The toes are three-quarters to nearly fully webbed (Robinson, 1998).

Figure 2: Adult Green and Golden Bell Frog (Litoria aurea)
(Source: A. White (2007), as in the NCIG plan)

2.2.2 Tadpoles

- Relatively large, reaching 65 to 100 mm at limb bud development stage (DEC, 2005). May be confused with other large-bodied tadpoles of species in the KIWEF site; for example, Peron's Tree Frog (*Litoria peronii*).
- Deep bodied and possess long tails with a high fin that extends almost half way along the body (refer to Figure 3).
- Although not typically used in field identification given the need for a microscope, the mouthparts consist of two upper and three lower labial rows (Anstis, 2002).

Figure 3: Tadpole Green and Golden Bell Frog (Litoria aurea)
(Source: A. White (2007), as in the NCIG plan)

2.2.3 Similar Species within the KIWEF Area

The Green and Golden Bell Frog should not be confused with any other species in the KIWEF area, given its very distinctive features and large size, wart-free skin, expanded finger and toe pads, and lack of spotting or marbling on the hind side of the thigh (Robinson, 1998).

Nevertheless, to the untrained eye, metamorphosing individuals may be confused with the adults and metamorphs of the following species that are known to occur on the KIWEF site:

- Eastern Dwarf Tree Frog (*Litoria fallax*)

  This species is also green, but lacks any of the golden markings on the back and presents with a plain, single colour.

- Peron's Tree Frog (*Litoria peronii*)

  Adults have bright yellow with black mottling on armpits, groin, and backs of thighs. The back texture is rough, and often is covered with faint, emerald spots, giving its other common name, the Emerald-spotted Treefrog.

- Broad-palmed Rocket Frog (*Litoria latopalmata*)

This species ranges from light to dark brown on its back, sometimes with darker blotches. The backs of the thighs are yellow and dark brown.

- Spotted Marsh Frog (*Limnodynastes tasmaniensis*)

  Adults usually have large regularly-shaped olive green blotches on the back and sometimes have a yellow, red, or orange mid-dorsal stripe. The background colouration is not green.

2.3 Aspects of Ecology Important for Management

2.3.1 Preferred Habitat

The Green and Golden Bell Frog can be regarded as somewhat of a habitat generalist, dispersing widely and maturing early. It is known to inhabit marshes, dams and stream sides and appears to prefer those water bodies where Bulrushes (*Typha* spp.) or Spikerushes (*Eleocharis* spp.) grow (NPWS, 1999). In the Lower Hunter region, such plant species as Salt Marsh Rush (*Juncus kraussi*), Coast Club Rush (*Schoenoplectus subulatus*), and Salt Couch (*Sporobolus virginicus*) are indicators of habitat suitability for Green and Golden Bell Frogs (DECC, 2007). Such habitat is typically unshaded, free of Plague Minnow (*Gambusia holbrooki*), have a grassy area nearby and diurnal sheltering sites (NPWS, 1999).

Green and Golden Bell Frogs are also known to inhabit highly disturbed sites (NPWS, 1999), such as the KIWEF site.

Typically, Green and Golden Bell Frogs will require habitat for breeding, foraging, shelter, movement and over wintering. All such habitat types occur across the KIWEF site, and have been incorporated under the banner of known and potential Green and Golden Bell Frog habitat by GHD (2010a). These habitat areas are indicated on Figure 1.

2.3.2 Habits

The Green and Golden Bell Frog is frequently active during the day, although it is known to forage at night on insects, as well as other frogs (Cogger, 2000; Barker *et al*., 1995; NPWS, 1999). Tadpoles are known to feed on algae and other vegetative matter (NPWS, 1999; Anstis, 2002).

The Green and Golden Bell Frog exhibits strong migration tendencies, and is known to travel significant distances across often seemingly inhospitable habitat (DECC, 2007). Distances of up to 1.5 km in a single day/night are not unknown (Wellington, 1998; Pyke and White, 2001; DECC, 2007). It should be noted that such movements most often occurred during or immediately after significant rain events.

2.3.3 Breeding

The Green and Golden Bell Frog usually breeds in summer when conditions are warm and wet, typically after rain (Cogger, 2000; Barker, *et al*., 1995). The core breeding period for this species is generally accepted to be between September and February (DECC, 2007), provided sufficient rainfall occurs during this time.

Males call while floating in water and females produce a floating raft of eggs, which gradually settle to the bottom (NPWS, 1999).

Tadpoles take around six weeks to develop depending on environmental conditions (for example, temperature) (Pyke and White, 1996; NPWS, 1999).

Adult male Green and Golden Bell Frogs may only live for around two years in a hostile environment but, typically, life expectancy is likely to vary markedly according to the quality of the habitat (Goldingay and Newell, 2005).

2.3.4 Threats

Frog Chytrid Fungus (FCF) has been identified as a key threatening process, at both the state and national level, for the Green and Golden Bell Frog (DSEWPC, 2009). FCF is widespread on Kooragang Island and Hexham Swamp, the other key Green and Golden Bell Frog population in the Newcastle area (DECC, 2007).

Recent evidence suggests that occasional exposure to saline influences and/or certain contaminants may be attenuating the effects of the FCF (DECC, 2007). Such saline and polluted conditions occur on the KIWEF site. Hypotheses supporting this scenario are presently being tested by M. Stockwell and M. Mahoney from the University of Newcastle (NCIG, 2007).

3.0 MANAGEMENT PROCEDURES

3.1 Identification and Delineation of Disturbance Areas

Known and potential Green and Golden Bell Frog habitat is located across the KIWEF site and surrounds. GHD (2010a) identified and mapped that habitat (as identified in Figure 5.5 of their report), which is presented in Figure 1 of this GGBF Management Plan. Prior to capping works commencing, this habitat will be clearly identified on the ground (with appropriate signage), and the locations of it communicated to personnel undertaking works on the site. This communication will be undertaken as part of the site induction (refer to section 3.3), and will include obligations of personnel to maintain and protect that habitat.

Ponds P and Q (that is, cells K26 and K32) will be subject to a separate Action Plan (Golder, 2011) due to their significance as habitat and the presence of contaminated soil and groundwater.

3.2 Identification of Areas of Disturbance to Habitat

As part of the capping strategy, a small proportion of the known and potential Green and Golden Bell Frog habitat may be disturbed. This habitat area comprises the fringing habitat adjacent to Deep Pond, that is the area located near K3/1W and the BOS area (Figure 1).

The frogs will be relocated within the KIWEF during the capping works.

3.3 Environment Induction and Training

All HDC personnel, contractors and sub-contractors will undergo environmental induction and training before commencing work on-site. As it pertains to the Green and Golden Bell Frog, information addressed during this training will include (NCIG, 2007):

- Green and Golden Bell Frog profile and identification (Section 2).
- Identification of Green and Golden Bell Frog habitat areas. Project personnel will be prohibited from entering Green and Golden Bell Frog habitat areas located outside defined works areas.
- Site hygiene management in accordance with the Hygiene Protocol (Section 3.4).
- Procedures to be followed in the event Green and Golden Bell Frogs are found (Section 3.6).

3.4 Site Hygiene Management

The proposed hygiene management protocol described below largely follows that prepared by NCIG (2007), which has been accepted by OEH.

FCF (refer to section 2.3.4) has the potential to adversely affect Green and Golden Bell Frogs. It is known to occur on Kooragang Island, and potentially on the KIWEF site. Infection occurs through waterborne zoospores released from an infected amphibian in water (NPWS, 2001) and the fungus infects both frogs and tadpoles (Berger *et al.*, 1999). Therefore, the spread of FCF can occur via the movement of water around the site and/or soil attached to equipment (both plant and personal protective equipment).

Typical clinical signs of frogs infected with FCF (after Berger *et al.*, 1999) include:

- lethargy
- loss of appetite
- skin discoloration
- presence of excessive sloughed skin
- sitting unprotected during the day with hind legs held loosely to the body.

3.4.1 Hygiene Training

To reduce the likelihood of spreading FCF, all HDC employees and contractors involved in activities in areas of known habitat for the Green and Golden Bell Frog (and other amphibian species) will be trained in site hygiene management in accordance with the hygiene protocol (Appendix A). This will be part of the environmental induction and training (Section 3.3).

3.4.2 Inspection and Disinfection of Mobile Plant

Any mobile plant entering and leaving the KIWEF site during the closure and capping activities will be routinely disinfected at a designated wash bay.

Similarly, personal protective equipment (PPE) of HDC employees and contractors entering and leaving the site will be disinfected as a matter of routine, following the methods outlined in the Hygiene Protocol (Appendix A).

Inspection and disinfection of mobile plant, and affected PPE, will be undertaken at a designated, concrete-bunded disinfection area at the entrance of the KIWEF site. The location of this area, and the disinfection procedure, will be incorporated into the site induction and training programme (refer to Section 3.3).

3.5 Pre-works Surveys for Disturbance Areas

Pre-works surveys will include targeted active searches of potential Green and Golden Bell Frog habitat located within proposed disturbance areas. These surveys will be undertaken by a suitably qualified and licensed ecologist.

The pre-works surveys (and, if applicable, relocation activities) will be conducted to minimise disruption to breeding activities and the need to relocate tadpoles or metamorphs, where practicable. All these activities will be conducted in accordance with the relevant measures outlined in the hygiene protocol (Section 3.4).

Habitat resources typically associated with the lifecycle components of the Green and Golden Bell Frog (for example, ponded areas, rocks, logs, tussock forming vegetation and other cover) will be searched during a diurnal visual inspection.

Following the diurnal habitat searches, a nocturnal habitat search may be conducted to assess nocturnal usage (that is, breeding/calling) in the habitat supported in the disturbance area, if the surveys are conducted during the core breeding season. The nocturnal habitat searches may include:

- searching of habitat features, which were searched during the day
- spotlighting
- call play-back.

In the event that any Green and Golden Bell Frogs are observed during the diurnal or nocturnal searches, the relocation procedures outlined in Section 3.6 will be initiated prior to the commencement of disturbance works. In some cases a frog-proof fence may be used to protect the frogs in-situ or to exclude frogs from the surveyed area.

The results of the pre-works surveys will be recorded and reported in the Annual Environmental Management Report (AEMR) (Section 6).

3.6 Green and Golden Bell Frog Relocation Procedures

The proposed relocation procedure described below largely follows that proposed by NCIG (2007), which has been accepted by OEH.

3.6.1 Relocation Procedure during Pre-works Surveys

In the event a Green and Golden Bell Frog is identified within the disturbance areas during pre-works surveys, the following relocation procedure will be initiated:

a) The ecologist undertaking the pre-clearance survey will capture the frog.

b) If the frog appears to be healthy:

   a. A suitable release location in the immediate vicinity of the disturbance area, yet outside of potential areas of disturbance, will be identified by the ecologist.

   b. The frog will be released into the relocation area. Any frog to be relocated will be held in a cool, dark, moist place until nightfall. Where practicable, relocation will be timed to coincide with periods of recent rainfall to optimise chances of survival of the frog.

c) If the frog appears to be sick, or is dead:

   a. the procedures outlined in Section 3.6.3 will be followed.

Relocation of Green and Golden Bell Frogs during pre-works surveys will be conducted in accordance with the relevant measures outlined in the hygiene protocol (Section 3.4).

Details of Green and Golden Bell Frogs that are relocated (that is, lifecycle stage and sex of individual [if possible], location where found and location of release) conducted during pre-works surveys will be recorded and reported in the AEMR (Section 6).

3.6.2 Relocation Procedure Outside of Pre-works Surveys

In the event a frog is observed within the KIWEF site outside of the designated pre-works surveys (for example, within an area already disturbed), and is thought to be a Green and Golden Bell Frog, the following relocation procedure will be initiated if the frog is likely to be harmed by the capping works:

a) The observer will notify the HDC's Environmental Representative, or suitably-qualified ecologist, of the frog's location.

b) The Environmental Representative, or suitably-qualified ecologist, will determine whether the frog is likely to be harmed by works.

c) If the frog is likely to be harmed by works, a suitably-qualified ecologist, will capture the frog.

d) If the frog appears to be healthy:

   a. A suitable release location (that is, one of the potential relocation areas identified on Figure 1) will be identified by the ecologist.

   b. The frog will be released into the relocation area. Any frog to be relocated will be held in a cool, dark, moist place until nightfall. Where practicable, relocation will be timed to coincide with periods of recent rainfall to optimise chances of survival of the frog.

e) If the frog appears to be sick, or is dead:

   a. the procedures outlined in Section 3.6.3 will be followed.

Relocation of Green and Golden Bell Frogs outside pre-works surveys will be conducted in accordance with the relevant measures outlined in the hygiene protocol (Section 3.4).

Details of Green and Golden Bell Frogs that are relocated (that is, lifecycle stage and sex of individual [if possible], location where found and location of release) during pre-work surveys will be recorded and reported in the AEMR (Section 6).

3.6.3 Procedures for Handling Sick or Dead Green and Golden Bell Frogs

Table 1 presents the range of symptoms that may be exhibited by sick or dying frogs, while Table 2 provides diagnostic behaviour tests, which can be used to determine if a frog is sick (for example, infected with FCF) (after NCIG, 2007).

Table 1: Symptoms of sick and dying frogs

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

Source: after NPWS (2001)

Table 2: Diagnostic behaviour tests – sick frogs will fail one or more of the following tests

Test	Healthy	Sick
■ Gently touch with finger	■ Frog will blink.	■ Frog will not blink.
■ Turn frog on its back	■ Frog will flip back over.	■ Frog will remain on its back.
■ Hold frog gently by its mouth	■ Frog will use its forelimbs to try to remove grip	■ No response from frog

Source: after NPWS (2001)

In the event that a Green and Golden Bell Frog appears to be sick, or is dead, the following procedures will be followed (after NPWS, 2001):

- Disposable gloves will be worn when handling all frogs, as well as sick or dead frogs.
- To prevent cross-contamination, new gloves and a clean plastic bag will be used for each frog specimen.
- Frogs exhibiting one or more of the symptoms for sick frogs listed in Table 1 or 2, and considered unlikely to survive transportation will be euthanised[1].
- Sick frogs likely to survive transportation will be placed into either a moistened cloth bag with some damp leaf litter, or into a partially-inflated, clean plastic bag with damp leaf litter. All frogs will be kept separate during transportation.
- Dead frogs will be kept cool and preserved as soon as possible. The belly of the frog will be cut open and the specimen placed in preservative (approximately 10 times the volume of the specimen). Specimens will be preserved in either 65% ethanol or 10% buffered formalin.
- The recipient of the sick or dead frog will be contacted to confirm the appropriate procedure prior to transport[2].

[1] Terminally ill frogs will be placed into a container with the bottom covered with 3% chloral hydrate (NPWS, 2001).

- Containers will be labelled with the following details: date, location and species (if known).
- Standardised collection form will be filled out and a copy sent with the specimen (in Appendix A).
- Individual containers will be used for each specimen.

Details of sick or dead Green and Golden Bell Frogs found at the KIWEF site will be recorded and reported in the AEMR (Section 6).

[2] A list of potential sick and dead frog recipients is provided in Attachment 4 (NPWS, 2001), including Associate Professor Michael Mahony of the School of Biological Sciences, University of Newcastle.

4.0 GREEN AND GOLDEN BELL FROG MONITORING PROGRAMME

Baseline monitoring of the Green and Golden Bell Frog has been undertaken by GHD (2010 and Umwelt (2011).

NCIG has also implemented a monitoring programme that collects data that includes the Green and Golden Bell Frog populations on the KIWEF site.

The NCIG monitoring will be conducted annually until 2020 and then three-yearly till 2030. On the basis that the NCIG monitoring programme continues to be implemented, HDC do not propose to undertake any further monitoring, other than that specified in the Action Plan for the K26/K32 Ponds (Golder, 2011).

HDC propose to annually review the NCIG data to ensure that it meets HDC's requirements. The overall objective of HDC's review of the Green and Golden Bell Frog monitoring programme is to monitor the dynamics of the Green and Golden Bell Frog populations supported within known and potential habitat areas within the KIWEF site. The intention of the review programme will be to ascertain if the landfill closure works have an effect on the population.

Monitoring parameters that will be used for comparison will include, yet not be limited to:

a) Green and Golden Bell Frog presence/absence, distribution, habitat utilisation, behaviour and abnormalities.

b) observations of other frog species distribution, relative abundance and abnormalities.

c) habitat condition.

d) date

e) time of day

f) rainfall (mm)

g) site location (GPS co-ordinates and map location)

h) survey method utilised

i) sampling effort

j) habitats surveyed

k) weather conditions (including temperature)

l) number of observers

m) photographs taken

HDC will report to OEH annually for 5 years following the completion of the landfill closure works, unless analysis shows that Green and Golden Bell Frog populations are being impacted, then further reporting will be undertaken until a date agreed with OEH.

Monitoring and research to understand better the extent and dynamics of Green and Golden Bell Frog populations is a proposed action of the Draft Recovery Plan (DECC, 2005). This action has been adopted as a strategy to achieve the objectives of the Lower Hunter Management Plan. The results of this monitoring programme would contribute to this action/strategy.

The results of the monitoring programme will be recorded and reported in the AEMR (Section 6).

5.0 RESPONSE CRITERIA AND SPECIFIC MITIGATION AND MANAGEMENT MEASURES

The following proposed mitigation measures have been developed based on a review of information provided by GHD (2010a) and a review of site conditions.

5.1 Management of All Disturbance Areas

The following mitigation measures will be implemented to manage areas proposed for disturbance.

- The boundaries of all Green and Golden Bell Frog habitat will be clearly identified on the ground.
- Appropriate erosion and sediment control structures will be installed at least 30 metres upslope of all such habitat areas. These erosion and sediment control structures will be regularly inspected and maintained, particularly after significant rainfall events.
- All plant entering and leaving the KIWEF site will be, as a matter of routine, disinfected via a wash bay. The location and procedures involved at this wash bay will form part of the site induction and training (see Section 3.3). Records will be kept.
- Similarly, all HDC employees and contractors involved in activities in areas of known habitat for the Green and Golden Bell Frog (and other amphibian species) will be trained in site hygiene management in accordance with the hygiene protocol (Appendix A). This will be part of the environmental induction and training (Section 3.3). Records will be kept.
- All PPE in contact with soil, particularly boots, of HDC employees and contractors entering and leaving the site will be disinfected as a matter of routine, following the methods outlined in the Hygiene Protocol (Appendix A).
- All disinfection processes will be monitored and controlled at the KIWEF site's entry and exit point. The location of these disinfection bays, and the obligations of disinfection, will be communicated during the site induction and training (Section 3.3).
- All water required for dust suppression will be drawn from ponds established for the purpose. No water for dust suppression will be drawn from current ponds on the site. The establishment of dedicated dust suppression ponds will be undertaken to prevent the potential spread of Plague Minnow into ponds currently free of this species. The location and procedure for those dedicated dust suppression ponds will be communicated during the site induction and training (Section 3.3).
- Stormwater diversion measures, if required, will be put in place to maintain the current hydrological regime for the site.
- If practicable, the capping and grading activities will be scheduled to occur outside of the core Green and Golden Bell Frog breeding period (that is, September to March), especially in areas adjacent to known and potential breeding habitat.

5.2 Specific Management Measures for Disturbed Areas

The following mitigation measures will be implemented to manage areas proposed for disturbance. It should be noted that these measures do not negate the need for the measures outlined in Section 5.1.

- The disturbance area will be clearly delineated on the site plan and on the ground. The boundaries of the area and its location will be made known to all personnel involved during the site induction (refer to Section 3.3).
- One week prior to works commencing in the disturbance area, a pre-works survey will be conducted by a qualified ecologist (refer to Section 3.5 for a suggested survey protocol).

- In the event that any Green and Golden Bell Frogs are identified in the area, they will be relocated (using appropriate amphibian hygiene protocols) to known and suitable Green and Golden Bell Frog habitat areas immediately adjacent to the disturbance footprint (refer to Section 3.6 for appropriate relocation procedures).
- The works will be scheduled to occur outside of the core breeding period for Green and Golden Bell Frogs, that is, September to March.
- An on-site, suitably-qualified ecologist will be available during all clearing and capping works undertaken in the habitat areas to be disturbed. This person will be available to relocate Green and Golden Bell Frogs that may be found in the disturbance footprint during capping activities.
- In an attempt to limit the potential for Green and Golden Bell Frogs to enter the disturbance footprint, and if practicable, a frog-proof barrier will be erected around the disturbance footprint.
- Appropriate erosion and sediment control measures will be put in place around the disturbance area, prior to any works commencing, to prevent sediment from moving into adjacent habitat.
- Once works are complete, the restoration and rehabilitation of that habitat will be undertaken in accordance with a rehabilitation and revegetation plan.

5.3 Measures to Enhance Restore and Maintain Habitat

It is noted that the proposed capping works have been designed to minimise impacts on Green and Golden Bell Frog Habitat and will impact upon only two small areas.

It is anticipated that the mitigation measures presented in Sections 5.1 and 5.2 will assist in the management of the Green and Golden Bell Frogs, and their habitat on the KIWEF site, during and immediately following the landfill closure work, and the associated activities. In addition to those, the following mitigation measures have been developed to assist, where practicable, in the enhancement, restoration and maintenance of Green and Golden Bell Frog habitat following the completion of the landfill closure works.

- The capping strategy has been designed to limit and ultimately reduce the exposure of potential Green and Golden Bell Frog habitat, and the wider ecosystems of Kooragang Island, to soil and groundwater contaminants.
- As part of the rehabilitation and revegetation plan for the KIWEF site, open stormwater infrastructure across the KIWEF site may be planted with species known to be favoured by Green and Golden Bell Frogs. This revegetation and rehabilitation strategy will include a 2 metre wide buffer on either side of the stormwater drains. The intention of these areas is to provide movement corridors for Green and Golden Bell Frogs across the site.
- The capped areas will ideally be designed to shed water to table drains, which, in a similar manner to other stormwater infrastructure, will be vegetated with species known to be favourable to Green and Golden Bell Frogs.
- Drainage culverts will, where practicable, be vegetated and lined with rocks and objects that may provide temporary frog refuge, in the event that a frog seeks to traverse the future capped area of KIWEF.
- The drainage culverts in the NCIG rail loop may provide additional areas that can be rehabilitated to facilitate the migration and dispersal of the Green and Golden Bell Frog (Connell Hatch, 2008, in GHD, 2010b).

5.4 Response Criteria

5.4.1 General Site Environmental Management

As part of the overall environmental management plan for the site, during the landfill closure works, the HDC's environmental representative will conduct weekly inspections of all the management measures identified in Sections 5.1, 5.2 and 5.3. The results of these inspections will be recorded and a summary provided in the AEMR.

Should non-conformances be identified, HDC's environmental representative will contact the Site Foreman within 24 hours and request a remediation action. The Site Foreman will have 48 hours to correct the non-conformance.

5.4.2 Population Monitoring

If the results of the monitoring programme indicate a decline in Green and Golden Bell Frog numbers across the site, which cannot be attributed to natural population fluctuations and variability, and is potentially a direct result of the landfill closure works, specific response criteria will be developed by HDC, in consultation with the OEH. The aim of these response criteria will be to determine whether declining populations (if evident from the monitoring programme [Section 4]) are directly attributable to the capping project.

6.0 REPORTING AND REVIEW

In accordance with the *Approval of Surrender of Licence Number 6437*, the Director-General will be notified of any incident with actual or potential significant off-site impacts on people or the biophysical environment, as soon as practicable after the occurrence of the incident. The Director-General will be provided with written details of the incident within seven days of the date on which the incident occurred.

HDC will prepare an Annual Environmental Management Report (AEMR) that:

a) Reviews the performance of the capping project against this management plan.

b) Provides an overview of environmental management actions and summarises monitoring results over the 12 month reporting period.

c) Continues on an annual basis for a minimum of five years following completion of the Landfill Closure Works.

d) Will be phased out on presentation of adequate information to establish that the Landfill Closure Works have had no measurable impacts to Green and Golden Bell Frog populations on the KIWEF site. In the unlikely event that changes in the Green and Golden Bell Frog population are observed, which appear to be attributable to the Landfill Closure Works, extended review will be undertaken. This may involve a more detailed monitoring and investigation programme to address the potential cause of the decline in those areas. The programme will aim to identify direct evidence indicating that the Landfill Closure Works contributed to the decline. The details of that programme will be developed through discussion with OEH.

The AEMR will be distributed to relevant government agencies and stakeholders, and copies provided to other interested parties, if requested.

In accordance with the *Approval of Surrender of Licence Number 6437*, this management plan will be made available on the HDC website.

7.0 REFERENCES

Abbasi, SA. and Soni, R (1984). Teratogenic effects of chromium (vi) in environment as evidenced by the impact on larvae of amphibian *Rana Tigrina*: implications in the environmental management of chromium. *International Journal of Environmental Studies* 23(2): 131-137.

Anonymous (1999). Effects of sublethal lead exposure on the behaviours of Green Frog (*Rana clamitans*), Bullfrog (*Rana catesbiana*) and American Toad (*Bufo americanus*) tadpoles. *Marine and Freshwater Behaviour and Physiology* 32(1): 1-16.

Anstis, M (2002). *Tadpoles of South-eastern Australia*, New Holland, Sydney.

Arrieta, MA, Bruzzone, L, Apartin, C, Rosenberg, CE, Fink, NE and Saliban, A (2004). Biosensors of inorganic lead exposure and effect in an adult amphibian. *Archives of Environmental Contamination and Toxicology* 46(2): 224-230.

Barker, J, Grigg, GC and Tyler, MJ (1995) *A field guide to Australian Frogs*. Surrey Beatty and Sons, Chipping Norton.

Berger, L, Speare, R and Hyatt, A (1999) Chytrid fungi and amphibian declines: overview, implications and future directions. In *'Declines and Disappearances of Australian Frogs'*. (Ed. A. Campbell.) pp. 23-33. Environment Australia, Canberra.

Cogger, HG (2000) *Reptiles and Amphibians of Australia*. Reed New Holland. Australia.

Department of Environment and Conservation (2005) *Draft Recovery Plan for the Green and Golden Bell Frog (*Litoria aurea*).* Hurstville, NSW.

Department of Environment and Climate Change (2007) *Draft Management Plan for the Green and Golden Bell Frog Key Population in the Lower Hunter*. Sydney, NSW.

Department of Sustainability, Environment, Water, Populations and Communities (2009) *Significant impact guidelines for the vulnerable Green and Golden Bell Frog (*Litoria aurea*)*, Nationally threatened species and ecological communities; Background paper to the EPBC Act policy statement 3.19.

GHD (2010a). *Revised Capping Strategy, Flora and Fauna Impact Assessment*, Revision 3

GHD (2010b). *Revised Final Landform and Capping Strategy*, Revision 4

Goldingay, R.L. and Newell, D.A. (2005) Aspects of the Population Ecology of the Green and Golden Bell Frog Litoria aurea at the Northern End of its Range. Australian Zoologist 33: 49-59.

Marquis, O, Millery, A, Guittonneau, S and Miaud, C (2006). Toxicity of PAHs and jelly protection of eggs in the Common frog Rana temporaria. *Amphibia-Reptilia*: 27(3): 472-475.

Newcastle Coal Infrastructure Group (2007) *Coal Export Terminal Green and Golden Bell Frog Management Plan,* (Document No. GGBFMP-R01-E.DOC)

National Parks and Wildlife Service (1999) *Threatened Species Information, Green and Golden Bell Frog* Litoria aurea (Lesson, 1829).

National Parks and Wildlife Service (2001) *Threatened Species Management Information Circular No. 6 - Hygiene Protocol for the Control of Disease in Frogs*.

Pyke, GH and White, AW (1996) Habitat Requirements for the Green and Golden Bell Frog *Litoria aurea* (Anura: Hylidae). *Australian Zoologist* 30: 224-232.

Robinson, M. (1998) *A Field Guide to Frogs of Australia*. Reed New Holland, Australia.

Tyler, MJ and Knight, F (2009) *Field Guide to the Frogs of Australia*, CSIRO Publishing, Australia.

Wellington, R (1998) *An outline of the currently known state-wide conservation situation of the Green and Golden Bell Frog* Litoria aurea: *Discussion and Overview*. Unpublished Report to the GGBF Recovery Team.

Umwelt (Australia) Pty Limited (2011) *March 2011 Green and Golden Bell Frog (*Litoria aurea*) Survey at the Kooragang Island Waste Emplacement Facility*, prepared for HDC.

Rice, TM, Oris, JT and Taylor, DH (2002). Effects of growth and changes in organ distribution of Bullfrog larvae exposed to lead throughout metamorphosis. *Bulletin of Environmental Contamination and Toxicology*, 68: 8-17.

Stabenau, E, *et al.* (2006). Uptake and Elimination of Naphthalene from Liver, Lung, and Muscle Tissue in the Leopard frog (*Rana pipiens*). *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances & Environmental Engineering* 41(8): 1449-1461.

Wang, MZ. and Jia XY (2008) Low levels of lead exposure induce oxidative damage and DNA damage in the testes of the frog *Rana nigromaculata*. *Ecotoxicology*: 1-6.

Report Signature Page

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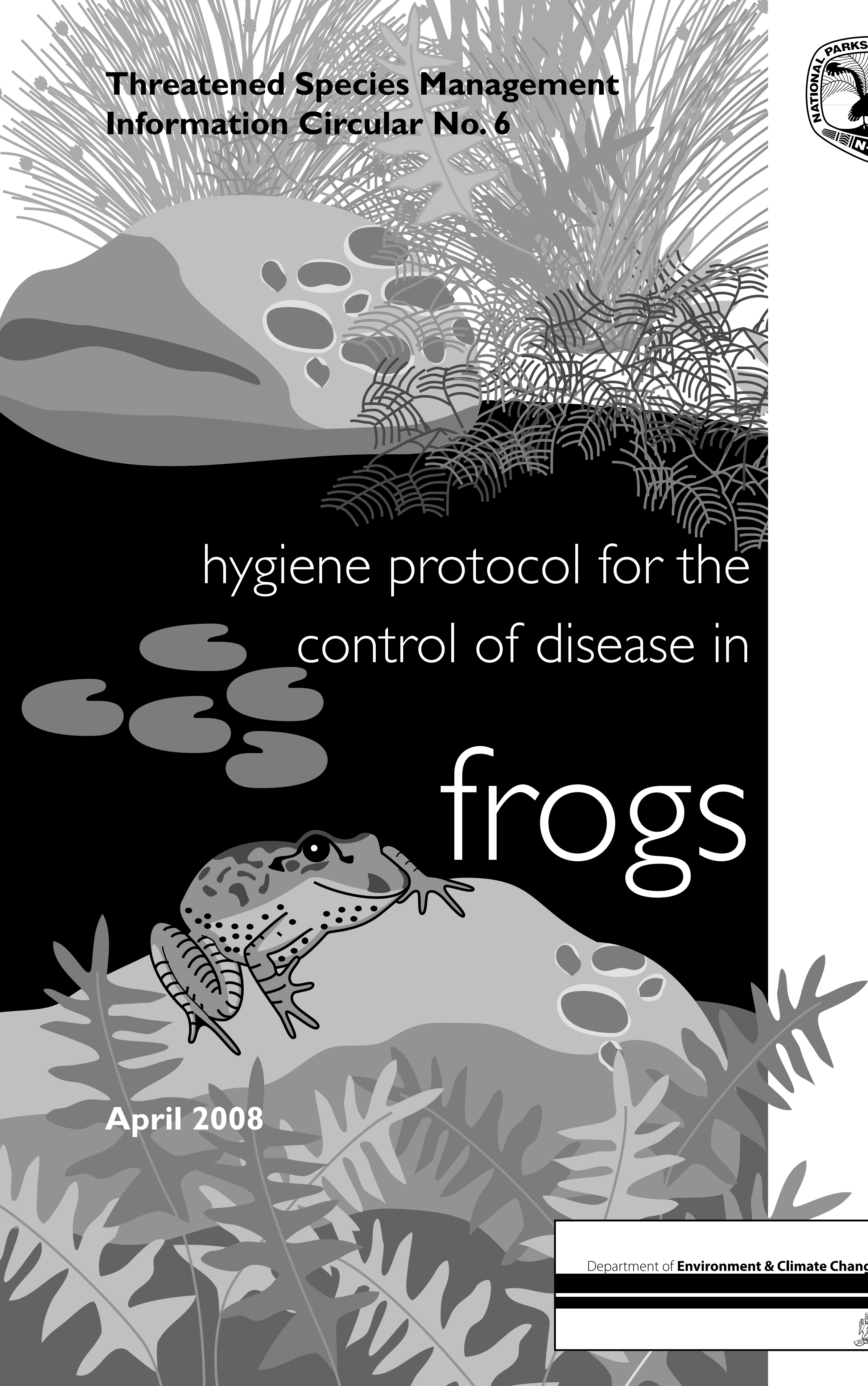
APPENDIX A

Hygiene Protocol for the Control of Disease in Frogs

Threatened Species Management Information Circular No. 6



hygiene protocol for the control of disease in frogs

April 2008

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This hygiene protocol is an adaptation of the Declining Amphibian Population Task Force (DAPTF) Fieldwork Code of Practice and the recommendations of Speare et al. (1999) and has drawn on recommendations from earlier guidelines prepared by Environment ACT.

Foundation for National Parks and Wildlife funded the printing of this protocol.

hygiene protocol for the control of disease in frogs

1 introduction

This information circular outlines measures to:

- Prevent or reduce disease causing pathogens being transferred within and between wild populations of frogs.
- Ensure captive frogs are not infected prior to release.
- Deal safely with unintentionally transported frogs.
- Assist with the proper identification and management of sick and dead frogs in the wild.

1.1 Who should read this document?

This protocol is intended for use by all researchers, wildlife consultants, fauna surveyors and students undertaking frog field-work. In addition, the protocol should be read by Department of Environment and Climate Change (DECC) personnel, frog keepers, wildlife rescue and carer organisations, herpetological/frog interest groups/ societies, fauna park/zoo operators/workers and other individuals who regularly deal with or are likely to encounter frogs.

This protocol outlines the expectations of the DECC regarding precautionary procedures to be employed when working with frog populations. The intention is to promote implementation of hygiene procedures by all individuals working with frogs. New licences and licence renewals will be conditional upon incorporation of the protocol. The DECC recognises that some variation from the protocol may be appropriate for particular research and frog handling activities. Such variation proposals should accompany any licence application or renewal to the DECC.

1.2 Background

1.2.1 Amphibian Chytrid Fungus

The apparent decline of frogs, including extinctions of species and local populations, has attracted increased international and national concern. Many potential causes for frog declines have been proposed (eg see Pechmann et al., 1991; Ferrero and Bergin, 1993; Pechmann and Wilbur, 1994; Pounds and Crump, 1994; Pounds et al., 1997). However, the patterns of decline at many locations suggest that epidemic disease maybe the cause (Richards et al., 1993; Laurance et al., 1996; Alford and Richards, 1997). Recent research has implicated a water-borne fungal pathogen *Batrachochytrium dendrobatidis* as the likely specific causative agent in many of these declines both in Australia and elsewhere (Berger et al., 1998; 1999). This agent is commonly known as the amphibian or frog chytrid fungus and is responsible for the disease Chytridiomycosis (Berger et al., 1999).

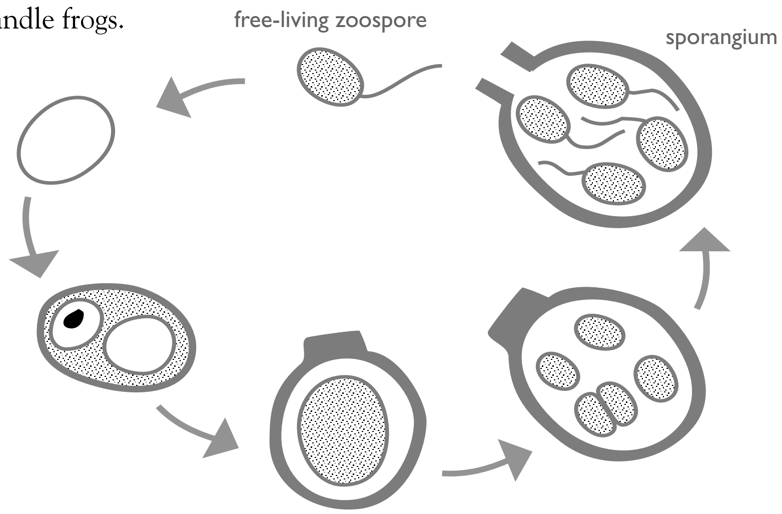
B. dendrobatidis is a form of fungus belonging to the phylum Chytridiomycota. Most species within this phylum occur as free-living saprophytic fungi in water and soil and have been found in almost every type of environment including deserts, artic tundra and rainforest and are considered important primary biodegraders (Powell 1993). *B. dendrobatidis* is a unique parasitic form of Chytridiomycete fungi, in that it invades the skin of amphibians, including tadpoles, often causing sporadic deaths with up to 100% mortality in some populations. Chytridiomycosis has been detected in over 40 species of native amphibian in Australia (Mahony and Workman 2000). However, it is not currently known whether the fungus is endemic or exotic to Australia.

The infective stage of *B. dendrobatidis* is the zoospore and transmission requires water (Berger et al.,1999). Zoospores released from an infected amphibian can potentially infect other amphibians in the same water. More research is needed on the dynamics of infection in the wild. *B. dendrobatidis* is known to be susceptible to seasonal temperature changes, dehydration, salinity, water pH, light, nutrition and dissolved oxygen (Berger et al., 1999).

1.3 Objectives

The objectives of the hygiene protocol are to:

- Recommend best-practice procedures for DECC personnel, researchers, consultants and other frog enthusiasts or individuals who handle frogs.
- Suggest workable strategies for those regularly working in the field with frogs or conducting fieldwork activities in wetlands and other aquatic environments where there is the potential for spreading pathogens such as the frog chytrid fungus.
- Provide background information and guidance to people who provide advice or supervise frog related activities.
- Provide standard licence conditions for workers engaged in frog related activities.
- Inform Animal Care and Ethics Committees (ACEC) for their consideration when granting research approvals.



Life cycle of frog chytrid fungus from infective free-living zoospore stage to sporangium (adapted from L. Berger).

2 site hygiene management

A checklist of risk management procedures and recommended standard hygiene kit is provided in Appendix 1. Please note Footnote 1 on page 4.

Individuals studying frogs often travel and collect samples of frogs from multiple sites. Some frog populations can be particularly sensitive to the introduction of infectious pathogens such as the frog chytrid fungus. Also, the arrangement of populations in the landscape may make frogs particularly vulnerable to transmission of infectious pathogens. Therefore, it is important that frog workers recognise the boundaries between sites and undertake measures which reduce the likelihood of spreading infection.

Where critically endangered species or populations of particular risk are known to occur, this protocol should be applied over very short distances ie a single site may need to be subdivided and treated as separate sites.

When planning to survey multiple sites, always start at a site where frog chytrid fungus is not known to be present before entering other infected areas.

2.1 Defining a site

Defining the boundary of a site maybe problematic. In some places, the boundary between sites will be obvious but in others, less so. Undertaking work at a number of sites or conducting routine monitoring at a series of sites within walking distance creates obvious difficulties with boundary definitions. It is likely that defining the boundary between sites will differ among localities. It may be that a natural or constructed feature forms a logical indicator of a site boundary eg a road/track, a large body of water such as a river or the sea, a marked habitat change or a catchment boundary.

As a guiding principle, each individual waterbody should be considered a separate site.

When working along a river or stream or around a wetland or a series of interconnecting ponds it is reasonable, in most instances, to treat such examples as a single site for the purposes of this protocol. Such a case would occur in areas where frogs are known to have free interchange between ponds.

Where a stream consists of a series of distinctive tributaries or sub-catchments or where there is an obvious break or division then they should be treated as separate sites, particularly if there is no known interchange of frogs between sites.

2.2 On-site hygiene

When travelling from site to site it is recommended that the following hygiene precautions be undertaken to minimise the transfer of disease from footwear, equipment and/or vehicles.

Footwear

Footwear must be thoroughly cleaned and disinfected at the commencement of fieldwork and between each sampling site.

This can be achieved by initially scraping boots clear of mud and standing the soles in a disinfecting solution. The remainder of the boot should be rinsed or sprayed with a disinfecting solution that contains *benzalkonium chloride* as the active ingredient. Disinfecting solutions should be prevented from entering any water bodies.

Rubber boots such as 'gum boots' or 'Wellingtons' are recommended because of the ease with which they can be cleaned and disinfected.

Several changes of footwear bagged between sites might be a practical alternative to cleaning.

Equipment

Equipment such as nets, balances, callipers, bags, scalpels, headlamps, torches, wetsuits and waders etc that are used at one site must be cleaned and disinfected before re-use at another site.

Disposable items should be used where possible. Non-disposable equipment should be used only once during a particular field exercise and disinfected later or disinfected at the site between uses using procedures outlined in 2.4 below.

Vehicles

Where necessary, vehicle tyres should be sprayed/flushed with a disinfecting solution in high-risk areas.

Transmission of disease from vehicles is unlikely to be a problem. However, if a vehicle is used to traverse a known frog site, which could result in mud and water being transferred to other bodies of water or frog sites, then wheels and tyres should undergo cleaning and disinfection. This should be carried out at a safe distance from water bodies, so that the disinfecting solution can infiltrate soil rather than run-off into a nearby water body.

Spraying with 'toilet duck' (active ingredient *benzalkonium chloride*) is recommended to disinfect car wheels and tyres.

Cleaning of footwear before getting back into the car will prevent the transfer of pathogens from/to vehicle floor and control pedals.

2.3 Handling of frogs in the field

The spread of pathogenic organisms, such as the frog chytrid fungus, may occur as a result of handling frogs.

Frogs should only be handled when necessary.

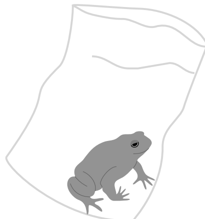
Where handling of frogs is necessary the risk of pathogen transfer should be minimised as follows:

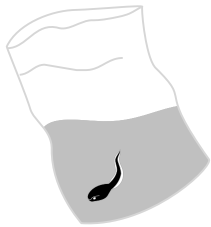
- Hands should be either cleaned and disinfected between samples or a new pair of disposable gloves used for each sample[1]. This may be achieved by commencing with a work area that has a dish containing a disinfecting solution and paper towels.
- A 'one bag – one frog' approach to frog handling should be used especially where several people are working together with one person processing frogs and others doing the collecting. Bags should not be reused.
- A 'one bag – one sample' approach to tadpole sampling should be used. Bags should not be reused.

Researchers who use toe clipping or Passive Integrated Transponder (PIT) tagging are likely to increase the risk of transmitting disease between frogs due to the possibility of directly introducing pathogens into the frogs' system. This can be minimised by using:

- Disposable sterile instruments
- Instruments disinfected previously and used once
- Instruments disinfected in between each frog

Disinfecting solutions containing *benzalkonium chloride* are readily available from local supermarkets. Some brands include Toilet Duck, Sanpic, New Clenz and Pine Clean.





[1] As a principle, this protocol assumes that not all frogs in an infected pond will be contaminated by the frog chytrid fungus. The infective load of a body of water may not be high enough to cause cross contamination of individual frogs in the same pond. Therefore care should be taken to use separate gloves and bags and clean hands for each sample, to avoid transmission of high infective loads between individuals.

Open wounds from toe clipping and PIT tagging should be sealed with a cyanoacrylate compound such as *Vetbond©* to reduce the likelihood of entry of pathogens. The DECC ACEC further recommends the application of topical anaesthetic *Xylocaine©* cream and *Betadine©* disinfectant (1% solution) before and after any surgical procedure. This should then be followed by the wound sealant.

All used disinfecting solutions, gloves and other disposable items should be stored in a sharps or other waste container and disposed or sterilised appropriately at the completion of fieldwork. Disinfecting solutions must not come into contact with frogs or be permitted to contaminate any water bodies

2.4 Disinfection Methods

Disinfecting agents for hands and equipment must be effective against bacteria and both the vegetative and spore stages of fungi. The following agents are recommended:

- Chloramine and Chlorhexidine based products such as *Halamid©*, *Halasept©* or *Hexifoam©* are effective against both bacteria and fungi. These products are suitable for use on hands, footwear, instruments and other equipment. The manufacturers instructions should be followed when preparing these solutions.
- Bleach and alcohol (ethanol or methanol), diluted to appropriate concentrations can be effective against bacteria and fungi. However, these substances may be less practical because of their corrosive and hazardous nature.

  When using methanol either:

  - immerse in 70% methanol for 30 minutes or
  - dip in 100% methanol then flame for 10 seconds or boil in water for 10 minutes

Fresh bleach (5% concentration) may be also effective against other frog pathogens such as Rana Virus.

Some equipment not easily disinfected in these ways can be effectively cleaned using medical standard 70% isopropyl alcohol wipes – *Isowipes©*.

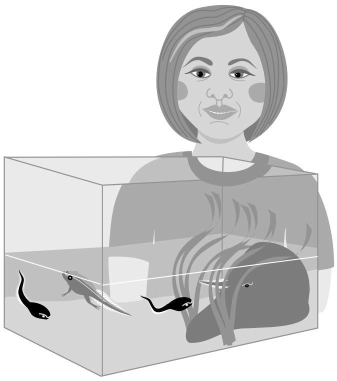
3 captive frog hygiene management

3.1 Housing frogs and tadpoles

Frogs and tadpoles should only be removed from a site when absolutely necessary.

When it is necessary for frogs or tadpoles to be collected and held for a period of time, the following measures should be undertaken:

- Animals obtained at different sites should be kept isolated from each other and from other captive animals.
- Aquaria set up to hold frogs should not share water, equipment or any filtration system. Splashes of water from adjacent enclosures or drops of water on nets may transfer pathogens between enclosures.
- Prior to housing frogs or tadpoles, ensure that tanks, aquaria and any associated equipment are disinfected.
- Tanks and equipment should be cleaned, disinfected and dried immediately after frogs/tadpoles are removed.



Careful maintenance of your enclosures will ensure a safe and hygienic environment for captive frogs and tadpoles.

When contemplating a release of captive bred tadpoles for conservation purposes a Translocation Proposal should be submitted to the DECC and pathological screening for disease should be undertaken (see also DECC Translocation Policy). Tadpoles can be tested by randomly removing 10 individuals at 6 weeks and again at 2 weeks before anticipated release. Testing could be undertaken by the pathology section at Taronga Zoo, Newcastle University, CSIRO Australian Animal Health Laboratories at Geelong and James Cook University at Townsville. Such an arrangement would need to be negotiated by contacting one of these institutions well before the anticipated release date. (see Appendix 2 for contact details)

DECC have licenced NSW Schools to allow students and/or teachers to remove tadpoles for classroom life cycle studies. They are authorised to remove individuals from only one location, each school also requires endorsement from Department of Education and Training Animal Care and Ethics Committee and comply with this protocol.

Tadpoles collected for these purposes are to be obtained from the local area of the school and are not to be obtained from DECC Reserves. As soon as tadpoles have transformed, froglets must be returned to the exact point of capture. Tadpoles from different locations are not to be mixed.

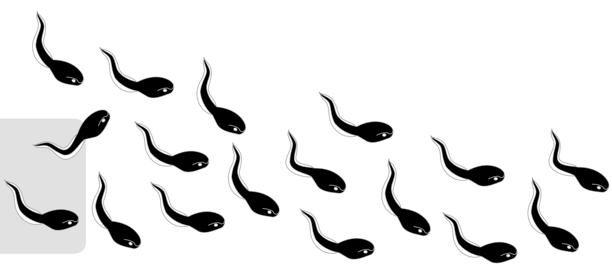
Antifungal cleansing treatments to clear tadpoles of the frog chytrid fungus are currently being trialed. In the future, such a treatment may be an added procedure required prior to froglet releases.

Detailed information on safely maintaining frogs in captivity is provided in Voigt (2001).

3.2 Tadpole treatment

In most instances:

Release to the wild of tadpoles held or bred in captivity should be avoided.



3.3 Frog treatment

The rigour with which frogs must be treated to ensure pathogens are not introduced to native populations means that any proposal for the removal of adult frogs (particularly threatened species) from wild populations should be given careful consideration.

When it is essential for frogs to be removed from the wild, the following should apply.

Individuals to be released should be quarantined for a period of 2 months and monitored for any signs of illness or disease.

Frogs must not be released if any evidence of illness or infection is detected. If illness is suspected, further advice must be sought from a designated frog recipient (Appendix 2) as soon as possible to determine the nature of the problem. Chytridiomycosis can be diagnosed in live frogs by microscopical examination of preserved toe clips or from shedding skin samples. Research is still in progress on the development of a simple technique for the detection of Chytridiomycosis and a treatment for infected frogs.

Current methods which may be used include:

- A technique for the treatment of potentially infected frogs is to place the frogs individually in a 1mg/L benzalkonium chloride solution for 1 hour on days 1, 3, 5, 9, 11 and 13 of the treatment period. Frogs are then isolated/quarantined for two months. This and other possible treatments are documented in Berger and Speare (1998)
- *Betadine*© and *Bactone*© treatments have also been used on adult frogs with some success (M. Mahony, Newcastle University pers. comm.)
- *Itraconazole*© is an expensive drug which has been used successfully (Lee Berger CSIRO Australian Animal Health Laboratory pers. comm.). Information on this method is available on the Website http://www.jcu.edu.au/school/PHTM/frogs/adms/attach6.pdf.

Frogs undergoing treatment should be housed individually and kept separate from non-infected individuals.

3.4 Displaced frogs

Displaced frogs are those native frog species and introduced Cane Toads (Bufo marinus) which have been unintentionally transported around the country with fresh produce, transported produce and landscaping supplies. Procedures to be undertaken when encountering introduced/displaced native frog species (as well as Cane Toads) are as follows.

3.4.1 Banana box frogs

'Banana Box' frog is the term used to describe several native frog species (usually Litoria gracilenta, L. infrafrenata, L. bicolor and L. caerulea) commonly transported in fruit and vegetable shipments and landscaping supplies. In the past, well meaning individuals have attempted to return these frogs to their place of origin but this is usually impossible to do accurately. There is risk of spread of disease if these frogs are transferred from place to place.

It is strongly recommended that:

Displaced Banana Box frogs should be treated as if they are infected and should not to be freighted anywhere for release to the wild unless specifically approved by DECC.

When encountering a displaced frog:

- Contact a licensed wildlife carer organisation to collect the animal. The frog should then undergo a quarantine period of 2 months along with an approved disinfection treatment.
- Post-quarantine, the frog (if one of the species identified above) may be transferred to a licensed frog keeper. All other species require the permission from DECC Wildlife Licensing and Management Unit (WLMU) prior to transfer. Licensed carer groups are to record and receipt frogs obtained and disposed of in this way.
- Licensed Frog Keepers are to list these frogs in their annual licence returns to DECC.

Frogs held by licensed frog keepers are not to be released to the wild except with specific DECC approval.

Displaced frogs may be made available to recognised institutions for research projects, display purposes or perhaps offered to the Australian Museum as scientific specimens once approval has been provided by the DECC WLMU.

Frogs are often unintentionally transported with fresh produce and landscaping supplies. They are collectively known as 'banana box' or displaced frogs.

3.4.2 Cane toads

Cane toads are known carriers of the Frog chytrid fungus and should not be knowingly transported or released to the wild.

If a cane toad is discovered outside of its normal range, it should be humanely euthanased in accordance with the recommended NSW Animal Welfare Advisory Council procedure (see Appendix 3). Care should be taken to avoid euthanasia of native species due to mistaken identity.

3.4.3 Local frog species

Frogs encountered on roads, around dwellings and gardens or in swimming pools should not be considered as displaced frogs.

Frogs encountered in these situations should be assisted off roads, away from dwellings, or out of swimming pools preferably to the nearest area of vegetation or suitable habitat.

Incidences of frogs spawning or tadpoles appearing in swimming pools should be referred to a wildlife carer/rescue organisation for assistance (see Appendix 4).

Contact the Frogwatch Helpline if you are unsure whether a frog is a local species or displaced.

An NPWS information brochure titled 'Cane Toads in NSW' provides further information on cane toads and assistance with identification of some of the commonly misidentified native species. This information is also available on the DECC website.

4 sick or dead frogs

Unless an obvious cause of illness or death is evident (eg predation or road mortality): Sick or dead frogs encountered in the wild should be collected and disposed of in accordance with the procedures described in section 4.2 below.

4.1 Symptoms of sick and dying frogs

Sick and dying frogs exhibit a range of symptoms characteristic of chytrid infection. Symptoms may be expressed in the external appearance or behaviour of the animal. A summary of these symptoms are described below. More detailed information can be found in Berger et al., (1999) or at the James Cook University Amphibian Disease website at: http://www/jcu.edu.au/school/phtm/PHTM/frogs/ampdis.htm.

Appearance (one or more symptoms)

- darker or blotchy upper (dorsal) surface
- reddish/pink-tinged lower (ventral) surface and/or legs and/or webbing or toes
- swollen hind limbs
- very thin or emaciated
- skin lesions (sores, lumps)
- infected eyes
- obvious asymmetric appearance

Behaviour (one or more symptoms)

- lethargic limb movements, especially hind limbs
- abnormal behaviour (eg a nocturnal, burrowing or arboreal frog sitting in the open during the day and making no vigorous attempt to escape when approached)
- little or no movement when touched

Great barred frog (*Mixophyes fasciolatus*) with severe Chytrid infection — note lethargic attitude and sloughing skin. Photo: L. Berger

Diagnostic behaviour tests

Sick frogs will fail one or more of the following tests:

test	healthy	sick
Gently touch with finger	Frog will blink	Frog will not blink above the eye
Turn frog on its back	Frog will flip back over	Frog will remain on its back
Hold frog gently by its mouth	Frog will use its forelimbs to try to remove grip	No response from frog

4.2 What to do with sick or dead frogs

A procedure for the preparation and transport of a sick or dead frog is given below[2]. Adherence to this procedure will ensure the animal is maintained in a suitable condition for pathological examination and assist the DECC and researchers to determine the extent of the disease and the number of species affected.

- Disposable gloves should be worn when handling sick or dead frogs. Avoid handling food and touching your mouth or eyes as this could transfer pathogens and toxic skin secretions from some frog species.
- New gloves and a clean plastic bag should be used for each frog specimen to prevent cross-contamination. When gloves are unavailable, use an implement to transfer the frog to a container rather than using bare hands.
- If the frog is dead, keep the specimen cool and preserve as soon as possible (as frogs decompose quickly after death making examination difficult). Specimens can be fixed/preserved in 70% ethanol or 10% buffered formalin.

Cut open the belly and place the frog in about 10 times its own volume of preservative. Alternatively, specimens can be frozen (although this makes tissues unsuitable for some tests). If numerous frogs are collected, some should be preserved and some should be frozen. Portions of a dead frog can be sent for analysis eg a preserved foot, leg or a portion of abdominal skin.

- The container should be labelled showing at least the species, date and location. A standardised collection form is provided in Appendix 5.
- If the frog is alive but unlikely to survive transportation (death appears imminent), euthanase the frog (see Appendix 3) and place the specimen in a freezer. Once frozen, the specimen is ready for shipment to the address provided below.
- If the frog is alive and likely to survive transportation, place the frog into either a moistened cloth bag with some damp leaf litter or into a plastic bag with damp leaf litter and partially inflated before sealing. Remember to keep all frogs separated during transportation.
- Preserved samples can be sent in jars or wrapped in wet cloth, sealed in bags and placed inside a padded box.
- Send frozen samples in an esky with dry ice (available from BOC/CIG Gas outlets).
- Place live or frozen specimens into a small styrafoam esky (available from K-Mart/Big W for approximately $2.50).
- Seal esky with packaging tape and address to one of the laboratories listed in Appendix 4.
- Send the package by courier.

Further information on sick and dying frogs is available on the Amphibian Disease Home Page at http://www.jcu.edu.au/dept/PHTM/frogs/ampidis.htm — in particular refer to *'What to do with dead or ill frogs'*.

[2] The measures described below are standard procedures and may vary slightly depending on the distance and time required to reach the intended recipient. Contact the intended recipient of the sick or dead frog prior to sending to confirm the appropriate procedure.

5 references

Alford, R.A. and Richards, S.J. (1997) Lack of evidence for epidemic disease as an agent in the catastrophic decline of Australian rainforest frogs. *Conserv. Biol. 11*: 1026-1029.

Berger, L., Speare, R. (1998) Chytridiomycosis - a new disease of amphibians. *ANZCCART News 11(4)*: 1-3.

Berger, L., Speare, R., Daszac, P., Green, D.E., Cunningham, A.A., Goggin, C.L., Slocombe, R., Ragan, M.A., Hyatt, A.D., McDonald, K.R., Hines, H.B., Lips, K.R., Marantelli, G. and Parkes, H. (1998) Chytridiomycosis causes amphibian mortality associated with population declines in the rainforests of Australia and Central America. *Proc. Nat. Acad. Sci. 95:* 9031-9036.

Berger, L., Speare, R. and Hyatt, A. (1999) Chytrid fungi and amphibian declines: Overview, implications and future directions. In: Campbell, A. (Editor) Declines and disappearances of Australian frogs. Biodiversity Group, Environment Australia.

Environment ACT (1999) Guidelines for minimising introduction and spread of frog pathogens. Environment ACT. Canberra.

Ferrero, T.J. and Bergin, S. (1993) Review of environmental factors influencing the declines of Australian frogs. In: Lunney, D. and Ayers, D. (Editors) Herpetology in Australia: a diverse discipline. Trans. R. Zool. Soc. Mosman.

Laurance, W.F., McDonald, K.R. and Speare, R. (1996) Epidemic disease and catastrophic decline of Australian rainforest frogs. *Conserv. Biol. 77:* 203-212.

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

National Parks and Wildlife Service (2000) Helping frogs survive- A guide for frog enthusiasts. (Prepared by Voight, L., Haering, R., and Wellington, R). NPWS Hurstville. NSW.

Pechmann, J.H.K. and Wilbur, H.M. (1994) Putting declining amphibian populations into perspective: natural fluctuations and human impacts. *Herpetologica 50:* 64-84.

Pechmann, J.H.K., Scott, D.E., Semlitsch, R.D., Caldwell, J.P., Vitt, L.J. and Gibson, J.W. (1991) Declining amphibian populations: the problem of separating human impacts from natural fluctuations. *Science 253:* 892-895.

Pounds, J.A. and Crump, M.L. (1994) Amphibian declines and climate disturbance: the case for the golden toad and harlequin frog. *Conserv. Biol. 8:* 72-85.

Pounds, J.A., Fogden, M.P.L., Savage, J.M. and Gorman, G.C. (1997) Test of null models for amphibian declines on a tropical mountain. *Conserv. Biol. 11:* 1307-1322.

Powell, M.J. (1993) Looking at mycology with a Janus face: A glimpse of chytridiomycetes active in the environment. *Mycologia 85:* 1-20.

Richards, S.J., McDonald, K.R. and Alford, R.A. (1993) Declines in populations of Australia's endemic tropical rainforest frogs. *Pacific Conserv. Biol. 1*: 66-77.

Speare, R., Berger, L. and Hines, H. (1999) How to reduce the risk of you transmitting an infectious agent between frogs and between sites. Amphibian Diseases Home Page 22/1/99, (http://www.jcu.edu.au/dept/PHTM/frogs/ampdis.htm.).

Voight, L. (2001) Frogfacts No. 8. Frog hygiene for captive frogs (draft publication). FATS. Group. Sydney.

appendix 1

hygiene protocol checklist and field kit

The following checklist and field kit are designed to assist with minimising the risk of transferring pathogens between frogs.

Have you considered the following questions before handling frogs in the field:

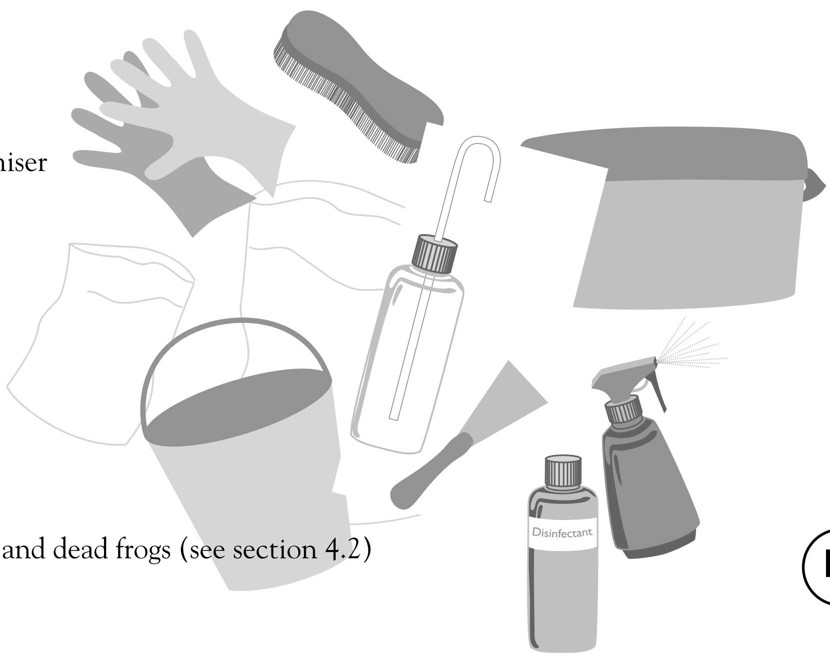
- Has your proposed field trip been sufficiently well planned to consider hygiene issues?
- Have you taken into account boundaries between sites (particularly where endangered species or populations at risk are known to occur)?
- Have footwear disinfection procedures been considered and a strategy adopted?
- Have you planned the equipment you will be using and developed a disinfection strategy?
- Are you are planning to visit sites where vehicle disinfection will be needed (consider both vehicle wheels/tyres and control pedals) and if so, do you have a plan to deal with vehicle disinfection?
- Have handling procedures been planned to minimise the risk of frog to frog pathogen transmission?
- Do you have a planned disinfection procedure to deal with equipment, apparel and direct contact with frogs?

If you answered NO to any of these questions please re-read the relevant section of the DECC Hygiene Protocol for the Control of Disease in Frogs and apply a suitable strategy.

Field hygiene kit

When planning to survey frogs in the field a portable field hygiene kit should be assembled to assist with implementing this protocol. Recommended contents of a field hygiene kit would include:

- Small styrofoam eski
- Disposable gloves
- Disinfectant spray bottle (atomiser spray) and/or wash bottle
- Disinfecting solutions
- Wash bottle
- Scraper or scrubbing brush
- Small bucket
- Plastic bags large and small
- Container for waste disposal
- Materials for dealing with sick and dead frogs (see section 4.2)



appendix 2

designated sick and dead frog recipients

Always contact the relevant specialist prior to sending a sick or dead frog. In some cases, only wild frogs will be assessed for disease. Analysis may also attract a small fee per sample.

Contact one of the following specialists to arrange receipt and analyse sick and dead frogs. Make contact prior to dispatching package:

Karrie Rose
Australian Registry if Wildlife Health
Taronga Conservation Society, Australia
PO Box 20
MOSMAN NSW 2088

Phone: 02 9978 4749
Fax: 02 9978 4516
Krose@zoo.nsw.gov.au

Diana Mendez or
Rick Speare
School of Public Health,
Tropical Medicine and
Rehabilitation Sciences
James Cook University
Douglas Campus
TOWNSVILLE QLD 4811

Phone: 07 4796 1735
Fax: 07 4796 1767
Diana.Mendez@jcu.edu.au
Richard.Speare@jcu.edu.au

Michael Mahony
School of Biological Sciences
University of Newcastle
CALLAGHAN NSW 2308

Phone: 02 4921 6014
Fax: 02 4921 6923
bimjm@cc.newcastle.edu.au

For information on frog keeping licences and approvals to move some species of displaced frog contact:

Co-ordinator, Wildlife Licensing
Wildlife Licensing and Management Unit
DECC
PO Box 1967
Hurstville NSW 1481
Ph 02 9585 6481
Fax 02 9585 6401
wildlife.licensing@environment.nsw.gov.au

For information on the possible identity of displaced frogs contact:

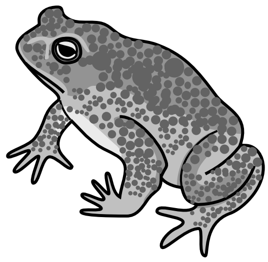
Frog and Tadpole Society (FATS)
Frogwatch Helpline

Ph: 0419 249 728

appendix 3

NSW Animal Welfare Advisory Council methodology

The NSW Animal Welfare Advisory Council procedure for humanely euthanasing cane toads or terminally ill frogs is stated as follows:



- Using gloves, or some other implement, place cane toad or terminally ill frog into a plastic bag.
- Cool in the refrigerator to 4°C.
- Crush cranium with a swift blow using a blunt instrument.

Note: Before killing any frog presumed to be a cane toad, ensure that it has been correctly identified and if outside the normal range for cane toads in NSW (north coast) that local DECC regional office is informed.

appendix 4

licensed wildlife carer and rescue organisations

Following is a list of wildlife rehabilitation groups licensed by Department of Environment and Climate Change (NSW):

Northern NSW

Australian Seabird Rescue
For Australian Wildlife Needing Aid (FAWNA)
Friends of the Koala
Friends of Waterways (Gunnedah)
Great Lakes Wildlife Rescue
Koala Preservation Society of NSW
Northern Rivers Wildlife Carers
Northern Tablelands Wildlife Carers
Tweed Valley Wildlife Carers
Seaworld Australia
WIRES branches in Northern NSW

Southern NSW

Looking After Our Kosciuszko Orphans (LAOKO)
Native Animal Network Association
Native Animal Rescue Group
Wildcare Queanbeyan
WIRES branches in Southern NSW

Sydney, Hunter and Illawarra

Hunter Koala Preservation Society
Ku-ring-gai Bat Colony Committee
Kangaroo Protection Co-operative
Native Animal Trust Fund
Organisation for the Rescue and Research of Cetaceans (ORRCA)
Sydney Metropolitan Wildlife Services
Wildlife Aid
Wildlife Animal Rescue and Care (Wildlife ARC)
Waterfall Springs Wildlife Park
Oceanworld
Wildlife Care Centre, John Moroney Correctional Centre
Koalas in Care
WIRES branches around Sydney, Hunter and Illawarra

Western NSW

Rescue and Rehabilitation of Australian Native Animals (RRANA)
RSPCA Australian Capital Territory Inc.
Wildlife Carers Network (Central West)
WIRES branches in Western NSW
Cudgegong Wildlife Carers

[4] Note: some of these organisations may not care for frogs.

appendix 5 — sick or dead frog collection form

Sender details:

name: address: postcode:

phone: (w) (h) fax: email:

Collector details: (where different to sender)

name: address: postcode:

phone: (w) (h) fax: email:

Specimen details:

record no: no. of specimens: species name: date collected:
day/month/year

time collected: sex: status at time of collection: date sent:
male/female healthy(H)/ sick(S)/ dead(D) day/month/year

location: map grid reference:
(easting) (northing)

reason for collection:

Batch details for multiple species collection:

species	no.	locality	(AMG)	date	sex	status (H/S/D)

habitat type: vegetation type: micro habitat:
eg creek, swamp, forest eg rainforest, sedgeland eg creek bank, under log, amongst emergent vegetation, on ground in the open

unusual behaviour of sick frogs:
eg lethargic, convulsions, sitting in the open during the day, showing little or no movement when touched.

dead frogs appearance:
eg thin, reddening of skin on belly and/or toes, red spots, sore, lumps or discolouration on skin

deformed frogs: dead/sick tadpoles:
eg limb(s) missing, abnormal shape or length eg numbers/behaviour

unusual appearance of egg masses: recent use of agricultural chemicals in area:
eg grey or white eggs eg pesticides, herbicides, fertilisers

other potential causes of sickness/mortality/comments/additional information:

NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE

General inquiries: PO Box A290 South Sydney 1232
Phone: 9995 5000 or 1300 361967
Fax: 02 9995 5999 **Web site:** www.environment.nsw.gov.au

Department of **Environment & Climate Change** NSW

APPENDIX B

Limitations

LIMITATIONS

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Appendix C – Draft V2, Annual Report KIWEF GGBF Research Program, 2020-21 (University of Newcastle, 2021)

Green and Golden Bell Frog (*Litoria aurea*) Research Program on Kooragang Island: Annual Report (2020-2021)

Conducted by the Amphibian Research Group, University of Newcastle

Draft prepared – August 2021.

Executive Summary

This section highlights the key findings from the 2020-21 data:

1. Population estimate for *Litoria aurea* on Kooragang Island
2. Summary of detections
3. Multi-year pattern of *Litoria aurea* abundance
4. Rainfall pattern during the breeding season
5. Newly constructed wetlands
6. Juvenile demographic
7. Breeding records
8. Gambusia presence
9. Fire recovery since 2019
10. Increased detection at K22-23
11. Terrestrial habitat use

Note that relevant figures and tables are taken directly from the main section of the report and **retain their reference numbers from their respective sections** for ease of location (those numbers are also consistent with previous years' report, allowing for comparison across season).

1. <u>Population estimate for *Litoria aurea* on Kooragang Island</u>

After a decrease in the previous (2019-20) season, the population estimate for the L. aurea population on Kooragang Island increased towards the level seen in 2018-19.

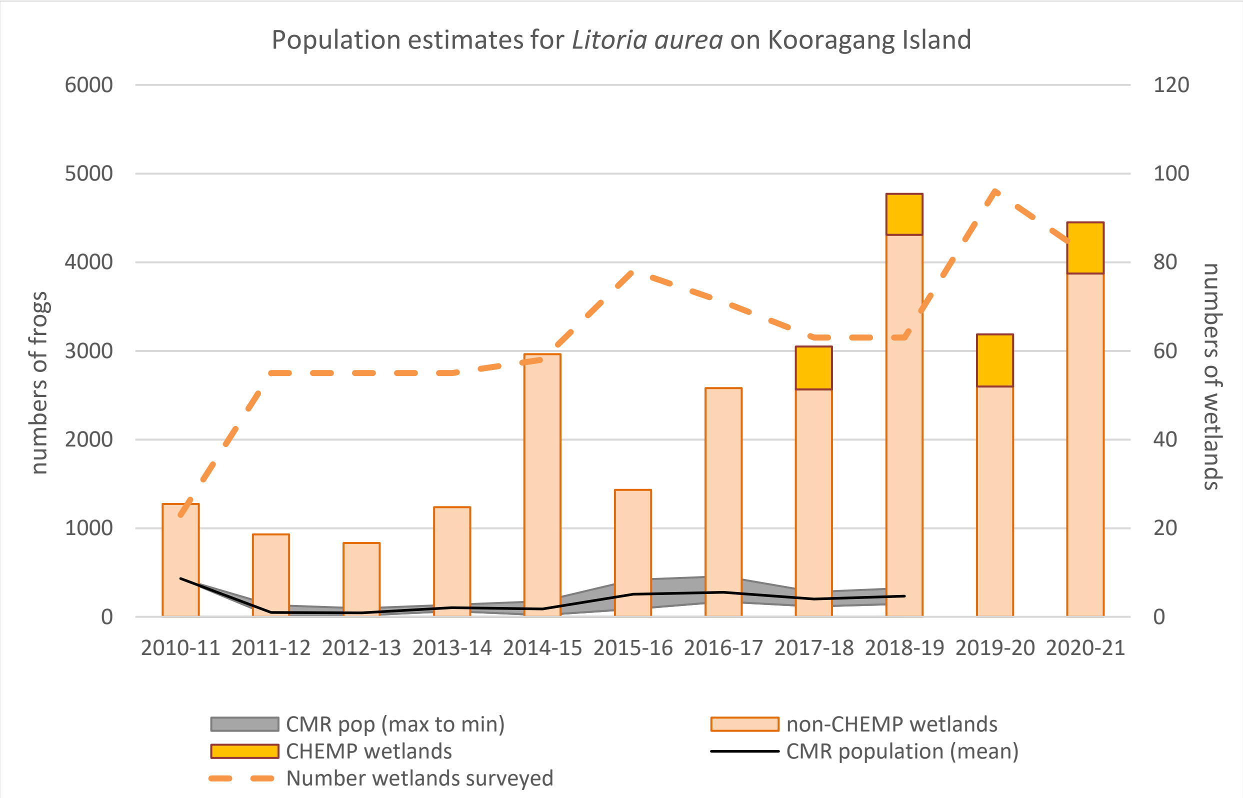


Figure 3.8.1: Population estimates for *L. aurea* on Kooragang Island. Data for 2010-2019 is from previous annual reports for the current project, while the 2019-20 data is from the current report. The light yellow columns show **maximal** population estimates derived from VES counts for the non-CHEMP wetlands only, while the darker orange columns show the maximum 2017-18, 2018-19 and 2019-20 estimates for all wetlands including the CHEMP wetlands (see data shown in Table 3.8.7). The black line shows the average (across all rounds in a given season) total N-hat for wetlands where CMR surveys were conducted, whilst the greyed area shows maximum and minimum N-hat values across all surveys for each season. The dashed green line shows the number of wetlands surveyed each season (Y2 axis).

A notable feature of the population estimates for 2020-21 were a substantial increase in the number of animals estimated for the different rounds, with the numbers increasing markedly through the season.

Round 1	874
Round 2	1,345
Round 3	3,916

It is important to understand that the population estimate is based upon Capture-Mark-Recapture methods, and only animals with a Snout-Vent Length (SVL) of 40 mm or more can be 'marked' (i.e. tagged with a PIT tag). Thus, these numbers relate only to the population of >40 mm *L. aurea*. The actual population includes many small juveniles who are counted in detection summaries (see point 2 below) but not in the population model.

The prolonged dry period prior to Feb 2020 likely resulted in a substantial reduction in the adult population of *L. aurea*. Heavy drought-breaking rains in Feb 2021 resulted in a very large breeding event in late summer / early spring of 2020 (noted in the 2019-20 annual report). Many of those young frogs survived the winter and were small juveniles in the early part of the 2020-21 season – present within the population, but too small to be tagged and thus included in the population estimate. However, by the end of the summer they had grown (Figure 3.4.5) to be large enough to be included in the population estimate, resulting in an apparent 5 fold increase in the population over the course of these season. The magnitude of that apparent increase is almost certainly an artefact of the methods used to derive the population estimate. Nevertheless, by the end of the 2020-21 season the population of large/juveniles and adulty *L.aurea* appears to have largely recovered from the decrease experienced during the drought of 2019.

Population saw an increase from previous year. *Only adults were chippable so increasing adult pop shows graduation of juvienile cohort into adulthood – relevant?*

2. Summary of *Litoria aurea* detection

Over the course of the season there was an increase in the number of animals captured and unique animals encountered with each subsequent round (Table 3.1.1). Given that search effort was relatively similar between Round 1 and Round 3, this positive trend indicates a general increase in frog numbers at wetlands sites from the start to the end of the breeding season. This could be attributed to the lower rainfall that occurred at the start of the season and larger rainfall amounts as the season progressed, influencing activity levels and animal movements.

	Round 1	Round 2	Round 3
	Total	**Total**	**Total**
Search effort	4,766	3,747	4,511
VES Detections	998	684	823
All Detections	1061	938	1,579
Captures	329	486	1,091
Unique	113	329	915

Table 3.1.1: Summary data from all surveys in 2020-21 season. 'Detections' refers to total encounters (i.e., captures and non-capture observations). Because some individuals are encountered and captured multiple times, 'Detections', and 'Captures' provide overestimates of the number of unique individual frogs actually encountered ('Unique').

As with previous survey seasons, the highest number of detections were in the Industrial Zone (Table 3.1.2), and even though a much larger number of surveys were conducted in this zone, the search sensitivity (an index of capture rates adjusted for search effort) of the Industrial Zone remains the highest. Compared with the most recent previous breeding seasons, detections were slightly lower than in 2019-20 but slightly higher than 2018-19. The peak in 2019-20 season is likely linked to the large breeding event that occurred in late summer of 2019.

Region (detections)	Search effort (VES)	VES	Total	Search Sensitivity
Northern island	2,323	34	35	0.01
Central island	2,764	376	615	0.14
Southern island (T4)	7,937	2,095	2,928	0.26

Jurisdiction (detections)	Search effort (VES)	VES	Total	Search Sensitivity
NPWS	2,404	119	135	0.05
NPWS (CHEMP)	1,575	32	32	0.02
NPWS (CHEMP)	725	187	199	0.26
PoN	383	72	284	0.19
PWCS	277	55	68	0.20
NCIG	114	51	53	0.45
HDC	7,546	1,989	2,807	0.26

Table 3.1.2: Location (summarised by Zone and Jurisdiction) of *L. aurea* detected.

Compared to the previous season, there was a decline in the proportion of captured animals that were adult male (down from 50% to 30%) and female (down from 26% to 11%), a slight increase in the proportion that were sub-adult female (up from 9% to 13%), and a considerable increase in the proportion that were juvenile (up from 15% to 46%). This occurred due to a large cohort of juveniles entering the population, mostly in the first half of the season, rather than a decline in adult populations.

	Primary VES	Total
Detections	2,505	3,578
Captures	1,044	1,906

	Captures	Unique
PIT tagged frogs	1,501	1,350

Demographic summary	Captured		PIT Taggable		Unique		Recapture index
	number	%	number	%	number	%	
juveniles (SVL < 49.5 mm)	877	46%	454	31%	431	32%	1.05
subadult females (49.5mm<SVL<58mm, no nups)	252	13%	252	17%	223	17%	1.13
adult males (>49.5, nups)	558	30%	558	38%	498	37%	1.12
adult females (>58mm SVL, no nups)	202	11%	202	14%	191	14%	1.06
Metamorphs	9		-		-		
unknown animals (not tagged)	8		7		7		
	1,906		**1,473**		**1,350**		

Table 3.1.3: Summary of demographic data. Recapture index shows the ratio of captures per unique individuals (i.e., higher values indicate a higher probability of recapture).

3. Multi-year pattern of *Litoria aurea* abundance

Despite a reduction in frog numbers, search sensitivity in 2020-21 compared to the previous year has increased dramatically in the Industrial (=Southern) Zone, where it is the highest it's been in the past seven seasons for both the north and south regions. The greatest jump in search sensitivity appears to be in subregions associated with the Rail loop and Deep pond. Search sensitivity has declined in both the Northern and Central Zones, though there has been an increase in the subregions associated with Bellfrog Way and the search sensitivity for adult frogs in the Central Zone actually increased slightly.

	All animals (not including mets)							**Adults Only**						
	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Jurisdiction														
NPWS	0.02	0.01	0.00	0.01	0.01	0.02	0.05	0.01	0.00	0.00	0.00	0.01	0.01	0.03
NCIG_CHEMP	-	-	-	0.02	0.04	0.04	0.02	-	-	-	0.01	0.03	0.04	0.01
BHP_CHEMP	0.00	0.07	-	0.26	0.20	0.23	0.26	0.00	0.05	-	0.12	0.09	0.07	0.18
PoN	0.04	0.06	0.11	0.12	0.07	0.20	0.19	0.02	0.02	0.06	0.10	0.05	0.20	0.09
PWCS	0.14	0.04	0.18	0.15	0.22	0.08	0.20	0.05	0.02	0.09	0.08	0.11	0.05	0.09
NCIG	0.00	0.03	0.26	0.14	0.18	0.08	0.45	0.00	0.01	0.19	0.08	0.10	0.05	0.25
HDC	0.04	0.02	0.46	0.09	0.12	0.17	0.26	0.03	0.01	0.04	0.02	0.06	0.05	0.08
HDC (BHP)	0.01	0.00	0.11	0.10	0.11	-	-	0.00	0.00	0.04	0.06	0.04	-	-
RMS	0.00	0.00	0.04	-	-	-	-	0.00	0.00	0.02	-	-	-	-
Zone														
Nth	0.01	0.00	0.00	0.01	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.02	0.03	0.01
Central	0.04	0.03	0.04	0.17	0.12	0.16	0.14	0.02	0.01	0.03	0.08	0.06	0.07	0.08
Southern	0.08	0.03	0.22	0.13	0.19	0.16	0.26	0.03	0.02	0.08	0.07	0.09	0.05	0.08
Region														
Hunter North River	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
School House	0.02	0.00	0.00	0.01	0.05	0.04	0.01	0.01	0.00	0.00	0.00	0.03	0.04	0.01
Cobbans Creek	0.03	0.03	0.00	0.23	0.17	0.20	0.14	0.03	0.02	0.00	0.10	0.08	0.06	0.09
Bellfrog Way	0.04	0.03	0.06	0.06	0.05	0.08	0.13	0.02	0.01	0.03	0.05	0.03	0.08	0.08
Industrial Zone North	0.15	0.05	0.19	0.17	0.22	0.11	0.24	0.06	0.03	0.10	0.09	0.12	0.04	0.07
Industrial Zone South	0.01	0.01	0.26	0.10	0.15	0.21	0.30	0.01	0.00	0.06	0.04	0.06	0.06	0.09
Subregion														
Scott's Point	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Riverside park	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Wet meadow	0.02	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01
Millam's Pond	0.00	0.00	0.00	0.02	0.05	0.07	0.02	0.00	0.00	0.00	0.00	0.04	0.07	0.01
Ramsar Road West	0.01	0.04	0.01	0.25	0.19	0.22	0.17	0.01	0.02	0.01	0.11	0.09	0.07	0.10
Ramsar Road East	0.03	0.01	0.00	0.00	0.00	0.04	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.05
Bellfrog Way West	0.02	0.00	0.00	0.01	0.02	0.03	0.26	0.01	0.00	0.00	0.00	0.01	0.02	0.18
Bellfrog Way NE	0.03	0.01	0.01	0.00	0.02	0.03	0.00	0.02	0.01	0.00	0.00	0.02	0.03	0.00
Bellfrog Way SE	0.04	0.05	0.09	0.12	0.07	0.20	0.19	0.02	0.02	0.05	0.10	0.05	0.20	0.09
Delta Ponds	0.47	0.32	0.18	0.17	0.19	0.08	0.20	0.08	0.18	0.10	0.07	0.11	0.05	0.09
KIWEF K7	0.08	0.01	0.20	0.14	0.09	0.07	0.11	0.06	0.01	0.10	0.11	0.07	0.05	0.05
NCIG rail central & east	0.00	0.02	0.20	0.12	0.16	0.11	0.40	0.00	0.01	0.15	0.07	0.08	0.05	0.14
Rail loop (K10 Nth)	0.04	0.03	0.64	0.09	0.09	0.19	0.31	0.03	0.01	0.05	0.02	0.06	0.05	0.07
Cormorant Road	0.00	0.00	0.04	-	-	-	-	0.00	0.00	0.02	-	-	-	-
Rail loop SW (K10 Sth)	0.00	0.00	0.14	0.07	0.26	0.44	0.26	0.00	0.00	0.09	0.03	0.07	0.08	0.09
NCIG rail south	0.01	0.00	0.12	0.10	0.13	0.05	0.34	0.00	0.00	0.04	0.05	0.04	0.04	0.12
KIWEF K2	0.04	0.00	0.03	0.11	0.07	0.05	0.16	0.04	0.00	0.02	0.07	0.03	0.03	0.06
Deep pond	0.01	0.03	0.18	0.22	0.30	0.15	0.39	0.01	0.02	0.08	0.07	0.15	0.06	0.09
KIWEF K5 (Area 2)	-	-	-	-	-	0.15	0.07	-	-	-	-	-	-	0.06

Table 3.9.3: Search sensitivity for the latest 2020-21 season along with the previous six seasons, summed for Jurisdiction, Zone, Region, and Subregion. The numbers indicate the number of frogs detected per person.minute of search effort, i.e. for a value of 0.25, one frog is detected every four person.minutes of search effort.

4. <u>Rainfall pattern during the breeding season</u>

The current breeding season experienced a high level of rainfall as a result of Australia moving into a La Niña event, with all months besides September having above long-term average rainfall. Wet conditions over the 2020 winter led to increased runoff feeding into wetlands into spring, resulting in all but one wetland being charged at the start of the *L. aurea* breeding season (September). Intermittent but multiple rainfall events subsequently occurred during the summer period, with no ponds experiencing a drying event. This is in contrast to the previous breeding season where drier than normal conditions caused most wetland sites to dry mid-season.

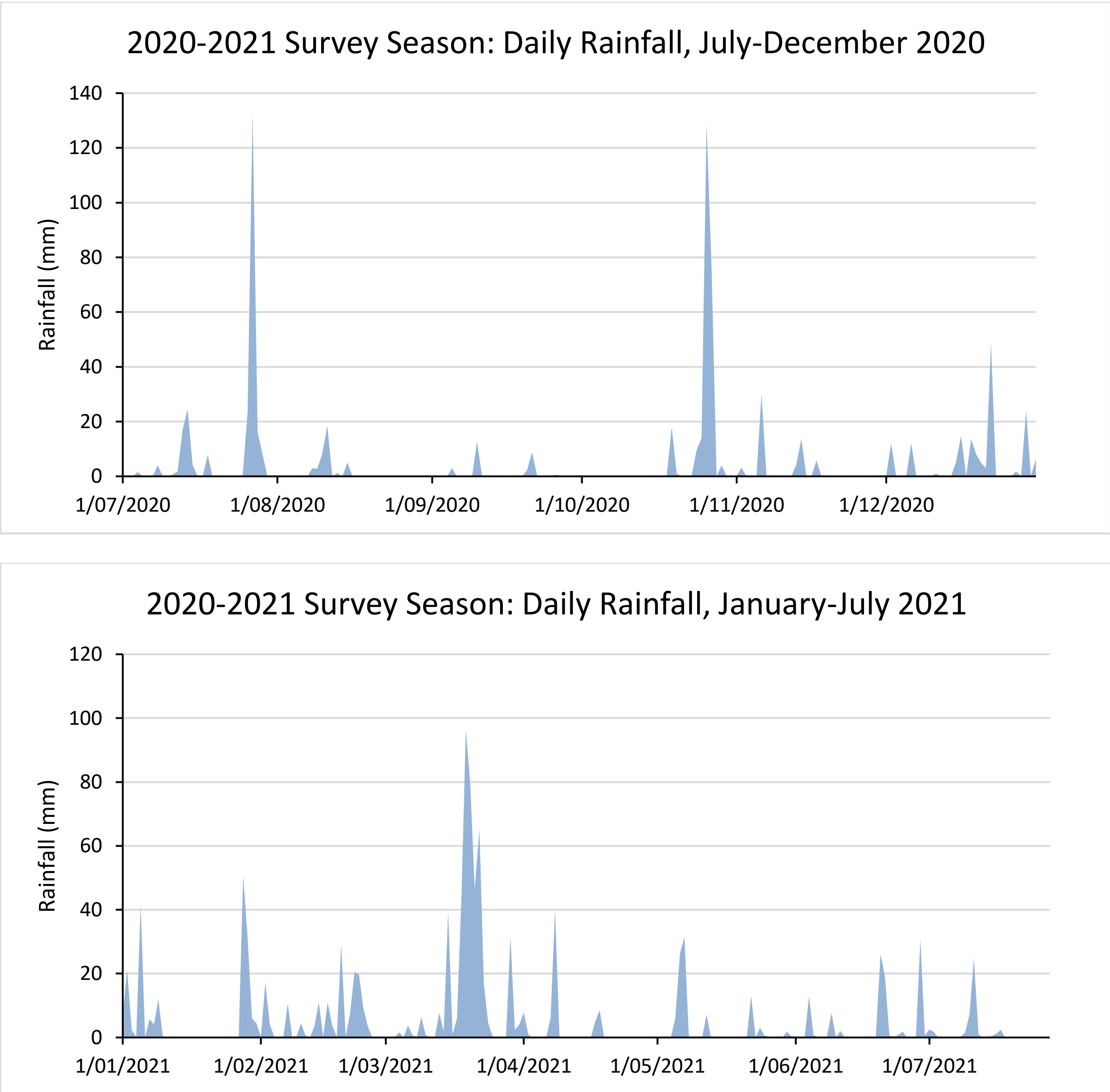


Figure 3.2.1: Weekly rainfall before, during, and after the 2020-21 survey season (October to April) on Kooragang Island. Measurements obtained from BoM records for Williamtown airport.

5. Newly constructed wetlands

In 2019-20, a juvenile dispersal event was detected within the terrestrial environment of the Industrial Zone. Several of these terrestrial areas have now undergone remediation, including the establishment of three new wetlands east of K105A in Area 2 (K124-6), and a further two wetlands in areas previously referred to as the 'Wedge' (K127) and 'Peninsula' (K128), both south of K105A. These wetlands are similar to other constructed HDC wetlands (e.g. K121-123), which have be shown to be highly effective in increasing frog occupation and breeding in areas within the Industrial Zone. While still in an early stage of succession and possessing little vegetation coverage, *L. aurea* were detected at each of these new wetlands. This included juveniles recorded at K126 and K127, which might suggest movement from the K105 wetlands, as well as the detection of breeding (i.e. tadpoles) at K128.

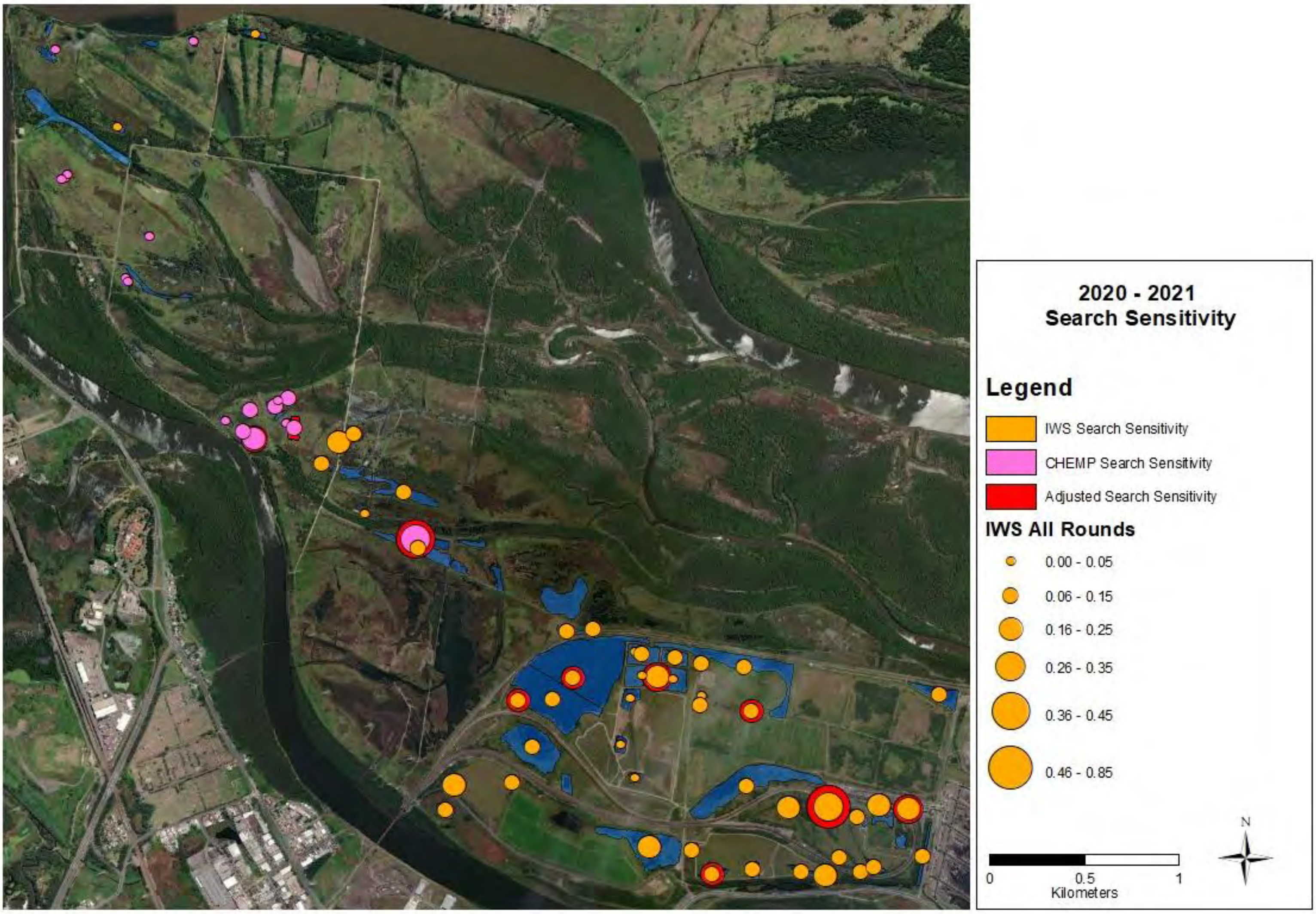


Figure 3.3.3: Search sensitivity (frogs detected per person.minute) across the 65 wetlands surveyed as part of 'whole island' monitoring in 2020-21, pooled across the principal survey rounds.

6. Juvenile demographic

Overall, the highest numbers of *L. aurea* were captured in round 3. However, what is interesting to note is that the demographic of animals detected changed over the season (Figure 3.4.1). In round 1 and 2, the majority of captures were juveniles, making up more than half of all captures in these rounds. This data suggests that animals that had overwintered as small juveniles emerged during the start of the breeding season. This is in contrast to round 3, where a majority of captures were adult males and only a quarter were juvenile captures, reflecting the growth of that juvenile cohort towards adulthood in the second half of the season.

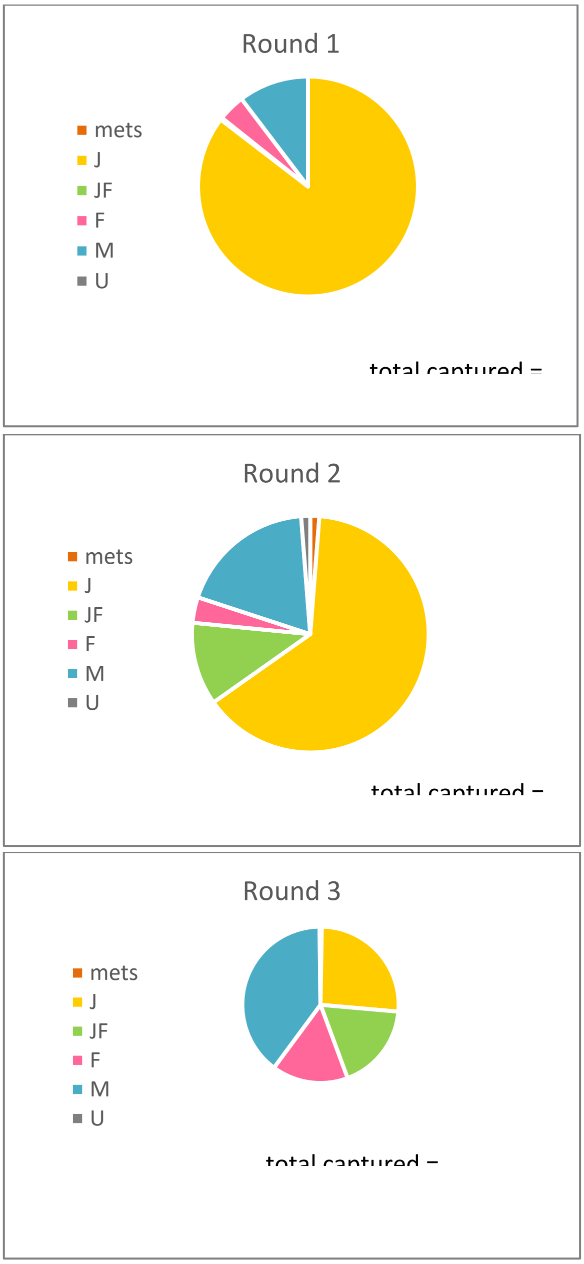


Figure 3.4.1: Summary demographics of all captured *L. aurea* (i.e. VES surveys, including recaptures and non-tagged individuals) for primary rounds. Mets, metamorphs; M, adult males; J, juveniles; JF, subadult females; F, adult females; U, animals of unknown demography.

We were able to track the maturation of the large juvenile cohort (that was spawned in February 2020) across the breeding season. Plots of size/frequency distribution over the different rounds (Figure 3.4.5) show a cohort of mid to large-sized juveniles in round 1 (September); these had a modal SVL of 34-36 mm and were likely spawned late in the previous season. By round 2 (November), this juvenile cohort showed a slight decrease in numbers and a shift in model SVL to 42-44 mm, both of which suggest that the juvenile population was maturing and that recruitment into the adult population had started to occur. The juvenile cohort captured in round 3 (February) showed further increase in model SVL and additional recruitment into the adult population.

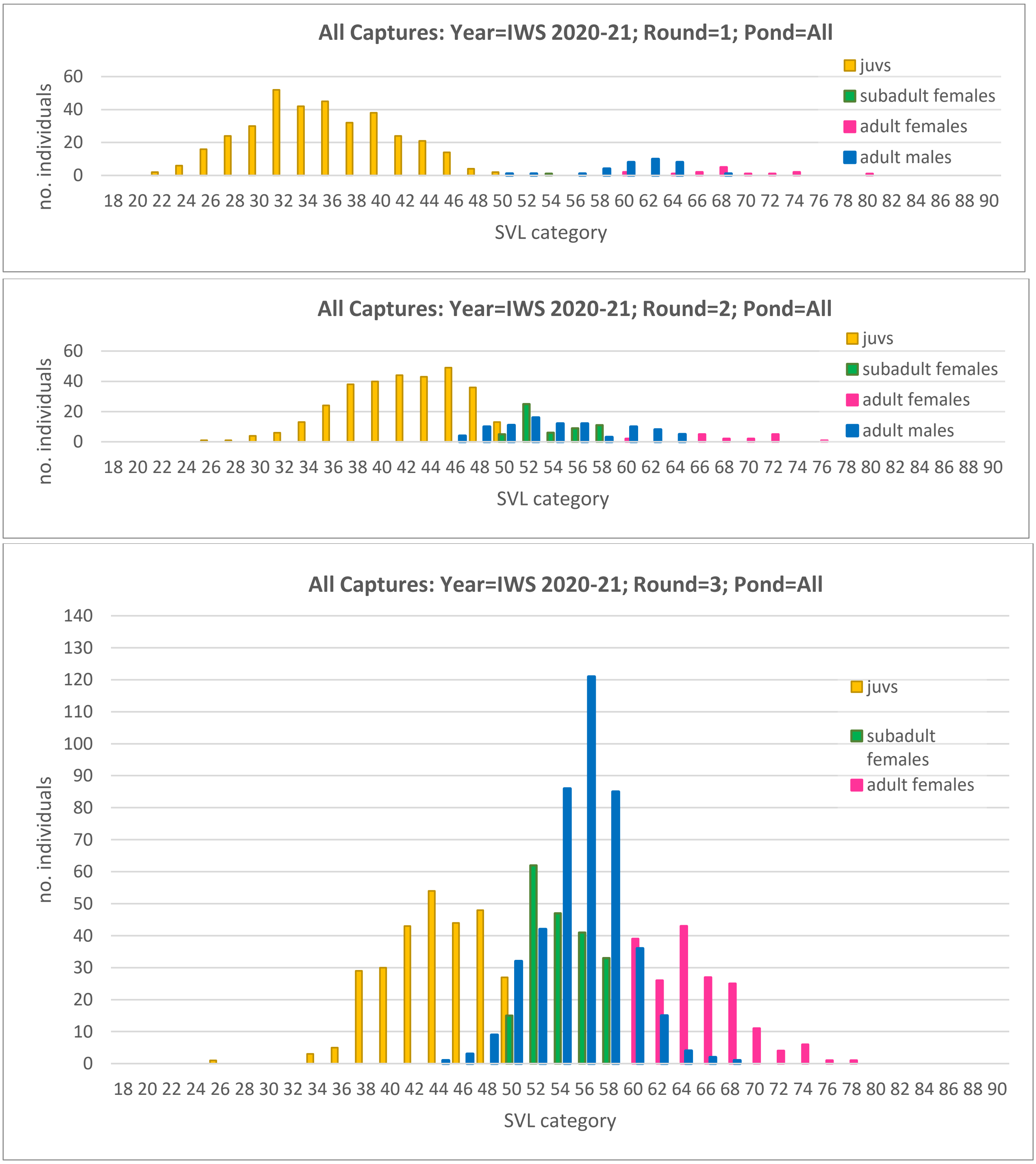


Figure 3.4.5: Frequency distribution of size classes, showing all captures for each survey round (VES). See Fig 3.4.1 for legend and Fig. 3.4.4. for explanation of size classes.

A very small cohort of small juveniles (SVL ~ 25 mm) detected in round 3 indicates a small amount of successful breeding during the summer of the 2020-21 season (see next section)

7. Breeding records

Breeding was detected in seven wetlands, as noted by the presence of *L. aurea* tadpoles and/or metamorphlings (Table 3.2.1). This is less than the previous breeding season (19 wetlands), which was a high across the island over the past seven years (Figure 3.6.1). Breeding in the current season occurred across all three zones, including in the northern zone (NCIG-7.2) which did not see any breeding in the previous season, and one wetland site that has recently been constructed (K128). There were no similarities in breeding sites between the current and previous breeding seasons except for K105B. Tadpoles were detected only in round 3 and only in a pond (K128) with *Gambusia* absent. In contrast, metamorphlings were detected in round 2 and 3, and in ponds with and without *Gambusia*. The lower detection of breeding is surprising given that higher than average rainfall this season should have been more conducive for widespread breeding, assuming that more regular rainfall allows ephemeral sites to remain full of water for longer portions of the season. Despite the low detection of breeding, large juvenile populations were detected across most wetland sites, suggesting that these cohorts spawned late in the previous season and overwintered.

Table 3.2.1: Summary of water presence at each wetland per round, along with presence of *Gambusia* and observed breeding.

Zone	Region	Pond	Early Spring hydrology (R1)	Late Spring hydrology (R2)	Late Summer hydrology (R3)	Gambusia	Breeding
Nth	NPWS	K2	1	1	1	-2	
Nth	NPWS	K3	1	1	1	1	
Nth	NPWS	K4	1	1	1	-2	
Nth	NPWS	K5	1	1	1	1	
Nth	NPWS	K7	1	1	1	-2	
Nth	NPWS	K58B	1	1	1	-2	
Nth	NCIG_CHEMP	NCIG-1.1	1	1	1	2	
Nth	NCIG_CHEMP	NCIG-1.3	1	1	1	1	
Nth	NCIG_CHEMP	NCIG-3.1	1	1	1	-2	
Nth	NCIG_CHEMP	NCIG-4.7	1	1	1	2	
Nth	NCIG_CHEMP	NCIG-4.9	1	1	1	1	
Nth	NCIG_CHEMP	NCIG-5.1	1	1	1	1	
Nth	NCIG_CHEMP	NCIG-7.1	1	1	1	1	
Nth	NCIG_CHEMP	NCIG-7.2	1	1	1	-2	mets
Nth	NCIG_CHEMP	NCIG-7.3	1	1	1	2	
Nth	NCIG_CHEMP	NCIG-T13	1	1	1	-2	
Nth	NCIG_CHEMP	NCIG-T14	1	1	1	-2	
Nth	NCIG_CHEMP	NCIG-T15	1	1	no data	-2	
Central	BHP_CHEMP	BHP-14A	no data	no data	1	1	
Central	BHP_CHEMP	BHP-1A	no data	no data	1	-2	
Central	BHP_CHEMP	BHP-1B	no data	no data	1	1	
Central	BHP_CHEMP	BHP-2A	no data	1	1	-2	
Central	BHP_CHEMP	BHP-2B	no data	1	1	-2	
Central	BHP_CHEMP	BHP-2C	no data	no data	1	-2	
Central	BHP_CHEMP	BHP-3A	no data	no data	1	-2	
Central	BHP_CHEMP	BHP-4A	no data	1	1	-2	
Central	BHP_CHEMP	BHP-4C	no data	1	1	-2	mets
Central	NPWS	K9A/B	1	1	1	1	
Central	NPWS	K9C	1	1	1	-2	
Central	NPWS	K9	1	1	1	-2	
Central	NPWS	K20A	1	no data	1	-2	
Central	NPWS	K20B	1	no data	1	1	
Central	NPWS	K26	1	1	1	1	
Central	NPWS	K48	1	1	no data	-2	
Central	NPWS	K13	1	1	1	-2	
Central	NPWS	K21	1	1	1	2	
Central	NPWS	K63	1	1	1	-2	
Central	PoN	K22	1	1	1	-2	
Central	PoN	K23	1	1	1	-2	
Southern	PWCS	K104	no data	1	1	1	
Southern	HDC	K103	1	1	1	2	
Southern	HDC	K105A	1	1	1	2	mets
Southern	HDC	K105AS	1	1	1	2	mets
Southern	HDC	K105B	1	1	1	1	mets
Southern	HDC	K106A	0	1	1	-2	
Southern	HDC	K106B	1	1	1	1	mets

Zone	Region	Pond	Early Spring hydrology (R1)	Late Spring hydrology (R2)	Late Summer hydrology (R3)	Gambusia	Breeding
Southern	HDC	K106C	no data	no data	1	-2	
Southern	HDC	K29	1	1	1	-2	
Southern	HDC	C1	no data	1	1	-2	
Southern	HDC	K31	1	1	1	-2	
Southern	HDC	K34	1	1	1	1	
Southern	HDC	K42	1	1	1	-2	
Southern	HDC	K102	no data	1	1	1	
Southern	HDC	K36	no data	1	1	-2	
Southern	HDC	C2	1	1	1	-2	
Southern	NCIG	K115	1	1	1	-2	
Southern	NCIG	K116	1	1	no data	-2	
Southern	HDC	K100A	no data	1	1	1	
Southern	HDC	K111	1	1	1	-2	
Southern	HDC	K112	1	1	1	-2	
Southern	HDC	K113	1	1	1	-2	
Southern	HDC	K114	1	1	1	-2	
Southern	HDC	K121	1	1	1	-2	
Southern	HDC	K122	1	1	1	-2	
Southern	HDC	K123	1	1	1	-2	
Southern	HDC	K46	no data	1	1	1	
Southern	HDC	K49B	1	1	1	-2	
Southern	HDC	K117	no data	1	no data	-2	
Southern	HDC	K118	no data	1	1	-2	
Southern	HDC	K124	no data	1	1	-2	
Southern	HDC	K125	no data	1	1	-2	
Southern	HDC	K126	no data	1	1	-2	
Southern	HDC	K127	no data	1	1	-2	
Southern	HDC	K128	no data	no data	1	-2	tads
Southern	HDC	E4	1	no data	1	-2	
Southern	HDC	W4	1	1	no data	-2	
Southern	HDC	W5	1	no data	1	-2	
Southern	HDC	C3	no data	1	1	-2	
Southern	HDC	C4	1	1	1	-2	
Southern	HDC	C5	1	1	1	-2	

Tads	tadpoles
Mets	metamorphs

0	dry
0.3	low
0.5	intermediate
1	good

2	*Gambusia* present
1	*Gambusia* (re)appeared
0	unknown status
-1	*Gambusia* disappeared
-2	*Gambusia* absent

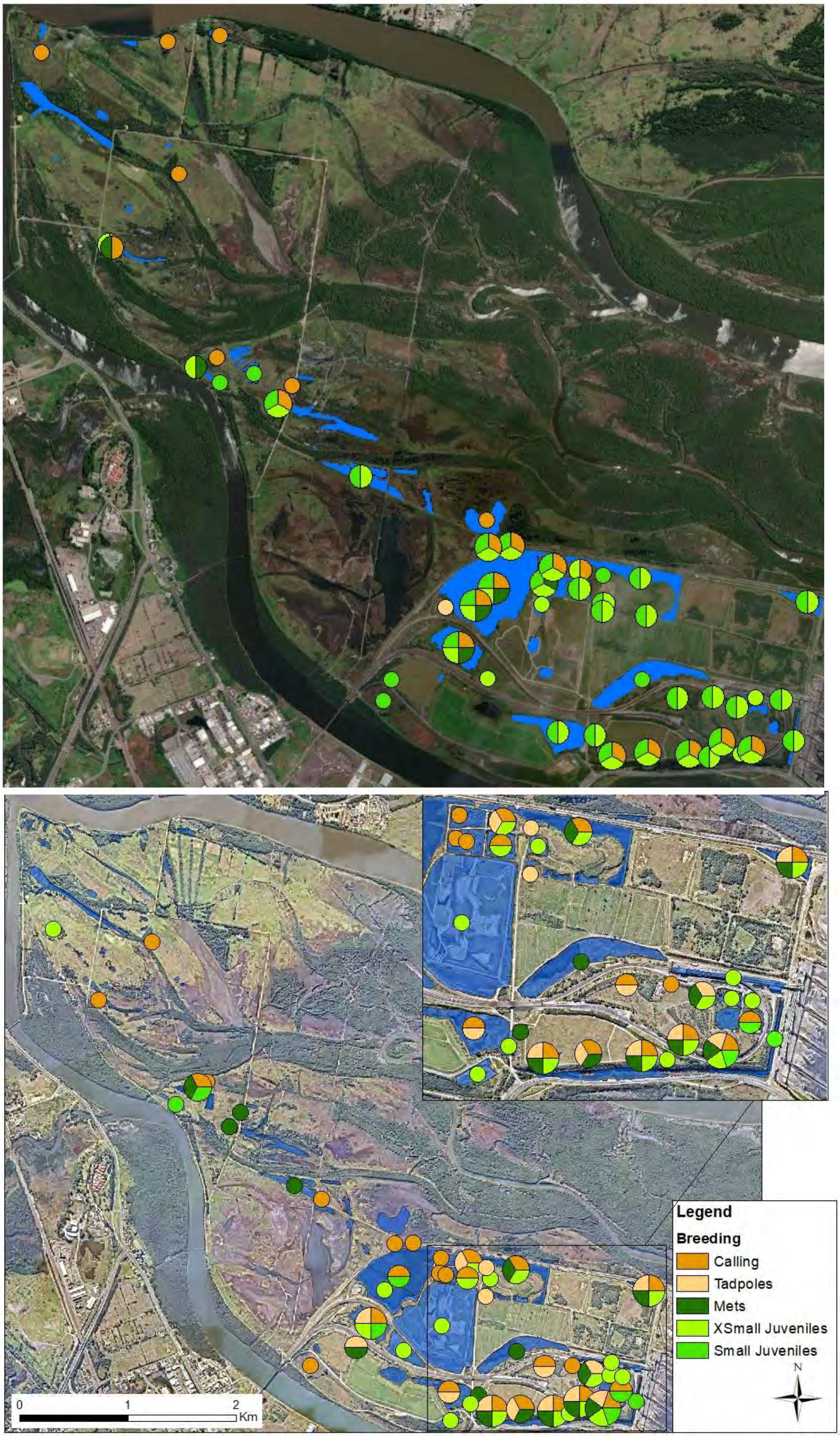


Figure 3.6.1: *L. aurea* breeding (i.e. calling, detection of tadpoles and/or metamorphs, small juveniles) during the 2020-21 (top) and 2019-20 (bottom) survey season. ‘Xsmall’ juveniles have SVL < 35 mm; ‘Small’ juveniles have 35 < SVL < 40 mm. Note that the size of the segments within the pie charts denotes only presence of an age/six class or breeding behaviour; it does not indicate the quantity within each category. See Figure 3.6.2 for close up of Industrial Zone wetlands.

8. Gambusia presence

Up until the 2019-20 breeding season, repeated years of dry summers excluded *Gambusia* from an increasing number of surveyed wetlands (Figure 3.2.8). This year, however, the fish has reappeared in 15 wetland sites in which detection did not occur by the end of the previous year, and is now present across all three islands zones (Figure 3.2.9). As of March 2020, 25 wetland sites are believed to contain *Gambusia*, compared to seven sites in 2020, 13 sites in 2019, 16 sites in 2018 and 24 in 2017. This reverse in trend is likely due to the limited amount of pond drying that occurred during the winter period and throughout the breeding season, given high amounts of rainfall.

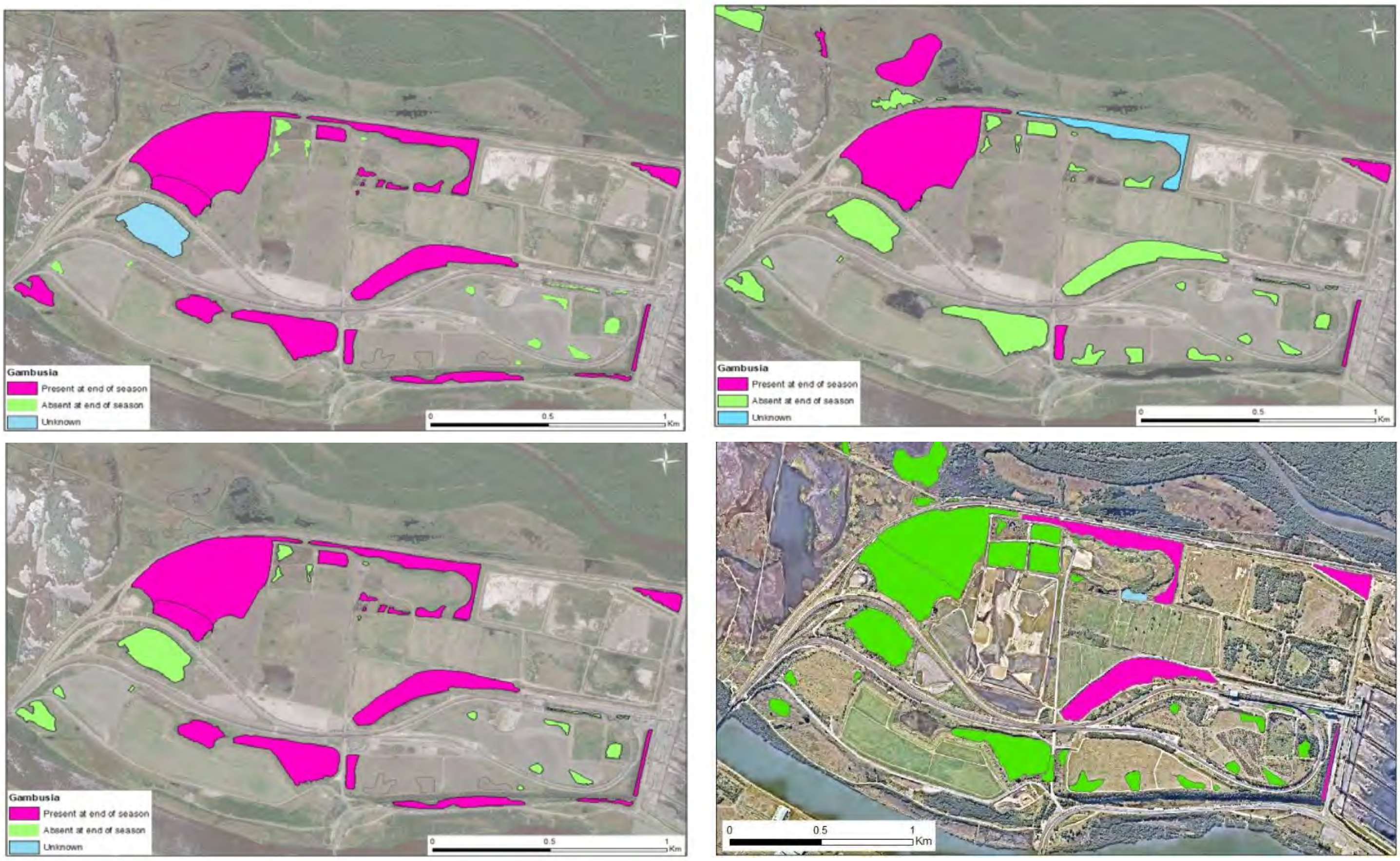


Figure 3.2.8: Distribution of *Gambusia* (shown in red-pink) across the **Southern** part of Kooragang Island, late summer of 2016 (top-left), 2017 (bottom-left), 2018 (top-right), and 2019 (bottom-right).

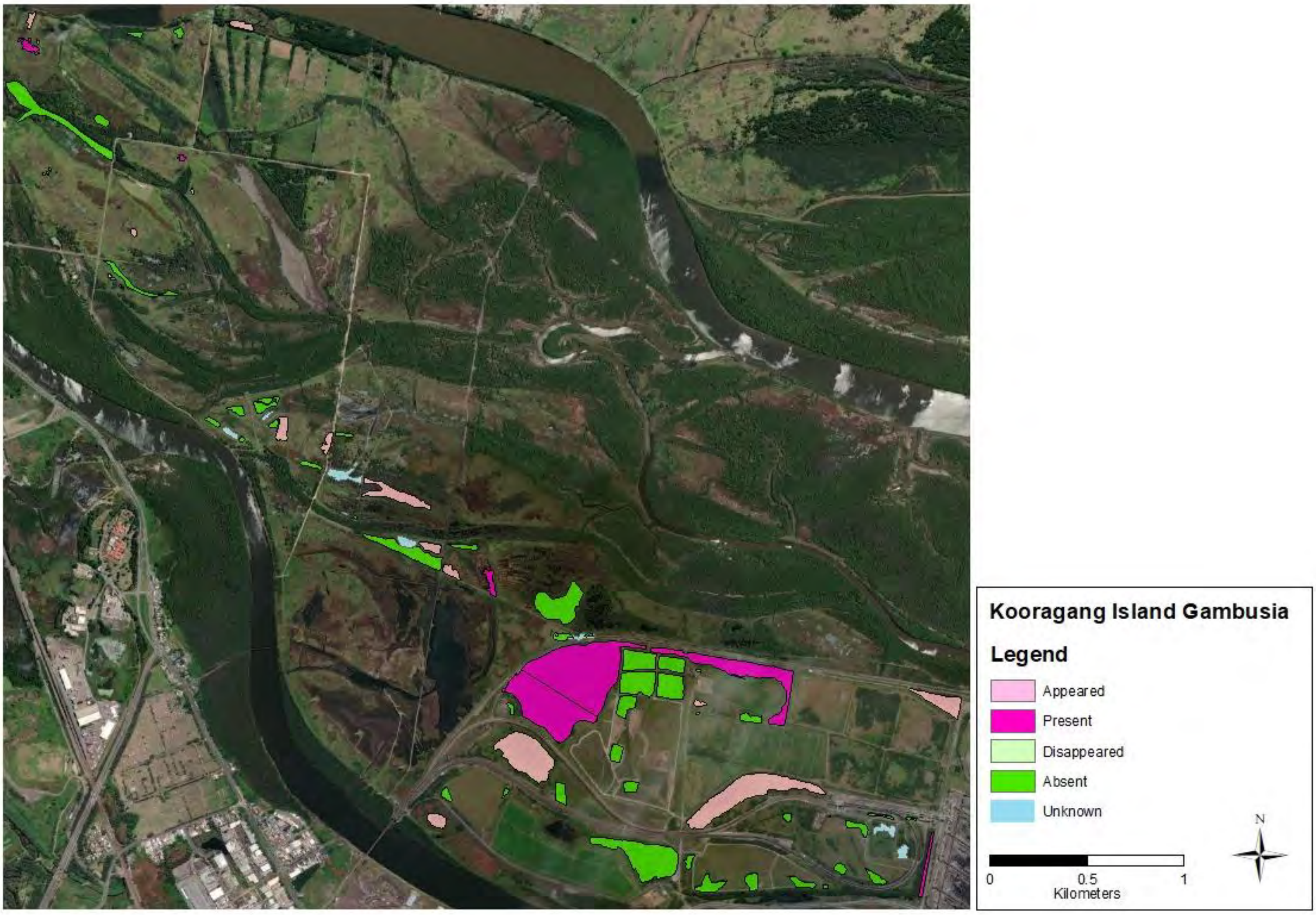


Figure 3.2.9: *Gambusia* distribution across wetlands at the end of the 2020-21 season.

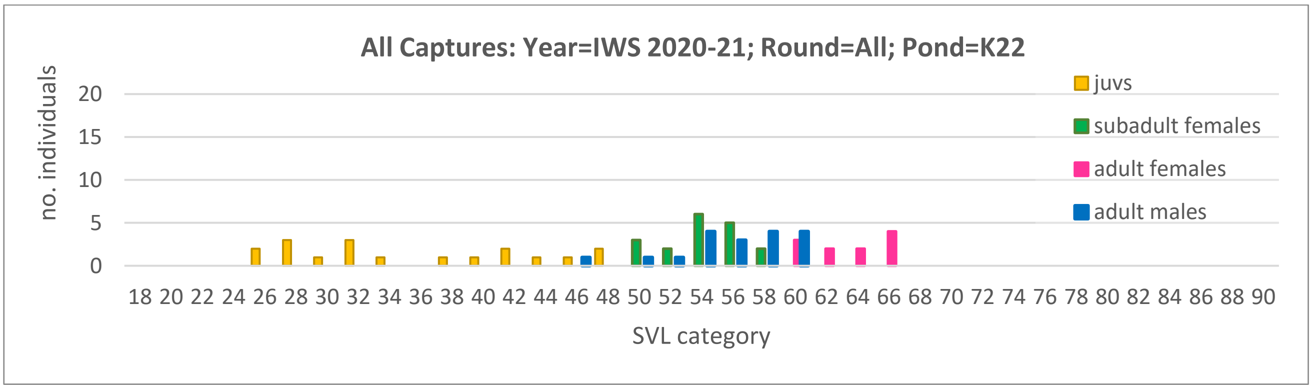
Note that the data for K105A shows very low densities of Gambusia in the southern and northern parts. This is in contrast to the previous breeding season were the northern part of K105A dried out during May 2019, eliminating Gambusia.

9. Fire recovery since 2019

Ground fires were ignited in January 2019 and swept across large portions of the Central and Industrial Zones, and were not fully extinguished until September 2019. Not only did this restrict access to some wetlands in that season, it also caused widespread destruction of aquatic and terrestrial vegetation at important *L. aurea* location, as well as frog deaths. Last season, there was evidence of partial recovery of many of these wetlands, including vegetation regrowth. Further recovery was apparent this year, including at extensively damaged sites, such as K106, K22 and K23 where juveniles and adult populations were detected. In addition, while the Cluster 1 tubs were all partially melted and their capacity to hold water substantially decreased by the 2019 fires, they too have continued to contained water and appear to remain useful habitat for the species.

10. Increased detection at K22-23

K22 and K23 are a pair of wetlands in close proximity to each other, situated immediately north of the PWCS rail line and adjacent to the north shore of K105A. Historically, these wetlands have held large numbers *of L. aurea* and have been the focus of intensive CMR surveys. While these wetlands have shown a steady decrease in usage since 2016-17, total numbers detected this year are the highest they've been for the past three years, brought on by the capture of a large number of juveniles (Figure 3.4.8). Indeed, a large proportion of captures in K22 and K23 were juveniles (28% and 43%, respectively). Among adults, a larger proportion of females were detected than males in K22, while nearly twice the number of males were detected than females in K23. In general, a much larger female population was detected at these wetlands when compared to the previous season, in which no females were recorded in K22 and females only made up 2% of the adult population in K23.



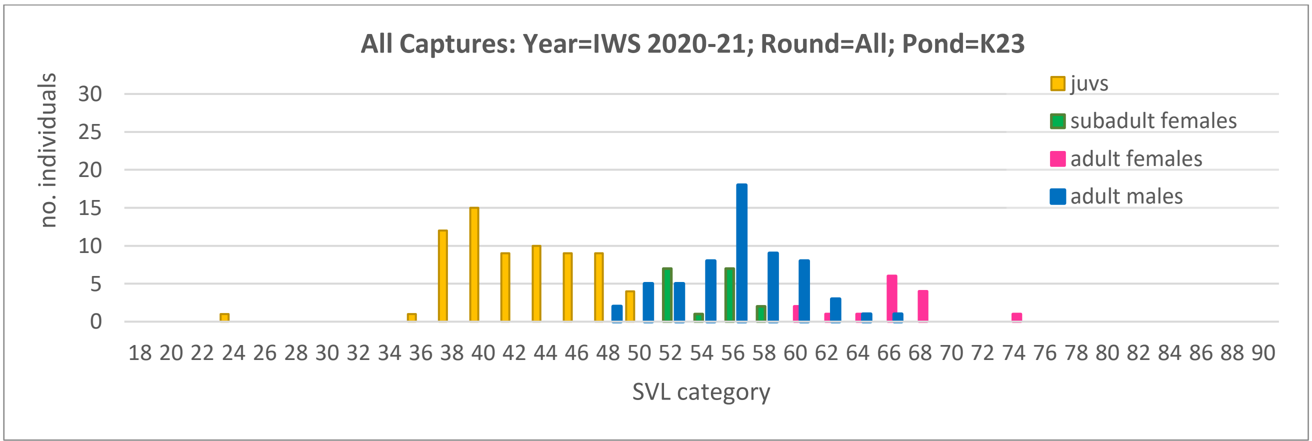


Figure 3.4.8: Top: frequency distributions for K22 and K23 wetlands all captured animals across the 2020-21 season, summed across all survey rounds. Refer to Fig. 3.4.6 for explanation of charts.

11. Terrestrial habitat use

It has traditionally been viewed that *L. aurea* movement is directional towards wetlands as a destination for activities such as reproduction and foraging. However, this may not always be the case and it is possible that suitable terrestrial habitat surrounding wetlands provides a destination for animals who are not directly engaging in reproductive behaviour. This was highlighted at the end of the 2019-20 breeding season, where a high number of juveniles were detected at fence lines established in terrestrial habitat away from water. This suggest that terrestrial habitat is critical for the movement of vulnerable juveniles away from their natal waterbodies when weather conditions are suitable. It is also becoming increasingly apparent that terrestrial habitats are used by adults for movement away for wetlands. Although quantitative data on use of terrestrial data was not collected for the 2020-21 IWS, large numbers of adults using the terrestrial habitat south of the K30 complex was observed in February 2021. Additionally, movement of large numbers of adults on the road between the BHP borrow pit and K49 A/B was observed during rain (also in February 2021).The influence of terrestrial habitat on wetland occupation will become a focus of future research on Kooragang island.

Contents

1. Introduction

1.1 Background to the study: Historical context and research objectives.

The Conservation Biology Research Group (formerly the Amphibian Research Group) at the University of Newcastle (UoN) has been conducting annual surveys of the green and golden bell frog (*Litoria aurea*) on Kooragang Island since 2010. The research aims to provide insight into the biology and ecology of this endangered species, in order to inform effective habitat management and creation by the partner organisations. Those partner organisations – Port Waratah Coal Services (PWCS), Newcastle Coal Infrastructure Group (NCIG), the Hunter and Central Coast Development Corporation (HCCDC; formally HDC), and more recently Port of Newcastle (PoN)– are involved with 'on ground' management and landscape works across Kooragang Island. By providing high quality data from population monitoring, this project aims to inform those activities to ensure long-term persistence of *L. aurea* on the island.

Over the course of these surveys more than five thousand *L. aurea* have been captured (with another five thousand animals captured as part of different PhD projects at UoN), with this extensive data set representing one of the most comprehensive investigations of this threatened species to date. Continuous monitoring of this scale, especially of amphibian species, remains rare in an Australian context, and yet is essential given that amphibian populations exhibit classic boom and bust population growth linked closely to climate and weather patterns. Only long-term datasets such as these allow scientists to determine whether changes to the conservation status of threatened species is associated with weather fluctuations or is influenced by acute human actions (eg habitat clearing and fragmentation). This is critically important for *L. aurea* as it is now found in less than 10% of its former range, confined largely to coastal environments that are also in high demand for human land use.

The original wetlands surveyed over the past decade have remained consistent, however, some additional wetlands have been constructed and others have been altered. The absolute number of wetlands surveyed has thus increased, and the focus of each seasons' survey has shifted when necessary to track significant changes in population demographics. Nevertheless, the primary aims and methodology of consecutive surveys has remained consistent between years, and the original project aims continue to be prioritized. With respect to population monitoring, these are:

1. Gaining general insights into the biology and ecology of *L. aurea*.
2. Meeting population monitoring requirements for operation on Kooragang Island by:
    a. Providing a population size estimate for *L. aurea* on the island;
    b. Describing the demographic composition of the island population of *L. aurea*; specifically, the ratio of adults to juveniles and the ratio of males to females.
    c. Defining the spatial distribution of *L. aurea* across the island, considering movement patterns and aggregations.
3. Informing 'on the ground' management plans of partner organisations to balance business with the protection of the existing population of *L. aurea* on Kooragang Island.

1.2 Context of the green and golden bell frog decline; bell frogs in SE Australia

The general background to the decline of *Litoria aurea* – a once common and widespread species along Australia's East Coast and inland tablelands from northern New South Wales to southern Victoria – has been described in detail in our previous annual reports (see, for example, McHenry et al. 2019) and various published papers (Mahony et al., 2013, Pyke and White, 1996, Pyke et al., 2002). The current population is understood to be much smaller than it was 50 years ago and persists in less than 10% of its historical range, occupying fewer than forty sites in a highly fragmented set of small refuge habitats (White and Pyke, 1996, Mahony et al., 2013). While there has been some argument about the causes of decline in this species, attention has focused upon three primary threats; (i) habitat loss/degradation, (ii) the invasive fish species *Gambusia holbrooki*, and (iii) the fungal disease known as 'chytrid'.

Habitat changes: The former range of *L. aurea* largely encompasses regions that have been highly modified for agriculture, urban development, and industry since European occupation. In NSW, the frog was distributed across the Eastern coastal plains and slopes, the coastal hinterland highlands on the east side of the Great Dividing Range, the tablelands that make up the upper parts of the Murray-Darling catchment on the west side of the Great Dividing Range, and the slopes and plains of the Murray River catchment. Most of these areas have been profoundly altered in the last 200 years, and hence the loss and degradation of habitat is a clear potential factor in the decline of this species in the last 50 years (Mahony 1999, Clemann & Gillespie 2012, Mahony et al. 2013). In particular, removal of riparian vegetation and river access by sheep and cattle has caused severe bank erosion and sedimentary infill of deeper holes in riverbeds, resulting in the loss of basking, foraging, and refuge microhabitats for frogs such as *L. aurea* that require access to standing water all year around (David Hunter, pers. comm.). Regulation of rivers by large dams has also altered the timing and extent of flooding events, which has likely had negative consequences for *L. aurea* breeding habitat.

The eastern plague minnow, *Gambusia holbrooki*: This invasive species was introduced to many countries including Australia through the 20th Century as a putative control measure against mosquitos. It has been described as a voracious predator and possesses a combination of life-history traits that make it a highly successful invader of aquatic ecosystems. It has been demonstrated to significantly reduce survivorship of *L. aurea* tadpoles in laboratory experiments (Morgan & Buttemer 1996, Pyke and White 2000). *Litoria aurea* tadpoles also do not show any avoidance or refuge seeking behaviours when introduced to *Gambusia*, further increasing their susceptibility (Hamer et al., 2002b). Its current range in NSW and Victoria has strong overlap with the locations from which bell frogs have declined; as a result, ecologists seeking to understand the decline of bell frogs in the 1990s drew attention to the potential impact of *Gambusia* (Gillespie 1996, Mahony 1999).

Chytrid: Over the course of the 1990s, ecologists suspected that the pattern of amphibian declines and extinctions closely fitted that of a disease epidemic, rather than the effects of habitat degradation or predation by an invasive species. Support for this was found in 1996 with the description of chytrid; more correctly known as chytridiomycosis, this is a disease caused by the pathogenic fungus *Batrachochytrium dendrobatidis* which can be fatal to a range of amphibian species (see summaries in Berger et al. 2007, Skerratt et al. 2018, Scheele et al. 2019).

Some aspects of the decline of *L. aurea* match the general pattern of chytrid-mediated decline of frog species. *Batrachochytrium dendrobatidis* is more active in cooler temperatures, and its greatest impacts have been upon frogs living at higher altitudes (Puschendorf et al. 2009, Puschendorf et al. 2013, Geoff Heard pers. comm.). This species has largely disappeared from the high altitude parts of its former range, and persists mainly in warmer coastal zones. More recently, *B. dendrobatidis* has been shown to have a low tolerance to saline environments, again consistent with the coastal distribution of surviving populations of *L. aurea*.

Combined effects: As much as chytrid appears to be the smoking gun behind *L. aurea* declines, there are some aspects that suggest that chytrid on its own may not be the whole story and that it is the interaction between these potential threatening processes that have contributed to declines. For example, at higher altitudes (coastal highlands of NSW and inland tablelands), *L. aurea* has experienced severe declines even with moderate or low habitat degradation and despite the absence of *Gambusia*. However, at lower altitudes and in more coastal areas, the situation becomes more complex. When *Gambusia* is present in high densities, the species persists only in saline environments, irrespective of the level of habitat degradation (coastal plains of NSW). When *Gambusia* is present at lower densities and habitat modification is not extreme, it may also persist (Mahony 1999, Gillespie & Clemann 2012). Similarly, where coastal plains have lower levels of both degradation and *Gambusia*, it persists (Heard et al. 2013, Gillespie and Clemann 2012), and where habitat modification is minimal and *Gambusia* is completely absent, the frog shows little evidence of decline (e.g., East Gippsland region of Victoria; Graeme Gillespie, pers. comm.). This pattern suggests that, whilst chytrid alone has likely extirpated *L. aurea* from the higher parts of its former range, the disease alone does not account for the pattern of decline in the lower-lying coastal and inland regions. The complexities of habitat degradation can be difficult to understand, but there appears to be a very clear signal with respect to the interaction between chytrid and *Gambusia.*

1.3 Threats interacting at a small scale: *Litoria aurea* on Kooragang Island

In laboratory challenge experiments, *L. aurea* is particularly susceptible to the chytrid fungus, (Stockwell et al., 2010), and whilst it is unlikely the disease kills all infected wild individuals, the fungus clearly poses substantial threat to the persistence of wild populations. Survival estimates of the Kooragang Island population demonstrate significantly lower over-winter survival rates in infected individuals when compared with non-infected individuals (Stockwell et al, 2011). The population level effects of this mortality are significant: infected populations are predicted to decline at twice the rate of healthy ones (Stockwell et al, 2011).

The majority of extant *L. aurea* populations are found in coastal environments, consistent with the suggestion that the sensitivity of the chytrid fungus to salt may explain the persistence of *L. aurea* in weakly saline environments (White, 2006; Stockwell et al., 2012). Significant negative correlations have been experimentally confirmed between infection load in captive *L. aurea* and the salinity of the water bodies they are kept in (Stockwell, 2011). Wild populations of *L. aurea* inhabiting water bodies with up to 3.5 ppt salt were also found to have lower infection loads than those frogs not exposed to saline conditions (Stockwell et al. 2012, Clulow et al. 2018). Indeed, salt concentrations above 2 ppt but not exceeding 5ppt were found to be beneficial (Stockwell et al., 2015b, Stockwell et al., 2015a). The potential for using salt as part of a management tool for *L. aurea* on Kooragang was investigated by Callen (2018), who found that an array of wetland habitats which provided wild *L. aurea* with access to at least some saline wetlands did result in improved survivorship.

Callen (2018) also found that variation in hydroperiod was also important for the persistence of the subpopulation that was the focus of the study. This variation in wetland characteristics between neighbouring wetlands has been dubbed the 'habitat mosaic' and is emerging as an important concept in the conservation management of *L. aurea*. Connectivity (proximity of an array of wetlands to each other, with suitable interconnecting habitat) is a key attribute of an effective mosaic (Hamer et al. 2008, Wassens et al. 2008, Heard et al. 2015), but variation in hydroperiod among wetlands is just as important (Klop-

Toker 2016, Callen 2018). In the context of *L. aurea* on Kooragang Island, an effective habitat mosaic should have variation in microhabitat sufficient to provide environmental protection against chytrid via access to increased salinity and temperatures (Heard et al. 2014, Heard et al. 2018). Variation in hydroperiod can also provide protection against *Gambusia*, which have a significant impact on *L. aurea* recruitment on the island (Klop-Toker 2016).

Whilst the relationship between *L. aurea* declines and the expansion of *Gambusia* into NSW has been debated, numerous sites exist where *L. aurea* declined despite local water bodies being free of the predatory fish (Mahony et al. 2013). While several studies have noted the co-occurrence of *L. aurea* tadpoles and *Gambusia* in the same water body (Sanders et al., 2015, Hamer et al., 2002a), the pattern seen from field studies on Kooragang leaves little doubt that *L. aurea* recruitment is heavily affected by the presence of *Gambusia* (Klop-Toker 2016, McHenry et al. 2017, 2019, this annual report). *Gambusia* do not affect adult *L. aurea* (Klop-Toker 2016), but their impact on tadpoles means that *L. aurea* populations subject to chytrid and coexisting with *Gambusia* will be subject to both increased adult morality and reduced recruitment. 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 the fish (Pyke and White 1996; Hamer et al. 2002; Pyke, White et al. 2002), highlighting the importance of designing wetland infrastructure to control for *Gambusia* infestation.

1.4 Research Objectives

Research objectives for the 2020-21 season are largely consistent with previous years, and target areas of *L. aurea* biology and ecology that are relevant for management of this species and its habitat on Kooragang Island:

1. What is the estimated population size on the island?
2. What is the demographic composition on the island?
    - What are the proportions of juveniles, adult males, and adult females?
    - How much recruitment is known, and where is it occurring on the island?
3. How do *L. aurea* utilise the island landscape?
    - What is the distribution?
    - What factors affect distribution, abundance, and recruitment?
4. What information can be gained from longitudinal data?
    - What are the growth patterns of *L. aurea* on the island?
    - How long do individual *L. aurea* persist?
    - What are the movements of *L. aurea* across the island?

In addition, there are several objectives that relate to specific management issues faced by partner organisations:

5. **Habitat corridor mitigation strategy (PWCS)**: A long-term aim is to decrease the proportion of *L. aurea* occupancy of wetlands in the north of the precinct (previously earmarked for development - see Section 2.1: Site Context), and to increase occupancy of wetlands in the southern part of that site. This requires detailed understanding of population numbers, distribution and movement in the northern and the southern parts of the Industrial Zone.

6. **Rail infrastructure mitigation strategy (NCIG)**: The construction of the NCIG 'rail loop' enclosed several wetlands that were important habitat for *L. aurea* with a high traffic rail line. It is important for NCIG to understand if the rail loop has effectively isolated the populations in those wetlands from the Kooragang Island metapopulation. This requires detailed understanding of population numbers, distribution, and movement within the rail loop and adjacent wetlands.

7. **Constructed wetlands strategy (HCCDC)**: As part of capping within the rail loop in 2015, HCCDC constructed sedimentation ponds that were designed to provide suitable habitat for *L. aurea*. The efficacy of that design, and the location of these artificial wetlands within the landscape, is an important question for HCCDC as further capping works are implemented. This requires detailed understanding of population numbers, distribution, and movement at the HCCDC constructed and adjacent wetlands.

2. Methods

2.1 Site context

Kooragang Island lies at the northern boundary of the Newcastle Local Government Area, on the NSW Central Coast (Figure 2.1.1). The island itself is estuarine in nature, and is bounded to the north and south by channels of the Hunter River. Soils are composed of deposited sand, silt and clay sediments. Several tidal channels extend onto the island, which historically once separated the current landmass into smaller islands prior to human development. The natural hydrology of the island has been considerably altered, with agricultural development (e.g., draining of land for pastures) and industrial activity (e.g., road construction and land reclamation). Its deltaic nature, which includes low elevation, supports a diversity of wetlands ranging from saltmarsh and tidal flats to freshwater swales and large permanent freshwater wetlands.

Sixty wetlands have been the focus of the island-wide surveys, and these were all surveyed again in the 2020-21 breeding season. Additional surveys of other wetlands were added to the dataset (Figure 2.1.2). This approach gives a largely consistent list of wetlands surveyed each year, with some variation between each season (see Table 2.2.1). Figures 2.1.3 and 2.1.4 show the nomenclature used by UoN to identify specific wetlands.

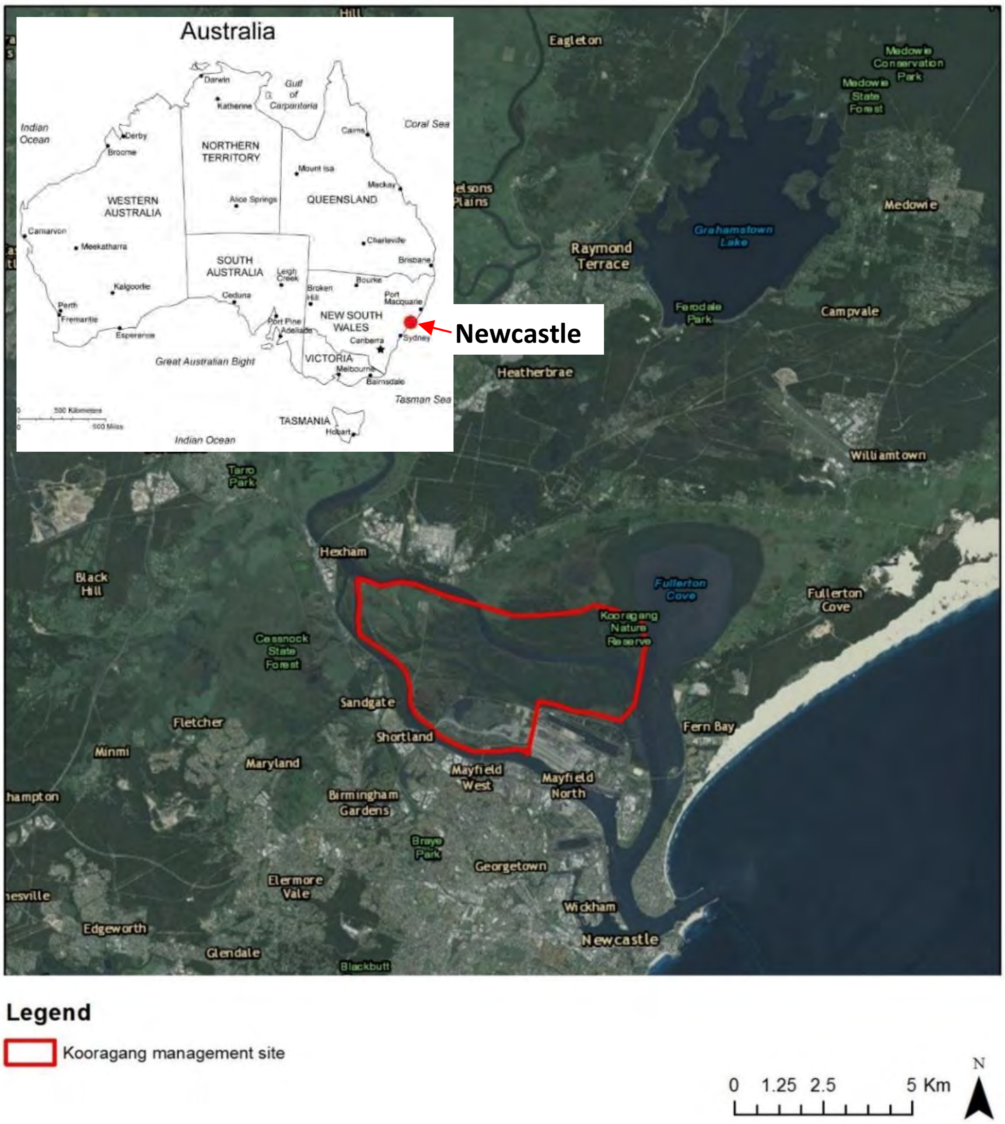


Figure 2.1.1: Contextual map depicting the location of Kooragang Island, near Newcastle, NSW.

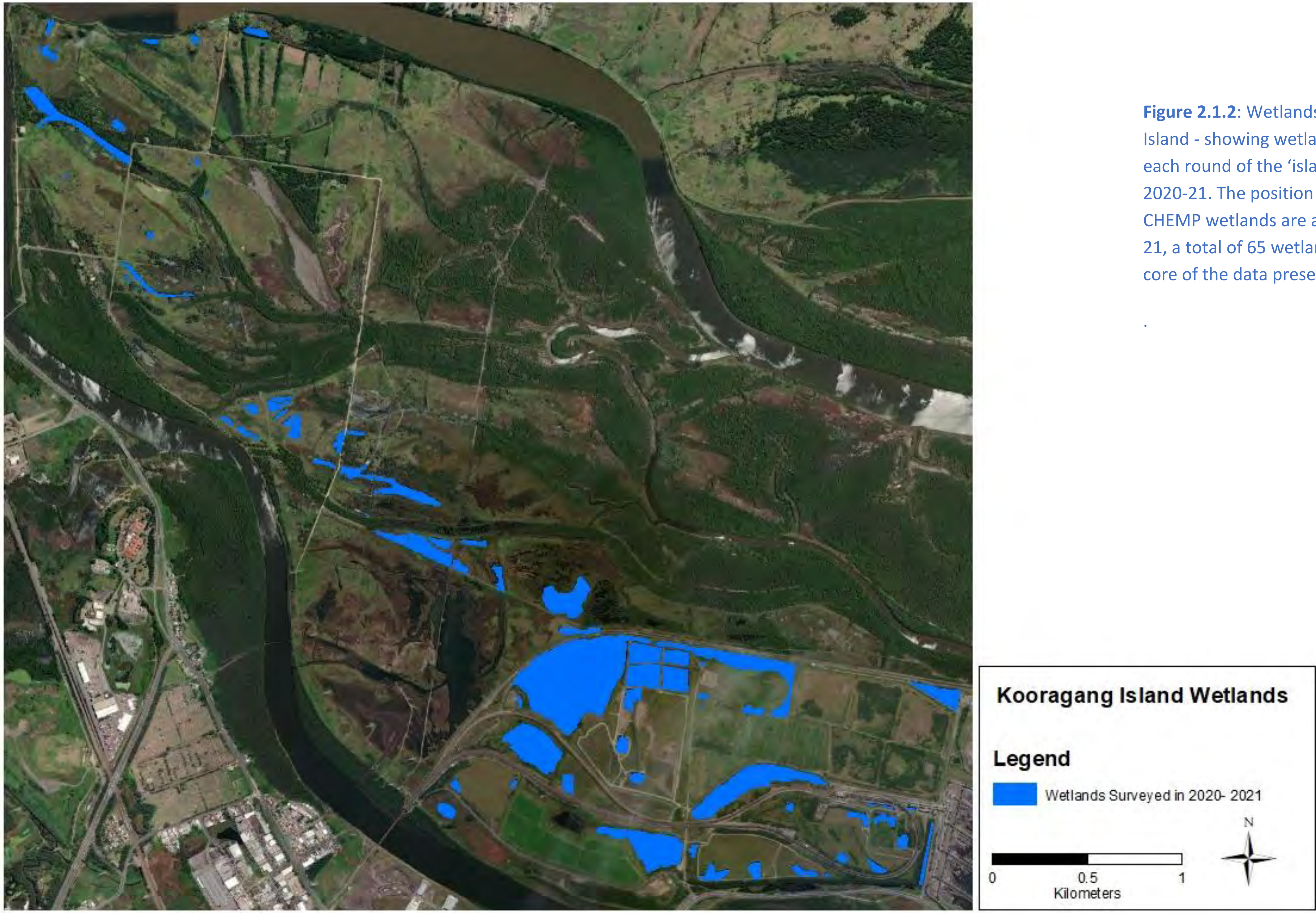


Figure 2.1.2: Wetlands of Kooragang Island - showing wetlands surveyed in each round of the 'island-wide' surveys of 2020-21. The position of NCIG and BHP CHEMP wetlands are also shown. In 2020-21, a total of 65 wetlands made up the core of the data presented in this report.

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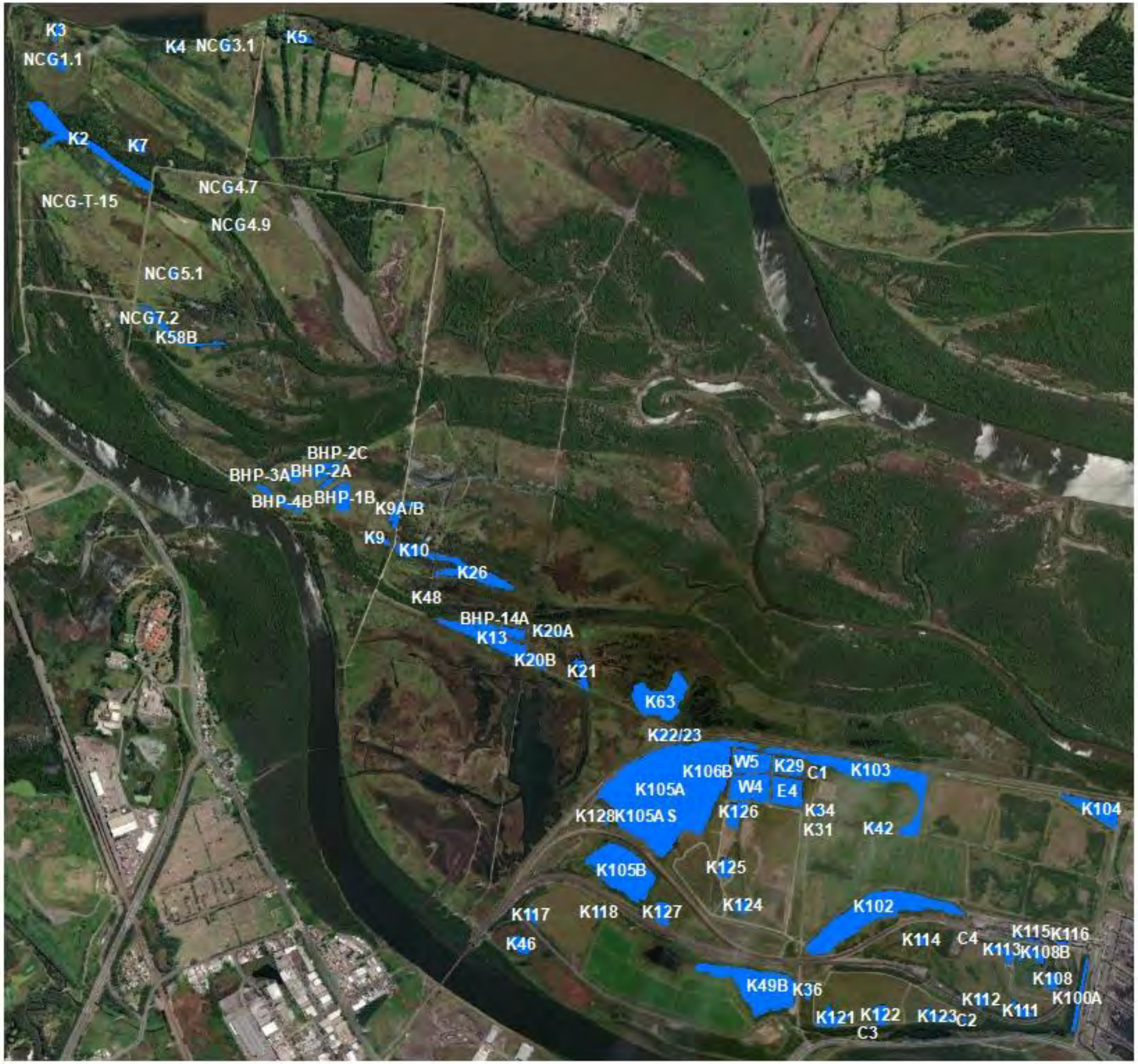

Figure 2.1.3: UoN reference labels for the wetlands shown in Figure 2.1.2.

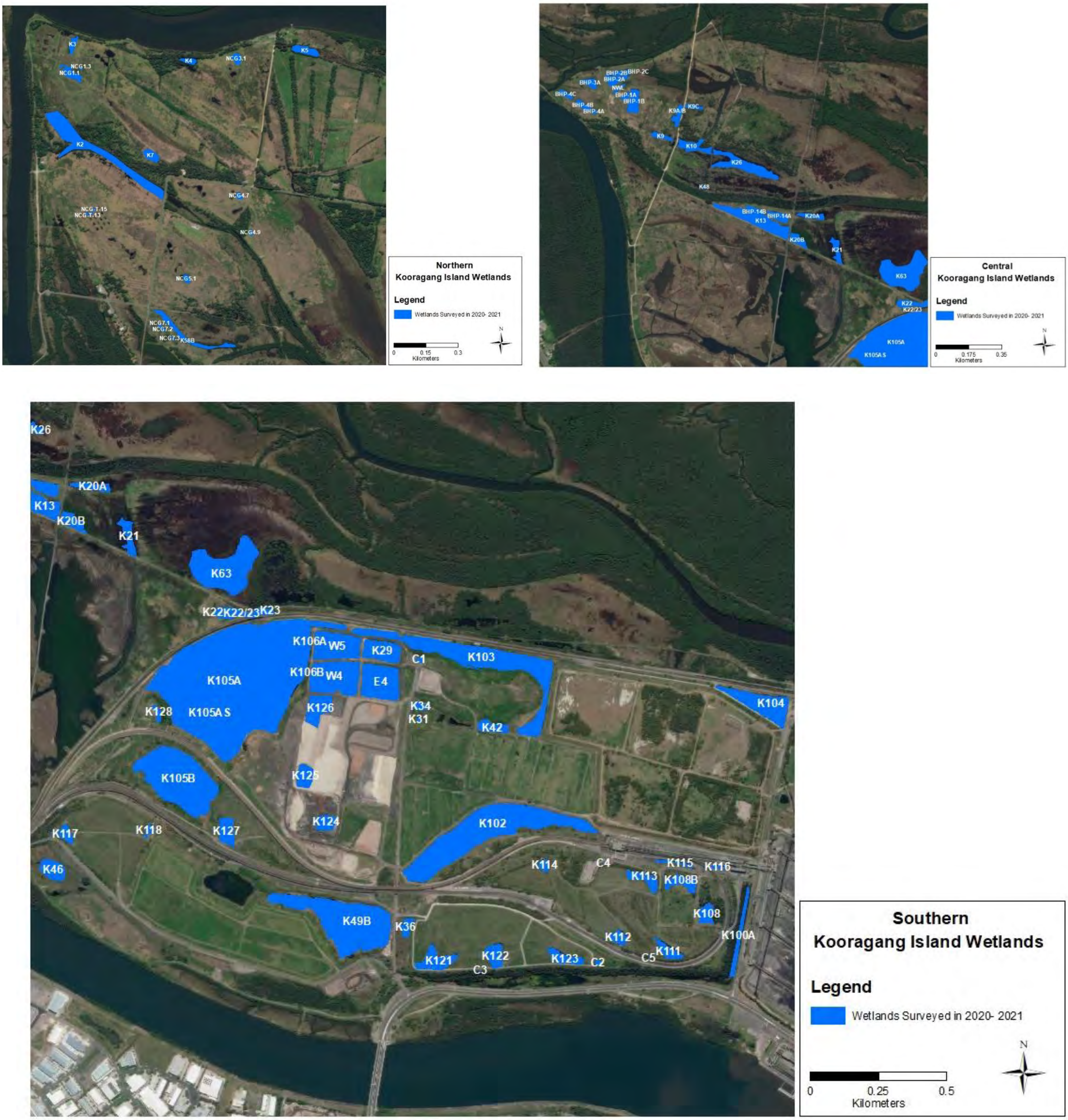

Figure 2.1.4: Close-up of wetlands (with UoN labels) in each of the three zones: Northern Zone (top-left), Central Zone, (top right), and Industrial Zone (bottom) – see Section 2.2. Note that the Industrial Zone lies in the southern portion of Kooragang Island.

2.2 Groupings of wetlands: Zones, Regions, Subregions, and Jurisdictions

To assist survey logistics and analysis of spatial patterns of *L. aurea* distribution, the surveyed wetlands on Kooragang Island are organised into areas as follows:

A. **Zones**: wetlands are grouped into three geographical zones - the Northern, Central and Industrial zones.

1. Northern Zone: this zone includes the Hunter Wetlands National Park from the Sandgate bridge in the south to Scott's Point in the north, and has an area of 377 ha. Within this zone there are 14 wetlands sampled as part of the program this year. 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 Zone: this zone also includes part of the National Park Estate. It ranges from the south from the PWCS rail line, 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 293 ha, of which 90% is mangrove forest community. Within this zone there are 15 wetlands sampled as part of this program this year. Compared to the Northern zone, this area has been less impacted by human activity. Nonetheless, there is evidence of historic disturbance, including clearing, draining, impounding, road construction, utility easements, and flood-gating.
3. Industrial Zone: Wetlands in this zone are located in the south-eastern part of the island, on industrial and commercial lands leased or owned by organisations undertaking a range of business activities on the site. The Industrial Zone is dominated by the Kooragang Island Waste Emplacement Facility (KIWEF), a series of constructed 'cells' on top of the estuarine wetland floor that were filled with industrial waste from the Newcastle steelworks and other heavy industry through the 20th Century. Some of the unfilled cells now provide wetland habitat, whilst closure works on filled cells have required the construction of sediment control ponds that have now also provided suitable habitat for *L. aurea*. Within this zone there are 36 wetlands sampled as part of this program this year, with a wide variety of types and sizes represented in the overall area of 346 ha. The northern part of the Industrial Zone was the approved site for the development of a fourth coal terminal ('T4'), but progress on that development was halted in 2019 and is not expected to proceed. Industry dominates this zone and it has been 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 protected from the chronic impacts of industrial activities. Compared to the rest of the site, this area has undergone the greatest level of historical disturbance and continues to be impacted by human activity, yet supports the largest numbers of *L. aurea* on Kooragang Island.

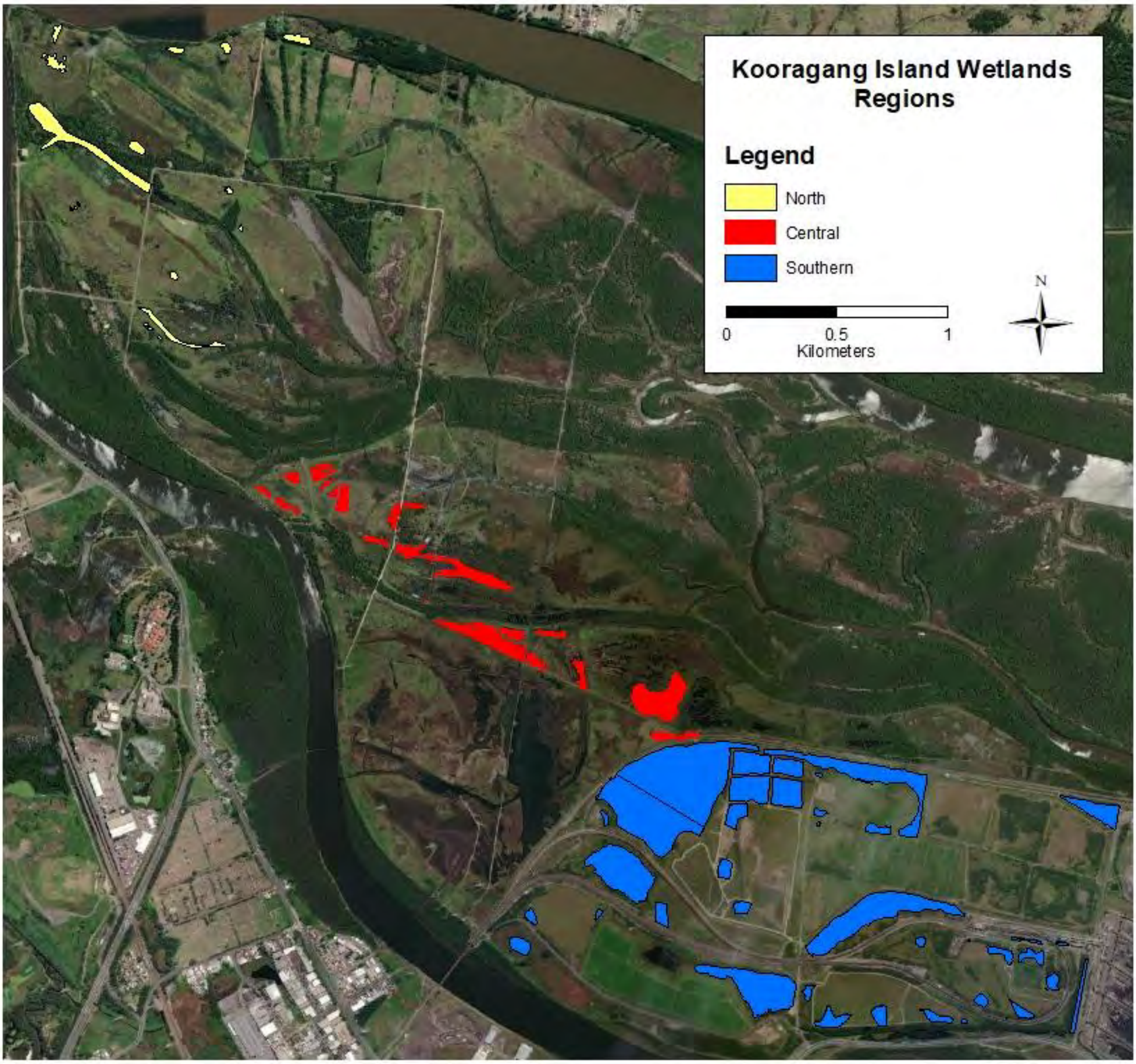

Figure 2.2.1: Location of surveyed wetlands on Kooragang Island within Zones; see text and Table 2.2.1 for explanation.

B. **Regions**: each zone is subdivided into two regions. This grouping of wetlands into regions allows (1) the habitat corridor mitigation strategy to be assessed (as this involves comparison of the northern vs southern parts of the Industrial Zone), and (2) equivalent subdivisions of the other two zones for the purposes of multi-year occupancy analysis (**Section 3.9**).

- Northern Zone:
  - i. Hunter River North
  - ii. School House
- Central Zone
  - iii. Cobban's Creek
  - iv. Bellfrog Way
- Industrial Zone
  - v. Industrial Zone North
  - vi. Industrial Zone South

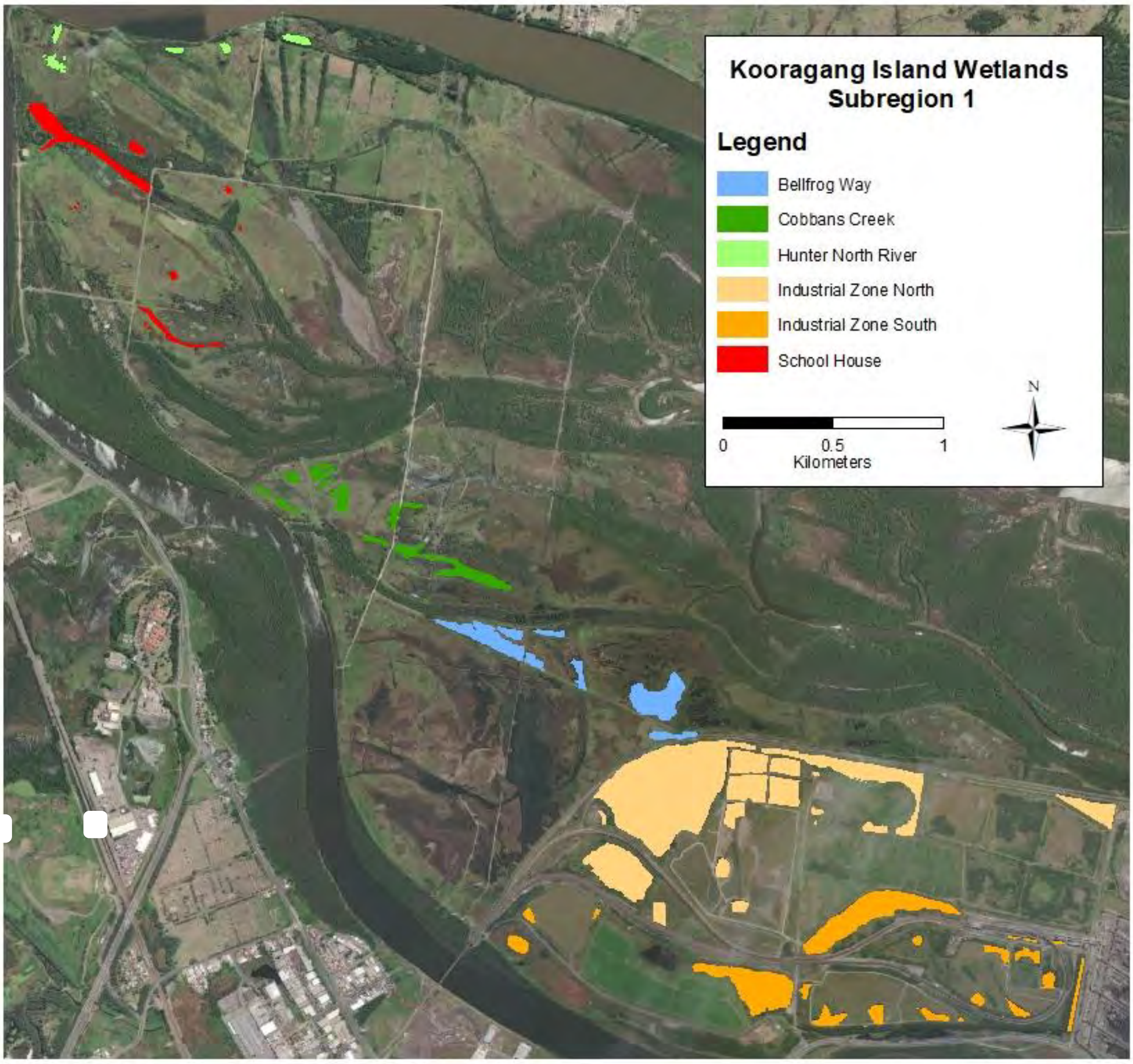

Figure 2.2.2: Allocation of surveyed wetlands to Regions. See text and **Table 2.2.1** for explanation.

Subregions: the regions are subdivided into a number of subregions, each at a consistent spatial scale (<1 km across) and determined by natural and artificial boundaries such as creeks, roads, and rail-lines. Grouping of wetlands at this scale is required for assessment of the rail infrastructure mitigation strategy and the constructed wetlands strategy:

- Hunter River North
  - Scott's Point
  - Riverside Park
- School House
  - Wet meadow
  - Millam's Pond
- Cobban's Creek
  - Ramsar Road West
  - Ramsar Road East
- Bellfrog Way
  - Bellfrog Way West
  - Bellfrog Way NE
  - Bellfrog Way SE
- Industrial Zone North
  - Delta Ponds
  - KIWEF *K7*
  - Deep Pond
- Industrial Zone South
  - NCIG rail central & east
  - Rail loop (*K10 North*)
  - Cormorant Road
  - Rail loop SW (*K10 South*)
  - KIWEF *K2*
  - KIWEF *K5* (Area 2)

A total of 65 focus wetlands were surveyed in the 2020-21 in each of the survey rounds. A further 18 non-focal wetlands were surveyed in each survey round. A full list of the wetlands included in each zone, region, and subregion is included in Table 2.2.1. Note that 'K' numbers relating to the KIWEF nomenclature of areas within the industrial zone are shown in *blue italic* font, and should not be confused with the 'K' numbers used in the UoN nomenclature for surveyed wetlands (the latter are shown in normal font).

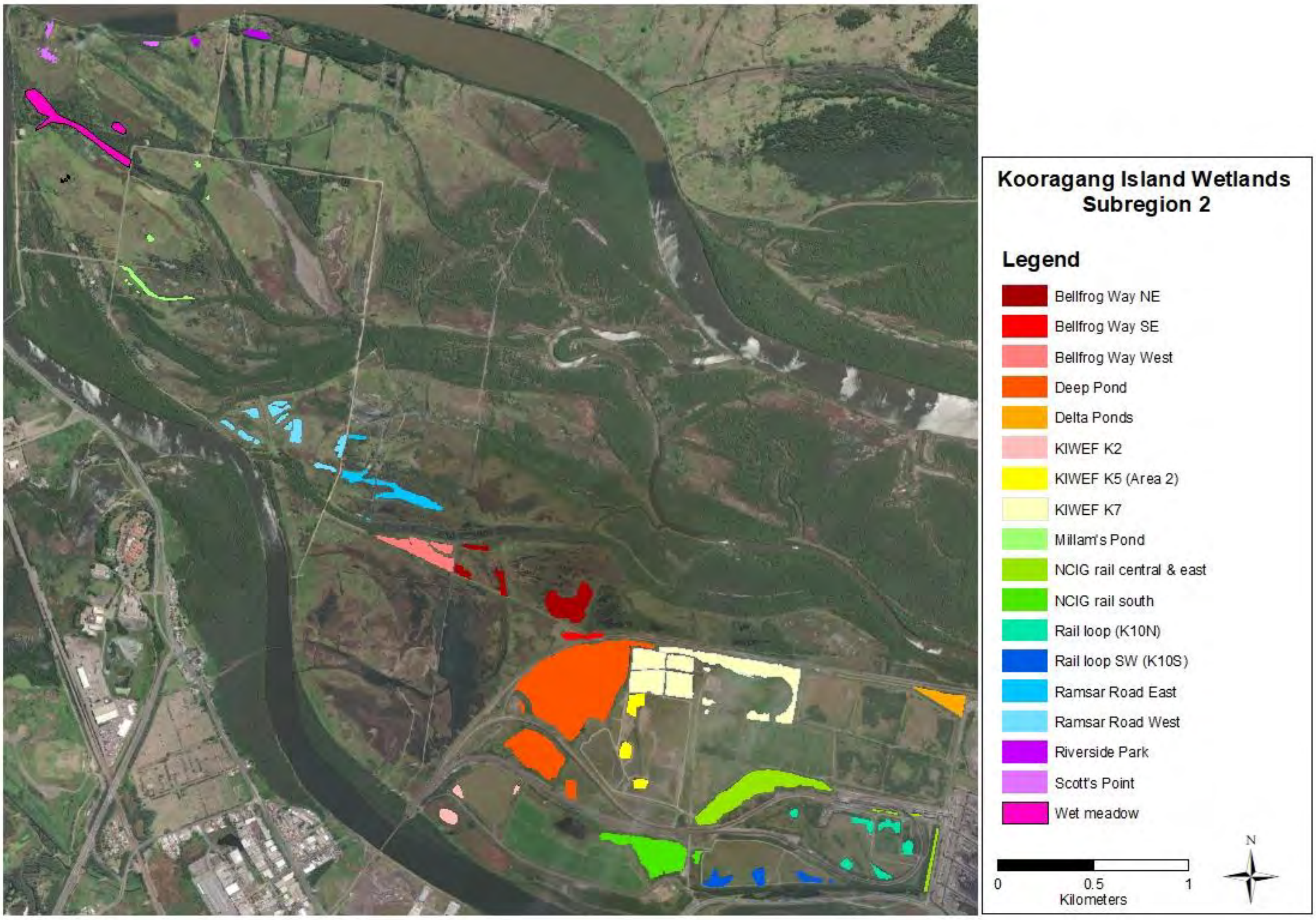

Figure 2.2.3: Allocation of surveyed wetlands to Subregions. See text and Table 2.2.1 for explanation.

Zone	Region	Subregions	Wetlands included
Nth	Hunter River North	Scott's Point	*K2S*, K3, K4, NCIG-1
		Riverside Park	*K15, K16, K18*, K5, *K6*, NCIG-3
	School House	Wet meadow	*K1, K17, K19*, K2, K7, *K8*, NCIG-T13, NCIG-T14, NCIG-T15
		Millam's Pond	*K27, K58A*, K58B, *K7A*, NCIG-4, NCIG-5, *NCIG-6*, NCIG-7
Central	Cobban's Creek	Ramsar Rd West	BHP-1, BHP-2, BHP-3, BHP-4, K9, K9A/B, *NWL*
		Ramsar Rd East	*K10, K25*, K26, K48, K9C
	Bellfrog Way	Bellfrog Way West	BHP-14, *K11*, *K12*, K13, *K45, K45A*
		Bellfrog Way NE	K20A, K20B, K21, K63
		Bellfrog Way SE	*K107, K20C*, K22, K23, *K24, K50*
Industrial	Industrial Zone North	Delta Ponds	K104
		KIWEF K7	C1, *Delta road*, E4, K103, K106A, K106B, K106C, K29, *K30*, *K30A, K30B*, K31, *K32*, *K33*, K34, *K35*, *K41*, K42, *PWCS K7 stockpile*, *S7*, W4, W5
		KIWEF K5	K124, K125, K126
		Deep Pond	K105A, K105AS, K105B, K127, K128
	Industrial Zone South	NCIG rail central & east	K100A, K102, K115, K116, *K119*, *NCIG dumpstation*
		Rail loop (*K10 North*)	C4, C5, EP-NE, EP-SW, *K108*, *K108B*, K111, K112, K113, K114, *K120*
		Rail loop SW (*K10 South*)	C2, C3, K121, K122, K123
		NCIG rail south	*BHP Borrow Pit*, *Daracon compound*, K36, *K49A*, K49B,
		KIWEF *K2*	K117, K118, *K44*, K46, *K47*
		Cormorant Road	*K100E, K100W*

Table 2.2.1: Categorisation of surveyed wetlands into Zones, Regions, and Subregions (see text for explanation; see also Figures 2.2.1 to 2.2.3). Wetlands shown in *italics* light font have been surveyed in previous years but were not surveyed in 2020-21. Underlined wetlands are those that are also surveyed in the SoS project.

Jurisdiction

Core wetlands surveyed for the Whole Island Monitoring Program fall under the following seven jurisdictional categories (see Figure 2.2.4).

- National Parks and Wildlife (NPWS): 14 wetlands (North and Central zones)
- CHEMP (NCIG and BHP): 13 wetlands in the North and Central zones of the National Park.
- Port of Newcastle (PoN): 2 wetlands (Central zone)
- Port Waratah Coal Services (PWCS): 1 wetland (Industrial Zone)
- Newcastle Coal Infrastructure Group (NCIG): 2 wetlands (Industrial Zone).
- Hunter Development Corporation (HDC): 33 wetlands (Industrial Zone)

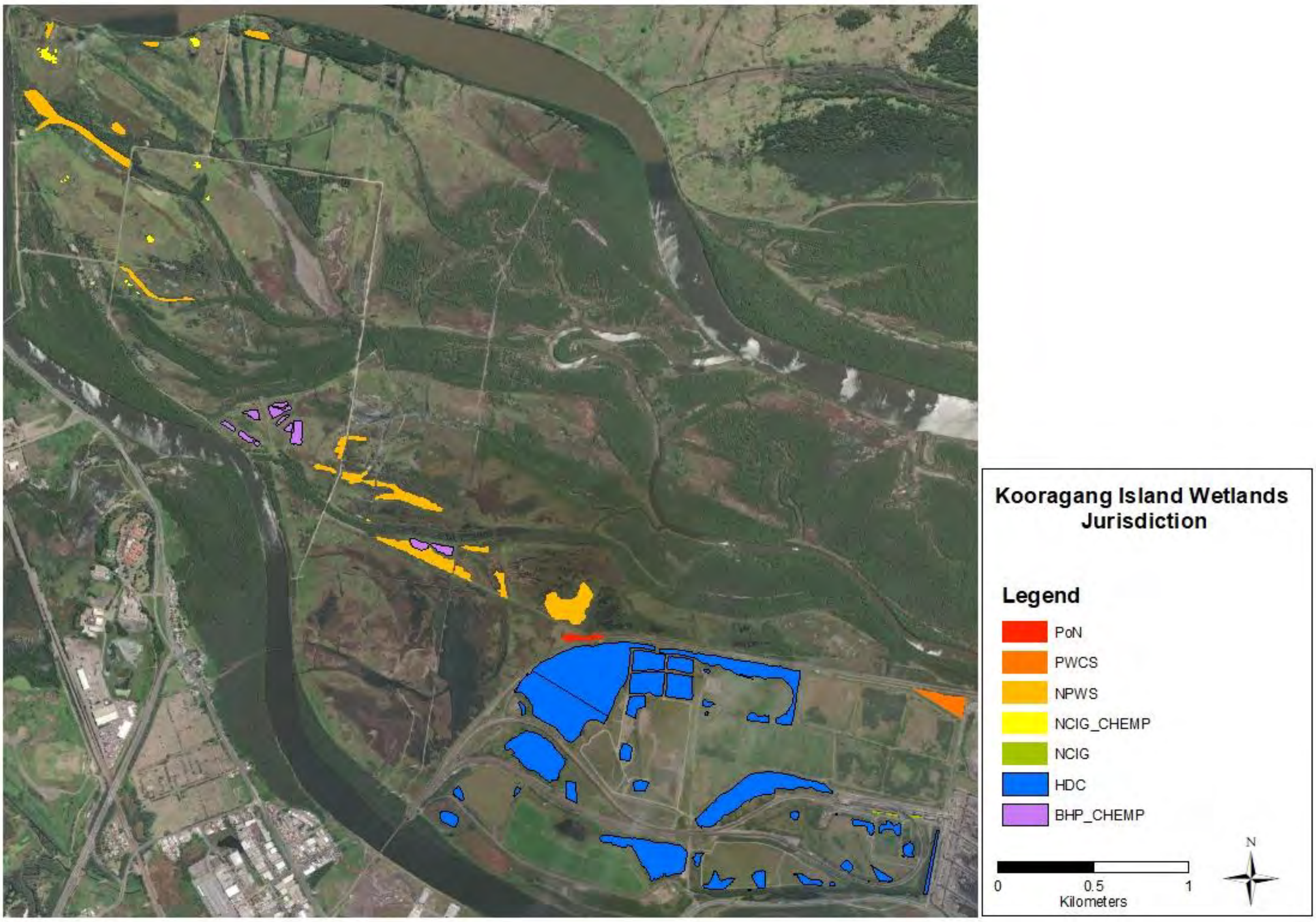

Figure 2.2.4: Named wetlands on Kooragang Island, summarized by jurisdiction. Note that not all of these were surveyed in the 2020-21 season (see text and Table 2.2.1)

2.3 Long-term monitoring approach

The whole island monitoring program has followed a standard method for nine years and was established to enable tracking of *L. aurea* distribution and abundance against time. In the past four years significant habitat creation projects and other landscape works have occurred on the site that materially should affect the distribution and abundance of the *L. aurea* population. These new wetlands must be included to enable assessment of the effectiveness of mitigation strategies in increasing distribution and abundance of the *L. aurea* population. Therefore, whilst consistency is important and we aim to monitor within a predefined set of wetlands, we must also be responsive to landscape changes (see Appendix A). Finally, several newly constructed wetlands created by HDC following capping works across the southern part of the Industrial Zone were included in surveys.

2.4 Survey techniques

Visual Encounter Survey (VES) of wetlands involved systematic night-time surveying by between 2-6 people, using >150 lumen LED head torches. Surveys began by listening for calling activity, before using call playback to try and elicit a response. The survey itself involves walking slowly through the wetland and surrounding terrestrial habitat, paying careful attention to vegetation, which *L. aurea* tend to associate with (mainly emergent reeds).

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, wind speed (average and maximum), and relative humidity, using a multi-probe instrument (Kestrel).

Methodology - Adult Frogs

For each survey, each surveyor recorded

i. Start and end times of survey,
ii. Any frogs (*L. aurea* 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 *L. aurea* encountered:
    - Time of capture
    - Habitat structure (tree, reed, grass, rock, ground, aquatic)
    - Height from ground/water surface
    - Distance from water's edge
    - Size class (adult/juvenile)
    - Calling occurrence
    - Other relevant observations

In general, we attempted to capture all *L. aurea* observed. This was done using a thin plastic bag (sandwich bags). 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 (NSW NPWS Hygiene Protocol). The capture site was marked with flagging tape or on a sketch map of the wetland.

Captured frogs were processed as follows:

i. Scanned using a Passive Induction Transponder reader to see if the frog had been previously captured and tagged.
ii. If the frog had a passive induction transponder (PIT) tag, the number was recorded.
iii. Visual inspection of frog for injuries, as well as nuptial pads (to identify males from females) and candle lit (to identify gravid females).
iv. Snout-vent-length (SVL) and tibia length (TL) were measured using callipers.
v. Body weight was measured using a 10g, 60g or 100g spring balance (Pesola).
vi. The frog was swabbed for chytrid fungus by the standard protocol used by the UoN Amphibian Research Lab (two 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 sample (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 and metamorphs

Where possible, tadpoles were collected in the field and identified in the lab, using the key in Anstis (2002). Metamorph*s* were identified and classified on the basis of the presence of a tail stub combined with adult colouration.

Data collection

Tissue samples and swabs were marked using the bar code from the PIT label. Processing took approximately 10 person-minutes per frog. Not every frog captured is weighed (the project already has hundreds of data points for length-weight relationship from this population, and taking weight measurements adds to the per-frog processing time). Swabs for chytrid are not collected in the summer, while tissue samples for genetic analysis are collected from a subsample of captured frogs only. Frogs were returned to their point of capture after completion of the survey.

A single **primary** VES was performed at each wetland during each survey round; three survey rounds were performed between September 2020 and March 2021. In Visual Encounter Surveys, the entirety of each 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.

2.5 Search effort

VES summary (primary VES)	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**
Wetlands surveyed	55	75	71	60	63	96	**82**
Total wetland surveys	118	150	195	245	207	333	**238**
Nights of field surveys	38	37	41	48	48	50	**48**
Total search effort VES (person.minutes)	7,979	8,899	8,861	11,201	13,375	15,737	**13,024**

Table2.5.1: Survey statistics and search effort for visual encounter surveys for *L. aurea* undertaken under the island-wide surveys across the seven most recent seasons.

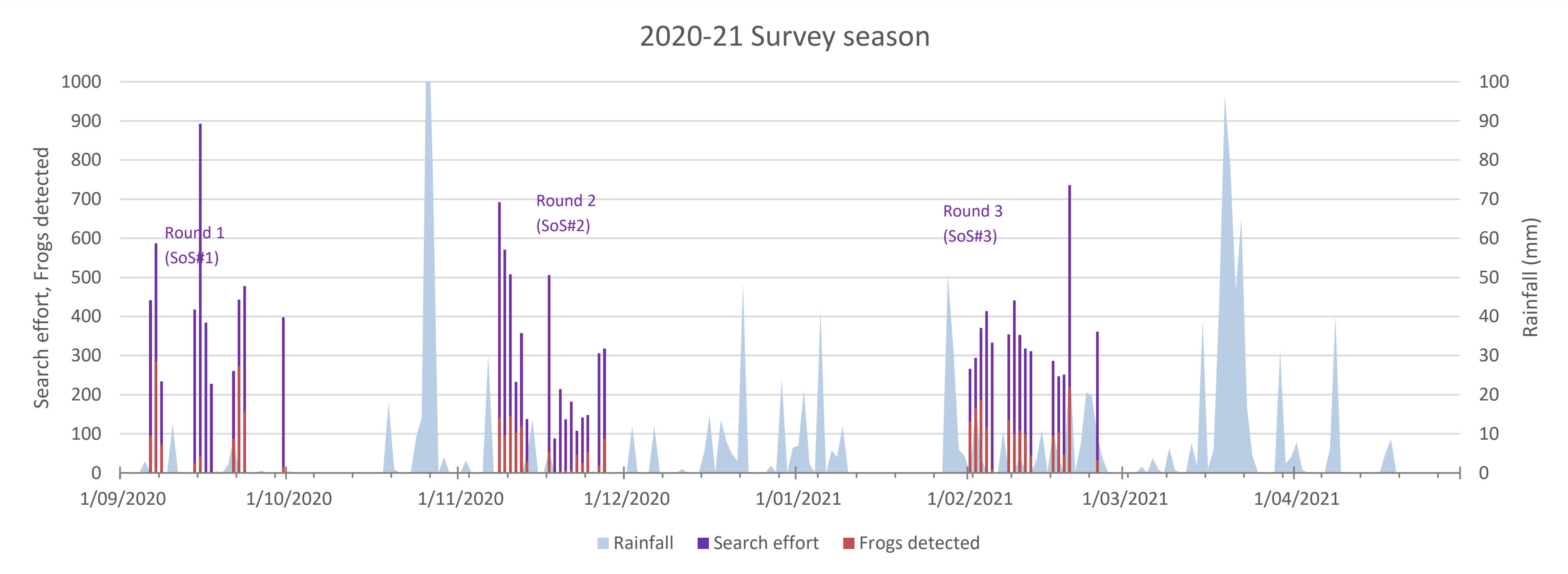

Figure 2.5.1: Search effort and *L. aurea* detections across the 2020-2021 survey period, shown alongside rainfall.

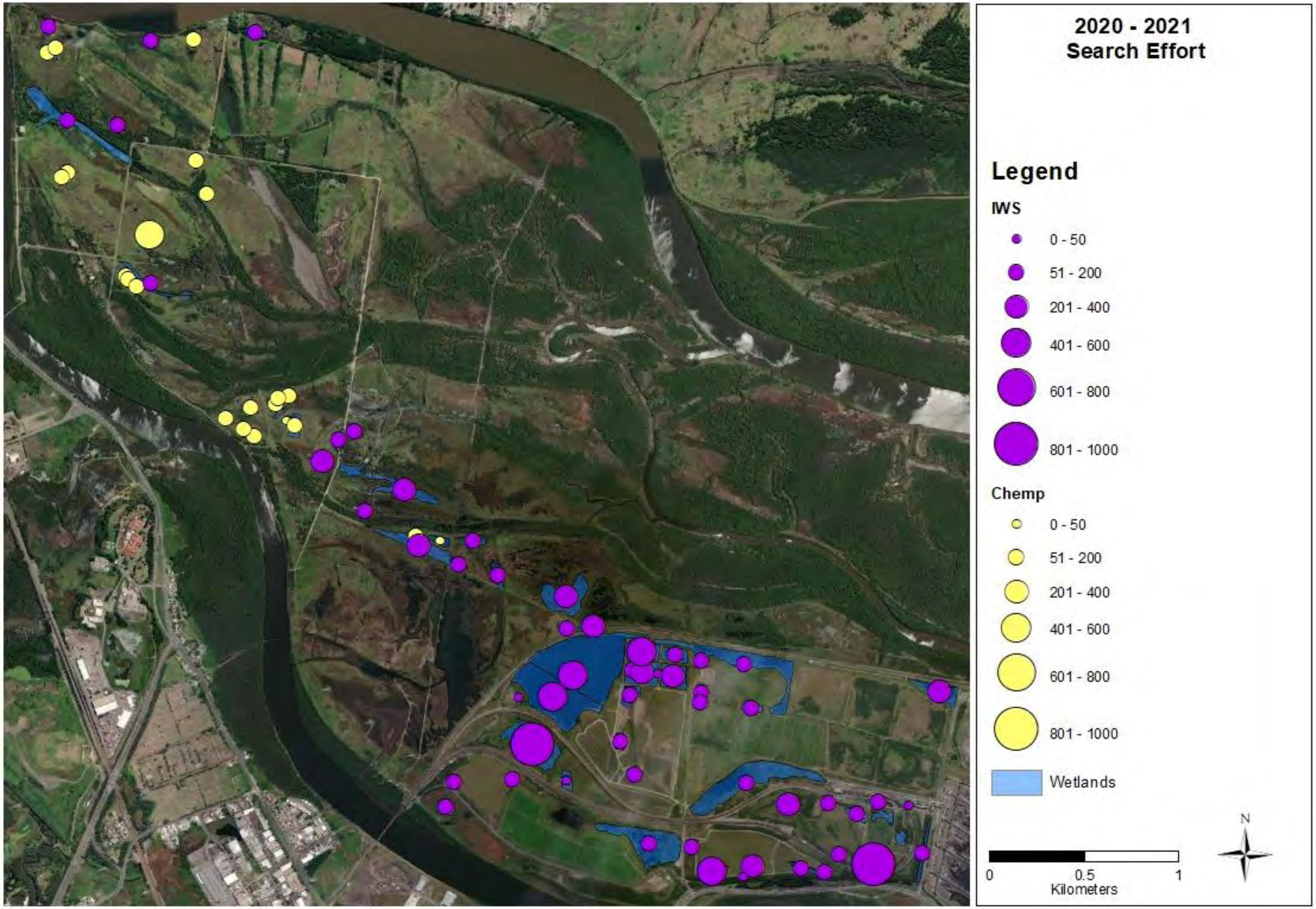

Figure 2.5.2: Search effort (person.minutes) across the 65 wetlands surveyed as part of Island-wide monitoring in 2020-21.

Note that the CHEMP wetlands shown here are only those included in the Save Our Species (SOS) and Island-wide 2020-21 surveys; they do not include all CHEMP wetlands

2.6 Methodological approaches used to address objectives

Estimating population size

Over past breeding seasons, population estimates have been obtained for three specific wetlands (K22-23, K29 'the cell' and K104) based on data from Capture-Mark-Recapture (CMR) surveys. 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 2.6.1). This CMR survey data can be used to extrapolate island-wide population estimates using VES survey data obtained from each wetland.

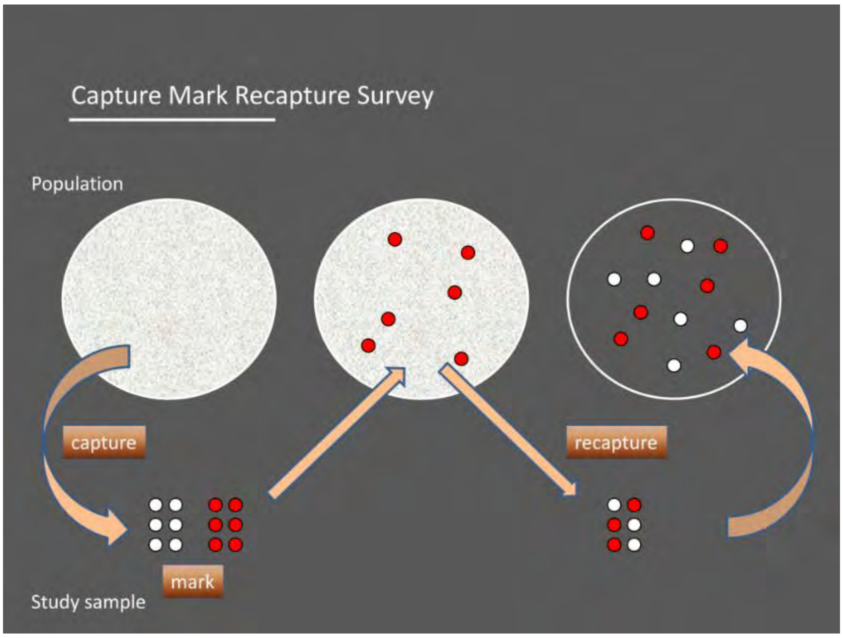

Figure 2.6.1. A simple illustration of capture-mark-recapture survey (based on two capture events only). Left circle: nothing is known about the population size, during the first capture event animals are caught, marked and released. Middle circle: the number of marked animals within the population is 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.

Assumptions applied to survey effort and population modelling

For analytical purposes, we assume that survey efforts were consistent across the entire monitoring season. In reality, there are several important sources of variation:

Within and between individual observers: survey effectiveness can vary among observers, particularly given that *L. aurea* are generally cryptic and difficult to see. To overcome detection bias we used a core of experienced observers within the survey teams but this remains an important methodological limitation.

<u>*Within and between sites*</u>: Along with being cryptic and difficult to see, *L. aurea* 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 K7, K5, K4; also K13, K21, K108) 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. The constructed HDC wetlands can also contain high numbers of frogs (e.g., K111, K114), and the lack of mature vegetation at these sites, combined with their size, makes detection rates high. Conversely, parts of a wetland with dense *Typha* and especially *Phragmites* may hold large numbers of *L. aurea*, but have low detection rates. Weather conditions also influence detection probability; warmer nights with low wind speeds seem to be better for detecting *L. aurea* (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, with survey effort calculated as part of the detection probability. 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 thrice, one in late spring, one in mid-summer, and a final survey round in late summer/early autumn. Despite this design, the *L. aurea* breeding season is often punctuated with discrete rainfall events that occur in the middle of and before surveys. Such events do effect 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.

Demographic composition and effective population size

To construct the age-class structure of the *L. aurea* population we determined the age of individual frogs collected based upon a growth curve developed for this species on Kooragang Island (see Hamer et. al., 2008 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 tadpoles may overwinter and metamorphose early in a subsequent breeding year, adding 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.

Designation of adult males, adult females, and sub-adult females.

In previous years, we categorised animals into age classes by using SVL data, based on the analysis of Hamer et al. (2008). Adulthood is defined as the capacity to reproduce. In 2015-16, this was designated as SVL >49 mm for males, and SVL > 68 mm for females. This difference between the sexes is due to the fact that *L. aurea* adults are sexually dimorphic; females reach a large body size and mass than the equivalent aged males. Based on these criteria, the categories used in earlier years of the project were:

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.

The very large number of captures in the 2016-17 provided the opportunity to test these categories quantitatively. Males were determined on the basis of nuptial pads. Since females are identified on the basis of the absence of these pads, there is some uncertainty as to what point a small individual can be considered a juvenile female as opposed to a juvenile.

Plotting the percentage of males captured against SVL (Figure 2.6.2) indicates that, between 50 mm and 60 mm SVL, adult males are consistently 60% of the population. At 48 mm, about 35% of captured animals display nuptial pads, but above 49 mm 60% do. An animal above 49 mm without nuptial pads is therefore a sub-adult female (until large enough to be considered an adult female).

Gravid females can be detected by ‘candle-lighting’ (= ‘candling’), i.e., placing a bright light such as a head-torch against their back, and looking at the silhouetted visceral organs from the ventral surface for the presence of eggs (Figure 2.6.3). Large females were checked for gravidity *ad hoc*. The smallest females to be found gravid were 58 mm SVL, and by 68 mm 100% of inspected females were gravid. The onset of adulthood for females is therefore less than 68 mm (used in 2015-16); we used a length of 58 mm in this analysis. Note that this is similar to the analysis conducted in the previous two years, but quite different to the categories used to analyse demography in previous years.

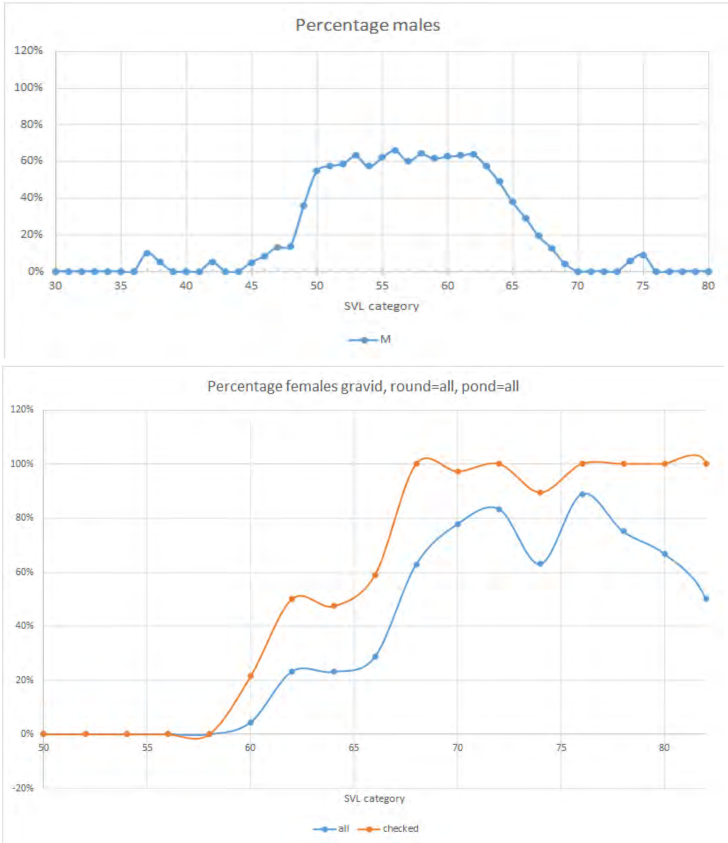

Figure 2.6.2: Proportion of animals that can be confirmed as reproductively mature (i.e., adult), plotted against SVL. Top, males; Bottom, females captured in 2016-17 surveys. In the lower chart, the red line represents the number of females found to be gravid, as a proportion of the animals inspected for gravidity, whilst the blue line shows that number as a proportion of all animals captured.

Figure 2.6.3: Illustration of the 'candle-light' method of checking for gravidity in females. A large, bilateral mass in the mid to upper trunk region indicates enlarged ovaries and thus gravidity.

The categories used this year are thus:

- Nuptial pads apparent → adult male (typically > 44-58 mm SVL)
- Body length < 49 mm and nuptial pads not apparent → Juvenile (sex unknown)
- Body length > 49 mm, nuptial pads not apparent → juvenile female

Body length > 58 mm, nuptial pads not apparent → adult female

3. Results

3.1. Summary of survey counts

	Round 1	Round 2	Round 3
	Total	**Total**	**Total**
Search effort	4,766	3,747	4,511
VES Detections	998	684	823
All Detections	1061	938	1,579
Captures	329	486	1,091
Unique	113	329	915

Table 3.1.1: Summary data from all surveys in 2020-21 season. 'Detections' refers to total encounters (i.e., captures and non-capture observations). Because some individuals are encountered and captured multiple times, 'Detections', and 'Captures' provide overestimates of the number of unique individual frogs actually encountered ('Unique').

The highest number of detections were in the Round 3 (February) (Table 3.1.1). There was an increase in animal captured and unique animals encountered with each subsequent round. Given that search effort was relatively similar between Round 1 and Round 3, this positive trend indicates a general increase in frog numbers at wetlands sites from the start to the end of the breeding season. This could be attributed to the lower rainfall that occurred at the start of the season and larger rainfall amounts as the season progressed, influencing activity levels and animal movements.

Region (detections)	**Search effort (VES)**	**VES**	**Total**	**Search Sensitivity**
Northern island	2,323	34	35	0.01
Central island	2,764	376	615	0.14
Southern island (T4)	7,937	2,095	2,928	0.26

Jurisdiction (detections)	**Search effort (VES)**	**VES**	**Total**	**Search Sensitivity**
NPWS	2,404	119	135	0.05
NPWS (CHEMP)	1,575	32	32	0.02
NPWS (CHEMP)	725	187	199	0.26
PoN	383	72	284	0.19
PWCS	277	55	68	0.20
NCIG	114	51	53	0.45
HDC	7,546	1,989	2,807	0.26

Table 3.1.2: Location (summarised by Zone and Jurisdiction) of *L. aurea* detected.

As with previous survey seasons, the highest number of detections were in the Industrial Zone (Table 3.1.2), though a much larger number of surveys were conducted in this zone. If survey effort is taken into consideration, the highest number of frogs detected per unit of search effort was found within the NCIG jurisdiction. Compared with the previous breeding season, numbers have decreased across each zone, most significantly in the Industrial zone. This decrease is also apparent within each jurisdiction except for PoN and could be an artifact of the large breeding events that occurred in the previous season that caused numbers to be inflated.

The total number of frogs detected across the three survey rounds was nearly half that of the previous season (Table 3.1.3). However, the total number of animals captured and unique individuals encountered were more than double that of the previous season. Both of these results are likely a consequence of the significant breeding events that occurred late in the previous season, when few juvenile animals were captured and microchipped.

	Primary VES	Total
Detections	2,505	3,578
Captures	1,044	1,906

	Captures	Unique
PIT tagged frogs	1,501	1,350

Demographic summary	Captured		PIT Taggable		Unique		Recapture index
	number	%	number	%	number	%	
juveniles (SVL < 49.5 mm)	877	46%	454	31%	431	32%	1.05
subadult females (49.5mm<SVL<58mm, no nups)	252	13%	252	17%	223	17%	1.13
adult males (>49.5, nups)	558	30%	558	38%	498	37%	1.12
adult females (>58mm SVL, no nups)	202	11%	202	14%	191	14%	1.06
Metamorphs	9		-		-		
unknown animals (not tagged)	8		7		7		
	1,906		**1,473**		**1,350**		

Table 3.1.3: Summary of demographic data. Recapture index shows the ratio of captures per unique individuals (i.e., higher values indicate a higher probability of recapture).

Compared to the previous season, there was a decline in the proportion of captured animals that were adult male (down from 50% to 30%) and female (down from 26% to 11%), a slight increase in the proportion that were sub-adult female (up from 9% to 13%), and a considerable increase in the proportion that were juvenile (up from 15% to 46%). These trends are also found when considering the proportion of unique animals captured. However, overall, the number of animals captured, pit taggable and unique have more than doubled since the previous season.

The recapture index for adult females was higher for adult males (1.12) and sub-adult females (1.13); this means that the probability of recapturing adult females and juveniles were low compared to other demographics. This result contrasts with previous years, where the recapture index for adult females has been higher than for other demographics, and may indicate that adult females were more dispersed across the landscape. Note that this figure is dependent on accurate categorisation of females of SVL ≥ 58 mm as reproductively mature adults (see Section 2.6 above and 3.6 below for discussion of this key issue); this categorisation is based upon candling but more reliable data (such as hormonal analysis) is needed to have full confidence in this size threshold.

Only frogs above 40 mm SVL are tagged, and smaller individuals are counted but not tagged. As such, the large percentage of PIT taggable animals that were juvenile reflects either a large juvenile population or that a large proportion of juveniles were captured at a chippable size. The percentage of animals captured that are juvenile is high compared to the previous season, despite the large number of juveniles detected in that season, which is driven by the low numbers that were actually captured.

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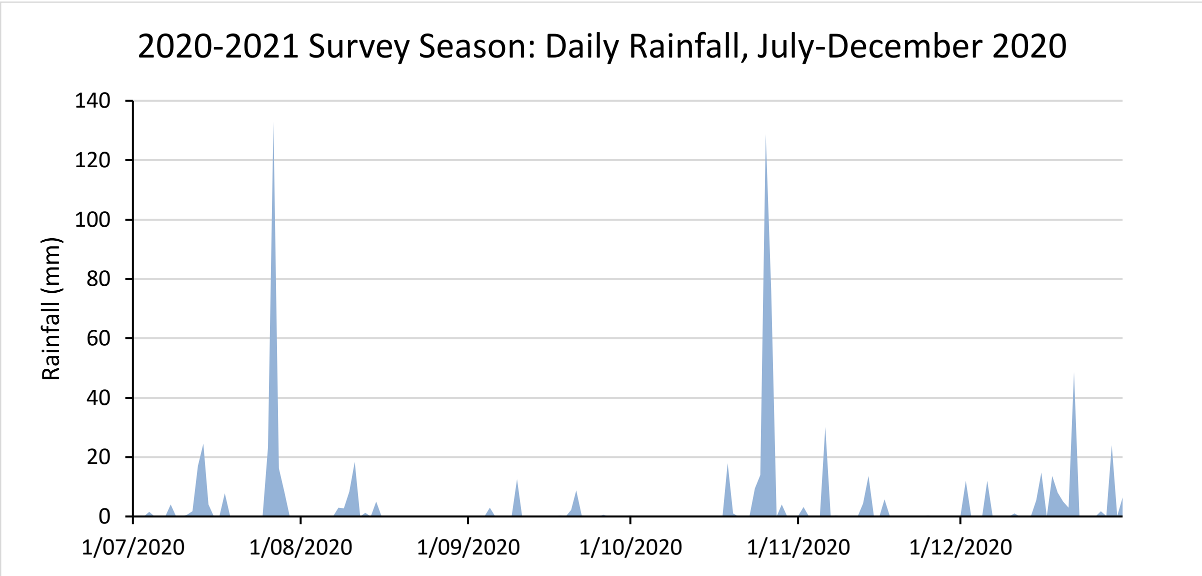
3.2. Seasonal context: environmental factors

Overview

The current breeding season experienced a high level of rainfall as a result of Australia moving into a La Niña event, with all months besides September having above long-term average rainfall. Wet conditions over the 2020 winter led to increased runoff feeding into wetlands into spring, resulting in a majority of sites being charged at the start of the *L. aurea* breeding season (September). Intermittent but multiple rainfall events subsequently occurred during the summer period, with few ponds experiencing a drying event. This is in contrast to the previous breeding season where drier than normal conditions caused most wetland sites to dry mid-season.



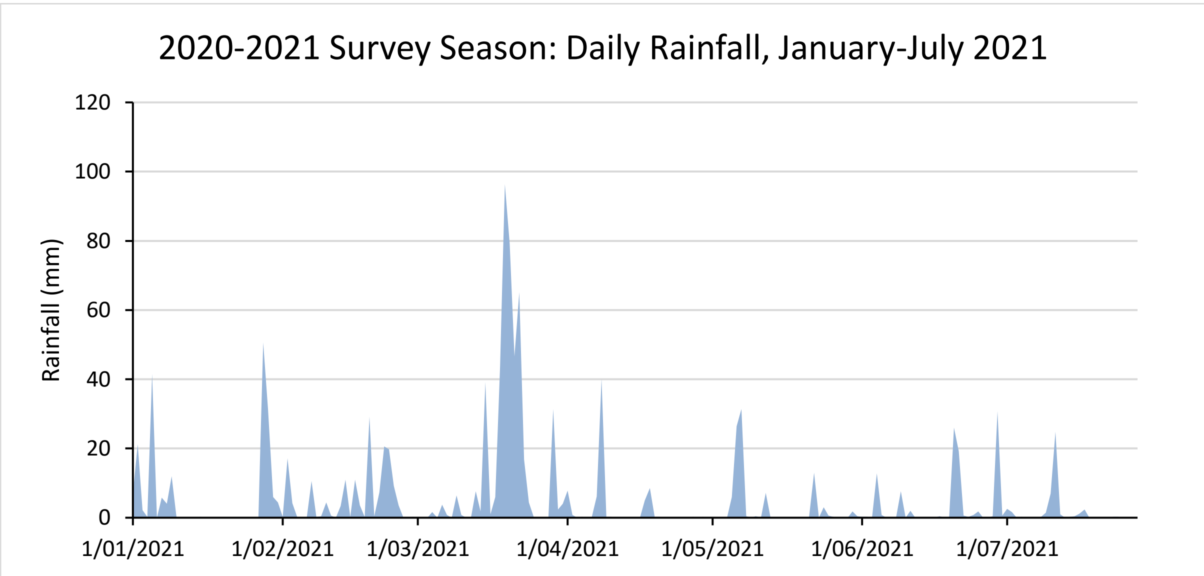


Figure 3.2.1: Weekly rainfall before, during, and after the 2020-21 survey season (October to April) on Kooragang Island. Measurements obtained from BoM records for Williamtown airport.

Table 3.2.1: Summary of water presence at each wetland per round, along with presence of *Gambusia* and observed breeding.

Zone	Region	Pond	Early Spring hydrology (R1)	Late Spring hydrology (R2)	Late Summer hydrology (R3)	Gambusia	Breeding
Nth	NPWS	K2	1	1	1	-2	
Nth	NPWS	K3	1	1	1	1	
Nth	NPWS	K4	1	1	1	-2	
Nth	NPWS	K5	1	1	1	1	
Nth	NPWS	K7	1	1	1	-2	
Nth	NPWS	K58B	1	1	1	-2	
Nth	NCIG_CHEMP	NCIG-1.1	1	1	1	2	
Nth	NCIG_CHEMP	NCIG-1.3	1	1	1	1	
Nth	NCIG_CHEMP	NCIG-3.1	1	1	1	-2	
Nth	NCIG_CHEMP	NCIG-4.7	1	1	1	2	
Nth	NCIG_CHEMP	NCIG-4.9	1	1	1	1	
Nth	NCIG_CHEMP	NCIG-5.1	1	1	1	1	
Nth	NCIG_CHEMP	NCIG-7.1	1	1	1	1	
Nth	NCIG_CHEMP	NCIG-7.2	1	1	1	-2	mets
Nth	NCIG_CHEMP	NCIG-7.3	1	1	1	2	
Nth	NCIG_CHEMP	NCIG-T13	1	1	1	-2	
Nth	NCIG_CHEMP	NCIG-T14	1	1	1	-2	
Nth	NCIG_CHEMP	NCIG-T15	1	1	no data	-2	
Central	BHP_CHEMP	BHP-14A	no data	no data	1	1	
Central	BHP_CHEMP	BHP-1A	no data	no data	1	-2	
Central	BHP_CHEMP	BHP-1B	no data	no data	1	1	
Central	BHP_CHEMP	BHP-2A	no data	1	1	-2	
Central	BHP_CHEMP	BHP-2B	no data	1	1	-2	
Central	BHP_CHEMP	BHP-2C	no data	no data	1	-2	
Central	BHP_CHEMP	BHP-3A	no data	no data	1	-2	
Central	BHP_CHEMP	BHP-4A	no data	1	1	-2	
Central	BHP_CHEMP	BHP-4C	no data	1	1	-2	mets
Central	NPWS	K9A/B	1	1	1	1	
Central	NPWS	K9C	1	1	1	-2	
Central	NPWS	K9	1	1	1	-2	
Central	NPWS	K20A	1	no data	1	-2	
Central	NPWS	K20B	1	no data	1	1	
Central	NPWS	K26	1	1	1	1	
Central	NPWS	K48	1	1	no data	-2	
Central	NPWS	K13	1	1	1	-2	
Central	NPWS	K21	1	1	1	2	
Central	NPWS	K63	1	1	1	-2	
Central	PoN	K22	1	1	1	-2	
Central	PoN	K23	1	1	1	-2	
Southern	PWCS	K104	no data	1	1	1	
Southern	HDC	K103	1	1	1	2	

Southern	HDC	K105A	1	1	1	2	mets
Southern	HDC	K105AS	1	1	1	2	mets
Southern	HDC	K105B	1	1	1	1	mets
Southern	HDC	K106A	0	1	1	-2	
Southern	HDC	K106B	1	1	1	1	mets
Southern	HDC	K106C	no data	no data	1	-2	
Southern	HDC	K29	1	1	1	-2	
Southern	HDC	C1	no data	1	1	-2	
Southern	HDC	K31	1	1	1	-2	
Southern	HDC	K34	1	1	1	1	
Southern	HDC	K42	1	1	1	-2	
Southern	HDC	K102	no data	1	1	1	
Southern	HDC	K36	no data	1	1	-2	
Southern	HDC	C2	1	1	1	-2	
Southern	NCIG	K115	1	1	1	-2	
Southern	NCIG	K116	1	1	no data	-2	
Southern	HDC	K100A	no data	1	1	1	
Southern	HDC	K111	1	1	1	-2	
Southern	HDC	K112	1	1	1	-2	
Southern	HDC	K113	1	1	1	-2	
Southern	HDC	K114	1	1	1	-2	
Southern	HDC	K121	1	1	1	-2	
Southern	HDC	K122	1	1	1	-2	
Southern	HDC	K123	1	1	1	-2	
Southern	HDC	K46	no data	1	1	1	
Southern	HDC	K49B	1	1	1	-2	
Southern	HDC	K117	no data	1	no data	-2	
Southern	HDC	K118	no data	1	1	-2	
Southern	HDC	K124	no data	1	1	-2	
Southern	HDC	K125	no data	1	1	-2	
Southern	HDC	K126	no data	1	1	-2	
Southern	HDC	K127	no data	1	1	-2	
Southern	HDC	K128	no data	no data	1	-2	tads
Southern	HDC	E4	1	no data	1	-2	
Southern	HDC	W4	1	1	no data	-2	
Southern	HDC	W5	1	no data	1	-2	
Southern	HDC	C3	no data	1	1	-2	
Southern	HDC	C4	1	1	1	-2	
Southern	HDC	C5	1	1	1	-2	

Tads	tadpoles
Mets	metamorphs

0	dry
0.3	low
0.5	intermediate
1	good

2	*Gambusia* present
1	*Gambusia* (re)appeared
0	unknown status
-1	*Gambusia* disappeared
-2	*Gambusia* absent

Up until the 2019-20 breeding season, repeated years of dry summers excluded *Gambusia* from an increasing number of surveyed wetlands. This year, however, the fish has reappeared in 15 wetland sites in which detection did not occur by the end of the previous year, and is now present across all three islands zones. As of March 2020, 25 wetland sites are believed to contain *Gambusia*, compared to seven sites in 2020, 13 sites in 2019, 16 sites in 2018 and 24 in 2017. This reverse in trend is likely due to the limited amount of pond drying that occurred during the winter period and throughout the breeding season, given high amounts of rainfall.

Breeding was detected in seven wetlands, as noted by the presence of *L. aurea* tadpoles and/or metamorphlings. This is less than the previous breeding season (19 wetlands), which was a high across the island over the past seven years. Breeding in the current season occurred across all three zones, including in the northern zone (NCIG-7.2) which did not see any breeding in the previous season, and one wetland site that has recently been constructed (K128). There were no similarities in breeding sites between the current and previous breeding seasons except for K105B. Tadpoles were detected only in round 3 and only in ponds with *Gambusia* absent. In contrast, metamorphlings were detected in round 2 and 3, and in ponds with and without *Gambusia*.

Hydrology

Higher than average rainfall during the end of the previous season and over the course of the winter, nonbreeding period caused nearly all wetland sites to be full of water by the start of the 2020-21 season. In fact, the only site to be dry was K106A. No wetland drying was detected in subsequent rounds and K106A was recharged by round 2, suggesting that strong rainfall kept all sites full of water throughout the season. This is compared to the previous breeding season, were a majority of wetland sites dried entirely mid-season due to lower than average summer rainfall. Due to the lack of change in wetland hydrology between primary VES rounds this season, figures have not been provided for this section.

Salinity

The maximum salinity levels recorded across the breeding season are shown in Figure 3.2.5. A majority of surveyed wetlands (71%) recorded salinity values less than 2 ppt, well below the known tolerance levels observed for successful development in *L. aurea* tadpoles (up to 5 ppt in the field). A further 8% of wetlands had salinity values ranging between 2 and 5 ppt, while 21% of wetlands had salinity values above 5 ppt. As with the previous season, the highest salinity levels were seen at wetlands in the Central Zone, including K9C (36 ppt) and BHP-14A (28 ppt), indicating connectivity with estuarine water, especially during drier periods when they can be inundated by estuarine water during king tides. Generally, salinity was lower in constructed wetlands in the Industrial Zone compared to natural wetlands across the island.

Breeding only occurred at waterbodies with maximum salinity values below the known tolerance levels for *L. aurea* tadpoles. Ponds with evidence of breeding with the highest salinity values where the K105 wetlands (values ranging between 1.6 and 1.9 ppt). However, it must be stated that maximum salinity levels were not necessarily recorded at the same time that breeding was observed.

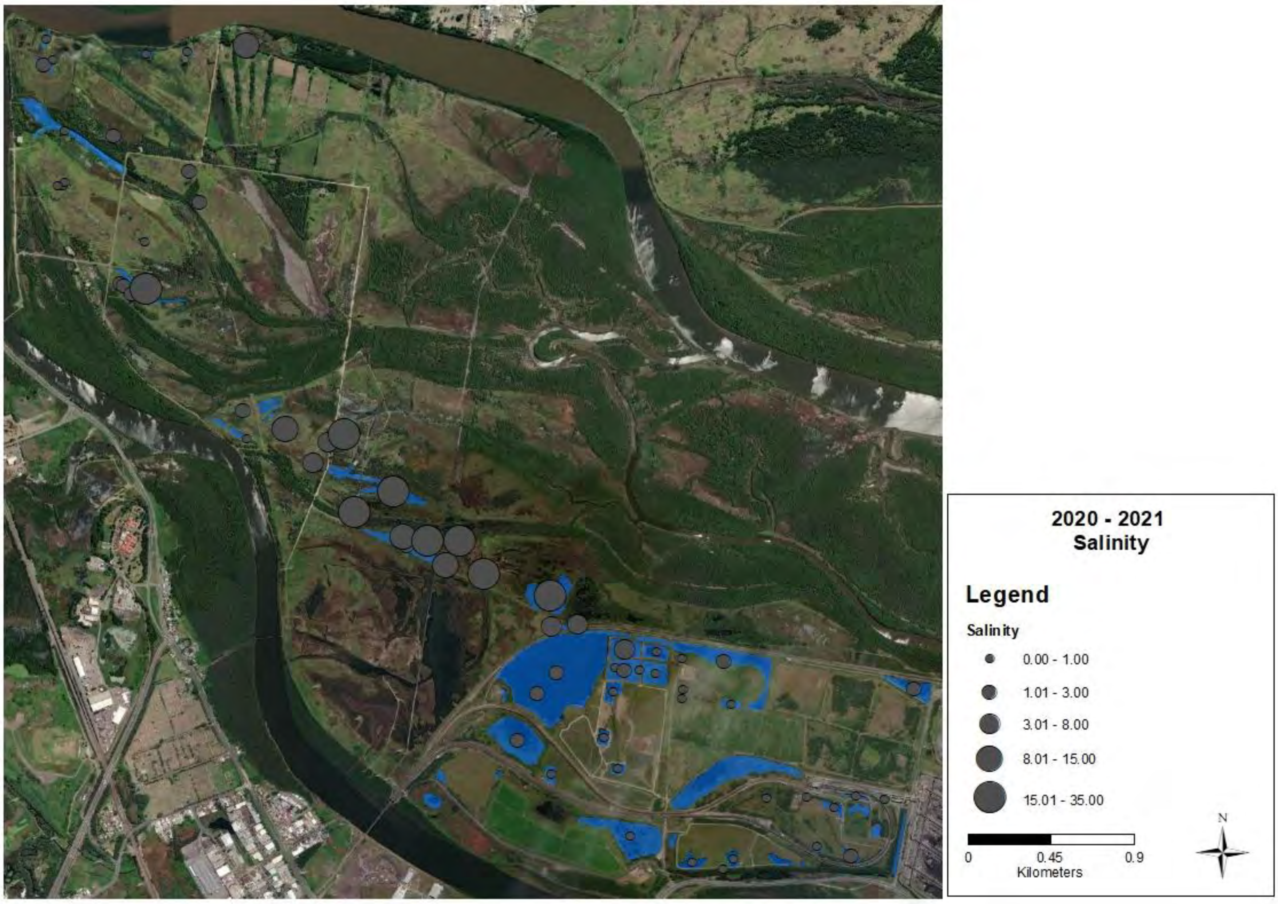


Figure 3.2.5: Maximum salinity levels (ppt) recorded across the 2020-21 survey season.

Table 3.2.2: Maximum salinity recorded at wetlands during the 2020-21 season

Pond	max salinity (ppt)
K2	0.69
K3	0.41
K4	1.00
K5	15.85
K7	1.93
K58B	22.64
NCIG-1.1	1.20
NCIG-3.1	0.48
NCIG-4.7	1.20
NCIG-5.1	0.23
NCIG-7.1	2.45
NCIG-T13	0.87
NCIG-T14	0.42
NCIG-T15	0.72
BHP-1A	0.46
BHP-2C	
BHP-3A	1.81
BHP-4B	
BHP-14A	31.94
K9A/B	8.18
K9C	35.90
K9	4.21
K26	24.85
K48	27.94
K13	1.96
K21	15.20
K63	25.29
K22	3.98
K23	3.73
K104	1.84
K103	1.32
K105A	1.97
K105AS	1.72
K105B	1.63
K106A	
K106B	0.35
K106C	0.39
K29	0.80
C1	0.19
K31	0.69
K34	0.27

Pond	max salinity (ppt)
K42	0.94
K102	
K36	
C2	0.00
K115	0.34
K116	0.66
K100A	
K108	
K111	1.01
K112	0.21
K113	0.14
K114	0.96
K121	0.09
K122	0.07
K123	
K46	
K49B	0.30
K117	
K118	
K124	0.14
K125	0.10
K126	0.14
K127	0.31
K128	

Hydroperiod

It has become increasingly apparent that a mosaic of interconnected wetland habitats is required to maintain a healthy *L. aurea* population on Kooragang Island. Wetland hydroperiod is a key attribute of such mosaics, with clear evidence to suggest that frogs transition between sites due to spatio-temporal differences in resource availability. In particular, ephemeral sites are often used for breeding when they are recharged by rainfall, while more permanent sites are used as refuge when conditions become dry.

In this report, wetland hydroperiod has been categorised at a 'fine-grain' to capture the complexities of habitat that we perceive in the course of fieldwork and to ensure that it is relevant to understanding *L. aurea* ecology (Table 3.2.2). The 'finer-grained' categorisation used here has several advantages:

- It helps explain current *Gambusia* distribution; i.e., by distinguishing between wetlands that did not dry out in a drought year (deep permanent), and those that did dry out, the categorisation system accounts for the distribution and density of *Gambusia* immediately following a drought.
- It better shows the range of wetland hydroperiods in locations with good *L. aurea* numbers (e.g. around K29). This subtle variation in wetland hydroperiod within a relatively small area may be an important factor in determining habitat mosaics that support *L. aurea*.

Wetlands were allocated to one of these categories, based upon hydrology data from 2015-16 (a wet year) and 2016-17 (a dry year), as well as 2017-18 and 2018-19 (drought years) (Table 3.2.3, Figure 3.2.6, Figure 3.2.7).

Table 3.2.2: Categories of wetland hydroperiod used in the present analysis of *L. aurea* habitat on Kooragang Island

Category	Notes	Score
Managed (effectively permanent)	Artificial/operational ponds whose water levels can be regulated by deliberate removal or addition of water. (e.g., cluster ponds, NCIG conveyor ponds)	9
Saline (irregular)	Wetlands that can be influenced by large tides when their own levels of fresh water are low (i.e., a king tide during a drought). Lack of tidal flushing can produce hypersaline conditions (e.g., K26)	8
Saline (regular)	Wetlands that are close to estuarine waters and which are influenced by regular tidal cycles (e.g., K5)	7
Deep Permanent	Deep wetlands that always hold water	5
Nearly permanent	Hold water year around, except in drought (e.g., 2017-18)	4
Semi-permanent	Hold water year around in normal years but not in dry years (e.g., 2016-17)	3
Seasonal (long-term ephemeral)	Hold water for long periods after rain	2
Temporary (short-term ephemeral)	Hold water for short periods after rain (e.g., K106A, K106B), sufficient to allow breeding by *L. aurea*	1
Non-breeding ephemeral	Wetlands that even after significant rainfall only hold water for a period too short for successful breeding by *L. aurea* (e.g., K7)	0

Wetland	Score	Description
K2	2	Seasonal
K3	3	Semi-permanent
K4	2	Seasonal
K5	7	Saline (regular tidal)
K7	1	Temporary
K58B	8	Saline (irregular)
NCIG_1.1	5	Deep permanent
NCIG_3.1	2	Seasonal
NCIG_4.7	5	Deep permanent
NCIG_5.1	3	Semi-permanent
NCIG_7.1	5	Deep permanent
NCIG_T13	5	Deep permanent
NCIG_T14	2	Seasonal
NCIG_T15	5	Deep permanent
BHP-1A	5	Deep permanent
BHP-2C	5	Deep permanent
BHP-3A	5	Deep permanent
BHP-4B	3	Semi-permanent
BHP-14A	8	Saline (irregular)
K9A/B	8	Saline (irregular)
K9C	8	Saline (irregular)
K9	3	Semi-permanent
K26	8	Saline (irregular)
K48	8	Saline (irregular)
K13	2	Seasonal
K21	8	Saline (irregular)
K63	8	Saline (irregular)
K22	2	Seasonal
K23	4	Nearly permanent
K104	5	Deep permanent
K103	5	Deep permanent
K105A	5	Deep permanent
K105AS	5	Deep permanent
K105B	3	Semi-permanent
K106A	1	Temporary
K106B	1	Temporary
K106C	4	Nearly permanent
K29	4	Nearly permanent
C1	9	Managed
K31	3	Semi-permanent
K34	3	Semi-permanent
K42	4	Nearly permanent
K102	5	Deep permanent
K36	5	Deep permanent
C2	9	Managed
K115	9	Managed
K116	9	Managed
K100A	5	Deep permanent
K108	1	Temporary
K111	3	Semi-permanent
K112	2	Seasonal
K113	2	Seasonal
K114	3	Semi-permanent
K121	3	Semi-permanent
K122	3	Semi-permanent
K123	3	Semi-permanent
K46	3	Semi-permanent
K49B	4	Nearly permanent
K117	5	Deep permanent
K118	4	Nearly permanent
K124	4	Nearly permanent
K125	4	Nearly permanent
K126	4	Nearly permanent
K127	4	Nearly permanent
K128	4	Nearly permanent

Table 3.2.3: Categorisation of hydroperiod for the primary 65 wetlands surveyed in the 2020-21 season.

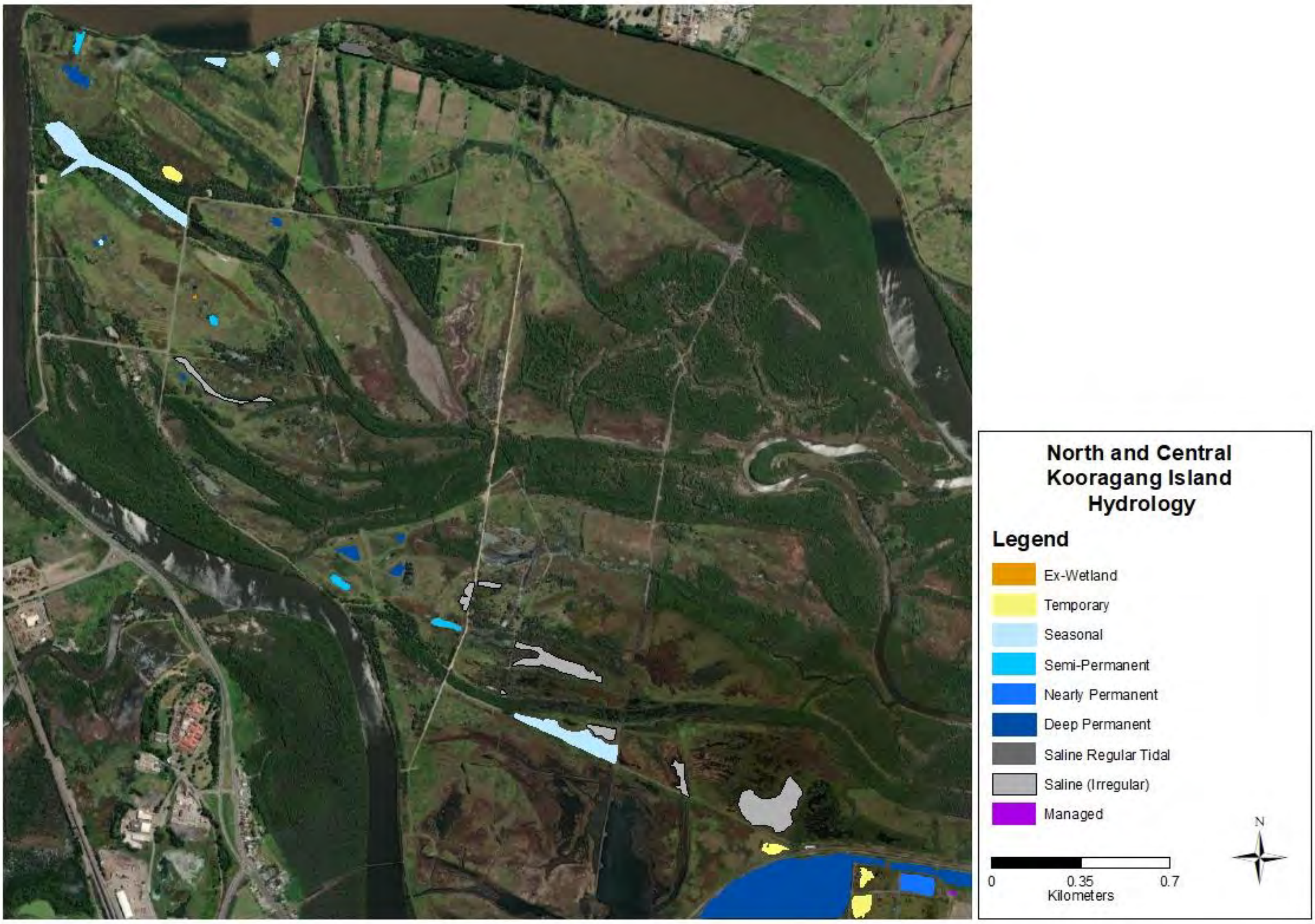


Figure 3.2.6: Hydroperiod scores for wetlands across the Northern and Central Zones of Kooragang Island, updated using information from the 2020-21 survey season. See text for explanation of categories

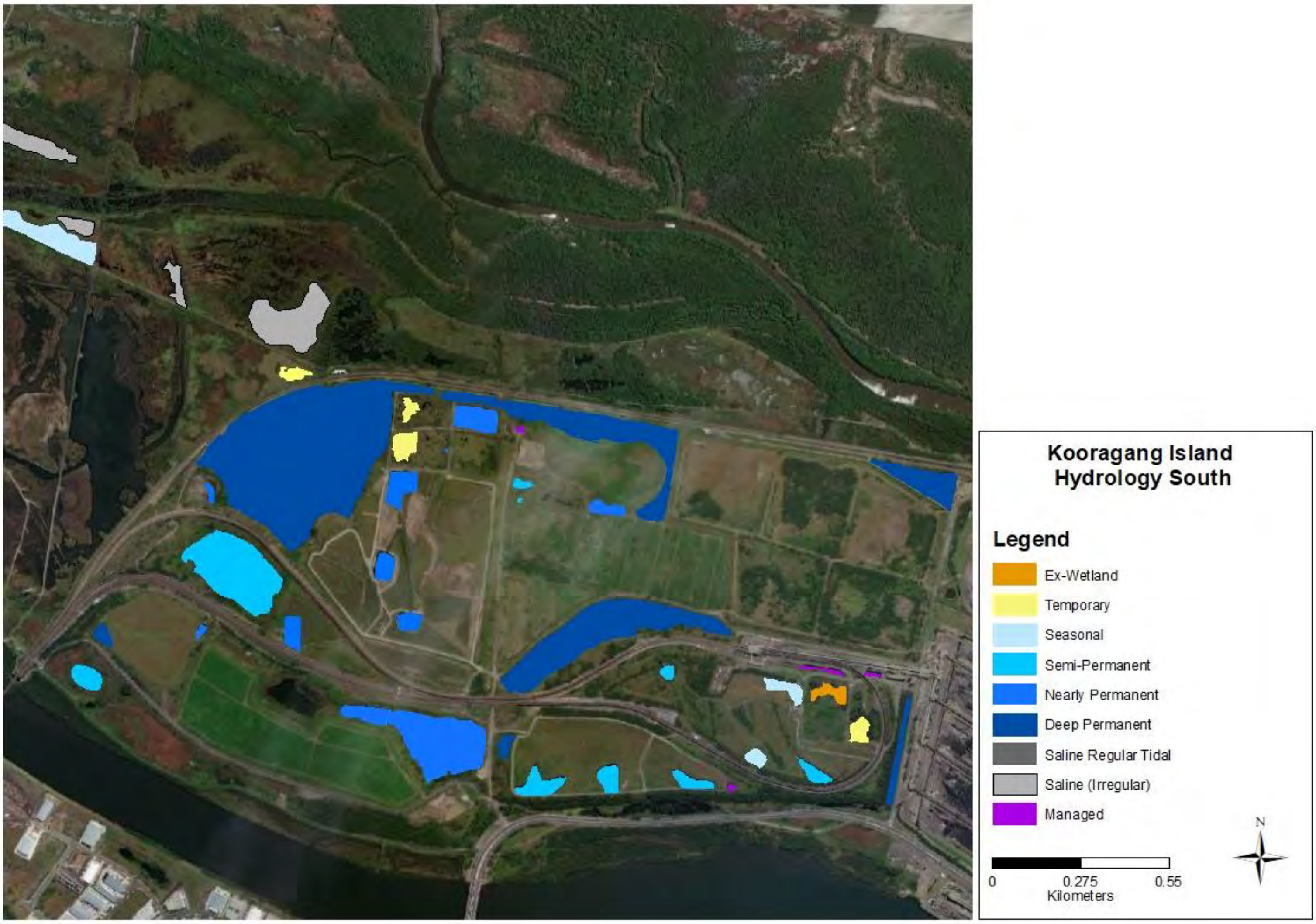
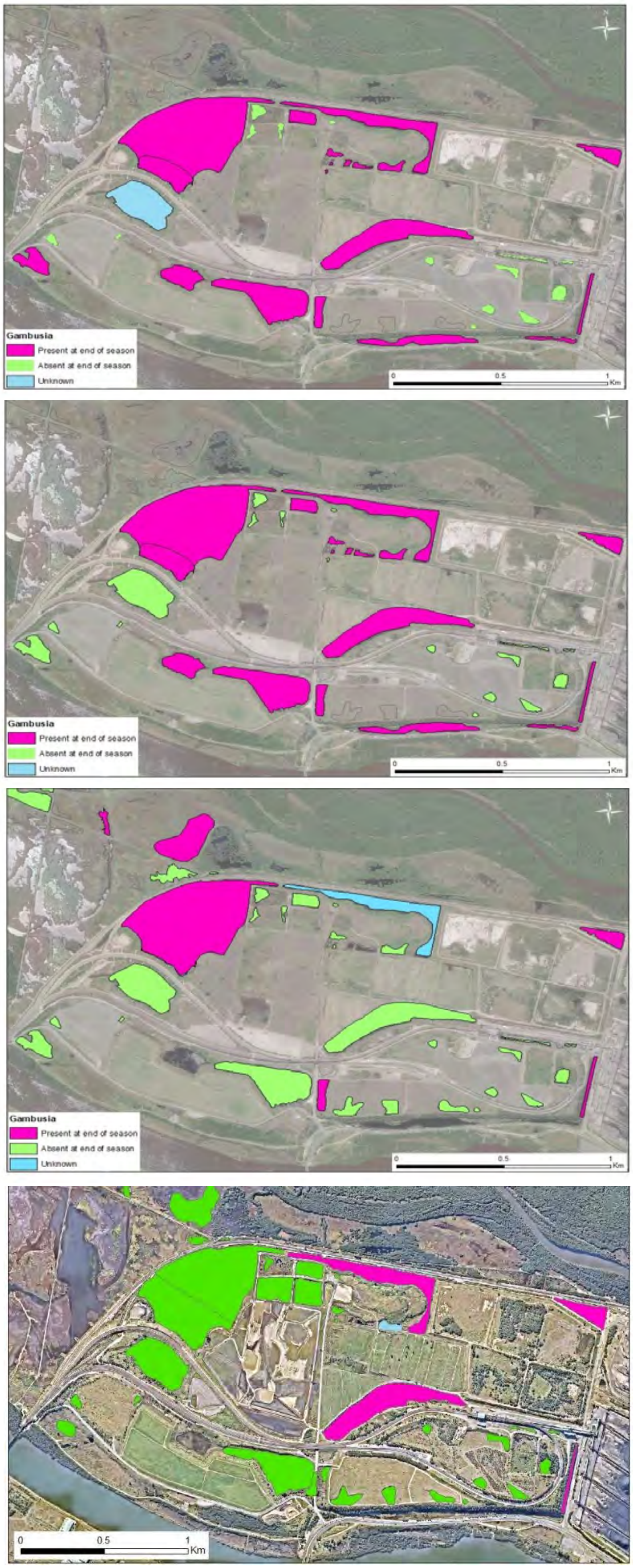


Figure 3.2.7: Close-up of wetland hydroperiod in the Industrial Zone of Kooragang Island. See text for explanation of categories. Note the diversity of hydroperiod categories for wetlands around K29 and the Rail-loop (c.f. habitat mosaic)

Gambusia



The repeated and incremental cycles of drying and recharging of wetlands has gradually removed *Gambusia* from much of the system since 2016. Across Kooragang Island, the number of wetlands with *Gambusia* present has declined from 65 in March 2016 to seven in March 2020 (Table 3.2.1). Within the Industrial Zone, only 13 wetlands were free of *Gambusia* in March 2016; by March 2020 that number had increased to 27, with *Gambusia* detected in only four wetlands within that zone (K100A, K102, K103 and K104). This trend over the recent years has largely been driven by lower-than-average rainfall. However, the arrival of a La Niña event in 2020-21 saw higher than average rainfall, which has reduced the number of wetlands that have dried this season. The total number of ponds on the island with Gambusia present has increased to 25. In the Industrial Zone, *Gambusia* were detected in 10 wetlands by the end of the current season.

Note that *Gambusia* have always been absent from the constructed HDC wetlands and the cluster ponds.

Figure 3.2.8: Distribution of *Gambusia* across the **Southern** part of Kooragang Island, late summer of 2016 (top), 2017 (middle), 2018 (middle), and 2019 (bottom).

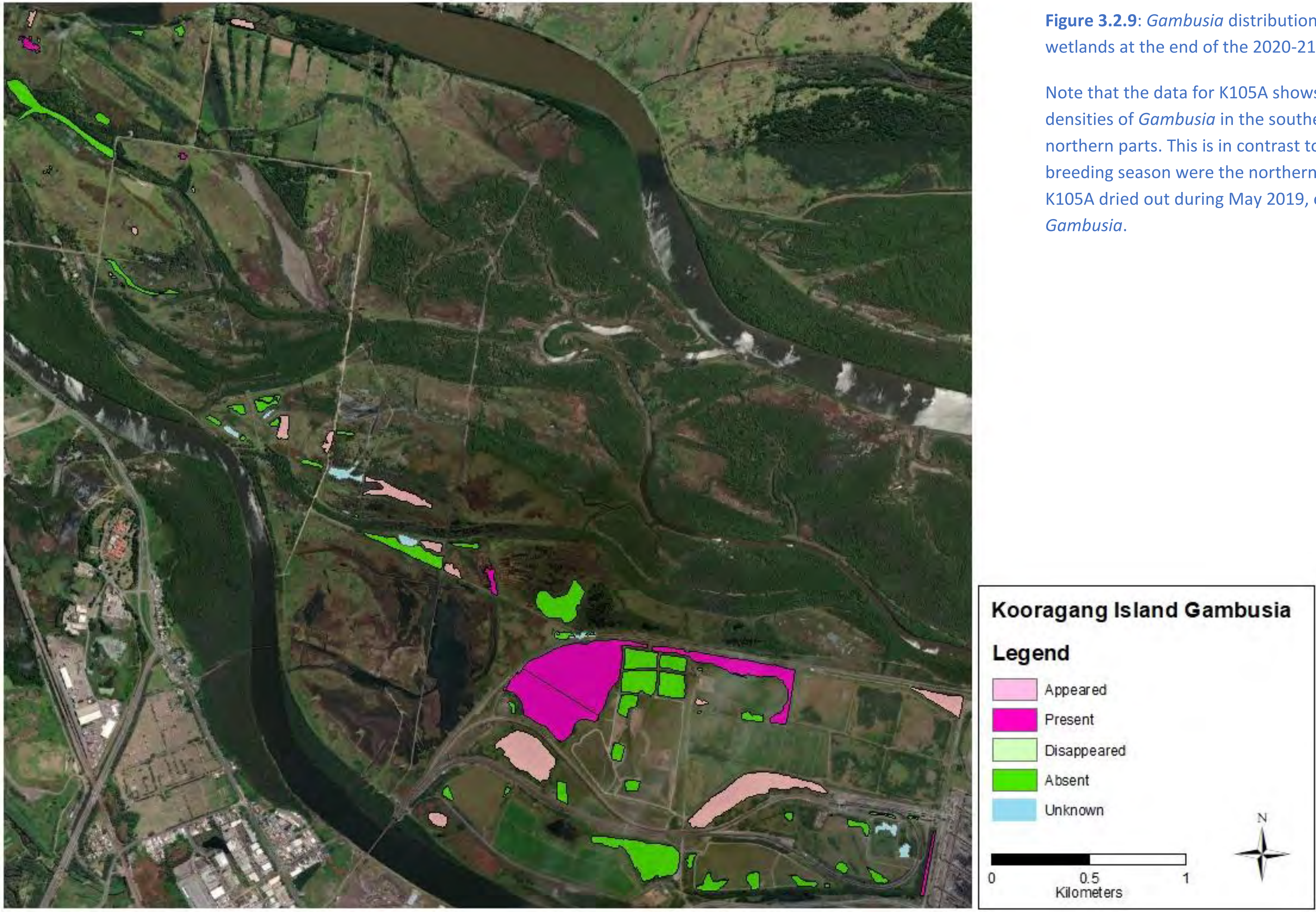


Figure 3.2.9: *Gambusia* distribution across wetlands at the end of the 2020-21 season.

Note that the data for K105A shows very low densities of *Gambusia* in the southern and northern parts. This is in contrast to the previous breeding season were the northern part of K105A dried out during May 2019, eliminating *Gambusia*.

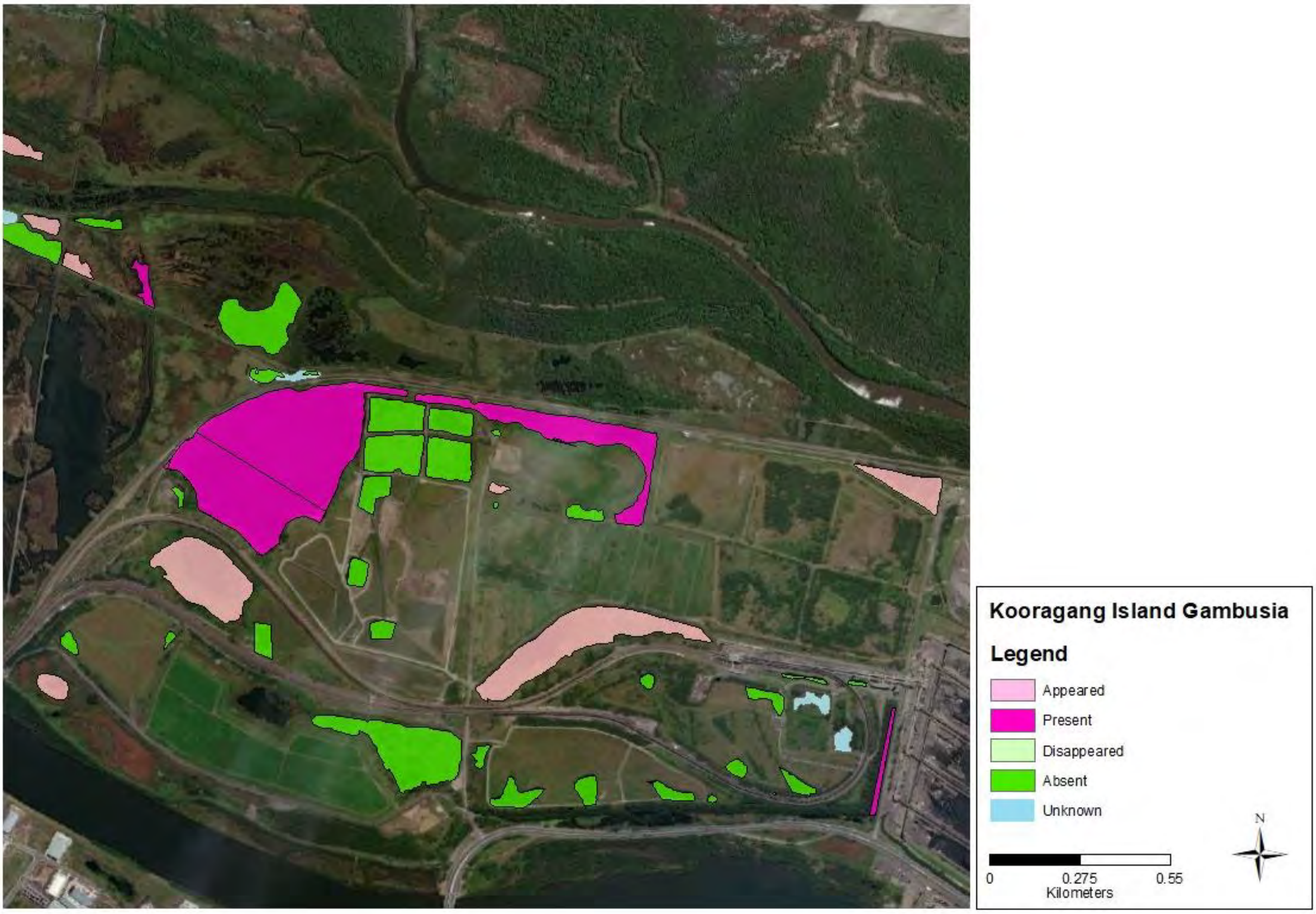


Figure 3.2.10: Gambusia distribution for the wetlands around the Industrial Zone; see Figure 3.2.9 for explanation.

3.3. Distribution of *Litoria aurea* across Kooragang Island

The distribution of *L. aurea* across Kooragang Island is shown using:

i. Search Sensitivity plots showing the number of frogs detected per unit search effort – it is thus a proxy measure of density or relative abundance (although it is affected by detectability).
ii. Demographic plots showing absolute numbers detected during standardised visual encounter surveys (VES).
iii. Demographic plots differ from search sensitivity plots in that they indicate the actual number of *L. aurea* detected during primary VES. They also show a demographic breakdown of those survey numbers. While VES surveys are standardised and timed for each wetland, many *L. aurea* are detected outside of the primary VES, such as in a secondary VES (which are undertaken for a variety of reasons, such as surveying for breeding behaviour following rain), and those detections are also shown in these figures.

Figure 3.3.1/2 shows Search Sensitivity calculated for primary VES for the three completed principal survey rounds (i.e. rounds 1, 2 and 3). Figure 3.3.3 shows the metric pooled across the whole season. Frogs were widely distributed across southern Kooragang, particularly across wetlands within the south region of the Industrial Zone (as with the previous two year). High densities were detected across the Industrial Zone, with the highest search sensitivity values obtained at K116, C4 and K106C. Unlike the previous season, high search sensitivity values were also obtained for the Central Zone (e.g. BHP-14B and BHP-4A). Significantly lower densities were obtained for the Northern Zones, which are findings similar to previous seasons.

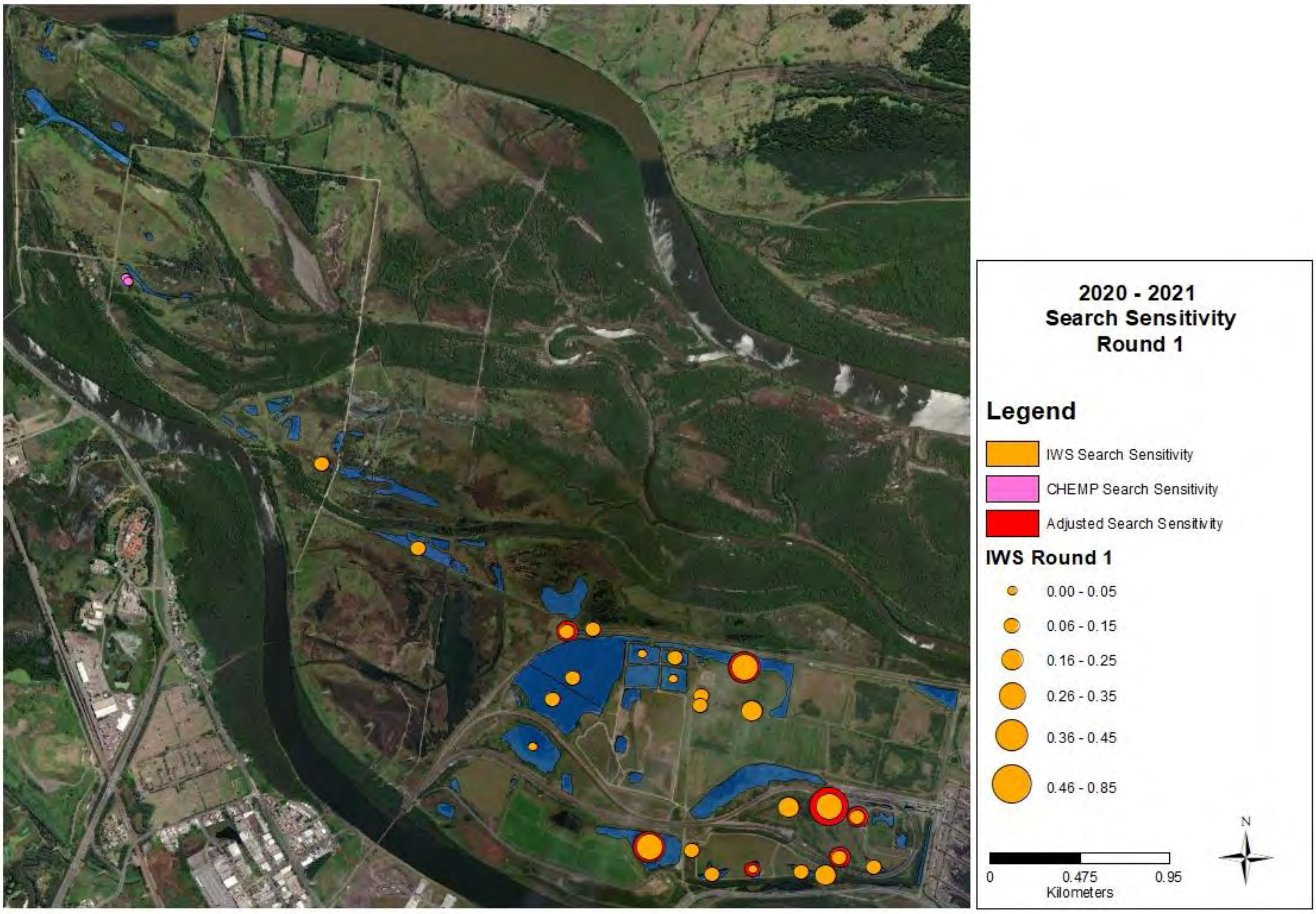


Figure 3.3.1: Search sensitivity (frogs detected per person.minute) across the 65 wetlands surveyed as part of 'whole island' monitoring in 2020-21, for Round 1 (September 2020).

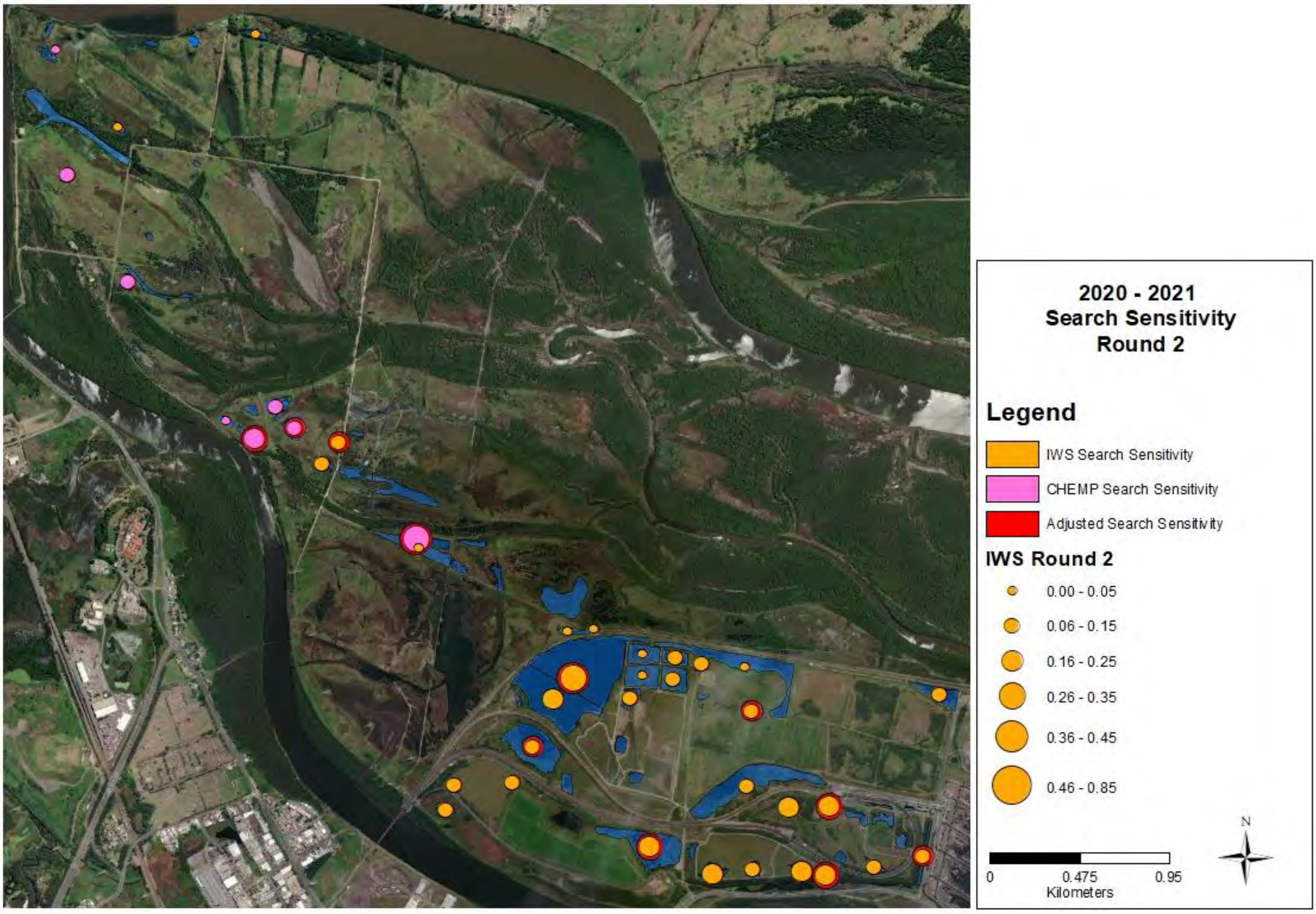


Figure 3.3.2a: Search sensitivity (frogs detected per person.minute) across the 65 wetlands surveyed as part of 'whole island' monitoring in 2020-21, for Round 2 (November, 2020).

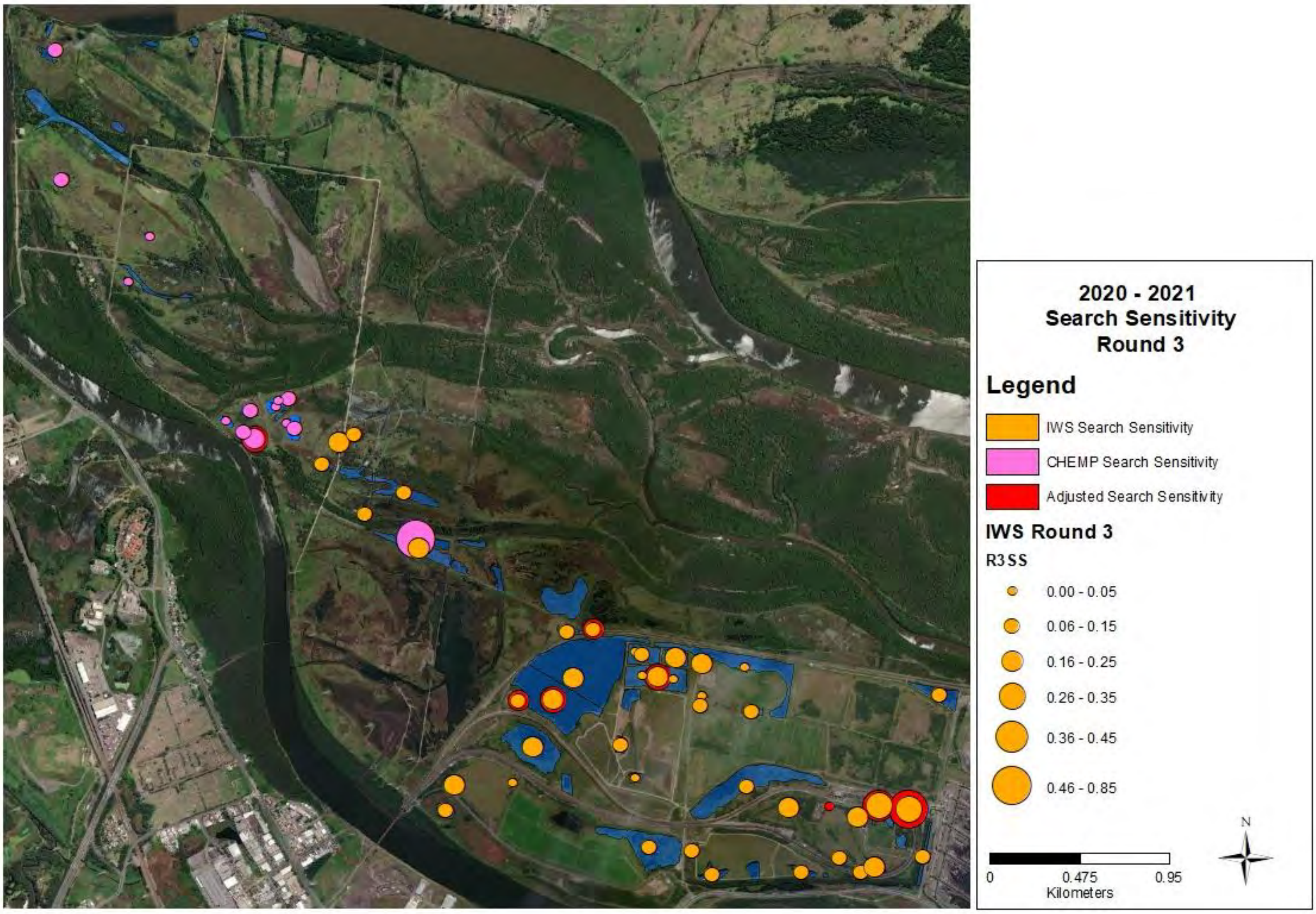


Figure 3.3.2b: Search sensitivity (frogs detected per person.minute) across the 65 wetlands surveyed as part of 'whole island' monitoring in 2020-21, for Round 3 (Febuary2021).

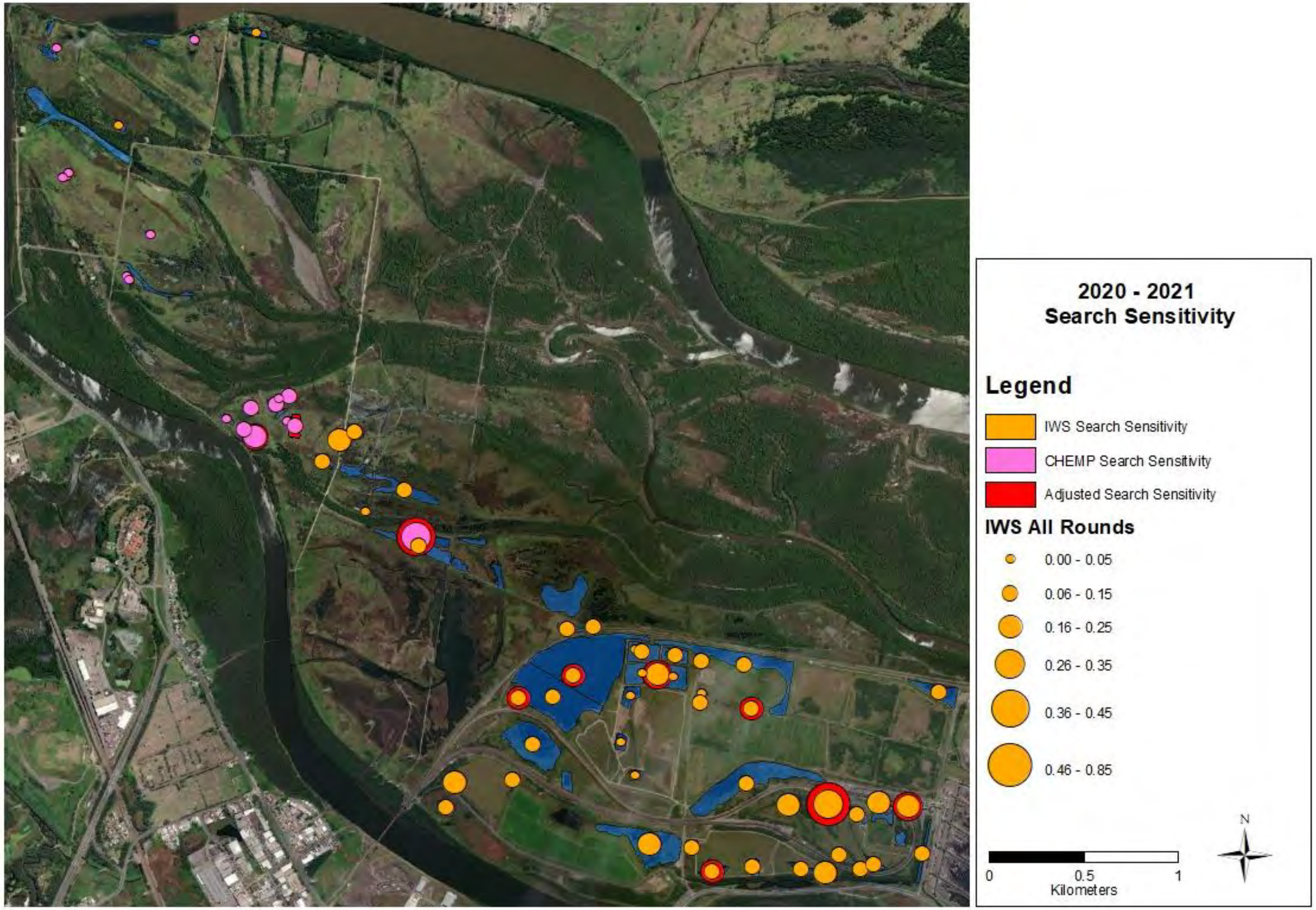


Figure 3.3.3: Search sensitivity (frogs detected per person.minute) across the 65 wetlands surveyed as part of 'whole island' monitoring in 2020-21, pooled across the principal survey rounds.

'Unadjusted' search sensitivity is simply <frogs detected in 1° VES> / <search effort at each wetland (in person.minutes)>. This is the same calculation as used in previous reports (and should be used when comparing data with those).

'Adjusted' search sensitivity deducts a fixed handling time (1 minute for each frog captured) from the total search effort for each wetland. This provides a better comparison between wetlands with high vs low numbers of frogs (within the same season).

Compare with the map of Search Effort (Fig. 2.5.2)

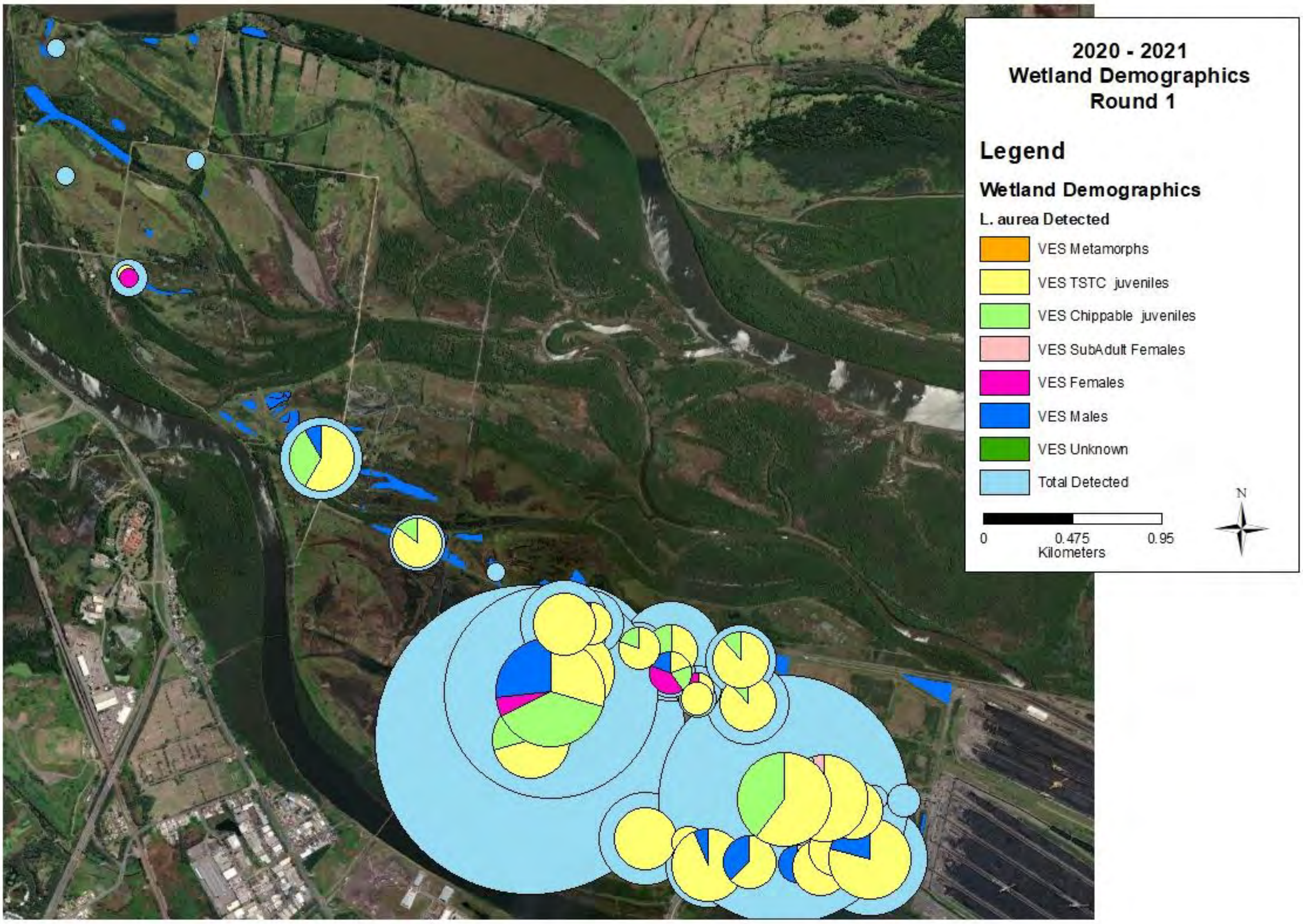


Figure 3.3.4: Demographic breakdown of frogs detected during round 1 in September 2020. **Total Detected** denotes animals that were detected during VES surveys. Breakdown into demographic groups is based upon data taken from frogs captured during VES surveys only. TSTC = 'Too Small to Chip', i.e. juveniles <40 mm SVL; 'Chippable Juvs' are juveniles that are >= 40 mm SVL. 'VES unknown' are animals detected during VES but not captured or readily identifiable as juveniles/adults. See Figure 3.3.5 caption for explanation of demographic categories.

Round 1 (September). Unlike other survey rounds, the first round of surveys was not conducted after a significant rainfall event. September was a period of low rainfall (total of 29 mm) in an otherwise wet season. Large numbers of individuals were detected in the Industrial Zone, including K111, K114, K105A, K105AS, K105B, K123. Within surveys, most animals captured at ponds within the Industrial Zone were juveniles. Within the Central Zone, larger numbers were detected at K9 and K42, which were primarily also juveniles. Juveniles were found in 34 wetlands (Figure 3.3.4), which is more than twice that of the previous season. Presumably, these individuals were spawned during rain in autumn and overwintered as tadpoles, given that no tadpoles or metamorphs were detected in this round. Across the island, there were few adult or sub-adult female detections (< 5 per pond), with most adults detected being male.

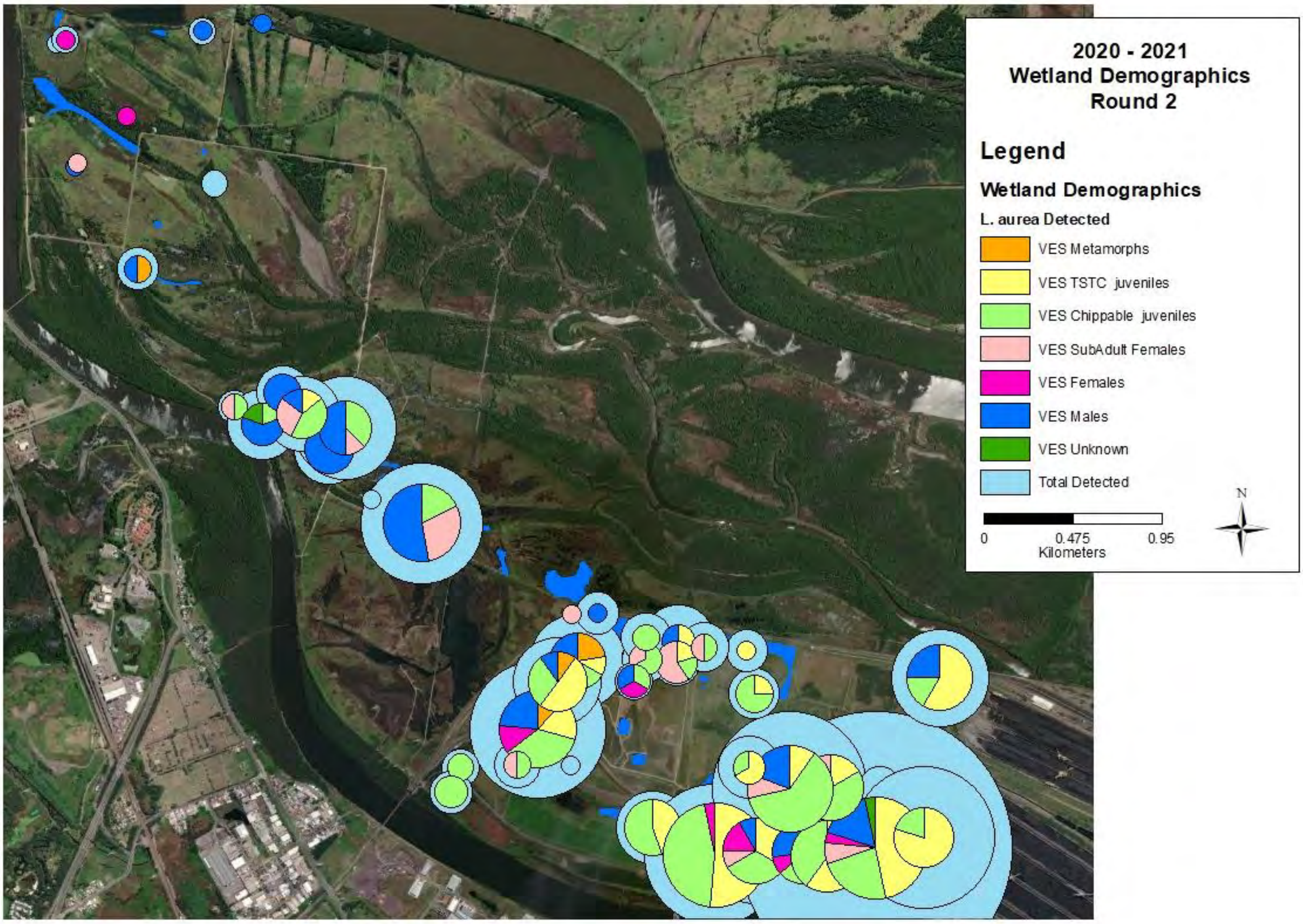


Figure 3.3.5: Demographic GIS plots for round 2 (November). **Total detected** denotes animals that were detected during VES surveys. Breakdown into demographic groups is based upon data taken from frogs captured during VES surveys only. TSTC = 'Too Small to Chip', i.e. juveniles <40 mm SVL; 'Chippable Juvs' are juveniles that are >= 40 mm SVL. 'VES unknown' are animals detected during VES but not captured or readily identifiable as juveniles/adults. Upper map shows the Northern and Central Zones, while the lower shows the Industrial Zone.

Round 2 (mid-late November 2020): commenced after early rainfall in November (~ 30.2 mm in one day), with additional rainfall also occurring throughout the month. Large numbers of frogs were detected primarily in the Industrial Zone, including K111, K114, C2, K100A and K121, as well as some ponds within the Central Zone (e.g. BHP-14B). Juveniles were detected across 42 wetland sites across the island, which is six times that recorded in the previous season. These may have been spawned during rainfall earlier in the season or may have overwintered as tadpoles. For many of the wetlands within the Industrial Zone, a large proportion of detections were still juvenile, similar to what occurred in round 1. In contrast, smaller proportions of juveniles versus adults were detected in the Central and Northern Zones.

As juvenile *L. aurea* move readily cross the landscape (unpublished data), their presence does not necessarily indicate breeding at these wetlands but does provide evidence to suggest they contain suitable habitat for young animals. More direct evidence of breeding, including metamorphs, were detected at three wetlands within the Industrial Zone (K105A, K105AS and K105A), as well as one wetland in the Northern Zone (NCIG-7.2). This suggests that's breeding occurred earlier in the season.

A larger number of adults were detected in this round compared to first. The largest adult populations detected were primarily of males in the industrial Zone (e.g. K111, and K105B) and the Central Zone (e.g. BHP-14B). The only large female population was detected at K111 (~ 20 individuals).

Round 3 (early-mid February 2021): This round started after a large rainfall event early in the month (114 mm over 8 days), with rainfall occurring throughout the month as well (total of 157 mm). The largest number of detections occurred primarily within the Industrial Zone (e.g. K111, K100A, K105A and K105B), as well as K22 within the Central Zone (Figure 3.3.6). Smaller numbers of juveniles were detected at ponds in this round when compared to the previous two, with the largest juvenile populations recorded at K23, K100A and K111. Even so, juveniles were still detected at 37 wetland sites. A large shift in adult detections was apparent in this round, with large numbers of both males and females found in the industrial Zone (e.g. K111, K100A, K105A and K105B), as well as in the Central Zone (e.g. K22 and K23). Despite the round falling within a wet period of the season, metamorphs were only detected at two wetlands (BHP-4C and K106B), indicating that breeding likely occurred mid-season.

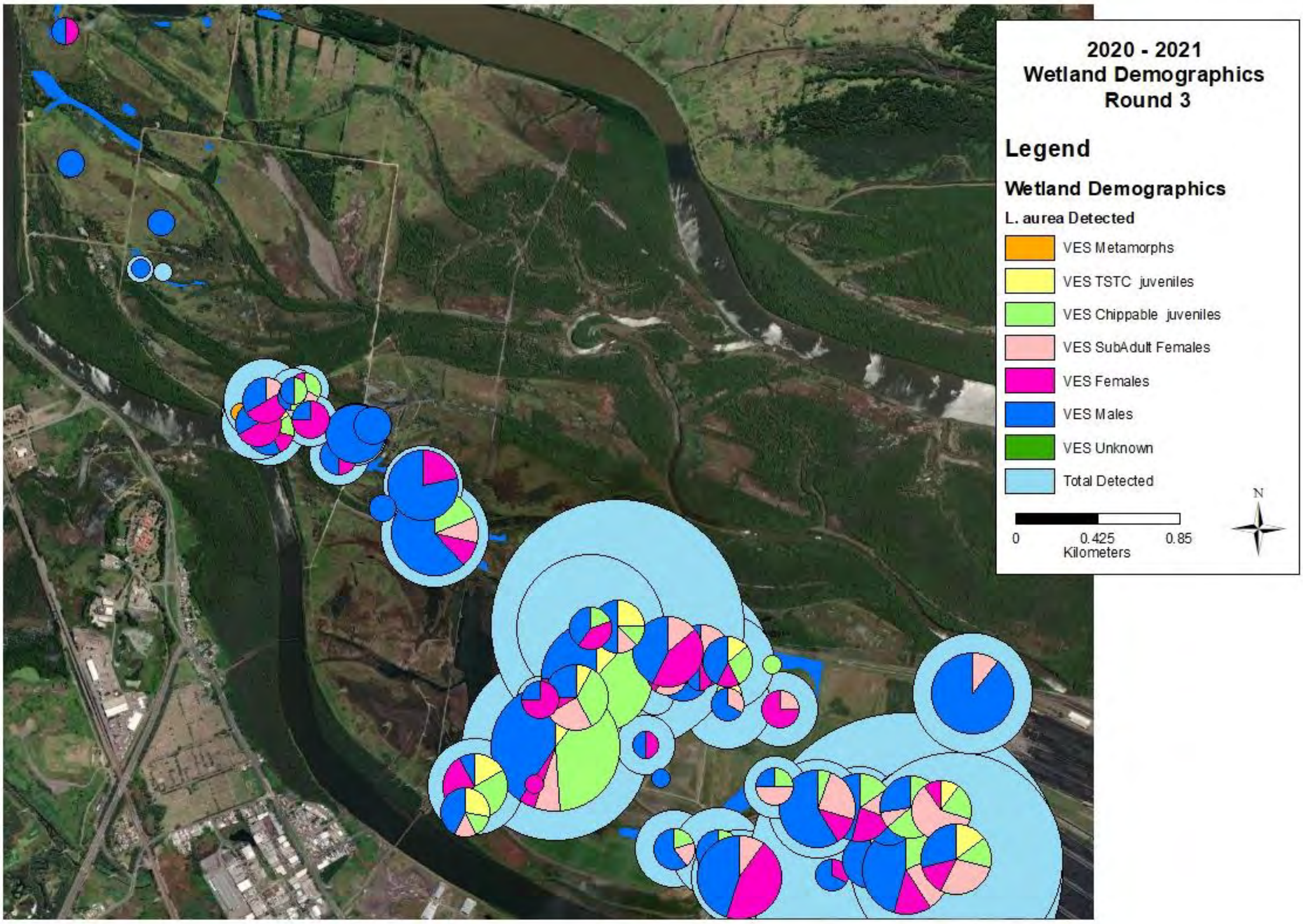


Figure 3.3.6: Demographic GIS plots for round 3 (February). **Total detected** denotes animals that were detected during VES surveys. Breakdown into demographic groups is based upon data taken from frogs captured during VES surveys only. TSTC = 'Too Small to Chip', i.e. juveniles <40 mm SVL; 'Chippable Juvs' are juveniles that are >= 40 mm SVL. 'VES unknown' are animals detected during VES but not captured or readily identifiable as juveniles/adults.

Total detected: Figure 3.3.8 shows all *L. aurea* detected, pooled across all surveys; another version of this is shown in Figure 4.4.1. It shows that relatively large juvenile populations were recorded across the Industrial Zone (K105A, 105AS, K105B, K114 and K111) and some sites within the Central Zone (K22 and K23). What is apparent is that juveniles were detected in a large number of wetlands across the island, which shows that dispersal events likely occurred broadly within Zones. While this is evidence that breeding did occur this season, few tadpoles and metamorphs were detected and only in a small number of wetlands. This is in contrasts to the previous season, indicating that large breeding events did not occur in 2020-21. Nevertheless, evidence of breeding was detected in all three island Zones. What is also apparent is the temporal shift in demographics over the season, with large numbers of juveniles in the first two rounds giving way to large numbers of adults in the third round.

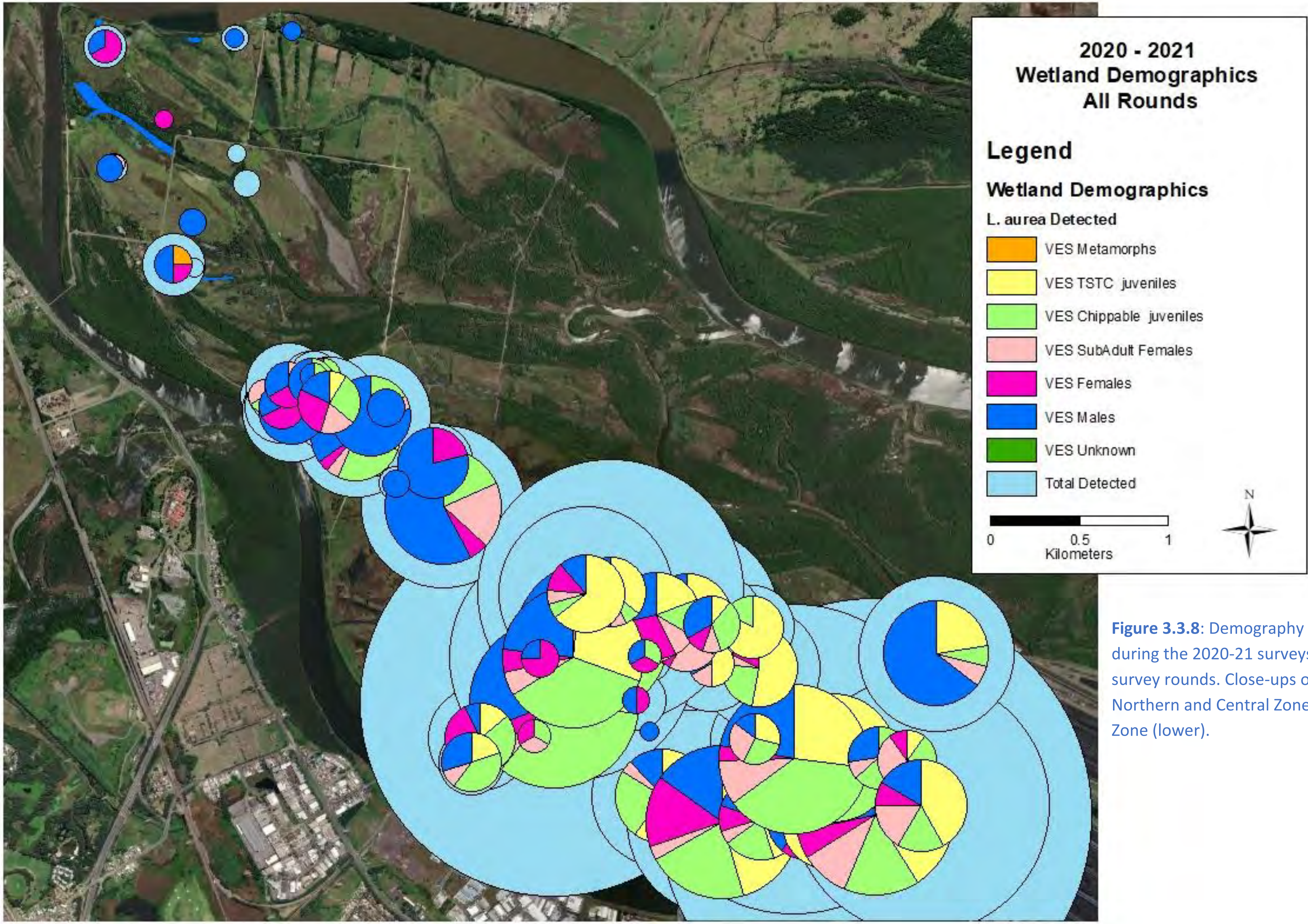
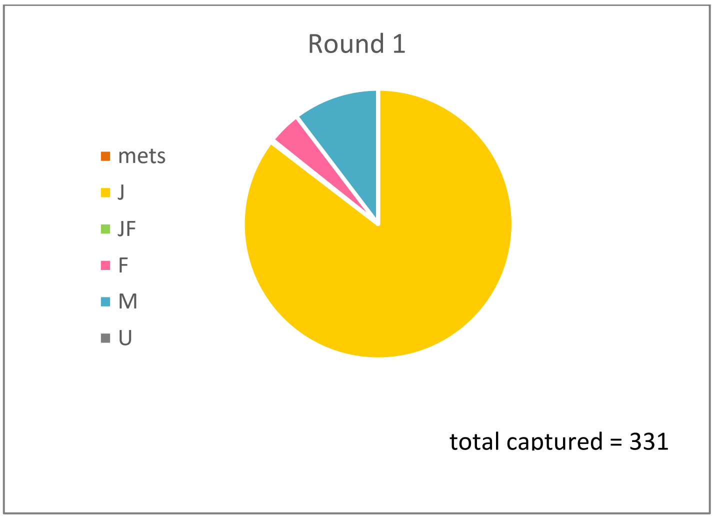
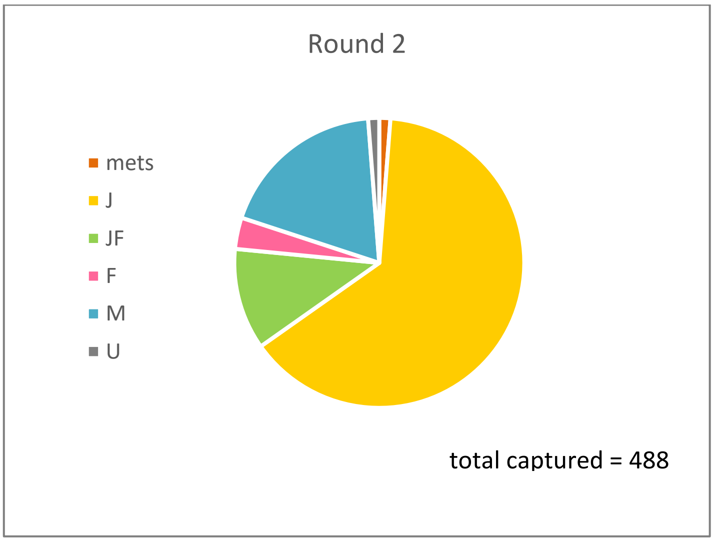


Figure 3.3.8: Demography of all detected frogs during the 2020-21 surveys, summed across all survey rounds. Close-ups on the right show Northern and Central Zones (upper) and Industrial Zone (lower).

3.4. Demographics

Proportions of juveniles, adult males, and adult females





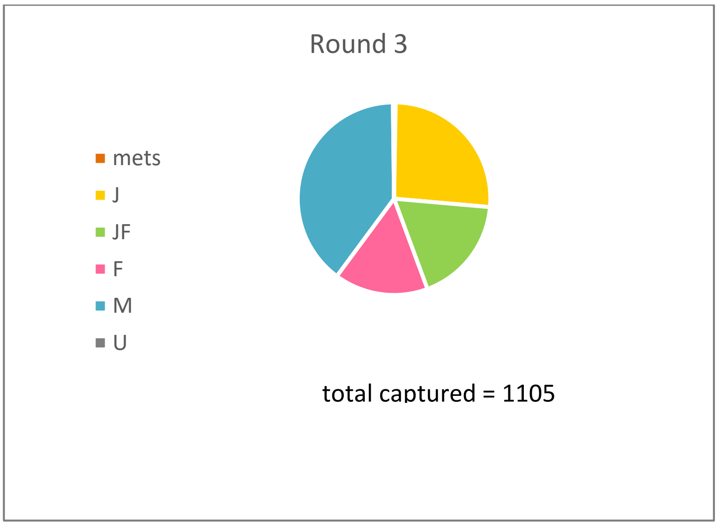
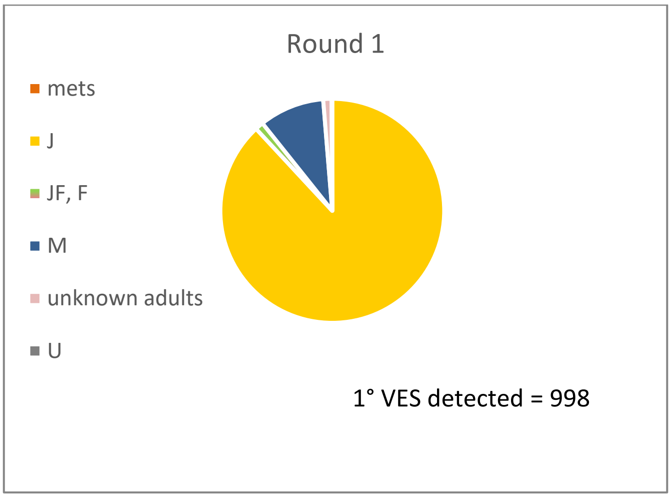
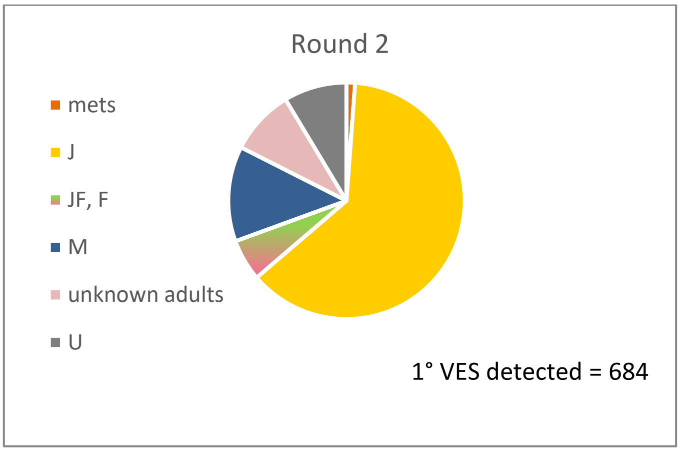


Figure 3.4.1: Summary demographics of all captured *L. aurea* (i.e. VES surveys, including recaptures and non-tagged individuals) for primary rounds. Mets, metamorphs; M, adult males; J, juveniles; JF, subadult females; F, adult females; U, animals of unknown demography.

Figure 3.4.1 presents the demographic data in the preceding section, summarised for **captured** *L. aurea* across all wetlands, whilst Figure 3.4.2 shows the data for VES **detections**. Overall, the highest numbers of *L. aurea* were captured in round 3. In round 1 and 2, the majority of captures were juveniles, making up more than half of all captures in these rounds. This data suggests that animals that had overwintered emerged during the start of the breeding season and that breeding events took place early within the current season as well. This is in contrast to round 3, where a majority of captures were adult males and only a quarter were juvenile captures, suggesting that a smaller breeding event occurred in the second half of the season.

VES Demographics





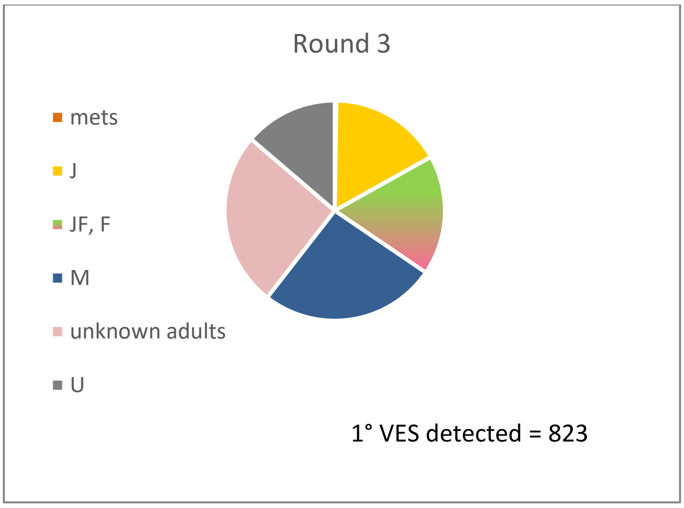


Figure 3.4.2: *L. aurea* detected during primary VES only, by round. M, adult males; F, adult females; JF, subadult females; J, juveniles; mets, metamorphs; unknown adults, *L. aurea* for whom demographic data was not collected (note that for these counts, subadult females and adult females are counted together).

Unique individuals

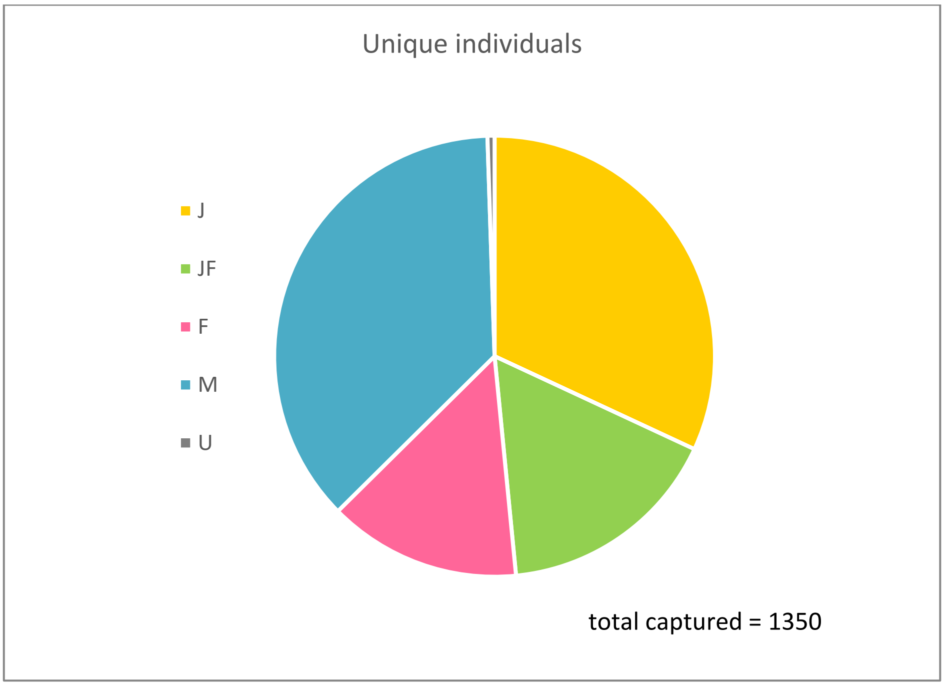


Figure 3.4.3A: Proportions and numbers of PIT-marked individuals captured during 2020-21 VES surveys. See Fig 3.4.1 for legend.

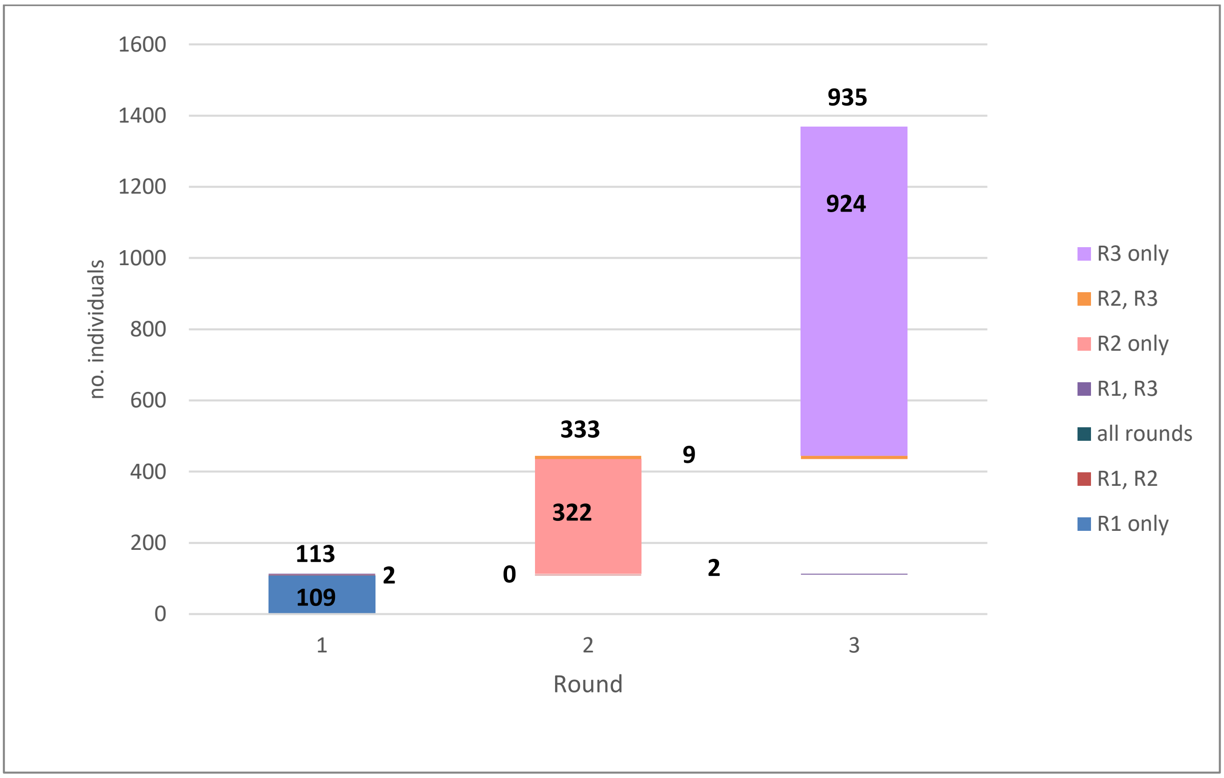
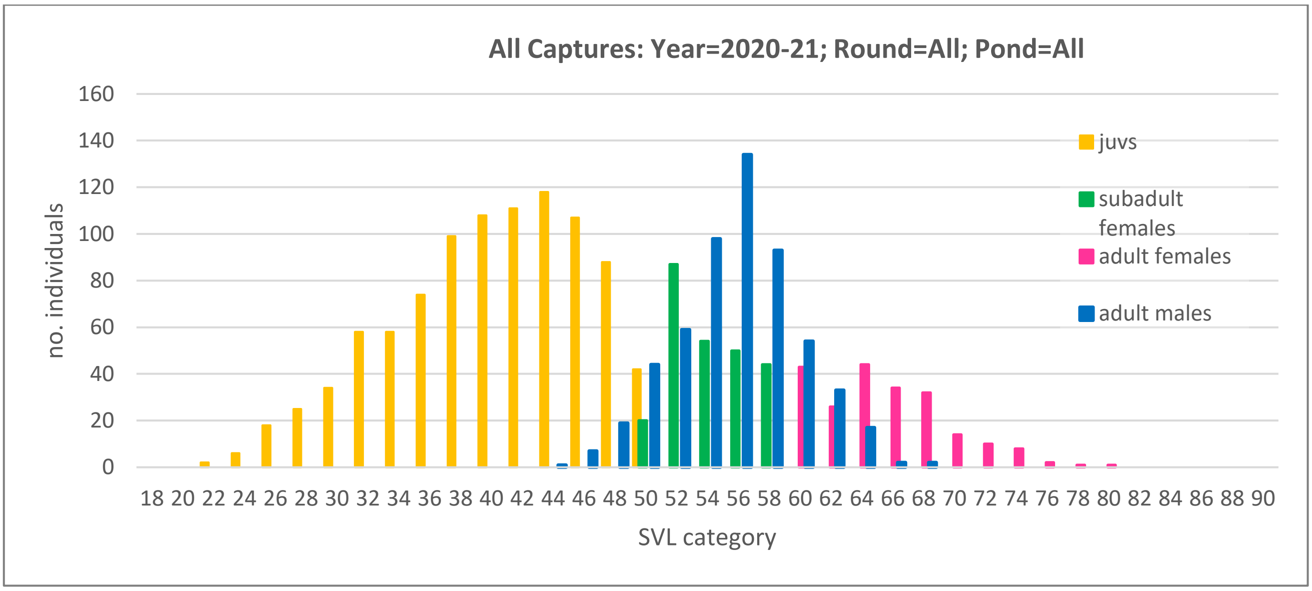


Figure 3.4.3B: Unique PIT-marked individuals captured in each of the three principal rounds, showing those animals caught in multiple rounds versus only one round.

Unique individuals are identified on the basis of PIT tags, and can only be ascertained from captured frogs. Figure 3.4.3A shows that, similar to the previous season, a large proportion of these were adult males, and that there were slightly more adult females than sub-adult females. A large proportion of unique individuals were juveniles, indicating that a large portion of juveniles that were captured were not small and above chippable size.

Figure 3.4.3B shows the pattern of capture of these individuals across the three complete rounds. More unique individuals were recorded in round 3 compared to any other round. A majority of individuals caught in each round were not caught again in the season, including 96% caught only in round 1, 97% caught only in round 2, and 99% caught only in round 3. Most recapture events occurred between successive rounds (e.g. 2 individuals between round 1 and 2, and 9 individuals between round 2 and 3), while a small number of individuals (2) caught in round 1 were re-caught in round 3. No individual was captured in all three rounds.

Size classes and cohorts of captured frogs



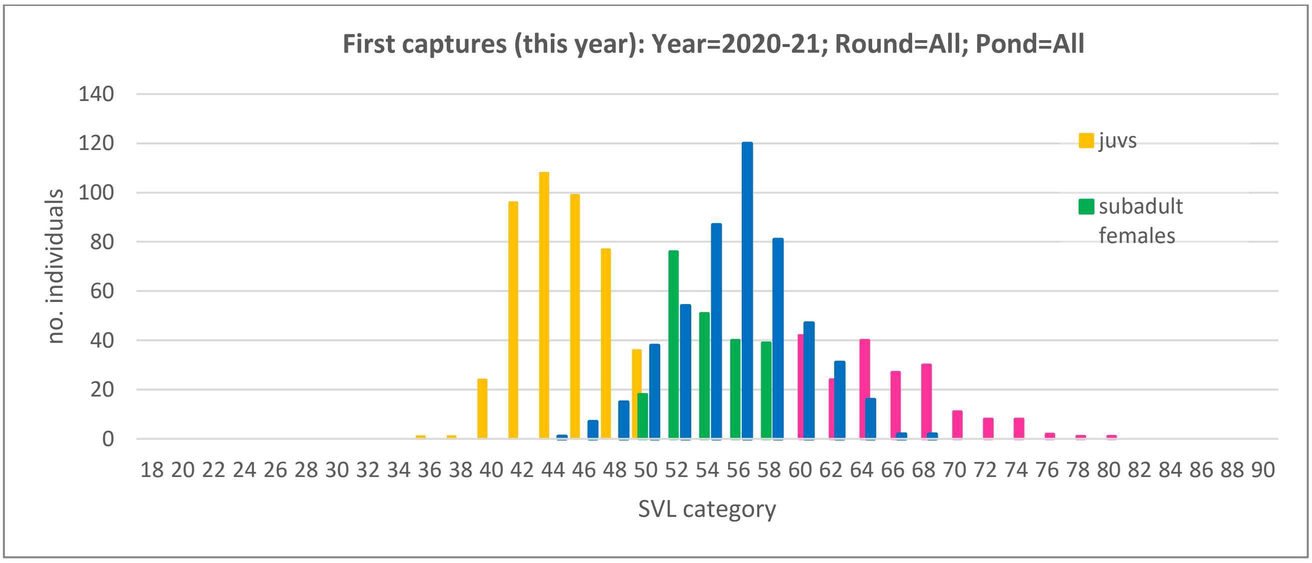


Figure 3.4.4: Frequency distribution of different sized animals captured during VES surveys. Size is measured by snout-vent length (SVL), and size categories are measurements 'binned' into 2 mm groups, i.e. the frequency of animals 56 mm > SVL >= 58 mm is shown in the column labelled '58'. **Top**; all captures where demographic data was recorded. **Below**: 'First captures' shows only unique PIT tagged individuals (generally, SVL > 40 mm), i.e. with recapture data removed.

Figure 3.4.4 shows the frequency distribution of SVL class (in 2 mm 'bins'). The difference between 'all captures' and 'first captures' indicates (1) recaptured individuals (for SVL > 40 mm), and (2) the number of captured juveniles that were too small to mark with PIT tags. As with previous seasons, a relatively larger number of adults captured were male, with most males being between 44 and 68 mm SVL. Unlike the previous season, the largest number of animals captured were juvenile, with sizes ranging between 20 and 48 mm SVL. A large proportion of juveniles were caught at a sufficient size (above approximately 40 mm) to be tagged.

All captures, by round

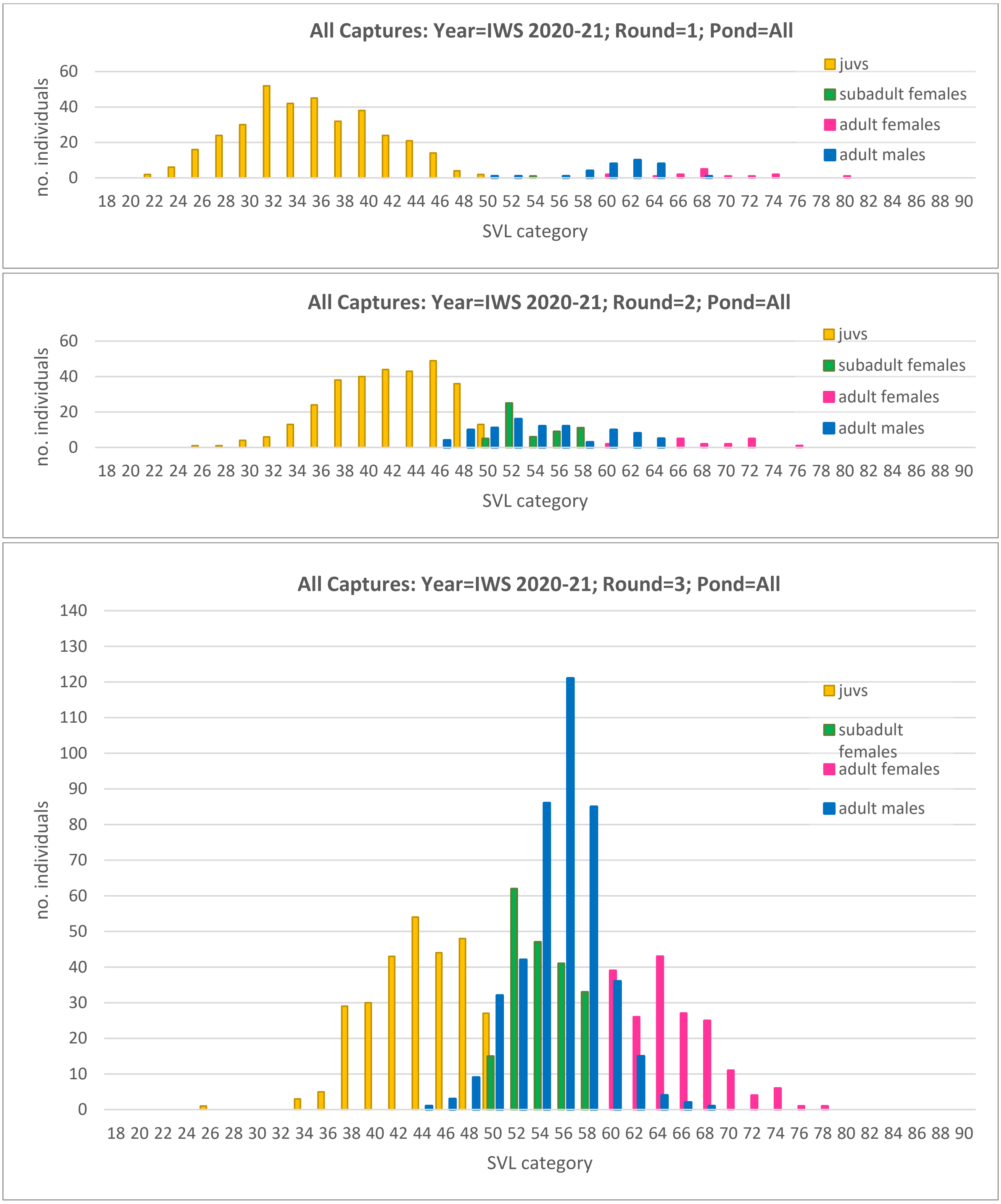


Figure 3.4.5: Frequency distribution of size classes, showing all captures for each survey round (VES). See Fig 3.4.1 for legend and Fig. 3.4.4. for explanation of size classes.

Plots of size/frequency distribution over the different rounds (Figure 3.4.5) show a cohort of mid to large-sized juveniles in round 1 (September); these had a modal SVL of 34-36 mm and were likely spawned late in the previous season. By round 2 (November), this juvenile cohort showed a slight decrease in numbers and a shift in model SVL to 42-44 mm, both of which suggest that the juvenile population was maturing and that recruitment into the adult population had started to occur. The juvenile cohort captured in round 3 (February) shared similar characteristics to the cohort captured in round 2, with a model SVL of 44-46 mm. This juvenile cohort detected in round 3 showed further maturation and recruitment into the adult population. In addition, there was evidence of a new cohort of juveniles that had emerged in round 3, with a model SVL of 26 mm.

Few adults of either sex were captured in round 1. This was also the case in round 2, where there was only a marginal increase in adult numbers, with the addition of a population of sub-adult females. This contrasted to round 3, where a large number of adult males and females were captured. In this round, a greater number of adult males were captured compared to adult females, with the number of adult and sub-adult females captured being relatively equal.

Captures by wetland

K29

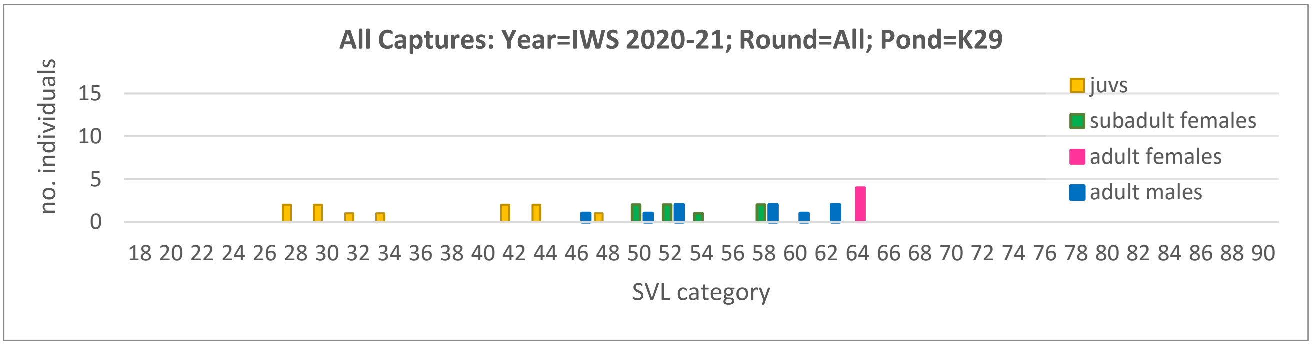


Figure 3.4.6: Frequency distribution of size classes at K29 for all captured animals, summed across all survey rounds. See Fig. 3.4.1 for legend and Fig. 3.4.4. for explanation of size classes.

The number of *L. aurea* captured at K29 was low, following a trend of declining numbers since 2015-16. However, the inability to survey the entire wetland area due to wall instability may be impacting these findings. The most abundant demographic captured was juvenile (35%) (Figure 3.4.6). A majority of juveniles were detected in round 1, suggesting that they were animals spawned in the previous season. Calling and extra small juveniles were detected, suggesting that breeding may ahve occurred at this wetland. However, as in previous years, it may also be possible that some juveniles were spawned in the nearby K105 wetlands and dispersed to K29 following metamorphosis.

K104

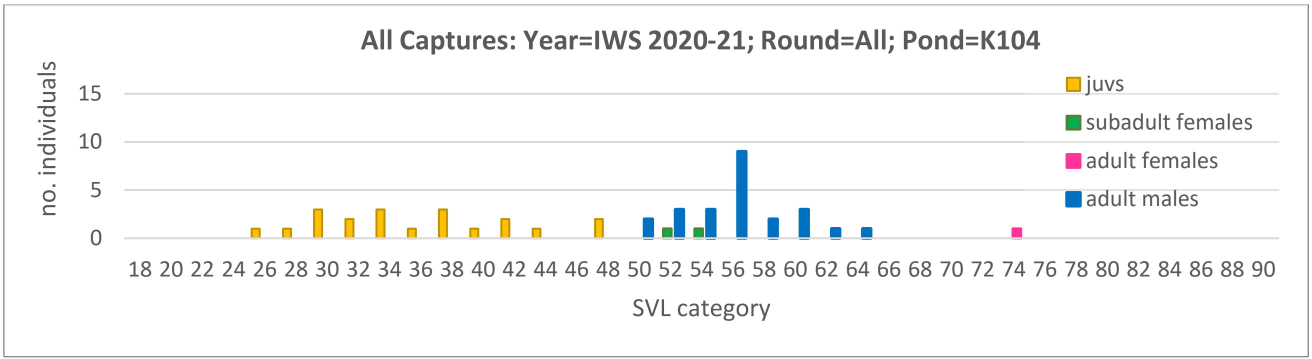
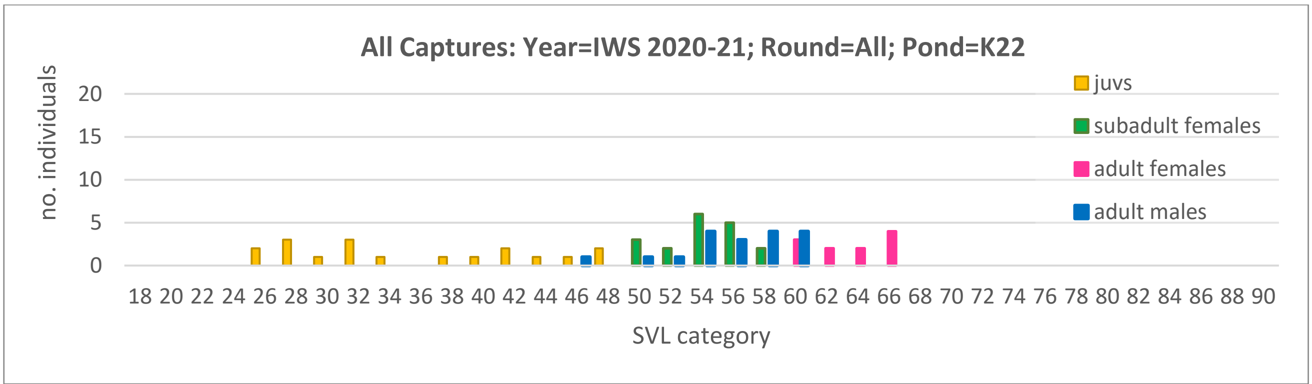


Figure 3.4.7: Frequency distributions for K104 wetland all captured animals, summed across all survey rounds. Refer to Fig. 3.4.6 for explanation of charts.

As with the previous season, the number of adults captured at K104 was relatively low, with the majority being male (89%). Most adults were detected in round 3. A large proportion of all captures were juveniles (42%). These were primarily captured in round 2, suggesting individuals may have spawned earlier in the season. Despite the presence of *Gambusia*, extra small juveniles were detected, suggesting that breeding may have occurred at this wetland.

K22-23



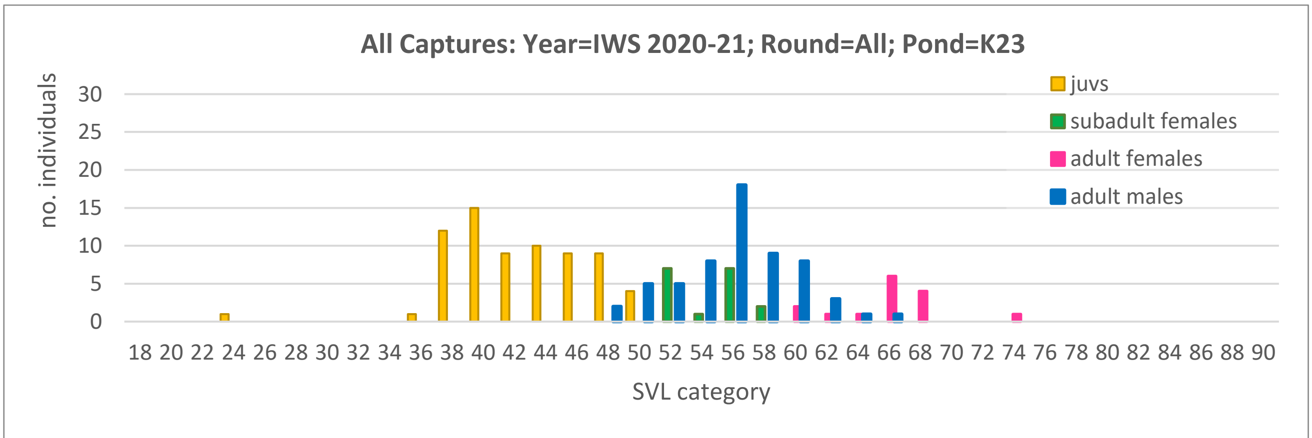
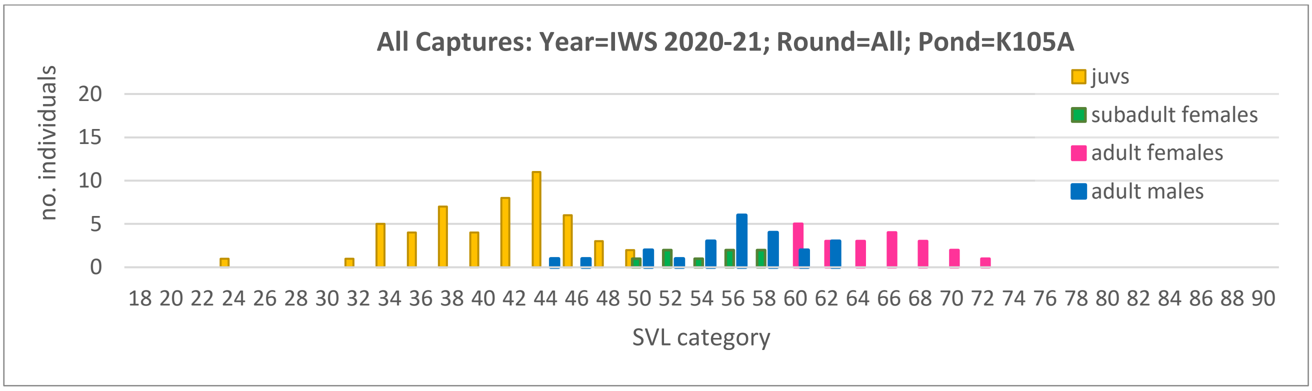
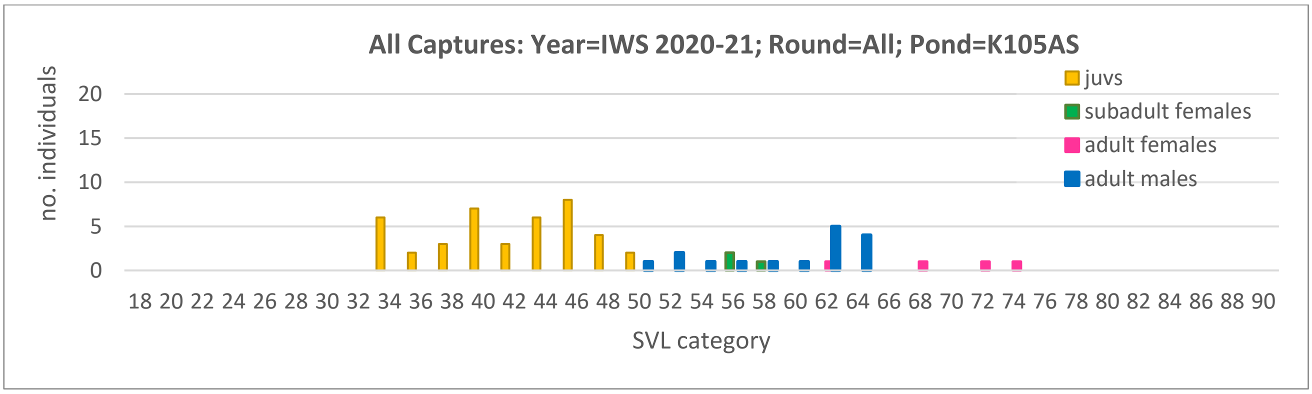


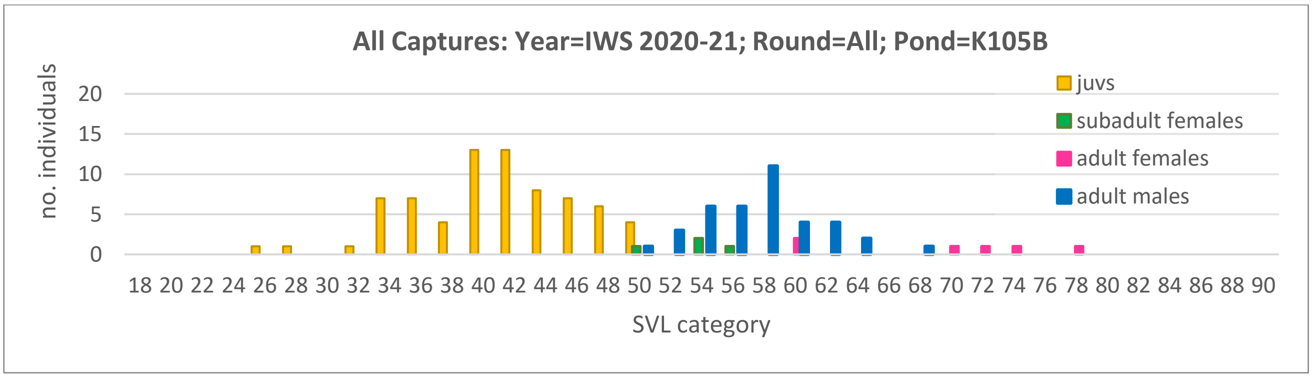
Figure 3.4.8: Top: frequency distributions for K22 and K23 wetlands all captured animals, summed across all survey rounds. Refer to Fig. 3.4.6 for explanation of charts.

K22 and K23 are a pair of wetlands in close proximity to each other, situated immediately north of the PWCS rail line and adjacent to the north shore of K105A. Historically, these wetlands have held large numbers *of L. aurea* and have been the focus of intensive CMR surveys. While these wetlands have shown a steady decrease in usage since 2016-17 (see discussion in Section 4.4, and data in Table 4.4.1), total number of detected during the 2020-21 season was higher than it has been for the past three years, brought on by the capture of a large number of juveniles. Indeed, a large proportion of captures in K22 and K23 were juveniles (28% and 43%, respectively). Among adults, a larger proportion of females were detected than males in K22, while nearly twice the number of males were detected than females in K23. In general, a much larger female population was detected at these wetlands when compared to the previous season, in which no females were recorded in K22 and females only made up 2% of the adult population in K23. No calling, tadpoles or metamorphs were detected at either wetland across the season, though extra small juveniles were detected at both. This is strong evidence that both sites have shown recovery since a grass fire destroyed aquatic and terrestrial vegetation in January 2019.

Deep pond wetlands







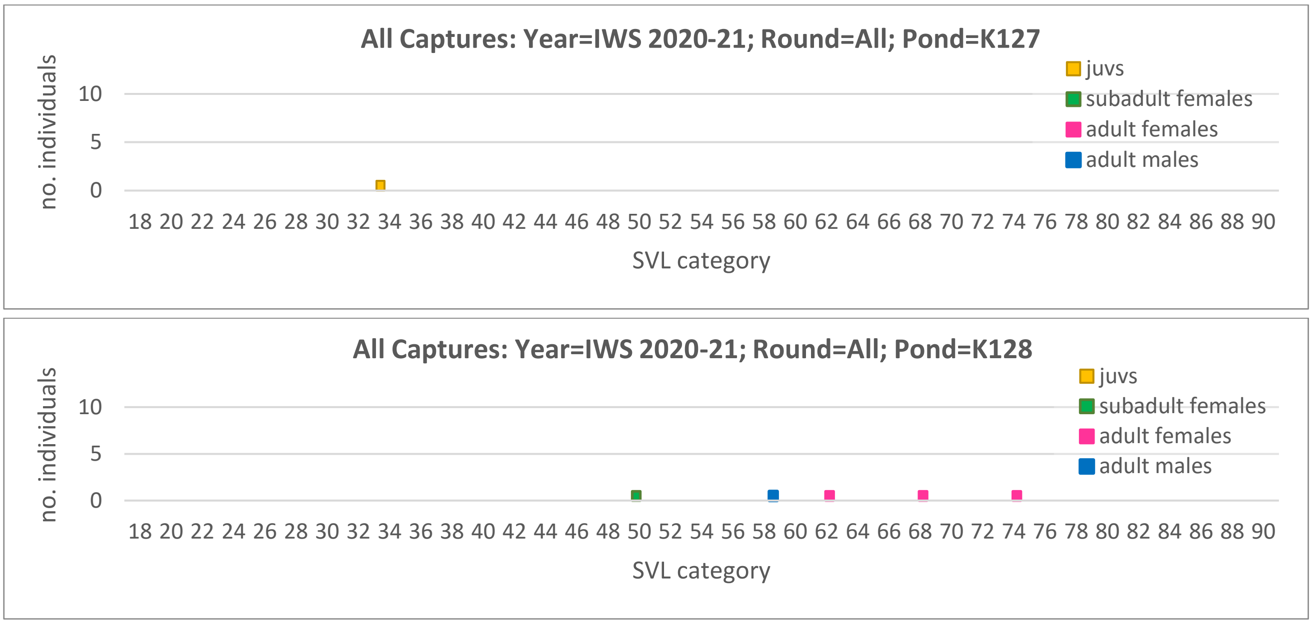


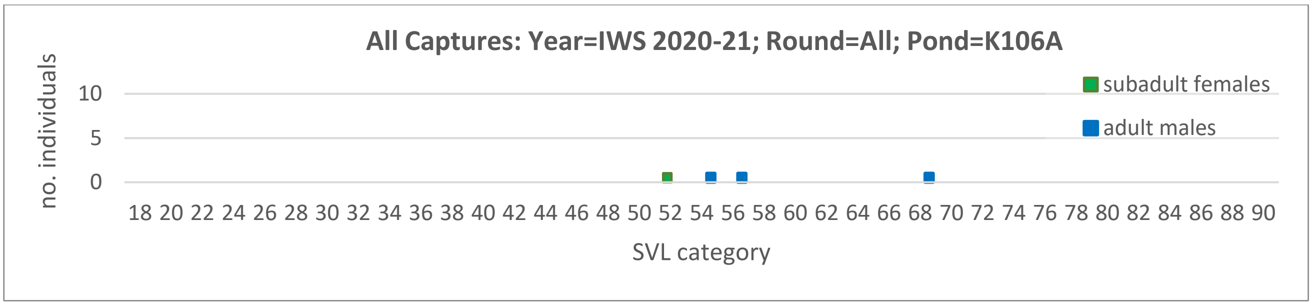
Figure 3.4.9: Frequency distributions for the large **K105** wetlands and newly constructed ponds K127 and K128 west of K29. Refer to Fig. 3.4.6 for explanation of charts.

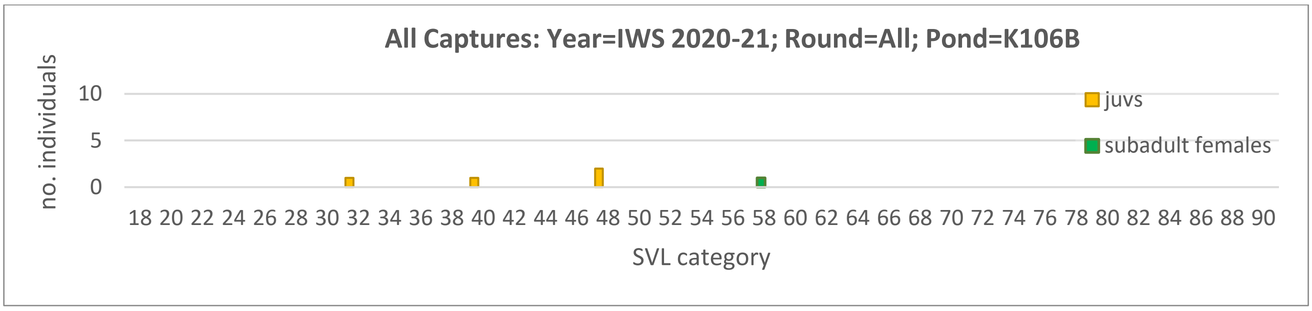
'Deep pond' was originally a single very large wetland in the NW part of the Industrial Zone; it sits on the original substrate of the island (rather than on artificial substrate, as is the case with some other wetlands), and appears to be a remnant of the natural wetlands in this part of Kooragang that were present prior to substantial alteration by human activity. Following the completion of the NCIG infrastructure, this wetland was split into a larger northern part (**K105A)**, and a smaller southern part **(K105B)**. These are surveyed separately; furthermore, the southern part of K105A has been surveyed separately to the northern edges and is labelled **K105AS** in our analyses.

The majority of adult captures at K105AS and K105B were males, while slightly more females than males were captured at K105A. In the previous season, K105A was the focus of a significant breeding event which resulted in large numbers of juveniles being present that year. In 2020-21, a majority of animals captured at all three wetlands were juveniles, ranging between 50 and 63% of all animals captured. In addition, calling, metamorphs and extra small juveniles were detected at all three wetlands. This indicates that breeding occurred at this site despite the presence of *Gambusia*, though *Gambusia* density may be low and dispersal between the ponds is possible. Juveniles were recorded in all wetlands across all three rounds, indicating that some animals were spawned in the previous season while others were spawned in breeding events that occurred in the current season.

K127 and K128 are newly constructed wetlands in close proximity to the K105 wetlands, which were built in areas of terrestrial habitat previously referred to as the 'wedge' and 'peninsula'. Despite being new aquatic habitats with little vegetation cover, they have already shown occupation by *L. aurea*. This is particularly apparent at K128, where adults of both sexes were detected. Tadpoles were also detected this season, indicating that breeding occurred at this site. Adults were not detected in K127 this season but extra small juveniles were, suggesting possible movement from the K105 wetlands.

K106 wetlands





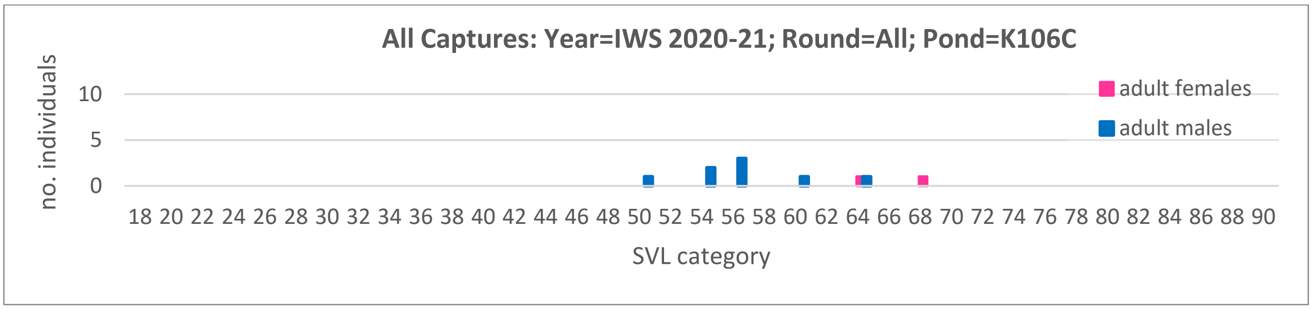


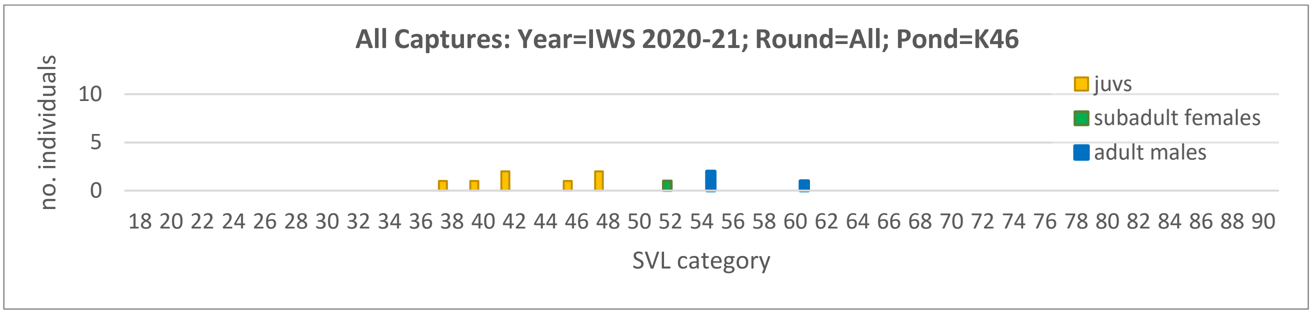
Figure 3.4.10: Frequency distributions for the K106A, K106B and K106C wetlands immediately west of K29. Refer to Fig. 3.4.6 for explanation of charts.

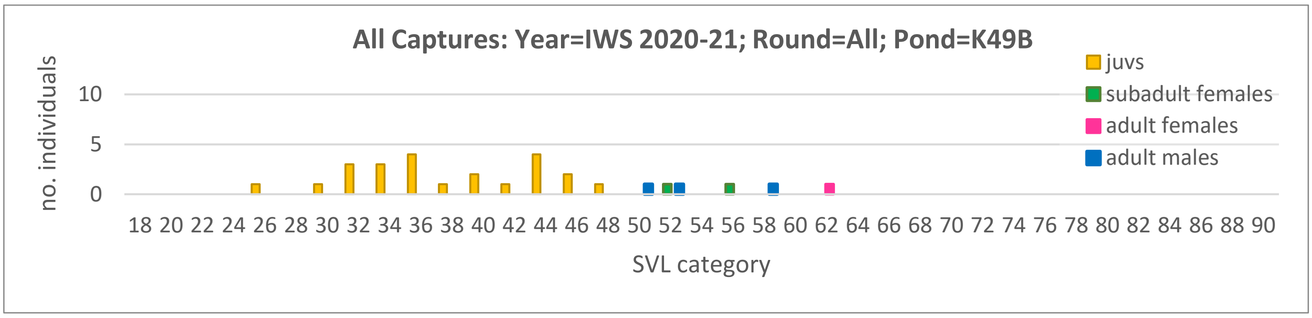
K106B is a temporary ephemeral wetland, and along with **K106A** has previously been a site of a very large breeding event (e.g. 2015-16). In this season, few adults were detected at both sites (< 10), with most being males in K106A and only adult (female) detected at K106B. Calling was detected at K106A, though there was no evidence of juvenile presence. In contrast, both metamorphs and extra small juveniles were detected in K106B, suggesting that breeding may have occurred here despite the presence of *Gambusia*.

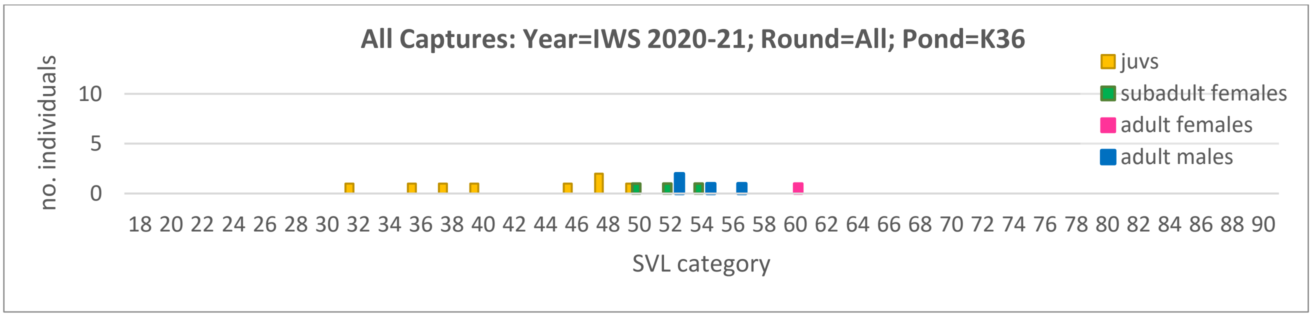
K106C is a small, deep wetland that is nearly permanent. It is well shaded and surrounded by emergent reeds, and has no *Gambusia*; in some ways, it might be considered a 'natural' version of the small refuge wetlands exemplified by the cluster ponds (C1 and C2). It usually contains a lot of adults, but this season had a small number (<10) of mostly male captures (Figure 3.4.10). One juvenile was detected in round 3, and since K106C is located close to the K105 wetlands, it is possible that animals may have dispersed from K105A. (Figure 3.4.10).

It must be noted that K106A, K106B, and K106C were all extensively damaged by a grass fire in January 2019, with most aquatic and terrestrial vegetation being burnt out. These wetlands were also partially affected by the ensuing ground fire for several months after January 2019. However, by May 2019 most of the aquatic vegetation had at least partially recovered. The detection of juveniles and possible breeding events at this site suggests that further recovery has occurred.

Southern Industrial Zone wetlands







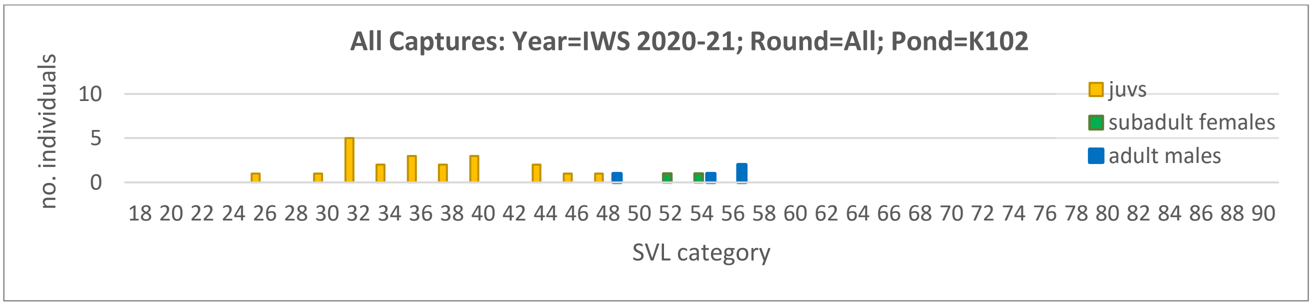
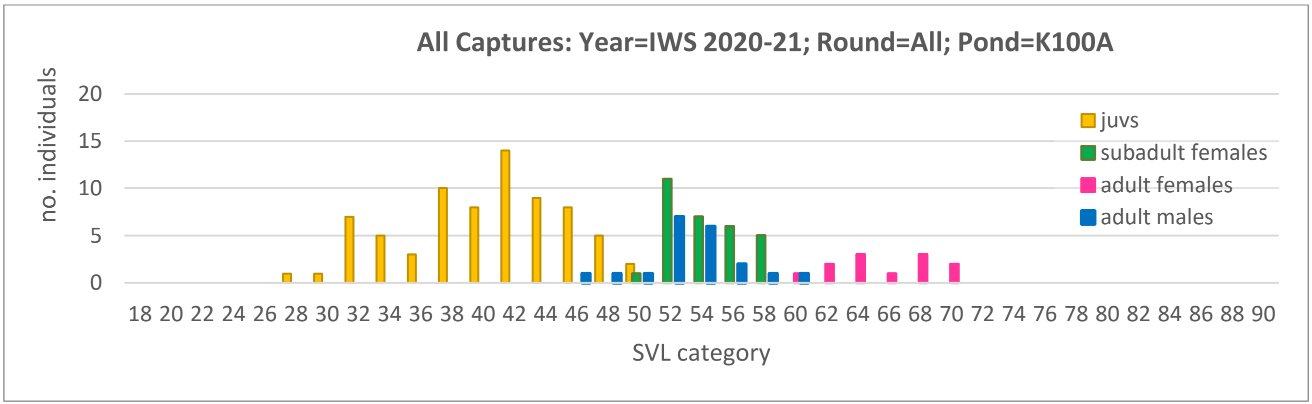


Figure 3.4.11: Frequency distributions for selected wetlands in the southern part of the Industrial Zone. Refer to Fig. 3.4.6 for explanation of charts.

Southern Industrial Zone wetlands: A number of wetlands across the southern region of the Industrial Zone have historically supported important numbers of *L. aurea*. Some of these are 'older' wetlands that have been established for many decades; they are shown in Figure 3.4.11.

The number of adults present in K46, K49B, K36 and K102 was low (<10), with the most abundant demographic instead being juveniles that made up the majority of all captures. There was no evidence of breeding at any of these wetlands, which contrast to the previous season were tadpoles were detected in K49B and metamorphs in K102. Each of these wetlands are classed as permanent wetlands and have retained water through the previous dry years; as such, they have consistently contained *Gambusia*. In 2020-21 *Gambusia* was present in K46 and K102 but absent from K49B and K36.

Wetlands near NCIG Rail Loop



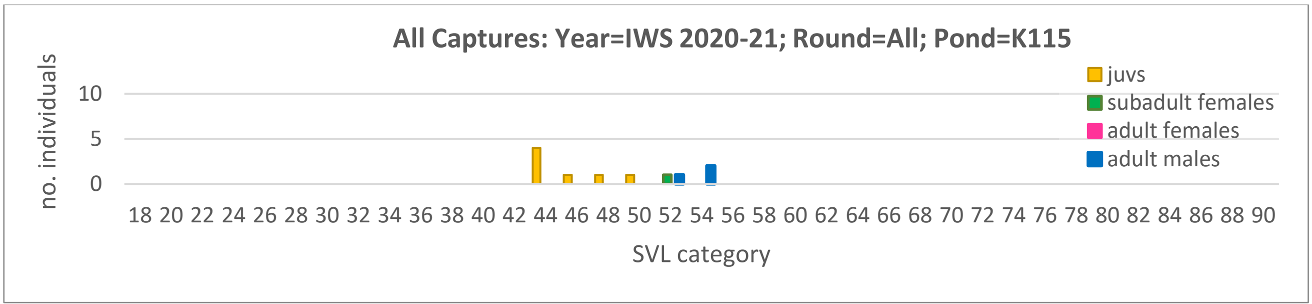
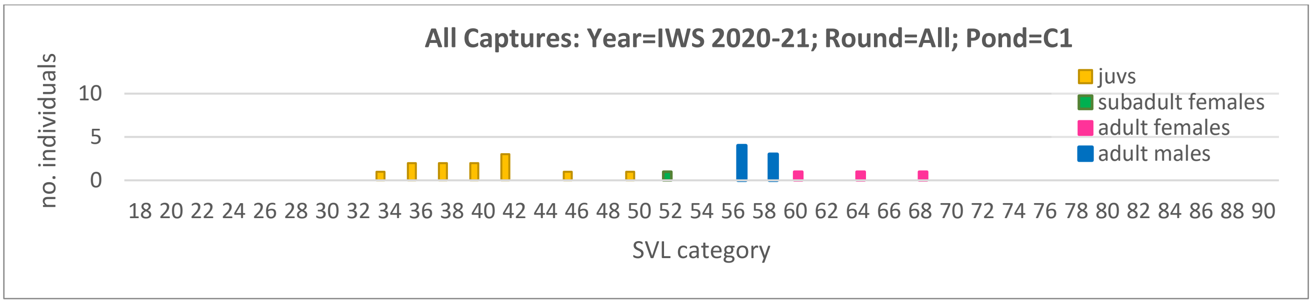


Figure 3.4.12: Frequency distributions for selected wetland immediately near the NCIG rail loop. Refer to Fig. 3.4.6 for explanation of charts.

K100A is a deep permanent wetland alongside Windmill Road, on the eastern edge of the Industrial Zone. It is surrounded by dense stands of *Casuarina* trees, and contains *Gambusia* in very high densities. As in previous years, comparatively more adult and sub-adult females were captured than adult males. However, the majority (~50%) of all animals captured in 2020-21 at this wetland were juveniles, including extra small juveniles, in round 2 and 3. It has been noted that K100A does not appear to support breeding, and it is possible that juveniles detected this year dispersed from neighbouring wetlands in the Industrial Zone.

K115 is an artificial sump pond for the NCIG dump station. It is a managed wetland (water is pumped in and drained out according to the operational requirements of the dump station), and is mostly clear of aquatic vegetation except for a dense patch of *Typha* reeds at its western end. This year, it contained few adults (<10), with most captures being juveniles. Breeding behaviours (such as calling, tadpoles, or metamorphs) have never been observed at K115, which was also apparent this year. However, it is close to K114 where breeding occurs consistently, and juveniles recorded at K115 may have been spawned here or in other HDC ponds close by.

Cluster ponds



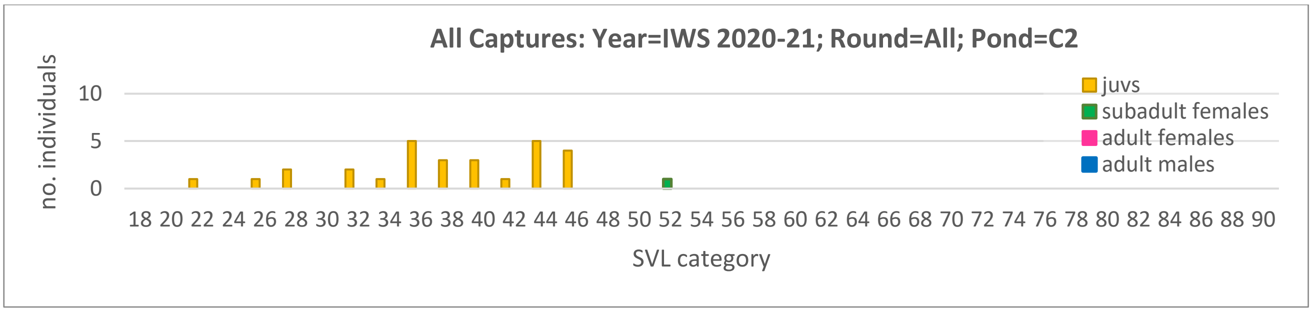


Figure 3.4.13: Frequency distributions for the PWCS 'Cluster Ponds'. Refer to Fig. 3.4.6 for explanation of charts.

The 'cluster ponds': these (**C1** and **C2**) are artificial wetlands installed by PWCS in the northern and southern regions of the Industrial Zone, respectively. Although they are small, they are deep permanent wetlands that can be managed to ensure they hold water during drought, and are free of *Gambusia*. C1 is part of the habitat mosaic close to K29, and has held relatively high densities of *L. aurea* for several seasons. When constructed, C2 was further away from other *L. aurea* habitat and until the construction of the HDC wetlands in 2015-17 contained no (or very few) *L. aurea*. With the construction of the HDC wetlands, C2 is now apparently part of a connected habitat mosaic, and supported *L. aurea* for the first time in the 2016-17 season.

In 2020-21, a small number of adults of both sexes were detected at C1 primarily in round 3 but were absent in round 1 (Figure 3.4.13). A small number of juveniles were captured, mostly in round 1. C1 is closely connected with K29 and K105A in terms of *L. aurea* movement, with many frogs moving between these sites. It is possible that juveniles dispersed to C1 from these nearby sites. It must be stated that C1 was extensively damaged by the grass fire that swept across the northern part of the Industrial Zone in early January 2019; the surrounding terrestrial vegetation was completely burnt, as was large parts of the aquatic vegetation. The tubs themselves were all partially melted and their capacity to hold water has been substantially decreased. Nonetheless, they have continued to contained water and appear to remain important permanent water for the species.

The number of *L. aurea* detected at the C2 cluster ponds has been steadily increasing since their first detection there in 2016-17. However, only one adult individual (sub-adult female) was captured in 2020-21 (Figure 3.4.13). A small number of juveniles (~30) juveniles were recorded in rounds 1 and 2, though no signs of breeding were apparent at this site (e.g. calling, tadpoles or metamorphs). The cluster ponds are the only well vegetated permanent wetlands in the *K10 South* and *K10 North* subregions. While they do not appear to provide breeding habitat themselves, they are close to several wetlands where high levels of breeding activity have been recorded in previous seasons (e.g. K121-123). It appears that the C2 clusters provide habitat for animals that have been spawned in those nearby wetlands, which could account for the relatively large number of sub-adult females found in most years, and could potentially be important refuges during extended dry periods.

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'New' cluster ponds

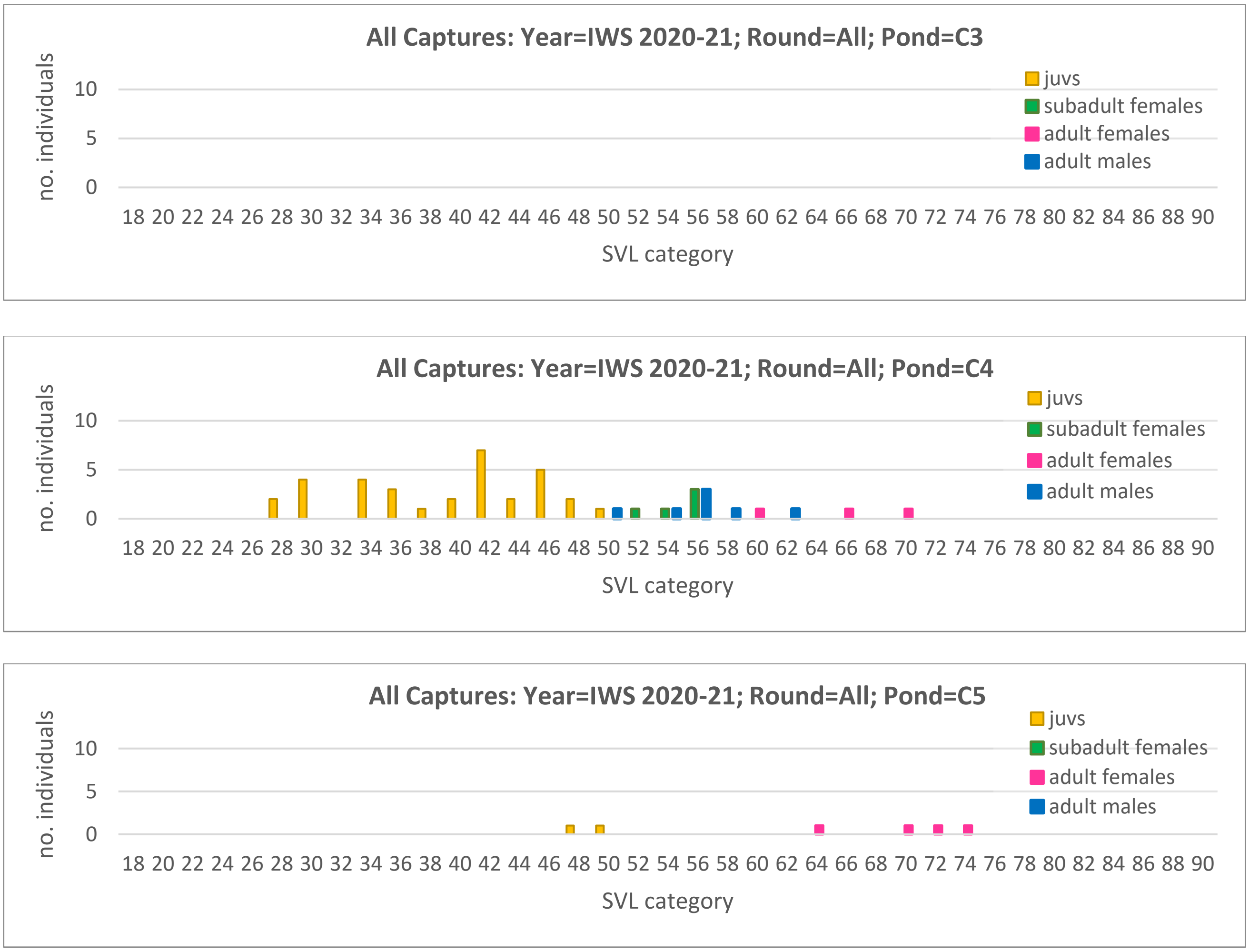
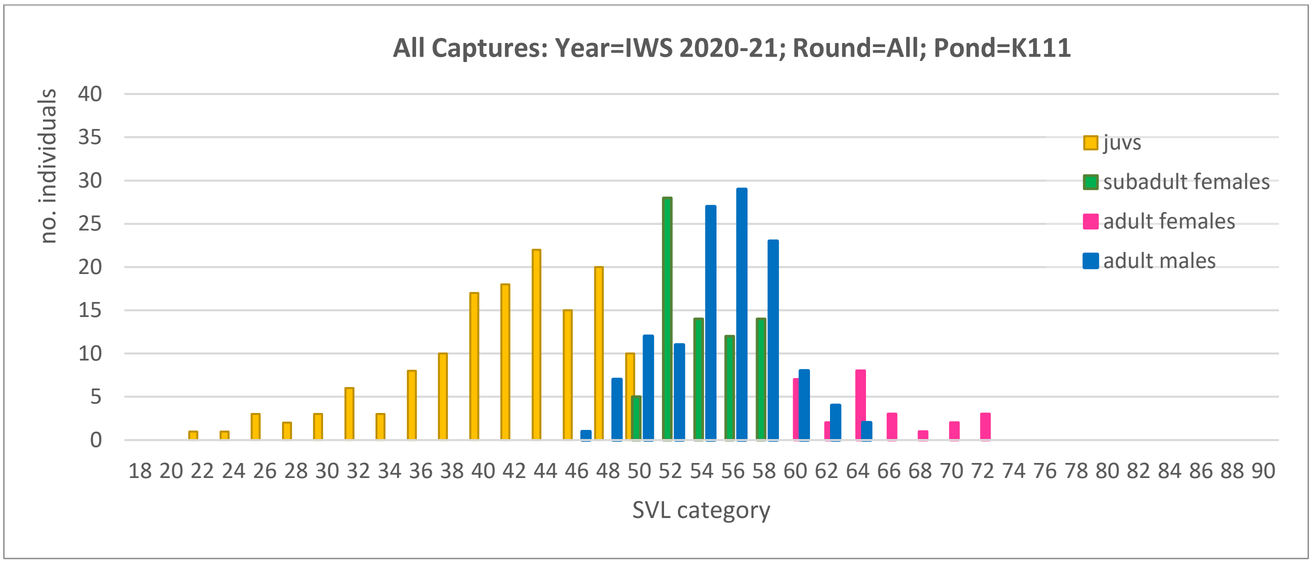
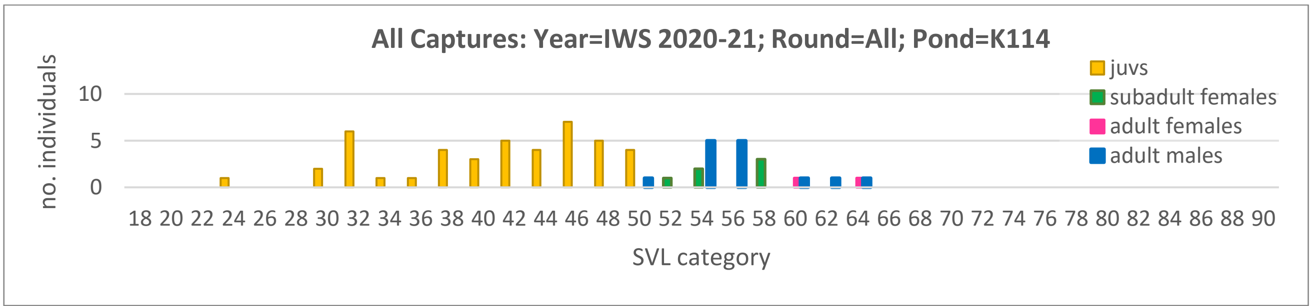


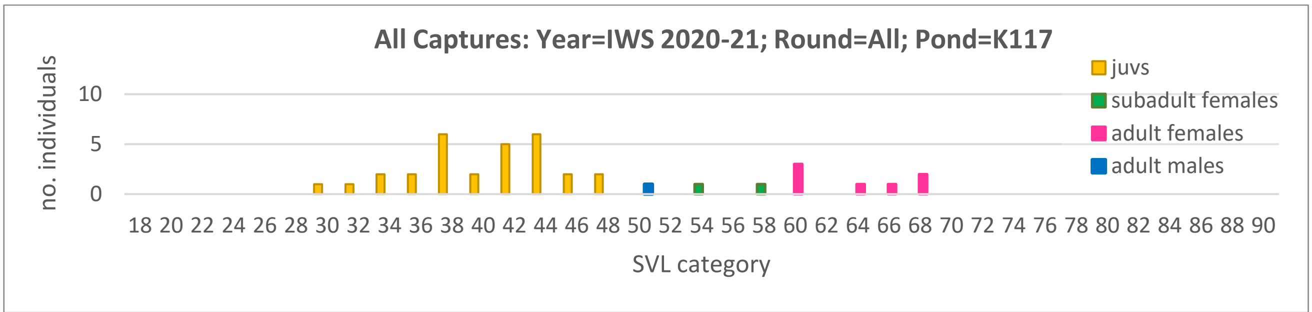
Figure 3.4.14: Frequency distributions for the 'new cluster ponds'. Refer to Fig. 3.4.6 for explanation of charts.

During the 2018-19 season, three new sets of smaller cluster ponds were installed in the *K10 South* and *K10 North* subregions. These new clusters each comprise two 4,500 litre tubs (comparable to the size of the tubs in each of the C1 and C2 clusters), and are located close to the HDC wetlands in those subregions. The intent was to provide additional wetlands that could function in the way that the C1 and C2 clusters appear to; i.e. providing small but permanent wetlands in their respective habitat mosaics. The C3 cluster was installed in *K10 South*, in between K121 and K122. The C4 and C5 clusters were located in *K10 North*; C4 in between K113 and K114, and C5 in between K111 and K112. Installation was November 2018. They have shown rapid colonisation by frog species, including *Litoria aurea*, *Litoria peronii*, *Limnodynastes peronii*, and *Limnodynastes tasmaniensis.* Across these three clusters, captures primarily occurred in C4 this year, with more than half being juveniles. No frogs were captured in C3, while a small number of juveniles and adult females were captured in C5. Juveniles at the clusters likely spawned in nearby wetlands.

HDC constructed wetlands







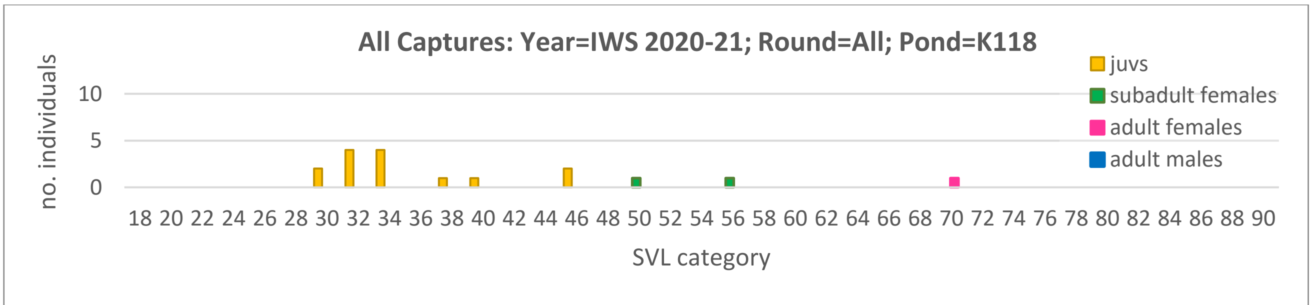


Figure 3.4.15: Frequency distributions for selected HDC constructed wetlands. Refer to Fig., 3.4.6 for explanation of charts.

In 2020-21, the greatest number of adult captures occurred at K111 when compared to other HDC constructed wetlands, including a large subadult female population. Juveniles were detected in all four constructed wetlands, with the highest numbers captured in K111. Juveniles were also the most abundant demographic captured in all four wetlands. Calling was detected at K111, and extra small juveniles were detected in K111 and K114, though no evidence of breeding at these constructed wetlands was found this season. This compares to 2019-20, where tadpoles were detected in K118 and metamorphs in K111.

K121-123

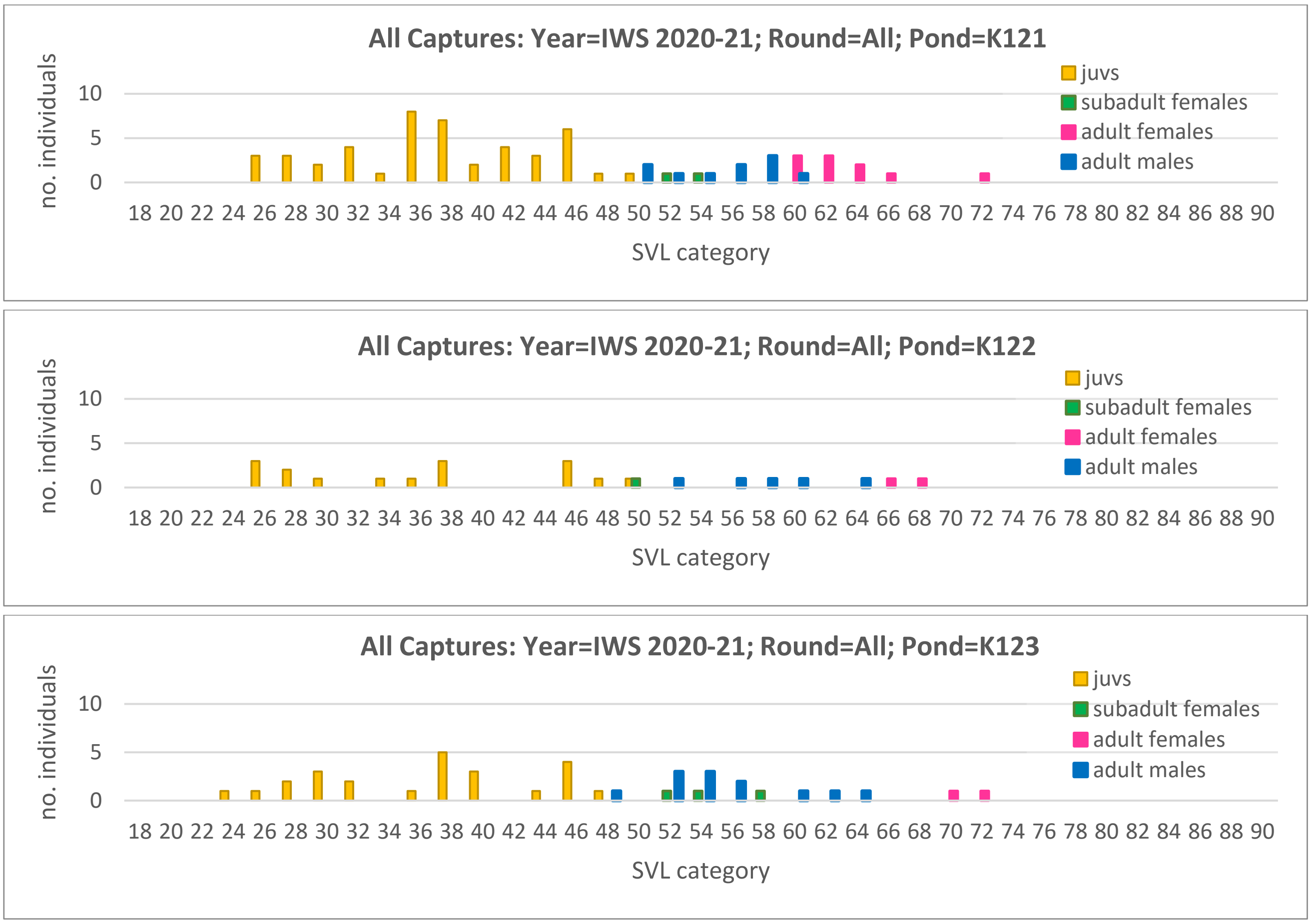
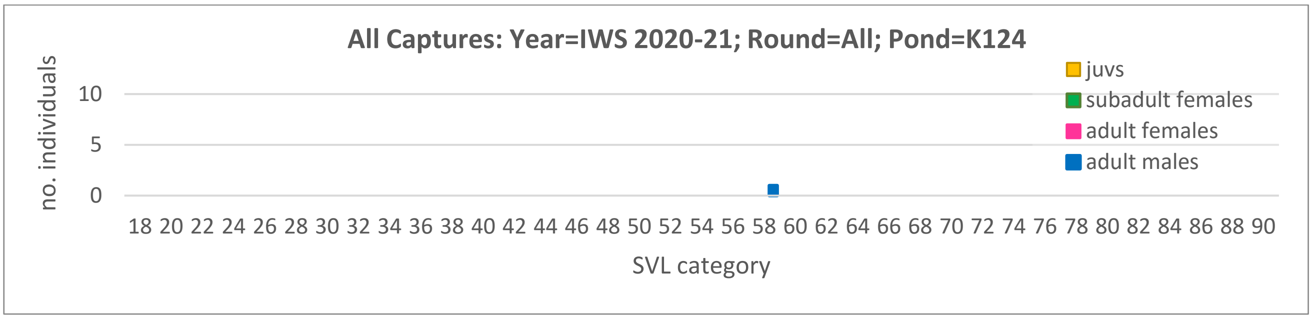
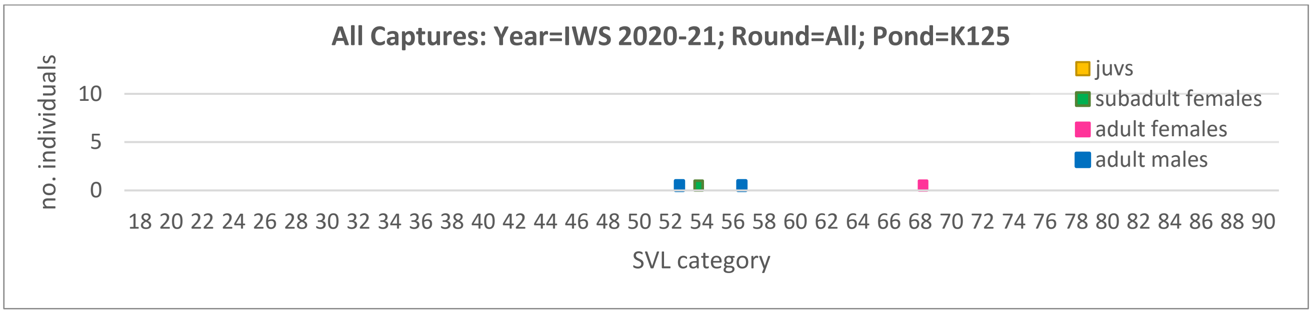


Figure 3.4.16: Frequency distributions for HDC constructed wetlands in the *K10 South* subregion. Refer to Fig., 3.4.6 for explanation of charts.

K121, **K122**, and **K123** were constructed in 2016-17 and are located in the *K10 South* subregion, adjacent to the rail loop. They lie between C2 and K36, and have greatly increased the amount of aquatic habitat in that area. A relatively small number of adults were captured in each wetland this season (<20), most of which were males. Juveniles made up the majority of captures at each wetland (60-70%), and were recorded across each wetland in round 1 and 2. Although calling and extra small juveniles were detected at all three wetlands, there was no evidence of breeding at this site this season, which contrasts to 2019-20 where tadpoles were detected in each wetland. It appears that K121 holds a relatively bigger population of frogs compared to K122 and K123.

Area 2





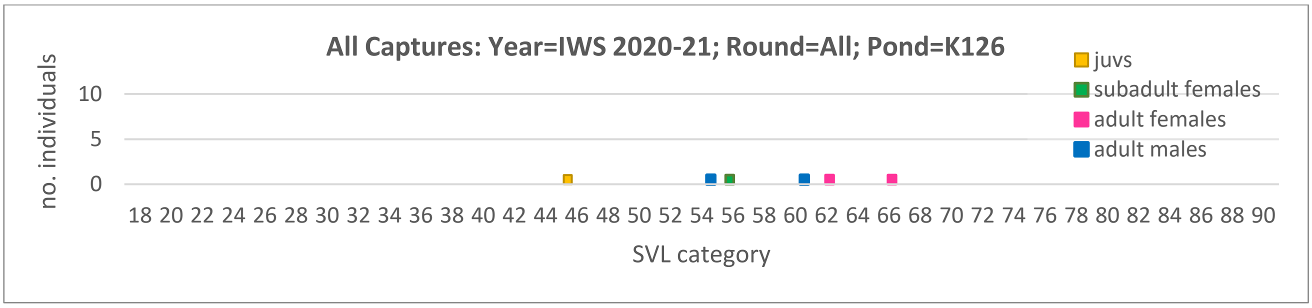


Figure 3.4.18: Frequency distributions for *L. aurea* captured in the Area wetlands. Refer to Fig., 3.4.6 for explanation of charts.

In 2019-20, a juvenile dispersal event was detected within the terrestrial environment of the Industrial Zone. An area of land referred to as Area 2, which lies adjacent to K105A, was fenced off to obtain measures of this event. This area has since undergone remediation, included the establishment of three new, constructed wetlands prior to the 2020-21 breeding season that are similar to other constructed HDC wetlands (e.g. K121-123). While still in an early stage of succession and possessing little vegetation coverage, *L. aurea* were detected at each of these wetlands, including a juvenile recorded at K126.

NCIG CHEMP wetlands

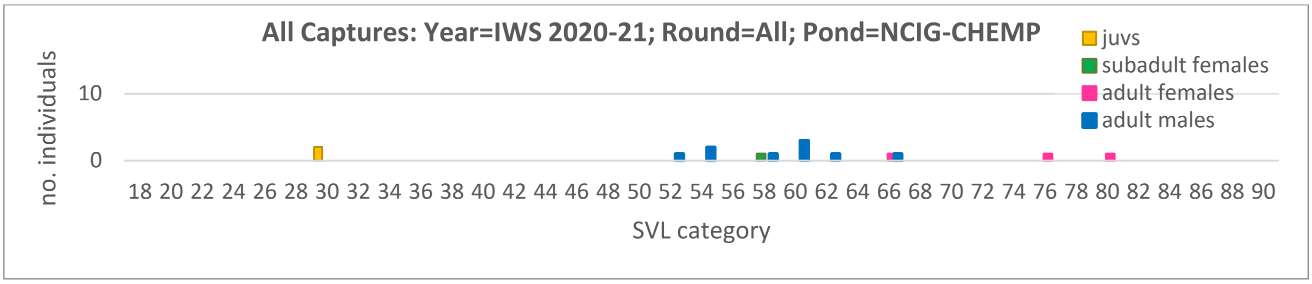


Figure 3.4.19: Frequency distributions for the NCIG CHEMP wetlands. Refer to Fig., 3.4.6 for explanation of charts.

The NCIG CHEMP wetlands were established in 2016 with the aim of providing suitable habitat for *L. aurea* in the northern region of Kooragang Island. At that time, the *L. aurea* population in the north of the island was very low (and had been for some 10 years previous; John Clulow, pers. comm.).

Not all of the NCIG CHEMP wetlands were surveyed as part of the island-wide surveys during the 2020-21 season; we surveyed twelve of these wetlands in each survey round. In those surveys, there has been a reduction in total adults captured from the previous year, with all wetlands site showing adult captures totalling less than 10 individuals. Adult captures occurred at eight wetlands (NCIG-1.3, 3.1, 5.1, 7.1, 7.2, T13, T14, and T15), including both adult males and females, while juveniles were detected at one wetland (NCIG-7.1). Metamorphs were also detected at one wetland (NCIG-7.2) in which *Gambusia* was absent, which suggests breeding occurred at this site.

Currently, these wetlands appear to be providing important habitat in this region of the island, particularly considering the low number of *L. aurea* detected in the north in previous seasons, with evidence suggesting they are now sites for breeding in the north.

The BHP CHEMP are a focus of a separate research agreement and the demographics of those will be reported separately.

3.5. Longitudinal data: persistence and movement

The best measures of how animals move around the study site, and how long they live comes from repeated surveys at selected wetlands. This provides what is known as a longitudinal dataset, and is enabled by the use of PIT tags.

In order to maximise the power of analysis of persistence and movement, we combined several datasets from research programs focusing on *L. aurea* on Kooragang Island. Five of these were from the island-wide research program for the past six breeding seasons (i.e. 2014-15, 2015-16, 2016-17, 2017-18, and 2018-19, 2019-20), along with the current 2020-21 season. We also included datasets from other research and monitoring projects conducted at the UoN Amphibian Research Laboratory. Combined, these sources resulted in a single dataset with >10,000 individual records of *L. aurea* captures where the frog was marked with a PIT tag (Table 3.5.1).

Source data	Seasons spanned
Alex Callen (PhD study)	2013-17
IWS 2014-15 (James & Campbell)	2014-15
IWS 2015-16 (McHenry & Moses)	2015-16
SOS surveys (Beranek, King, McHenry)	2016-18
IWS 2016-17 (McHenry & King)	2016-17
IWS 2017-18 (McHenry & Maynard)	2017-18
SOS surveys (Beranek, Lenga, McHenry, Maynard	2017-18
IWS 2018-19 (McHenry & Maynard)	2018-19
SOS surveys (Beranek, Lenga, McHenry, Maynard	2018-19
IWS 2019-20 (McHenry, Maynard, Callen)	2019-20
SOS surveys (Beranek, Sanders, Lenga, McHenry, Maynard, Callen)	2019-20
IWS 2019-20 (McHenry, Callen, Gould, Maynard)	2020-21
SOS surveys (Sanders, McHenry, Callen, Gould, Maynard)	2020-21

Table 3.5.1: Individual study datasets used for the longitudinal analysis of persistence and movement in this section. Names shown for IWS (Island Wide Survey) studies are project officers for each season.

Persistence

As used here, persistence refers to the period between the first and most recent capture of frogs, of taggable size, that were caught on multiple occasions. It is related to concepts of age and longevity, but is not identical to them as the age when they were first tagged is usually unknown.

Table 3.5.2 summarises the persistence of *L. aurea* based on the extended dataset. It shows that 3,414 tagged frogs where recaptured at least once. Of these, a large majority (73%) had less than six months between their first and last capture. Only 927 frogs had more than six months between first and last capture; for most of these (16% of all recaptured frogs) the period was less than 12 months. Only 388 frogs were recaptured more than 12 months after first capture (11% of all recaptured frogs). The number of frogs that persisted more than 2 years was 60, while 14 of these lasted longer than 3 years. Four animals persisted for more than 4 years.

Calculation of survivorship rate should include data for animals that were tagged but never recaptured, which have not been analysed here. However, calculating the proportion of marked-and-recaptured animals in each time class gives a 'persistence rate' which might be expected to have a similar shape to a true survival rate (Table 3.5.2). Persistence of animals even one year beyond the time of first capture is low, and persistence beyond 2 years is very low.

It is important to note that persistence time categories are not age categories. For example, an individual may be a year old when it is first marked; if it survives more than 12 months after that, then it has reached its third year. As frogs are only marked when they are large juveniles (i.e. SVL > 40 mm), they are generally at least six months old and more often are older.

Time between first and most recent capture	*N*	persistence rate
x > 4 years	7	0.2%
3 < x < 4 years	7	0.4%
2 < x < 3 years	46	1.8%
1 < x < 2 years	328	11.4%
6 < x < 12 months	539	27.2%
x < 6 months	2487	100.0%
Total	3414	

Table 3.5.2: Persistence of *L. aurea* marked in multiple studies. See text for explanation.

Movement

		prior to 2020-21	seen in 2020-21
Total animals tagged	12,181		
Total animals recaptured	3,738		
Total movements detected	941	607	334
Between K22-23	53	53	0
Within BHP_CHEMP (Ramsar Rd West)	345	345	0
Within NCIG_CHEMP stages	35	35	0
Other movements	508	174	334

Table 3.5.3: Movement detected from recaptures of *L. aurea* marked with PIT tags. Recaptures are taken to indicate a movement if they are located in a different wetland to the previous capture, i.e. they do not include movements within a wetland (which can be considerable). Data up to the 2019-20 season was detailed in the annual report for 2019-20 (McHenry et al. 2020) (middle column). Additional movements detected in the current 2020-21 season are summarised in the right-hand column. Most detected movements are between neighbouring CHEMP wetlands and between K22 and K23). The 'Other movements' involving movement detected in the current 2020-21 season are detailed in **Tables 3.5.4** and **3.5.5** and Figures 3.5.1 and **3.5.2**.

Table 3.5.4: Detected movement between study seasons, for data including 2019-20 season detections. Data sourced from multiple studies (see text). Coloured fonts show individuals where multiple movements were detected (compare with Table 3.5.5 and Figure 3.5.1, and with previous year's report).

Approximately 25% of recaptures (941 out of 3,738) indicated *L. aurea* that moved between wetlands from one capture to the next (Table 3.5.3). Of those, most were relatively small movements, such as within the BHP CHEMP wetlands in the Ramsar Rd West subregion, between K22 and K23, or within stages in the NCIG CHEMP wetlands. Details of the 112 'other' movements detected from 2014 to 2019 are provided in the 2018-19 annual report (McHenry et al. 2019). A further 334 'other' movements were detected in the 2020-21 season and these are shown here in Table 3.5.5 and in Figures 3.5.1 and 3.5.2 respectively.

Most movements between the previous and current seasons occurred within Zones. This included the movement of adult males from K29 into wetlands that are understood to form a consistent habitat mosaic in the Industrial Zone (K29, Deep pond, C1, and K106), as well as movement from K100A and C2 into K121-K123. Movements between the northern and southern Industrial Zones was also detected between K100A and K42, while movement was also detected out of the NCIG-CHEMP wetlands (4.9 and 7.2) to K3 and K58B. Most animals moved between wetlands less than 200m apart, though four individuals (three males and one female) did make much larger movements of more than 1000m.

ID for databasing	sex final	start date	start pond	end date	end pond
0007E6330B	M	10-02-2021	K23	12-03-2021	EP Fence
0007E50CC2	F	23-09-2020	K105AS	19-02-2021	W5 (NP)
0007E62D7C	M	17-02-2021	K100A	16-04-2021	K108B
0007E72798	F	17-02-2021	K100A	26-04-2021	K108
0007EA1328	M	03-02-2021	K115	12-04-2021	K113

Table 3.5.5: Detected movement within the 2019-20 study season. Data sourced from multiple studies (see text). Coloured fonts show individuals where multiple movements were detected (compare with Table 3.5.4 and Figure 3.5.2)

Within the 2019-20 season (Table 3.5.5), movements were made by nearly an equal number of adult males and females. Most detected movements were between Deep pond, K29 and K106 that form a mosaic within the Industrial Zone. In particular, several of these movements were of adult females out of K29, providing support for the suggestion that *L. aurea* will move from 'refuge' habitats (e.g. K29) to habitats that provide suitable breeding habitat at a particular time. Movements were also detected out of this mosaic to K23, which is nearby. Movements between the northern and southern Industrial Zones was also detected, including movement out of K100A and K115 into K105A. Movements between wetlands in the Southern region of the Industrial Zone show connectivity in this area, although at a lesser extent that in the Northern region.

In the Northern Zone of the island, the movement by an adult female from a permanent wetland (NCIG-7.3) to a nearby ephemeral wetland (K58) following heavy rain in early February, and then back to a permanent wetland (NCIG-7.2) in early autumn involved only small movements but demonstrates one of the breeding strategies used by *L. aurea*. Most movements were between wetlands less than 200 m apart. Larger movements of more than 1000 m were also detected, though these movements occurred over several months:

I. K102 to K23 (1,089m)
II. K155 to K105A (1,357m)
III. K122 to K46 (1,615)
IV. K104 to K23 (1,759m)
V. K100A to K105A (1,885m)

The movement of individuals between K104 and K23 shows that, despite its distance from other surveyed wetlands, K104 is not completely isolated. This connectivity of K104 to other wetlands was also found in the previous season, where individuals were found moving between K104 and K29.

Most movements detected since 2013 have been less than 500 m distance (94%), with most being less than 100 m. However, 26 movements have been greater than 1,000m (Table 3.5.6).

Table 3.5.6: frequency of movement distance for movements detected since 2013.

Most (60%) movements detected since 2013 involve males, eight of which were first caught as juveniles (Table 3.5.7). Of the 164 females detected, 17 were first caught as juveniles.

Sex	*n*
J(J)	115
J(M)	20
J(F)	34
M	448
F	302
Total	919

Table 3.5.7: Age/sex class summary of the 595 movements detected between 2012 and 2020. Brackets indicate sex at maturity for animals first captured as juveniles. See text for discussion.

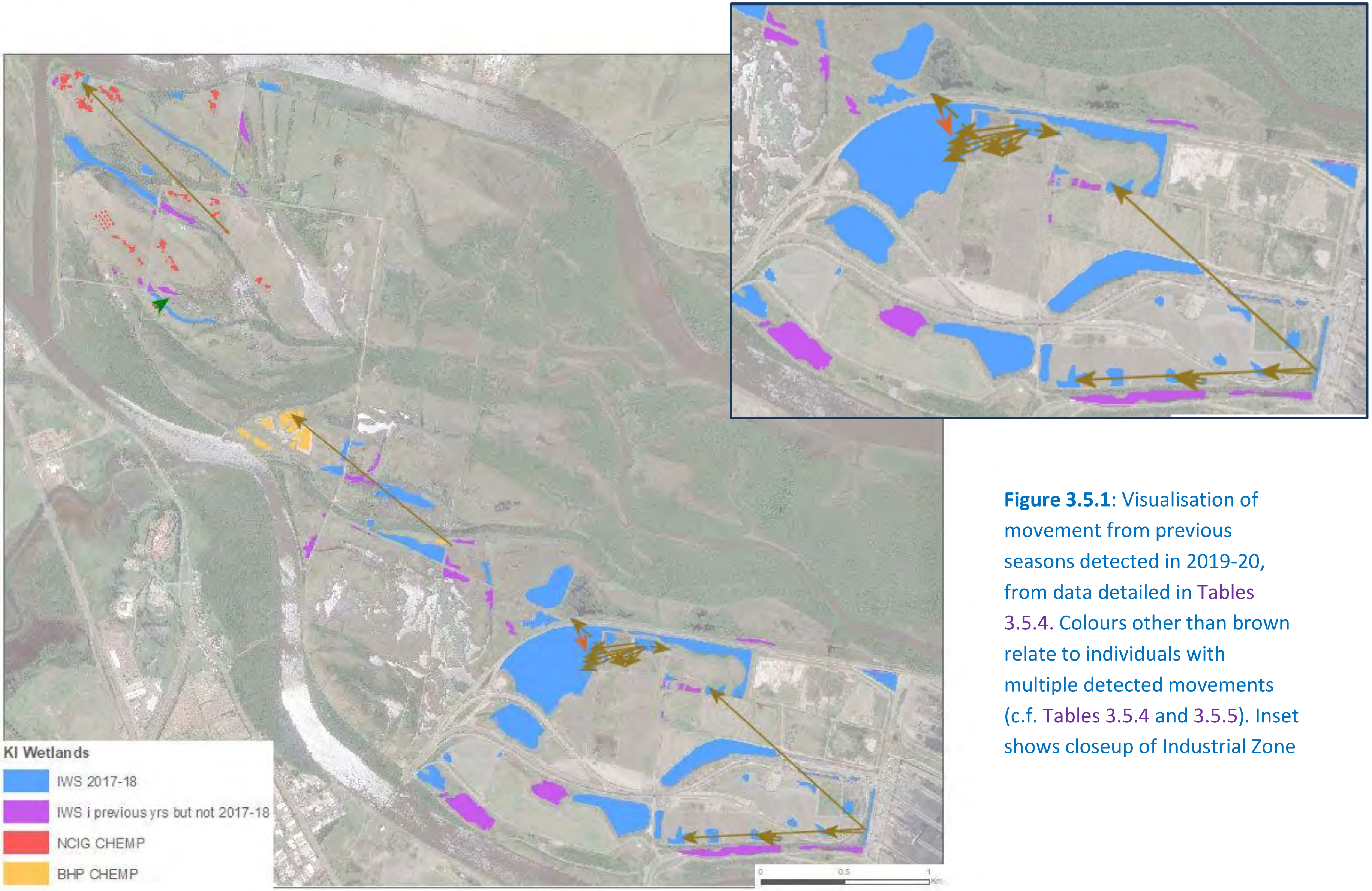


Figure 3.5.1: Visualisation of movement from previous seasons detected in 2019-20, from data detailed in Tables 3.5.4. Colours other than brown relate to individuals with multiple detected movements (c.f. Tables 3.5.4 and 3.5.5). Inset shows closeup of Industrial Zone

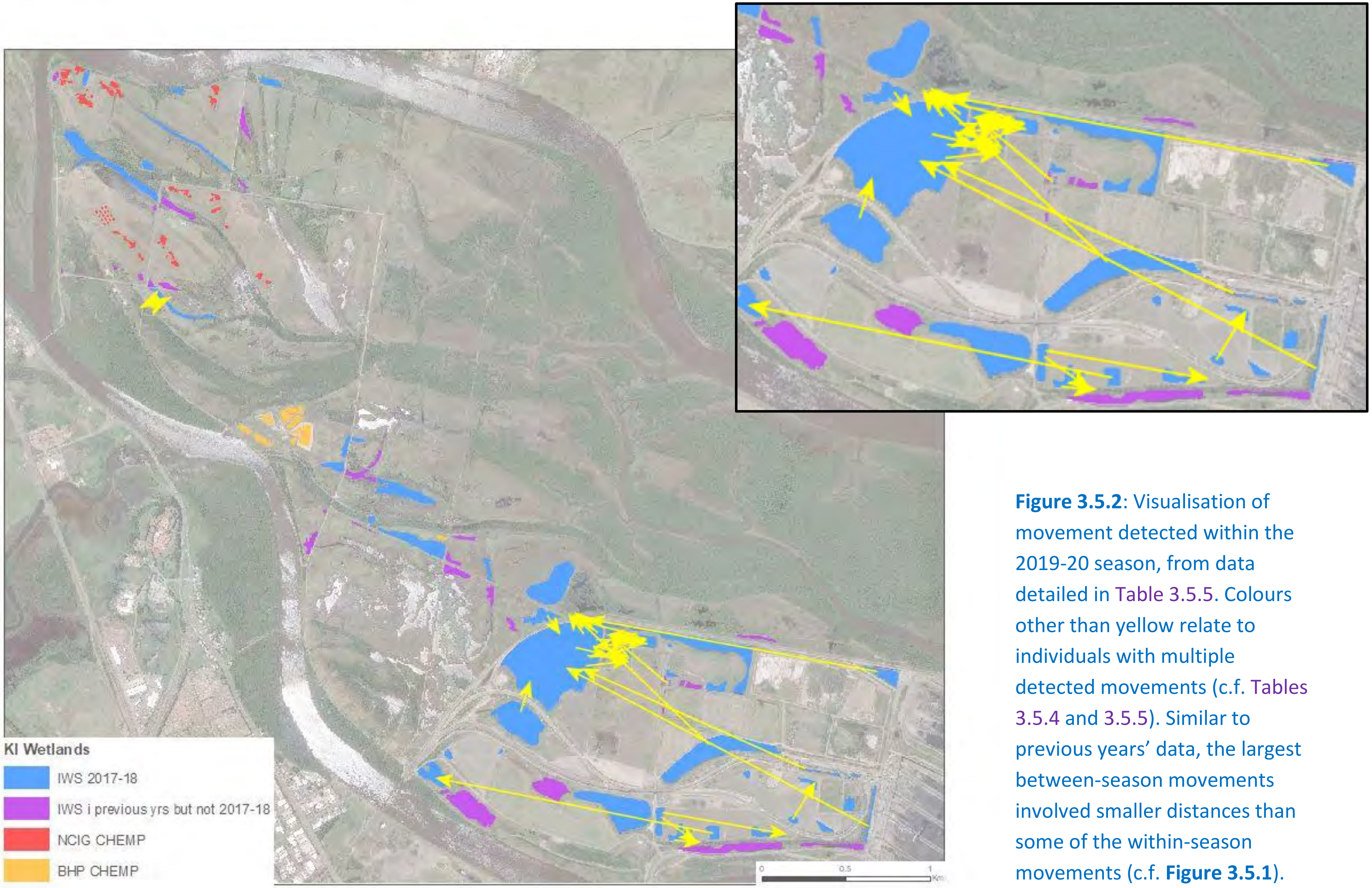


Figure 3.5.2: Visualisation of movement detected within the 2019-20 season, from data detailed in Table 3.5.5. Colours other than yellow relate to individuals with multiple detected movements (c.f. Tables 3.5.4 and 3.5.5). Similar to previous years' data, the largest between-season movements involved smaller distances than some of the within-season movements (c.f. **Figure 3.5.1**). Inset shows closeup of Industrial Zone.

Interaction between movement and persistence

A *prima facie* reading of the longitudinal data suggests that *L. aurea* on Kooragang Island show a high level of philopatry; the vast majority of individuals are re-caught in the same wetland of initial capture. Of the 3,414 recaptured animals, 2,487 were captured for the last time less than six months after their first capture. The probability of detecting movement in this time must inevitably be lower than for individuals with a greater time between first and last capture. Indeed, of the 2,487 frogs whose final capture was less than six months after their first, only 561 had moved (a proportion of 22.6%), although multiple movements were detected for some of these and the total number of movements for those 561 animals was 669. **This increased to more than 30% all individuals when the time between capture events was more than a year, and nearly 70% when the time between captures was more than three years.**

	maximum 'age'			'age' at movement		
	number of animals	oldest 'age' of animals that moved	number of movements detected	cumulative total of animals that made it to this age	animals that moved	most recent movement
x < 6 months	2487	561	669	3414	410	326
6 < x < 12 months	539	103	135	927	191	157
1 < x < 2 years	328	64	103	388	101	77
2 < x < 3 years	46	11	28	60	15	13
3 < x < 4 years	7	5	5	14	8	6
x > 4 years	7	0	1	7	3	3

Table 3.5.8: Numbers of *L. aurea* in each persistence 'age' class (c.f. Table 3.5.2), numbers of movements detected, and proportions thereof. Columns to the left ('non-cumulative') organise data according to the time between first and last capture of each frog. Columns to the right ('cumulative') show data according to the time between first capture and the detection of movement. See text for discussion.

3.6 Breeding and recruitment

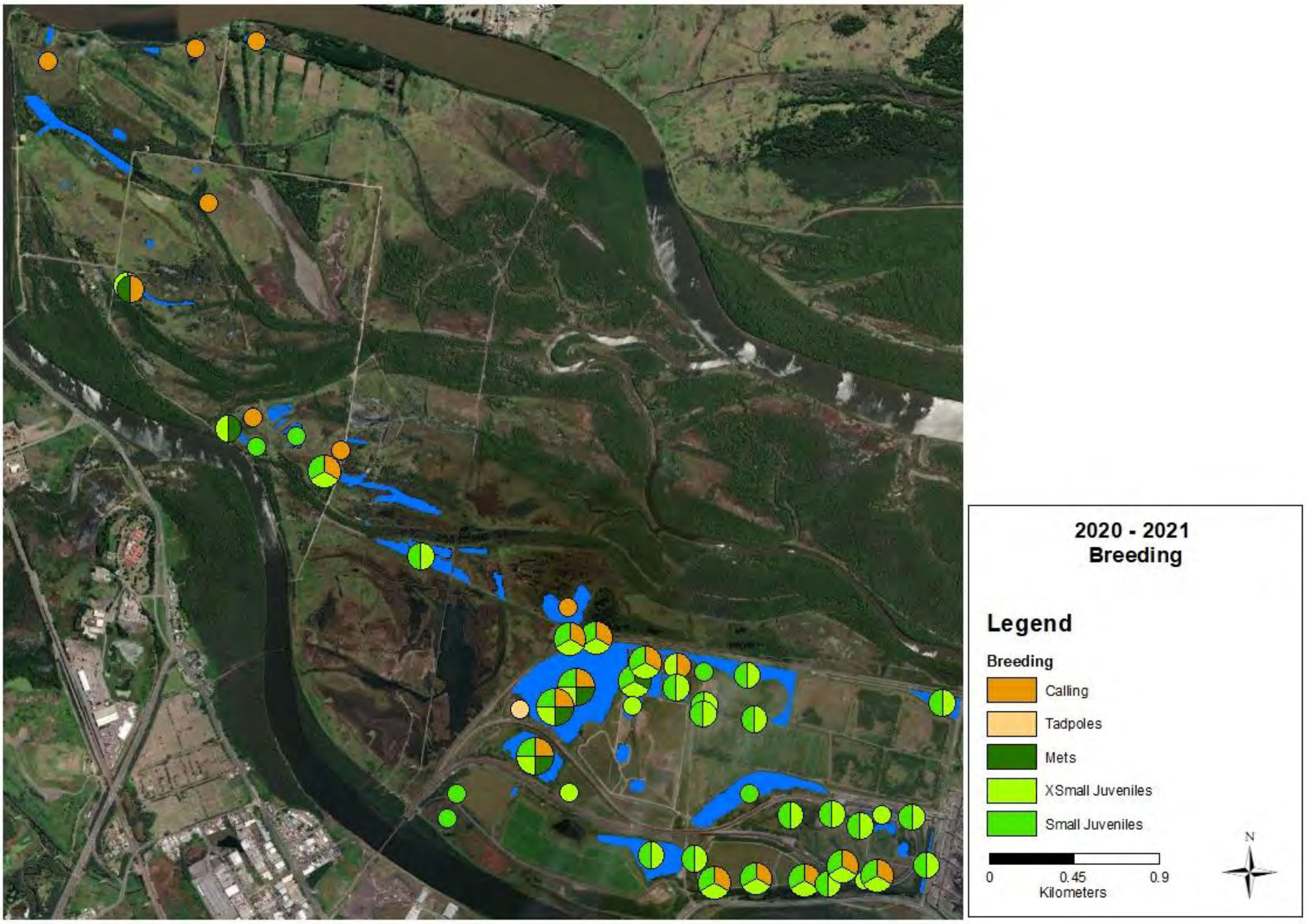


Figure 3.6.1: *L. aurea* breeding (i.e. calling, detection of tadpoles and/or metamorphs, small juveniles) during the 2020-21 survey season. 'Xsmall' juveniles have SVL < 35 mm; 'Small' juveniles have 35 < SVL < 40 mm. Note that the size of the segments within the pie charts denotes only presence of an age/six class or breeding behaviour; it does not indicate the quantity within each category. See Figure 3.6.2 for close up of Industrial Zone wetlands.

Across the season, calling was detected at 23 wetlands, though this does not necessarily indicate that breeding took place at these locations. Instead, the most direct evidence is the presence of *L. aurea* tadpoles. These were detected only at K128, a newly constructed wetland in the Industrial Zone, in round 3 (Figure 3.6.2).

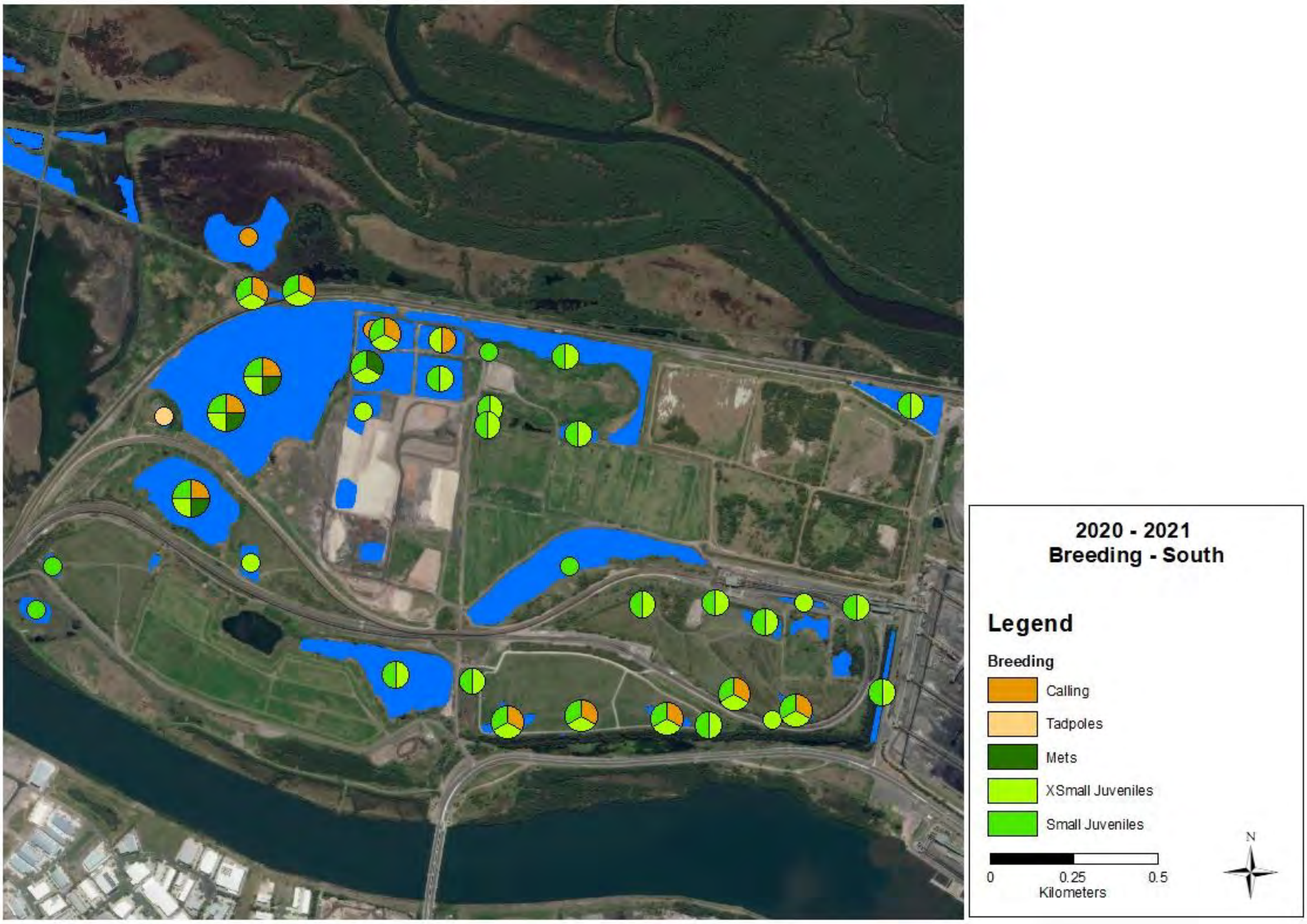


Figure 3.6.2: Evidence for *L. aurea* breeding in southern Kooragang Island. See Fig. 3.6.1 for explanation.

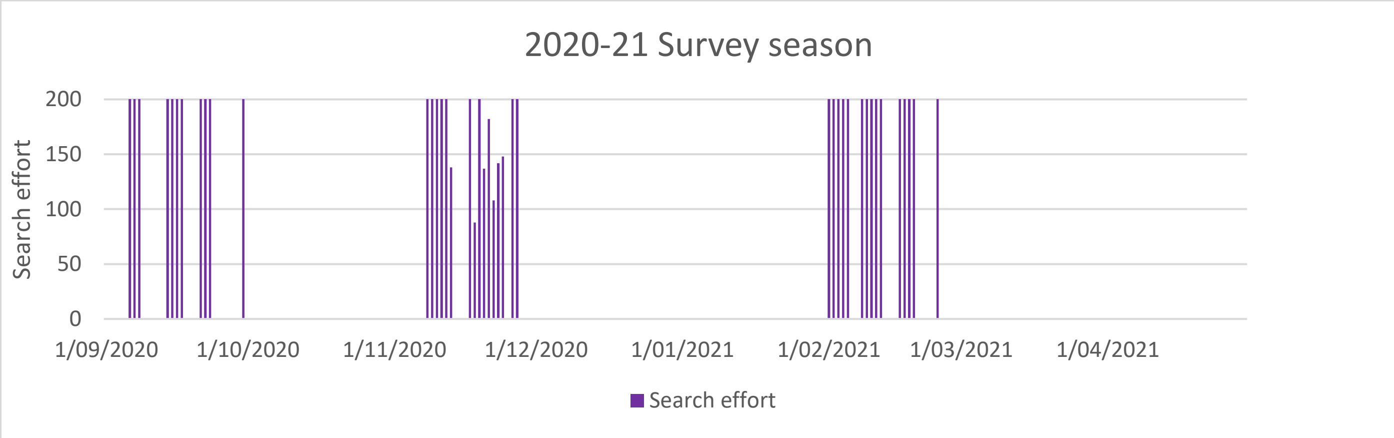
A difficulty with detecting *L. aurea* tadpoles is that positive identification in the field is difficult. In contrast, *L. aurea* metamorphs can be reliably identified in the field and usually (but not always) indicate breeding has occurred in the wetland where they were observed. Metamorphs are known to disperse over terrestrial habitat and so do not always indicate breeding at a specific wetland; but if present in large numbers then breeding can be confidently said to have occurred at the site of detection. Metamorphs were detected primarily at wetlands within the Industrial Zone (four wetlands), with few detections in the Central Zone (one wetland) and Northern Zone (one wetland). Note that Figures 3.6.1 shows only the presence/absence of tadpoles, metamorphs etc., not their abundance. The largest numbers of metamorphs were seen in four nearby wetlands in the southern region of the Industrial Zone (K105A, K105AS, K105B and K106B). A majority of metamorphs were detected in round 2 (November 2020), and a smaller number in round 3 (February 2021).

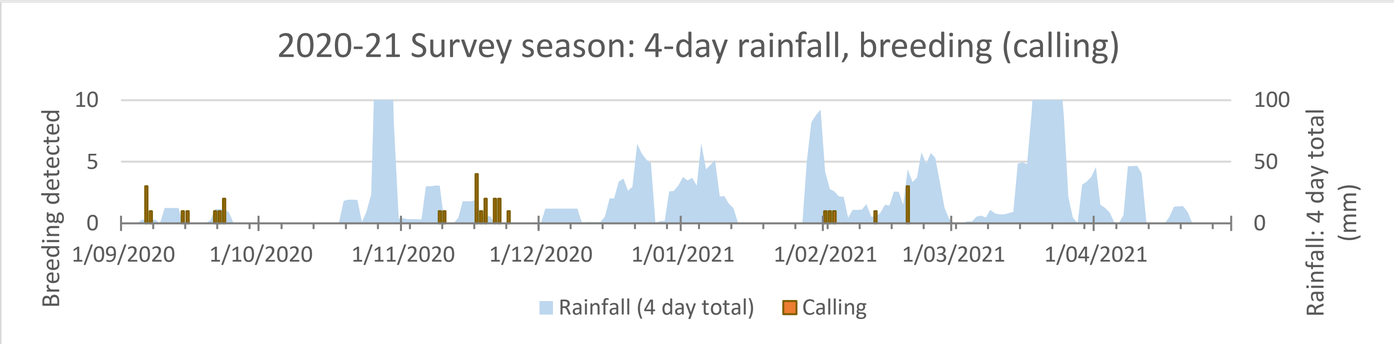
Juvenile frogs are, of course, mobile and do not provide a reliable indication that breeding as occurred in a specific wetland; however, large numbers of small juveniles (SVL < 30 mm) in a wetland are suggestive of a cohort of frogs that have spawned at that location. Large numbers (≥ 10) of very small juveniles were detected only in wetlands in the Industrial Zone. This included C4, C5, K111, K121 and K105B in round 1, as well as C2 and K111 in round 2. The largest number was captured at K105B, a large wetland in the southern region of the Industrial Zone were *Gambusia* was detected. Very few extra small juveniles were detected in round 3.

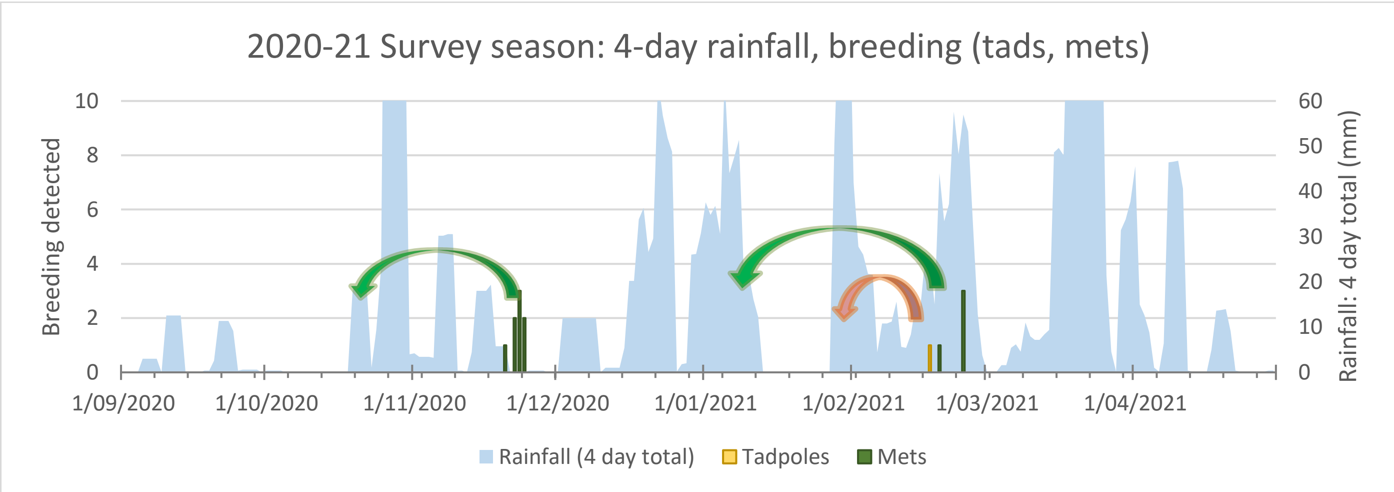
Tadpoles and metamorphs were detected mainly in wetlands classified as permanent (i.e., 'nearly permanent' or 'deep permanent' hydroperiod categories detailed in **Section 3.2**), except for K105A, K128 and BHP-4C which are semi-permanent, and NCIG-7.2 which is seasonal, demonstrating that *L. aurea* are not necessarily limited to ephemeral wetlands for breeding. Tadpoles were found at one wetland site in particular, which did not contain *Gambusia*. However, more than half of all records of metamorphlings occurred in ponds during times where *Gambusia* was also detected, which were all in the southern region of the Industrial Zone. Metamorphlings were detected in ponds without *Gambusia* in both the northern and central zones.

The presence of *L. aurea* offspring at various stages of development provides information on when spawning most probably occurred during the breeding season. Metamorphosis in *L. aurea* happens within a relatively short time frame and detection of metamorphs generally indicates spawning 4-5 weeks earlier (although this can extend to 6 weeks or more in spring or autumn, when temperatures are lower). The detection of tadpoles provides a less precise indication of spawning time but can still be correlated with rain events (Figure 3.6.3). The detection of very small ('Xsmall'; SVL < 35 mm) and small (35 < SVL < 40 mm) juveniles indicate cohorts resulting from periods of spawning in the current and previous breeding seasons. In particular:

1. Juveniles detected in round 1 likely spawned in the previous season (2019-20) and overwintered as tadpoles.
2. Juveniles detected in round 2 likely spawned early during the current season during Spring rainfall.
3. Juveniles detected in round 3 likely spawned during mid-season rainfall in December-January.


2020-21 Survey season
Search effort
200
150
100
50
0
1/09/2020
1/10/2020
1/11/2020
1/12/2020
1/01/2021
1/02/2021
1/03/2021
1/04/2021
Search effort


2020-21 Survey season: 4-day rainfall, breeding (calling)
Breeding detected
10
5
0
100
50
0
Rainfall: 4 day total (mm)
1/09/2020
1/10/2020
1/11/2020
1/12/2020
1/01/2021
1/02/2021
1/03/2021
1/04/2021
Rainfall (4 day total)
Calling


2020-21 Survey season: 4-day rainfall, breeding (tads, mets)
Breeding detected
10
8
6
4
2
0
60
50
40
30
20
10
0
Rainfall: 4 day total (mm)
1/09/2020
1/10/2020
1/11/2020
1/12/2020
1/01/2021
1/02/2021
1/03/2021
1/04/2021
Rainfall (4 day total)
Tadpoles
Mets

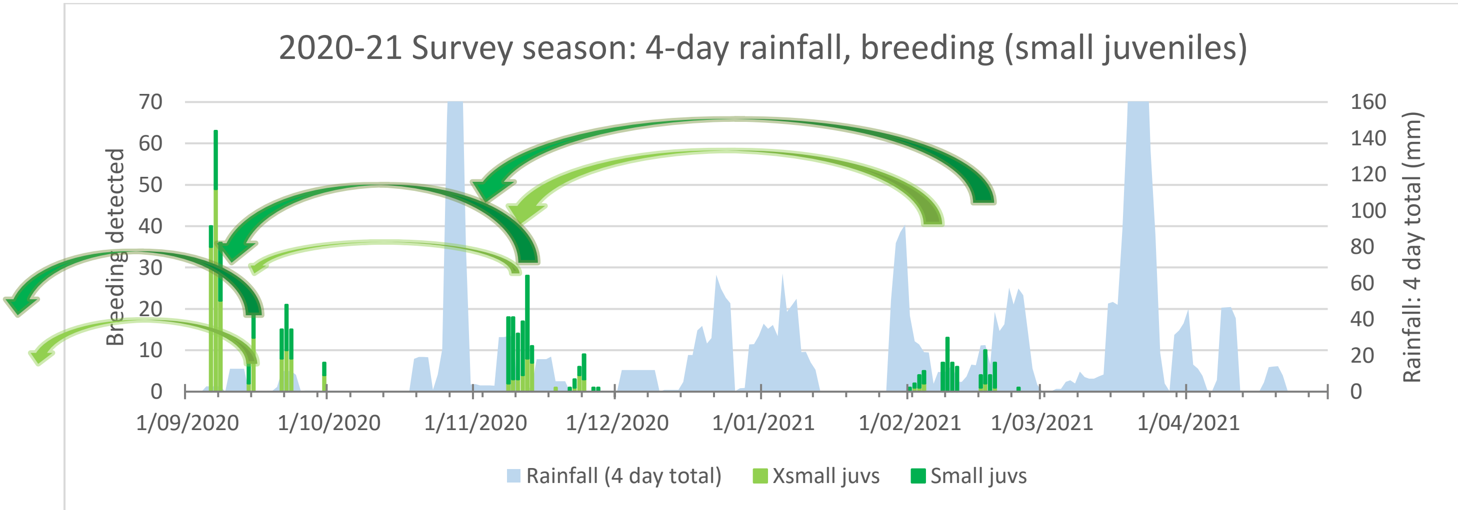
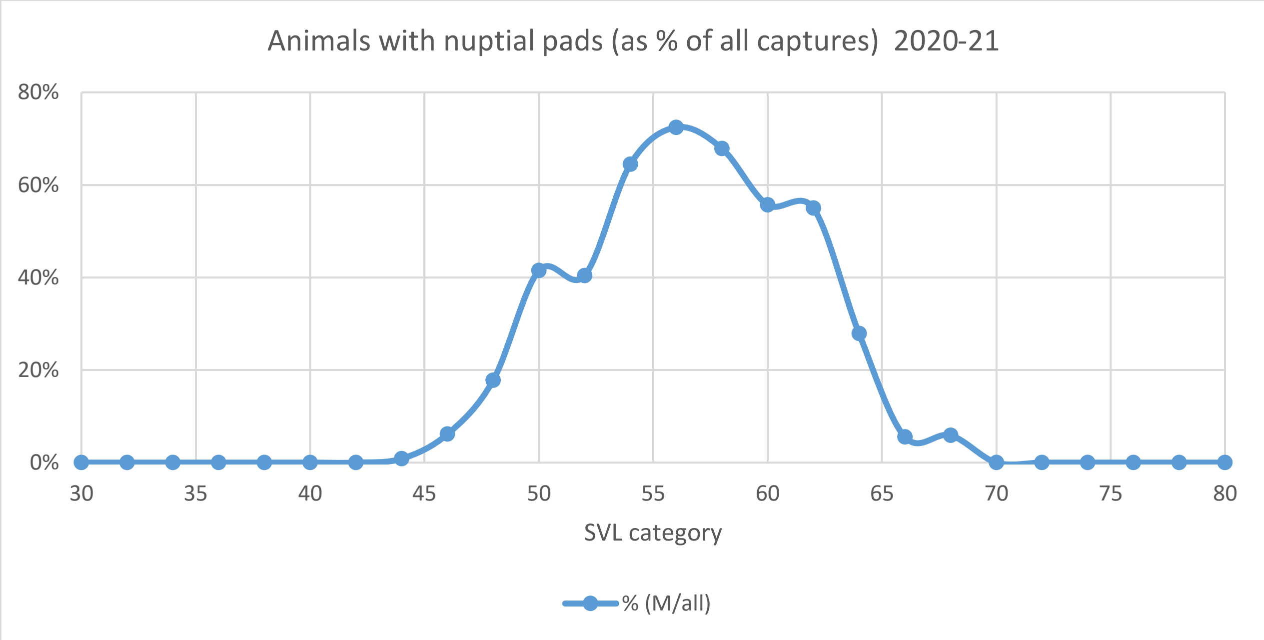

2020-21 Survey season: 4-day rainfall, breeding (small juveniles)
Breeding detected
70
60
50
40
30
20
10
0
160
140
120
100
80
60
40
20
0
Rainfall: 4 day total (mm)
1/09/2020
1/10/2020
1/11/2020
1/12/2020
1/01/2021
1/02/2021
1/03/2021
1/04/2021
Rainfall (4 day total)
Xsmall juvs
Small juvs

Figure 3.6.3: Survey nights (top), nights where calling was heard, detections of tadpoles and metamorphs, and detections of small juveniles (bottom), correlated with rainfall. Arrows indicate potential laying dates for animals detected as tadpoles (brown arrows), metamorphs (dark green), very small (‘Xsmall’; SVL < 35 mm; light green) and small (35 < SVL < 40 mm; dark green in bottom chart) juveniles. Numbered arrows related to potential cohorts outlined in the text.

Size at sexual maturity



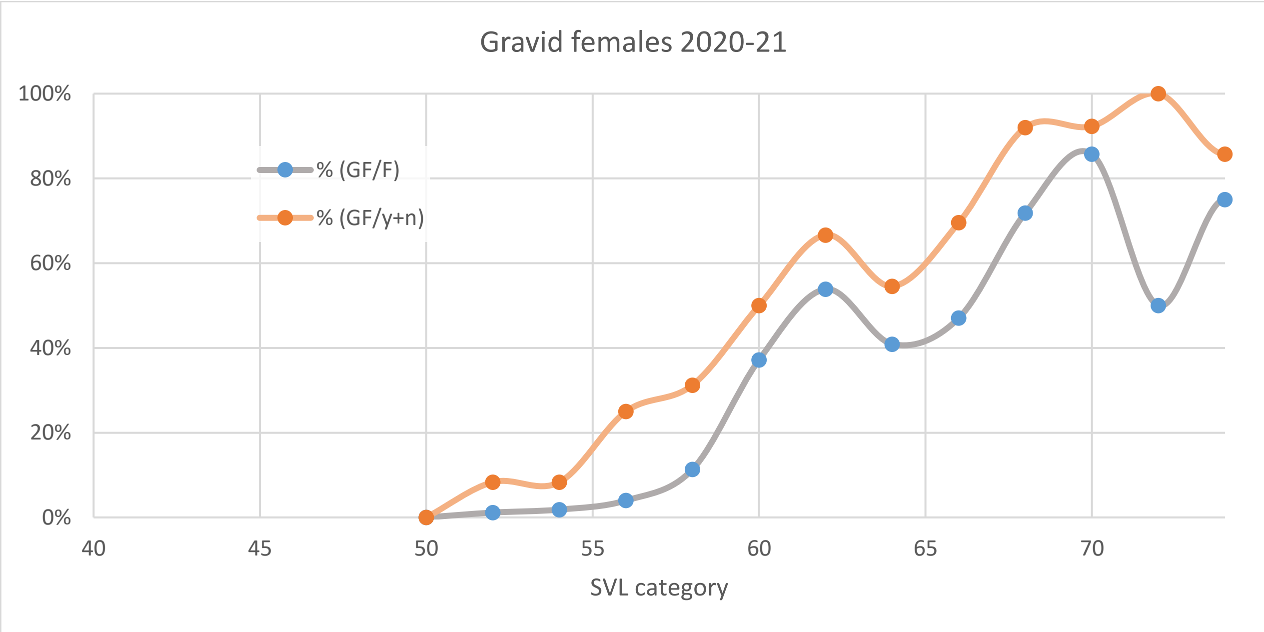


Figure 3.6.4: Proportions of animals with nuptial pads (top), and proportion of gravid animals (bottom). See text for discussion.

Data from the 2020-21 (Figure 3.6.4) is broadly consistent with the observation from the previous three seasons (Section 2.6, Figure 2.6.2), indicating that *L. aurea* males reach sexual maturity at approximately 45-50 mm SVL. There were, however, slight differences compared to previous seasons. The largest proportion of *L. aurea* with nuptial pads present in the current season (75%) occurred at an SVL of 56 mm. This is compared to the 2019-20 season where the largest proportion (80%) of *L. aurea* with nuptial pads plateaued at approximately 53 mm SVL, and in 2016-17 where a 60% plateau occurred around 50 mm SVL.

The exact point of this plateau does not affect the counts of males (which are only positively identified by the presence of nuptial pads), but does affect the counts of juvenile females (which are identified by the absence of nuptial pads but an SVL greater than 49.5 mm). The data from the current 2020-21 season indicates that that size threshold for identifying an animal as a juvenile female (as opposed to simply a juvenile of unknown gender) may be slightly too small. We have not adjusted that threshold in analysing the demographics, but highlight this issue here for future consideration.

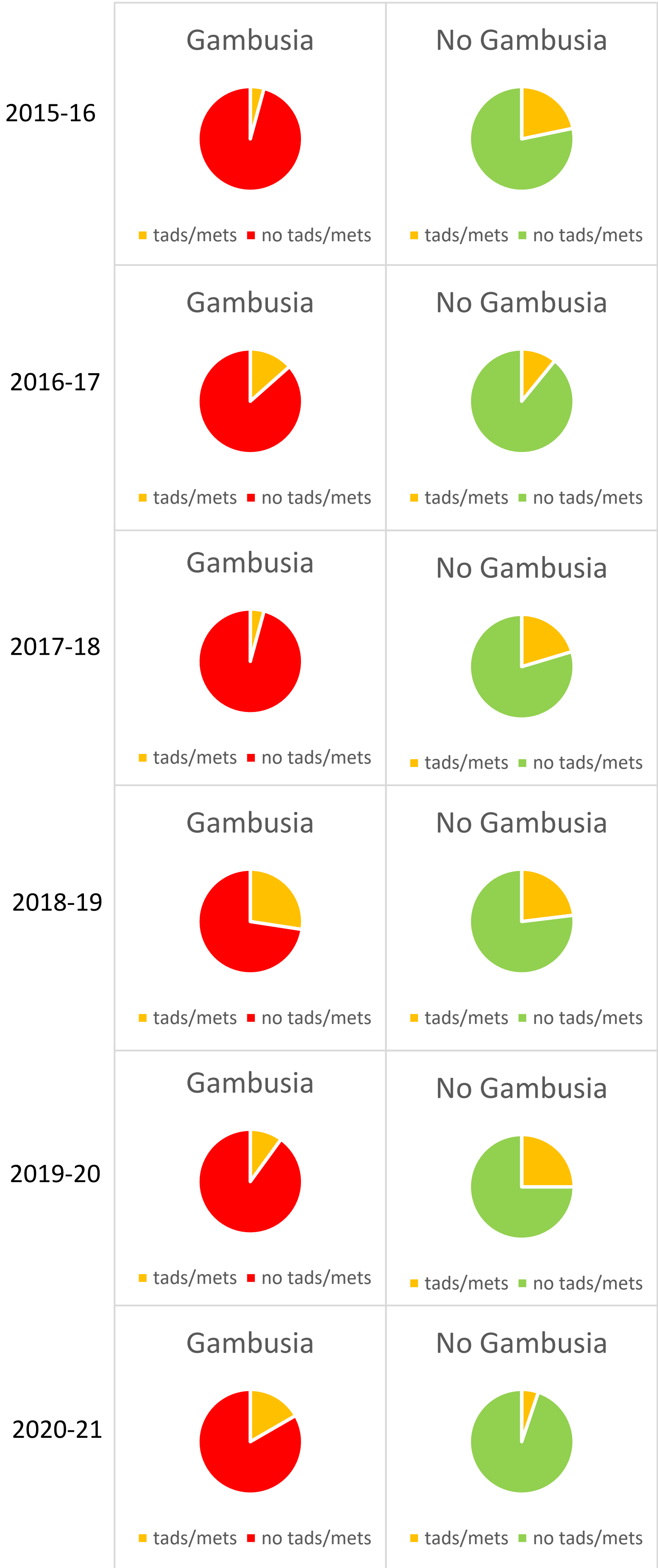
If the onset of sexual maturity for *L. aurea* females is the production of eggs, and if egg masses can be reliably detected using candling (Section 2.6), then it indicates that some females achieved sexual maturity in the 2020-21 breeding season at 52 mm SVL (Figure 3.6.4). This is the same as what was recorded in the previous two breeding seasons. There was a general increase in the percentage of females gravid with increases in size, and by 67 mm SVL more than 80% of the females candled were gravid. This differs from the previous season, where 80% of females candled were gravid by 57 mm SVL.

The size threshold used to delineate between adult and juvenile females in 2016-17 was 58 mm SVL; we here cautiously retain that threshold. Confirmation of sexual maturity in *L. aurea* below a SVL of 58 mm awaits confirmation from hormone analysis.

Interactions between breeding and *Gambusia*

	Total wetlands with	Gambusia	no Gambusia
2015-16	tads/mets	3	4
	no tads/mets	56	15
2016-17	tads/mets	3	5
	no tads/mets	21	42
2017-18	tads/mets	1	9
	no tads/mets	15	35
2018-19	tads/mets	3	11
	no tads/mets	10	49
2019-20	tads/mets	3	18
	no tads/mets	7	60
2020-21	tads/mets	4	3
	no tads/mets	20	55

Table 3.6.1: Interaction between presence of *Gambusia*, and breeding behaviour of *L. aurea* (as evidenced by the presence of tadpoles and/or metamorphs), for the current 2020-21 breeding season and previous five seasons.



[Figure 3.6.5](#) shows a strong interaction between the presence of *Gambusia* and breeding by *L. aurea in* 2015-16 and 2017-18. However, based only on binary presence-absence data, there appears to be no effect in some breeding years (e.g. 2016-17 and 2018-19). As noted previously (McHenry et al. 2019), looking simply at presence/absence of *Gambusia* may underestimate this effect. Breeding of *L. aurea* is likely to be related to density of *Gambusia*, not just presence. For instance, in K104 there was a significant breeding event in 2017-18; *Gambusia* was present, but at much lower densities than in 2015-16. Adjusting for the charts so that wetlands with low density and absence of *Gambusia* are grouped together again indicates that breeding across all years is generally seen more frequently when *Gambusia* is not abundant (Figure 3.6.5).

The differences in *Gambusia* presence/absence, as well as density are directly related to the hydrology of the wetland prior to the breeding season. Compared to the previous breeding season, there has been an apparent increase in the proportion of *Gambusia* present wetlands in which breeding is occurring and a reduction in those free of *Gambusia*. This is likely an artefact of the low number of breeding events that occurred this year which is skewing results, but could also be due to the lack of extensive pond drying this season that has enabled *Gambusia* to reinvade some pivotal sites.

Figure 3.6.5: Graphical representation of the data presented in Table 3.6.1. The filled charts at the bottom show the 2020-21 adjusted to show counts with low and/or zero densities of *Gambusia*.

3.7 Wetland Physiognomy

Wetland Physiognomy

Score	**5**	**4**	**3**	**2**	**1**
Size	Very large	Large	Med	Small	Very small
Openness (tall reeds)	Open	Nearly open	Partially open	Nearly closed	Closed
Edge vegetation extent (tall reeds)	Totally surrounded by reeds	Lots	Approx. half	Small amount	Very little/none

Table 3.6.3: Qualitative scores used for preliminary analysis of the effects of wetland physiognomy upon *L. aurea* abundance; c.f. Fig. 3.6.1, Fig.3.6.2.

3.8 Population Model

Population estimate of wetlands surveyed using Capture-Mark-Recapture

Previous seasons have used data from Capture-Mark-Recapture (CMR) surveys at three wetlands; K22/23, K29, and K104; that data provides a **detection ratio** (number of frogs present in a wetland compared with the number of frogs detected during VES). In the 2019-20 season CMR surveys were not undertaken due to logistical hurdles from the ground fire and COVID; instead, averaged detection ratios from previous years were used to generate the detection ratio. In the 2020-21 season we conducted CMR surveys at K22/23, K100A, and K111 (Table 3.8.1).

As detailed in **Section 2.6**, a single CMR survey at a given wetland should run for a minimum of three consecutive nights until the within-round recapture rate is above 20%. (i.e. when, on a given survey night, at least 20% of the animals captured had already been captured in that round: <marked animals recaptured on the night> / <total unique animals captured over the duration of the survey>). Note this not the same as 20% of animals being 'recaptures', i.e. animals that have previously been captured at some point in their lives. The information provided by a CMR survey round is maximised if there are at least 3 survey nights within the round.

As a matter of course we aim to complete a CMR survey at each of these three wetlands during each round. However, various logistical issues can impede these surveys; in previous years, CMR surveys have been abandoned because of insufficient frogs at the wetland in that round, sometimes combined with obvious high levels of immigration/emigration from the wetland during the survey, or because drying wetlands contain deep mud that makes intensive surveying treacherous. During the 2020-21 season, the CMR surveys in round 1 were not attempted as most frogs being detected in the first round were small juveniles (<40 mm SVL) that are unable to be tagged ('marked'). Ongoing COIVD restrictions in round 2 meant that we were only able to complete a CMR at K111. In round 3 we attempted CMR surveys at all three of the targeted sites; those at K111 and K22-23 were completed, but the survey at K100A could not be completed due to insufficient recapture rates.

Wetland	Dates of primary survey periods	no. secondary surveys	*L. aurea* captures (total; unique)	Final recap. rate (%)	Naïve population estimate
	Round 2				
K22/23	-	-	-	-	-
K100A	-	-		-	-
K111	8-10 Nov 2020	3	112; 72	39%	78
	Round 3				
K22/23	8-10 Feb 2021	3			
K100A	16-18 Feb 2021	3			
K111	1-3 Feb 2021	3			

Table 3.8.1: Surveys, captures, final recapture rates, and naïve population estimates at the three sites where CMR surveys were conducted. Final recapture is shown for last night of each survey (see text for explanation of calculation). Naïve population estimate is calculated as <total animals marked to date> x (<animals captured on final night>/<recaptured animals on final night>).

The results of the CMR surveys were analysed by Robust modelling using RMark code in the R programming language to interface with the program MARK (Table 3.3.3).

Rank	Model	No. of parameters	AIC_c	ΔAIC_c	weight (*w*)
	K111				
1	φ(.) *G′=G″=0 p=c*(sess) f0(sess)	13	-1010.8274	0.0000000	3.411246e-01
2	φ(t) *G′=G″(.) p=c*(.) f0(sess)	9	-1010.0878	0.7396027	2.356733e-01
3	φ(.) *G′=G″(.) p=c*(sess) f0(sess)	14	-1008.6399	2.1875067	1.142621e-01
	K22-K23				
1	φ(.) *G′=G″=0 p=c*(.) f0(sess)	5	-624.6922	0.0000000	3.613026e-01
2	φ(.) *G′=G″(.) p=c*(.) f0(sess)	6	-622.5531	2.139091	1.239862e-01
3	φ(.) *G′=G″=0 p=c*(t.sess) f0(sess)	6	-622.5531	2.139091	1.239862e-01

Table 3.8.2: 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 *L. aurea* at the CMR sites on Kooragang Island, 2018-19. In the best ranked models, net immigration/emigration (G', G") was set to zero. (.) indicates that the value of a parameter was constant, (t) that it varied with time, and (sess) that it varied between between primary sessions but was fixed for secondary sessions within each primary session.

Models are ranked according to their corrected Akaike Information Criteria (AICc) values. Delta AICc values <2 indicate reliable models. Instances where the top ranked model is the only one with a delta AICc <2 are taken as very strong support for that model.

The top ranked models produced highly convergent estimates of population size (N-hat values) for K29 and K104 (Table 3.8.3). Selecting the best ranked model for each CMR site allowed estimates of total population size for each site, in each round.

	1st Primary Session (round 1)			2nd Primary Session (round 2)			3rd Primary Session (round 3)		
Wetland	N-hat (pop. size)	95% confidence levels		N-hat (pop. size)	95% confidence levels		N-hat (pop. size)	95% confidence levels	
model #		Lower	Upper		Lower	Upper		Lower	Upper
K111									
#12	-	-	-	112	95	146	300	252	374
#17	-	-	-	126	107	157	280	244	334
#11	-	-	-	112	95	146	300	252	374
K22-K23									
#3	-	-	-	-	-	-	252	210	321
#2	-	-	-	-	-	-	252	210	321
#15	-	-	-	-	-	-	252	210	320

Table 3.8.3: Population estimates for the wetlands surveyed using Capture-Mark-Recapture, analysed by Robust Modelling. Results from a selection of the best models as ranked by AICc scores (c.f. Table 3.8.2) are presented. N-hat values are population estimates for each wetland, listed by each model for each round. The top ranking models provide consistent estimates, and the range of the 95% confidence levels is reasonably narrow for all population estimates.

The population estimates for the CMR sites are summed (Table 3.8.4).

	lower	N-hat	upper
Round 1			
Round 2*	95	112	146
Round 3**	454	532	655

Table 3.8.4: Total population estimates for CMR surveyed wetlands, for each round. Notes that only K29 and K104 were surveyed in each of the two rounds. The estimates from the robust models are based upon the top ranking model for each wetland, as shown in Table 3.8.3. The totals for the naïve population estimate are taken from Table 3.8.1. There is some degree of consilience between the estimates derived from the two approaches.

Using VES data to convert CMR results into an island wide estimate of *L. aurea* population on Kooragang Island

The first step in producing a whole-island estimate of *L. aurea* numbers is to determine the proportion of frogs inhabiting a wetland that are detected during a Visual Encounter Survey. This is achieved by using the CMR survey results to calculate a conversion factor (1/<proportion detected in VES>) that can be used to estimate the total number of *L. aurea* at each surveyed wetland, based on the number of frogs detected in each VES (Table 3.8.5).

	Conversion factor (= 'Detection ratio") (VES_detected -> CMR population_estimate)				
Wetland	min-lower	mean-lower	mean-N-hat	mean-upper	max-upper
all	1.80	4.81	**5.70**	7.31	16.46
K22/23	7.58	8.29	**9.95**	12.67	13.84
K111	1.62	3.97	**4.70**	6.03	16.97

Table 3.8.5: Conversion factors (calculated as <population estimate> / <number detected in VES>) for the three CMR wetlands. 'min', 'mean', and 'max' relate to the minimum, mean, and maximum values for that ratio respectively, as a result of different VES counts at each wetland during each round. 'lower', 'N-hat', and 'upper' relate to the range of population estimates calculated for each wetland using robust modelling (see Table 3.3.4). Combining these two dimensions of variation produces a range of estimates for the conversion factor (see text for discussion). The 'pooled' row shows values combined from all CMR surveys; the other rows show the values for each specific CMR wetland.

Note that this number should consider only 'taggable' frogs, i.e. adults and juveniles with an SVL of at least 40 mm; since only taggable frogs can be used to calculate the n-hat in the robust modelling of the CMR data, the conversion factor should only consider 'taggable' frogs detected during the VES. For captured frogs, this can be determined with confidence, but for uncaptured juveniles it represents a potential source of error as there is not way to determine how many may have been smaller than 40 mm SVL.

The pooled conversion factor for the 2020-21 data was 5.7; i.e., for every ≥ 40 mm SVL *L. aurea* detected during VES, we expect that a total of ≥ 40 mm SVL 5.3 frogs were actually present but that 4.7 remained undetected (the conversion factor is thus the inverse of the detection probability). This pooled value was affected by a very low value for K111, where detectability is apparently high; the value of 9.95 for K22/23 is perhaps more similar to many other wetlands but is higher than the values from previous years.

Combining the min, mean, and max values for the detected/population ratio with the 'N-hat', and also lower and upper 95% confidence intervals se estimates of CMR population size provides a range of values for the conversion factor. We use 5 of these potential values:

1. **Min-lower**: the minimum value of the <detected/population> ratio, using the lower estimate of population size.
2. **Mean-lower**: the mean value of the <detected/population> ratio, using the lower estimate of population size.
3. **Mean-N-hat**: the mean value of the <detected/population> ration, using the preferred ('N-hat') estimate of population size.
4. **Mean-upper**: the mean value of the <detected/population> ratio, using the upper estimate of population size.
5. **Max-upper**: the maximum value of the <detected/population> ratio, using the upper estimate of population size.

The range of values for conversion factors are then used to generate estimates of population size at the 62 wetlands that were surveyed only by VES.

The final step in making the island-wide population estimate is to adjust for those wetlands that are too large to fully survey in a 30 minute VES. For these, the proportion of the wetland surveyed during VES was measuring using GIS to calculate an area weighting.

The estimates for total population (*L. aurea* ≥ 40 mm SVL) for the VES surveyed wetlands are shown in Table 3.8.6.

	min-lower	mean-lower	mean-N-hat	mean-upper	max-upper
Non CHEMP wetlands					
Round 1	329	711	845	1,083	2,275
Round 2	324	768	912	1,169	2,514
Round 3	1,056	2,817	3,341	4,284	9,647
CHEMP wetlands					
Round 1	9	24	29	37	82
Round 2	137	365	433	556	1,251
Round 3	182	485	576	738	1,663
Total VES wetlands					
Round 1	338	735	874	1,119	2,357
Round 2	461	1,133	1,345	1,724	3,765
Round 3	1,238	3,302	3,916	5,022	11,309

Table 3.8.6: Population estimates for XX non-CHEMP and XX CHEMP wetlands. Estimates are based on the ratio of CMR(population):VES(detected) at the CMR survey sites (Table 3.8.5) Note that VES counts include K22-23 for rounds 1 and2, and K111 for round 1, as CMR surveys were not completed at those wetlands in those rounds. See text for explanation.

Combining the population estimates for the CMR (Table 3.8.3) and VES (Table 3.8.6) surveyed wetlands provides a range of estimates for the actual population size across all the wetlands surveyed on Kooragang Island over the 2020-21 season (Table 3.8.7).

	min-lower	mean-lower	mean-N-hat	mean-upper	max-upper
Round 1	338	735	**874**	1,119	2,357
Round 2	556	1,228	**1,457**	1,870	3,911
Round 3	1,692	3,756	**4,448**	5,677	11,964

Total population size (not including CHEMP wetlands)

	min-lower	mean-lower	mean-N-hat	mean-upper	max-upper
Round 1	329	711	**845**	1,083	2,275
Round 2	419	863	**1,024**	1,315	2,660
Round 3	1,510	3,271	**3,873**	4,939	10,302

Table 3.8.7: Estimates of total population size across all surveyed wetlands. See text for discussion.

These estimates should be interpreted as follows:

- It is **highly likely** that the population of 'taggable' (i.e > 40 mm SVL, which includes large juveniles and adults) *L. aurea* at the surveyed wetlands was between the 'min-lower' and 'max-upper' limits (i.e. between 338 and 2,357 in Sept 2020).
- It is **probable** that the population of taggable *L. aurea* was between the 'mean-lower' and the 'mean-upper' figures (i.e. between 1,228 and 1,870 in November 2020)
- The model estimation for the **approximate** population is the 'mean-N-hat' figure, i.e. 4,448 in Feb 2021.

It is not correct to say that that the population was 874 in round 1; rather, the population was **approximately** 874 *L. aurea* that were greater than 40 mm SVL.

A notable feature of the data is the large increase in the estimate of taggable L. aurea from round 1 (~874) to round 3 (~4,448). This is a result of the very large cohort of young animals that were present in the population in the early part of the season (having been spawned in the very large breeding event of Feb-March 2020). In the early rounds of the 2020-21 season, these were too small to be tagged and thus are not included in the population model estimate. By the later rounds, they were large enough to be included in the estimate. (See Figure 3.4.5 for a visual summary of the growth of this cohort through the season)>

Note that these estimates include the CHEMP wetlands created in the Central and Northern Zones of Kooragang Island. Comparing the estimate for the non-CHEMP wetlands with data from the previous two seasons provides some indicate of the population dynamics for *L. aurea* on Kooragang Island since the island-wide surveys began in 2010 (Figure 3.8.1)

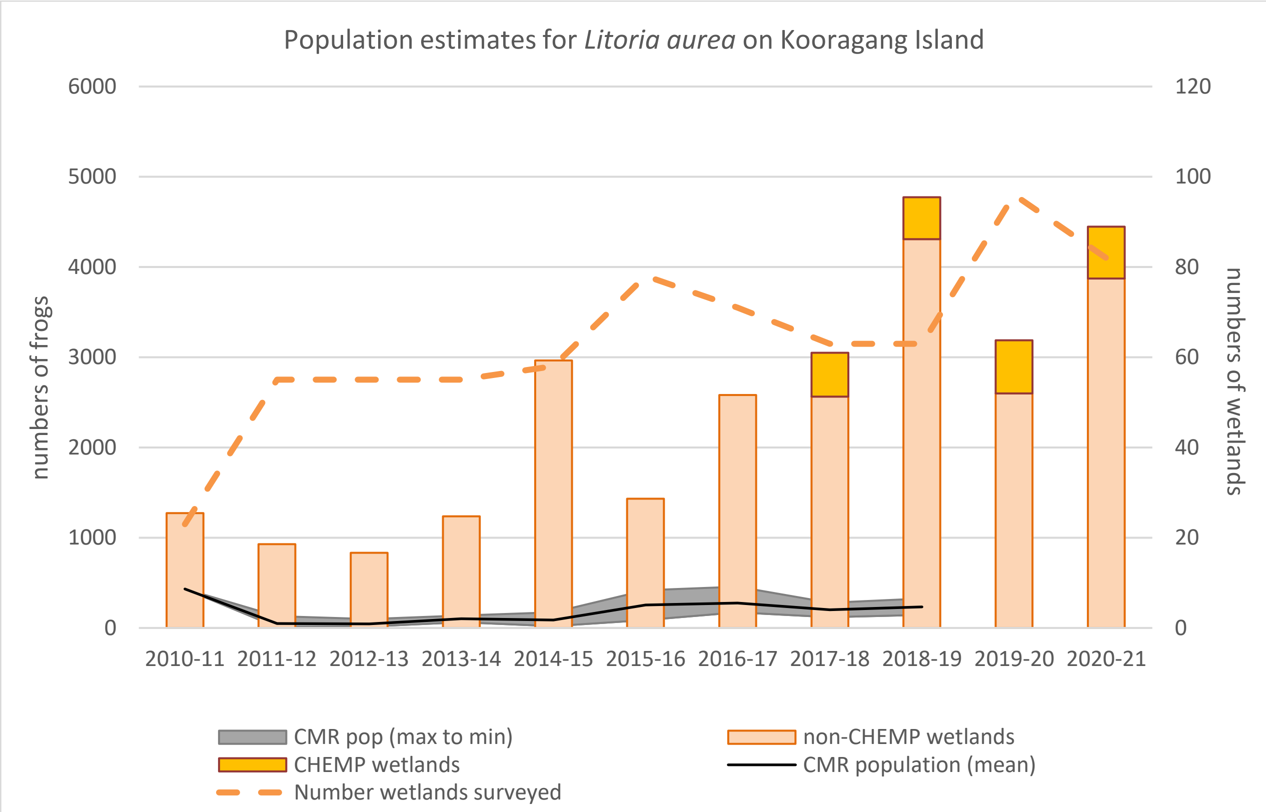


Figure 3.8.1: Population estimates for *L. aurea* on Kooragang Island. Data for 2010-2019 is from previous annual reports for the current project, while the 2019-20 data is from the current report. The light yellow columns show **maximal** population estimates derived from VES counts for the non-CHEMP wetlands only, while the darker orange columns show the maximum 2017-18, 2018-19 and 2019-20 estimates for all wetlands including the CHEMP wetlands (see data shown in Table 3.8.7). The black line shows the average (across all rounds in a given season) total N-hat for wetlands where CMR surveys were conducted, whilst the greyed area shows maximum and minimum N-hat values across all surveys for each season. The dashed green line shows the number of wetlands surveyed each season (Y2 axis).

3.9 Multi-year occupancy

To provide a spatio-temporal context for occupancy of Kooragang Island by *L. aurea*, data from 2014-21 (i.e. seven complete seasons) was analysed with respect to the subdivisions outlined in **Section 2.2**:

1. **Jurisdiction**: i.e. the organisations responsible for / active on various parts of the island.
2. **Zone**: splitting the island into three large-scale regions.
3. **Region**: subdivisions of zones, bounded broad geographic distance, at a scale of ~2 km.
4. **Subregion**: bounded by rail-lines, roads, and creeks, at a scale of up to ~1 km.

The following charts show data from survey counts, broken down by these four criteria. Survey count data is summarised according to:

i. **VES detected** (number of *L. aurea* detected during primary VES surveys)
ii. **Total detected** (number of *L. aurea* detected during all surveys)
iii. **Search sensitivity** (a proxy for density; the number of animals detected in VES divided by search effort)

Raw survey counts are not subject to the various assumptions inherent in estimating populations from robust modelling, and can therefore provide an additional and useful perspective on spatio-temporal trends in occupancy. However, they are a product of both occupancy and search effort; thus, in interpreting the counts to understand occupancy, it is important to take into account search effort. The landscape of Kooragang Island is not constant, and search effort and detectability has changed from year to year as new wetland habitats are created, and some old ones go through vegetative and hydrological changes.

For the data presented here, no single table provides a complete picture of *L. aurea* occupancy. Rather, the data for **VES Detected**, **Total Detected**, and **Search Sensitivity** should be viewed together. Large wetlands may contain large numbers of frogs (high values of **VES Detected** and **Total Detected**) at low or medium densities (lower values of **Search Sensitivity**). Conversely, small wetlands may contain high densities of frogs but with low overall numbers.

The search effort (measured in person.minutes) of VES surveys across the last seven seasons is shown in Table 3.9.1. Total search effort has shown a general increase over time. Compared to last year, search effort has increased in the northern zone, though there has been a decline in the Central and Southern Zones (c.f. Table 2.5.1). The HDC jurisdiction in particular has seen a reduction in search effort from 2019-20, though still much greater than all other seasons dating back to 2014-15. There has also been a reduction in search effort for the BHP-CHEMP wetlands but a marked increase for the NCIG-CHEMP wetlands. Each wetland takes a minimum of 30 person.minutes to survey over the season, and most take considerably more; as new wetlands have been constructed (HDC wetlands in the Industrial Zone, CHEMP wetlands in the Central and Northern Zones), the number of NPWS, PWCS, HDC (BHP) and RMS wetland surveys have been reduced slightly to keep survey logistics manageable. Search effort remains well distributed across the island as a whole (Figure 2.5.2).

	All animals (not including mets)						
	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Jurisdiction							
NPWS	2028	3693	2758	1460	1560	1851	2404
NCIG_CHEMP	0	0	0	296	2228	953	1575
BHP_CHEMP	30	279	0	1523	1483	2153	725
PoN	1475	697	1033	423	641	358	383
PWCS	2347	2224	3305	4563	4600	999	277
NCIG	104	348	319	574	680	128	114
HDC	393	720	848	1681	1677	9295	7546
HDC (BHP)	1304	615	442	582	506	0	0
RMS	298	278	156	0	0	0	0
Zone							
Nth	1027	1617	1056	1040	3014	1654	2323
Central	2423	3052	2735	2662	2898	3661	2764
Southern	4446	4185	5070	7400	7463	10422	7937
Region							
Hunter North River	611	657	395	414	1021	620	660
School House	469	960	661	626	1993	1034	1663
Cobbans Creek	458	1132	651	1728	1805	2507	1455
Bellfrog Way	1995	1920	2084	934	1093	1154	1309
Industrial Zone North	2093	1783	2887	3924	3840	5452	4256
Industrial Zone South	2353	2402	2183	3476	3623	4970	3681
Subregion							
Scott's Point	174	264	201	259	726	437	441
Riverside park	437	393	194	155	295	183	219
Wet meadow	395	678	448	410	426	414	559
Millam's Pond	74	282	213	216	1567	620	1104
Ramsar Road West	110	564	258	1601	1587	2251	1036
Ramsar Road East	348	568	393	127	218	256	419
Bellfrog Way West	152	403	350	205	201	376	368
Bellfrog Way NE	270	588	465	306	251	420	558
Bellfrog Way SE	1573	929	1269	423	641	358	383
Delta Ponds	435	195	570	881	845	999	277
KIWEF K7	1436	1441	1823	2037	1007	2025	1945
NCIG rail central & east	240	507	496	775	941	764	358
Rail loop (K10 Nth)	393	606	596	902	730	1568	1730
Cormorant Road	298	278	156	0	0	0	0
Rail loop SW (K10 Sth)	27	110	112	725	906	1372	1116
NCIG rail south	1345	555	474	405	529	657	228
KIWEF K2	50	346	349	669	517	609	249
Deep pond	222	147	494	1006	1988	1731	1851
KIWEF K5 (Area 2)	-	-	-	-	0	697	183

Table 3.9.1: Search effort (in person.minutes) across the latest 2020-21 season along with the previous six seasons, tabulated by Jurisdiction, Zone, Region, and Subregion. Note that search effort is measured for visual encounter surveys (VES) only.

	All animals (not including mets)							**Adults only**						
	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Jurisdiction														
NPWS	34	25	11	13	17	37	119	27	17	7	4	15	21	68
NCIG_CHEMP	0	0	0	5	87	41	31	0	0	0	2	65	40	21
BHP_CHEMP	0	19	0	394	298	491	185	0	13	0	178	138	157	129
PoN	59	42	109	50	48	70	72	27	13	65	44	29	70	35
PWCS	323	87	588	703	1012	84	55	128	52	303	377	508	50	25
NCIG	0	10	83	83	125	10	51	0	3	60	47	65	7	29
HDC	15	16	393	151	206	1544	1982	10	9	34	41	95	462	571
HDC (BHP)	10	2	48	58	54	0	0	6	0	18	35	20	0	0
RMS	0	0	6	0	0	0	0	0	0	3	0	0	0	0
Zone														
Nth	8	3	0	6	92	47	33	4	2	0	3	70	46	23
Central	85	83	120	456	358	592	374	50	41	72	225	177	242	230
Southern	348	115	1118	995	1397	1638	2088	144	64	418	500	688	519	625
Region														
Hunter North River	0	0	0	1	2	3	9	0	0	0	1	2	3	7
School House	8	3	0	5	90	44	24	4	2	0	2	68	43	16
Cobbans Creek	13	31	3	404	301	498	204	13	20	2	180	141	154	130
Bellfrog Way	72	52	117	52	57	94	170	37	21	70	45	36	88	100
Industrial Zone North	322	86	546	649	837	578	1001	127	52	278	347	463	245	308
Industrial Zone South	26	29	572	346	560	1060	1087	17	12	140	153	225	274	317
Subregion														
Scott's Point	0	0	0	1	2	2	6	0	0	0	1	2	2	4
Riverside park	0	0	0	0	0	1	3	0	0	0	0	0	1	3
Wet meadow	8	2	0	1	8	1	6	4	2	0	1	4	0	5
Millam's Pond	0	1	0	4	82	43	18	0	0	0	1	64	43	11
Ramsar Road West	1	25	2	404	301	489	180	1	14	2	180	141	154	107
Ramsar Road East	12	6	1	0	0	9	24	12	6	0	0	0	0	23
Bellfrog Way West	3	2	0	2	4	12	97	2	2	0	1	2	6	65
Bellfrog Way NE	8	4	3	0	5	12	1	6	3	1	0	5	12	0
Bellfrog Way SE	61	46	114	50	48	70	72	29	16	69	44	29	70	35
Delta Ponds	204	62	101	153	162	84	55	33	36	57	65	96	50	25
KIWEF K7	116	19	358	276	87	134	220	92	13	182	215	70	96	100
NCIG rail central & east	0	11	98	95	154	86	143	0	3	72	54	77	42	50
Rail loop (K10 Nth)	15	16	383	82	66	301	535	10	9	28	16	46	83	123
Cormorant Road	0	0	6	0	0	0	0	0	0	3	0	0	0	0
Rail loop SW (K10 Sth)	0	0	16	51	236	605	293	0	0	10	19	63	105	102
NCIG rail south	9	2	58	42	69	36	77	5	0	20	19	23	26	28
KIWEF K2	2	0	11	76	35	32	39	2	0	7	45	16	18	14
Deep pond	2	5	87	220	588	257	713	2	3	39	67	297	99	172
KIWEF K5 (Area 2)	-	-	-	-	-	103	13	-	-	-	-	-	0	11

Table 3.9.2: VES Detected numbers for the latest 2020-21 season along with the previous six seasons, summed for Jurisdiction, Zone, Region, and Subregion. Comparing the values for 'All *L. aurea*' (left columns) and 'Adult *L. aurea*' (right columns) provides an indication of the number of juveniles.

Data for **VES Detected** (Table 3.9.2) shows that the 2020-21 season had the highest numbers of *L. aurea* detected within VES. Most detections occurred in the south of the island, where there was an increase since last year, including both the north and south Industrial Zones. Detections in the Northern and Central Zones have decreased since last year. More than half of all detections in the Northern and Central Zones were classified as adults, while only 30% were classified as such in the Southern Zone, highlighting the continued importance of the Industrial Zone for breeding on the Island.

	All animals (not including mets)							Adults Only						
	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Jurisdiction														
NPWS	0.02	0.01	0.00	0.01	0.01	0.02	0.05	0.01	0.00	0.00	0.00	0.01	0.01	0.03
NCIG_CHEMP	-	-	-	0.02	0.04	0.04	0.02	-	-	-	0.01	0.03	0.04	0.01
BHP_CHEMP	0.00	0.07	-	0.26	0.20	0.23	0.26	0.00	0.05	-	0.12	0.09	0.07	0.18
PoN	0.04	0.06	0.11	0.12	0.07	0.20	0.19	0.02	0.02	0.06	0.10	0.05	0.20	0.09
PWCS	0.14	0.04	0.18	0.15	0.22	0.08	0.20	0.05	0.02	0.09	0.08	0.11	0.05	0.09
NCIG	0.00	0.03	0.26	0.14	0.18	0.08	0.45	0.00	0.01	0.19	0.08	0.10	0.05	0.25
HDC	0.04	0.02	0.46	0.09	0.12	0.17	0.26	0.03	0.01	0.04	0.02	0.06	0.05	0.08
HDC (BHP)	0.01	0.00	0.11	0.10	0.11	-	-	0.00	0.00	0.04	0.06	0.04	-	-
RMS	0.00	0.00	0.04	-	-	-	-	0.00	0.00	0.02	-	-	-	-
Zone														
Nth	0.01	0.00	0.00	0.01	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.02	0.03	0.01
Central	0.04	0.03	0.04	0.17	0.12	0.16	0.14	0.02	0.01	0.03	0.08	0.06	0.07	0.08
Southern	0.08	0.03	0.22	0.13	0.19	0.16	0.26	0.03	0.02	0.08	0.07	0.09	0.05	0.08
Region														
Hunter North River	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
School House	0.02	0.00	0.00	0.01	0.05	0.04	0.01	0.01	0.00	0.00	0.00	0.03	0.04	0.01
Cobbans Creek	0.03	0.03	0.00	0.23	0.17	0.20	0.14	0.03	0.02	0.00	0.10	0.08	0.06	0.09
Bellfrog Way	0.04	0.03	0.06	0.06	0.05	0.08	0.13	0.02	0.01	0.03	0.05	0.03	0.08	0.08
Industrial Zone North	0.15	0.05	0.19	0.17	0.22	0.11	0.24	0.06	0.03	0.10	0.09	0.12	0.04	0.07
Industrial Zone South	0.01	0.01	0.26	0.10	0.15	0.21	0.30	0.01	0.00	0.06	0.04	0.06	0.06	0.09
Subregion														
Scott's Point	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Riverside park	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Wet meadow	0.02	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01
Millam's Pond	0.00	0.00	0.00	0.02	0.05	0.07	0.02	0.00	0.00	0.00	0.00	0.04	0.07	0.01
Ramsar Road West	0.01	0.04	0.01	0.25	0.19	0.22	0.17	0.01	0.02	0.01	0.11	0.09	0.07	0.10
Ramsar Road East	0.03	0.01	0.00	0.00	0.00	0.04	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.05
Bellfrog Way West	0.02	0.00	0.00	0.01	0.02	0.03	0.26	0.01	0.00	0.00	0.00	0.01	0.02	0.18
Bellfrog Way NE	0.03	0.01	0.01	0.00	0.02	0.03	0.00	0.02	0.01	0.00	0.00	0.02	0.03	0.00
Bellfrog Way SE	0.04	0.05	0.09	0.12	0.07	0.20	0.19	0.02	0.02	0.05	0.10	0.05	0.20	0.09
Delta Ponds	0.47	0.32	0.18	0.17	0.19	0.08	0.20	0.08	0.18	0.10	0.07	0.11	0.05	0.09
KIWEF K7	0.08	0.01	0.20	0.14	0.09	0.07	0.11	0.06	0.01	0.10	0.11	0.07	0.05	0.05
NCIG rail central & east	0.00	0.02	0.20	0.12	0.16	0.11	0.40	0.00	0.01	0.15	0.07	0.08	0.05	0.14
Rail loop (K10 Nth)	0.04	0.03	0.64	0.09	0.09	0.19	0.31	0.03	0.01	0.05	0.02	0.06	0.05	0.07
Cormorant Road	0.00	0.00	0.04	-	-	-	-	0.00	0.00	0.02	-	-	-	-
Rail loop SW (K10 Sth)	0.00	0.00	0.14	0.07	0.26	0.44	0.26	0.00	0.00	0.09	0.03	0.07	0.08	0.09
NCIG rail south	0.01	0.00	0.12	0.10	0.13	0.05	0.34	0.00	0.00	0.04	0.05	0.04	0.04	0.12
KIWEF K2	0.04	0.00	0.03	0.11	0.07	0.05	0.16	0.04	0.00	0.02	0.07	0.03	0.03	0.06
Deep pond	0.01	0.03	0.18	0.22	0.30	0.15	0.39	0.01	0.02	0.08	0.07	0.15	0.06	0.09
KIWEF K5 (Area 2)	-	-	-	-	-	0.15	0.07	-	-	-	-	-	-	0.06

Table 3.9.3: Search sensitivity for the latest 2020-21 season along with the previous six seasons, summed for Jurisdiction, Zone, Region, and Subregion. The numbers indicate the number of frogs detected per person.minute of search effort, i.e. for a value of 0.25, one frog is detected every four person.minutes of search effort.

The overall trend continues to be an increase in the abundance of *L. aurea* over the seven years from 2014-15 to 2020-21. This does not appear to be a simple result of the increase in search effort. **Search Sensitivity** (Table 3.9.3), which is defined as the number of animals detected during VES per unit of search effort, has also increased steadily over this time. Indeed, search sensitivity in 2020-21 compared to the previous year has increased dramatically in the Industrial Zone, where it's the highest it's been in the past seven seasons for both the north and south regions. The greatest jump in search sensitivity appears to be in subregions associated with the Rail loop and Deep pond. In contrast, search sensitivity has declined slightly in both the Northern and Central Zones, though there has been an increase in the subregions associated with Bellfrog Way.

The **Total Detected** (Table 3.9.4) number of *L. aurea* has shown a change across time that differs between the three major zones. In the northern Zone, peak detection occurred in 2018-19 and has since started to show a decline that has continued into the current season. In the central Zone, detection peaked in 2017-18 and has since shown a decline that has continued into the current season. In the Industrial Zone, detections peaked in the previous season and have declined since. However, it must be stated that the large detection in 2019-20 was due to the large breeding events recorded in that season, which caused values to be inflated. As such, the decline in the current season is likely to reflect those seen in a year without a large breeding event. This is particularly highlighted by detections in Area 2, which were above 2000 in 2019-20 due to a large juvenile dispersal event, compared to 2020-21 where it declined to below 20. Nearly all subregions showed a decline in detections in the current season compared to the previous season, except for in the subregion associated with Bellfrog Way. What is apparent and consistent between years, including in the current season, is that there is a spatial shift in juvenile detections from very few in the Northern to more in the Southern Zone.

	All animals (not including mets)							Adults only						
	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Jurisdiction														
NPWS	44	29	27	13	17	42	135	35	20	14	4	15	22	82
NCIG_CHEMP	0	0	0	10	97	81	31	0	0	0	5	74	80	21
BHP_CHEMP	0	19	0	394	318	523	196	0	13	0	178	142	186	137
PoN	420	220	455	330	98	76	284	294	98	247	271	71	76	169
PWCS	534	922	2464	1918	2102	104	68	316	410	1389	1130	1156	69	29
NCIG	0	12	86	87	136	422	53	0	4	62	50	71	7	30
HDC	66	36	393	209	353	5335	2799	45	26	34	52	133	678	1000
HDC (BHP)	11	2	48	68	59	0	0	7	0	18	39	24	0	0
RMS	0	2	6	0	0	0	0	0	2	3	0	0	0	0
Zone														
Nth	10	4	0	11	102	88	34	6	3	0	6	79	87	24
Central	454	264	482	736	428	634	612	323	128	261	452	223	277	385
Southern	611	974	2997	2282	2650	5861	2920	368	442	1506	1271	1384	754	1059
Region														
Hunter North River	0	0	0	3	3	4	9	0	0	0	3	3	4	7
School House	10	4	0	8	99	84	25	6	3	0	3	76	83	17
Cobbans Creek	13	34	5	404	320	534	230	13	22	2	180	144	183	151
Bellfrog Way	441	230	477	332	108	100	382	310	106	259	272	79	94	234
Industrial Zone North	532	921	2420	1858	1962	3582	1226	314	410	1362	1094	1101	416	413
Industrial Zone South	79	53	577	424	688	2279	1694	54	32	144	177	283	338	646
Subregion														
Scott's Point	0	0	0	3	3	3	6	0	0	0	3	3	3	4
Riverside park	0	0	0	0	0	1	3	0	0	0	0	0	1	3
Wet meadow	10	3	0	1	8	1	6	6	3	0	1	4	0	5
Millam's Pond	0	1	0	7	91	83	19	0	0	0	2	72	83	12
Ramsar Road West	1	28	3	404	320	521	205	1	16	2	180	144	183	127
Ramsar Road East	12	6	2	0	0	13	25	12	6	0	0	0	0	24
Bellfrog Way West	4	2	7	2	5	12	97	3	2	2	1	3	6	65
Bellfrog Way NE	12	4	4	0	5	12	1	9	3	2	0	5	12	0
Bellfrog Way SE	425	224	466	330	98	76	284	298	101	255	271	71	76	169
Delta Ponds	209	859	718	559	720	104	68	38	364	372	236	428	69	29
KIWEF K7	321	57	1603	991	465	232	322	274	43	939	771	327	172	145
NCIG rail central & east	0	13	103	99	165	529	262	0	4	76	57	83	69	111
Rail loop (K10 Nth)	66	36	383	101	105	324	950	45	26	28	22	66	90	368
Cormorant Road	0	2	6	-	-	-	0	0	2	3	-	-	-	0
Rail loop SW (K10 Sth)	0	0	16	89	301	631	344	0	0	10	25	88	124	112
NCIG rail south	11	2	58	45	79	758	89	7	0	20	21	29	32	34
KIWEF K2	2	0	11	90	38	37	49	2	0	7	52	17	23	21
Deep pond	2	5	99	308	689	808	817	2	3	51	87	340	170	223
KIWEF K5 (Area 2)	-	-	-	-	-	2438	19	-	-	-	-	-	5	16

Table 3.9.4: Total Detected for the latest 2020-21 season along with the previous six seasons, summed for Jurisdiction, Zone, Region, and Subregion Areas with high values indicate the location of the CMR wetlands. Across most years, K22-23 in Bellfrog Way SE, and K29 in the KIWEF *K7* have been CMR locations. In 2014-15 K108 (in the Rail Loop *K10S*) was a CMR wetland, but was replaced by K104 (Delta Ponds) from 2015-16 onwards.

Within these overall trends, the data also provides an overview of the recent occupancy by *L. aurea* in different parts of the island. In terms of jurisdiction, animal numbers in NPWS wetlands have increased from previous years, with total detection the highest they've been over the past seven years. While there was an increase in search effort, density was also shown to have increased this season, though still much lower than densities recorded in the Industrial Zone jurisdictions. Numbers at the NCIG CHEMP wetlands have continued to show a decline since a peak in 2018-19, with the lowest recorded density values recorded from any jurisdiction. At the BHP CHEMP wetlands, numbers have undergone a sharp decline since a peak in 2019-20 that is likely due to a drop in search effort. Even so, densities at these wetlands are the highest they've been over the past seven years. A notable trend up until 2019-20 has been the decrease in numbers in the PoN wetlands; these include K22 and K23, which have historically been considered significant wetlands for the *L. aurea* populations of Kooragang Island. However, total detections have increased considerably at these wetlands this season and are now the highest they have been for three years.

Following changes in jurisdiction of many of the wetlands in the Industrial Zone in the previous years, only one of the surveyed wetlands is currently counted as a PWCS wetland and, as such, the totals for PWCS are low. There was a decrease in counts at both the NCIG and HDC wetlands from a peak last year. The HDC wetlands now include many of the wetlands formerly administered by PWCS, and consequently search effort in HDC wetlands was the highest across all jurisdictions in 2020-21. It also showed one of the highest frog densities out of all jurisdictions, with a large proportion of detections being juvenile. The NCIG wetlands saw a sharp increase in frog density, which was the highest recorded this season, despite search effort being low.

At the regional level, there was a decrease in detections at Cobbans Creek from a peak in 2019-20, along with a decline in density. There has also been a continued decline in detections at School House from a peak in 2018-19, with a decline also seen in density. While there has been a decrease in detections at both regions within the Industrial Zone, densities have increased for both. There has been a trend of gradual increase detection at Hunter North River, though frog density remains very low. This year Bellfrog Way showed a marked increased in detections and frog density, which are the highest they've been in the past four years. The majority of detection in all zones have been adults, except for both regions of the Industrial Zone.

4. Discussion

Conservation biology of *L. aurea* on Kooragang Island

1. **Population size**: Averaging model estimates from capture-mark-recapture data over the previous three breeding seasons indicates that a total of approximately six *L. aurea* individuals with SVL ≥ 40 mm are generally present for every one individual detected during VES. Based on this ratio, and the number of VES detections obtained during island-wide surveys of 60 wetlands this year, the *L. aurea* population of Kooragang Island is currently standing at approximately 3,000. This is similar to the calculations obtained for the 2017-18 season, though smaller than for calculations obtained for 2018-19, and could suggest that the population is starting to stabilise after a long term but gradual upward trend since 2010-11. This season, nearly half of the population was located at constructed wetlands, indicating that these man-made aquatic sites are providing the necessary resources for *L. aurea* occupation and usage.

   Raw counts of abundance and density also suggest that, from 2014, population levels have continued to increase but that they have possibly also started to stabilise. Only slight increases have been seen across the Northern, Central and southern Industrial Zones, while a decrease has been seen in the northern Industrial Zone.

   Applying pooled model estimates or consistent estimates to VES data each year may be an effective means of comparing population sizes between years and should be continued.

2. **Demography**
   a. Age/sex class structure: For those frogs where age/sex class was identified, more than half of individuals detected in several rounds were juveniles. In particular, three quarters in the first round, two thirds in the second round and a quarter in the third round were juveniles. This is in contrast to the previous season, were less than a third of detections in each round were juveniles. Of the individual adults captured and identified, approximately half to two-thirds were male, which is broadly consistent with the pattern in recent seasons.

      Unlike previous seasons, we were able to closely follow a large juvenile cohort between rounds as they developed matured. These juveniles were first detected in round 1 and likely spawned in the previous season and overwintered as tadpoles. They showed a clear shift in SVL between each round, slowly increasing and then merging with the adult cohort sizes, indicating that some juveniles had become recruited into the adult population before the end of the season.

   b. Recruitment: 4 wetlands in the Industrial Zone held either tadpoles and/or metamorphs at some point during the 2020-21 breeding season, mostly in round 2 (November 2020), and a smaller number in round 3 (February 2021). This is down from 16 wetlands in the previous season. These breeding events were recorded only in wetlands within the northern region of the Industrial Zone. This includes the K105 (deep ponds) wetlands, which has been sites of breeding in previous years, as well as in one of the newly constructed wetlands (K128) near K105AS. Breeding events also occurred at one of the BHP-CHEMP wetlands in the central Zone, and one of the NCIG-CHEMP wetlands in the Northern Zone. Similar to last season, this indicates that breeding took place across the entire island.

      Large numbers (≥ 10) of very small juveniles were detected only in wetlands in the Industrial Zone. This included C4, C5, K111, K121 and K105B in round 1, which likely spawned in the previous season, as well as C2 and K111 in round 2, which likely spawned early in the current season. The largest number was captured at K105B, a large wetland in the southern region of the Industrial Zone were Gambusia was detected. Very few extra small juveniles were detected in round 3, which likely spawned during mid-season rainfall in December-January.

Tadpoles and metamorphs were detected mainly in wetlands classified as permanent (i.e. ‘nearly permanent’ or ‘deep permanent’), or semi/nearly permanent, except for K106A which is considered temporary and NCIG-7.2 which is seasonal. This demonstrates that *L. aurea* are not necessarily limited to ephemeral wetlands for breeding. The lack of breeding at temporary sites this season cannot be accounted for by dry conditions causing them to be dry.

c. Gravid females: Using 58 mm as the threshold for the onset of female reproductive maturity means about a quarter of adult captured on Kooragang Island were female. Total percentage of animals captured that were adult were down this year due to the large number of juveniles that made up nearly half of all captures. 191 PIT tagged females were detected across the 2020-21 season, which is a similar number to the corresponding data from the four previous seasons. This indicates some level of population stability and that the effective population size of *L. aurea* on Kooragang Island is sufficient for at least the immediate persistence of the population. However, the low percentage of recapture events between years suggest that few individuals are making it to multiple breeding periods. This is cause for concern for two reasons: i) females generally take longer to reach sexual maturity than males, and ii) just two consecutive years of poor recruitment is predicted to have a strong negative effect on population size.

3. Survey rounds and weather

The largest number of adult captures occurred in Round 1, which followed rain in early September. Movement and widespread calling indicate that a breeding event likely took place in this early part of the season following that rainfall event. This is supported by the detection of small numbers of metamorphs and juveniles in Round 2. Fewer captures occurred in Round 2, which is to be expected given that conditions in summer were dry, with lower than average rainfall. Many of the wetlands dried completely during the early to mid-summer period, including many that have historically been characterised as ‘permanent’. Round 3 occurred during a period of late summer rainfall in February that re-charged wetlands and sparked a large breeding event. Evidence for this come from the large number of adult females detected during this round, as well as the large number of metamorphs and juveniles detected later in Rounds 4 and 4.1 (see below). Large numbers of metamorphs were detected in Round 4 in K111, K121, K122 and K123, indicating highly suitable conditions for offspring survival.

Near the end of the season in April (Round 4.1), a large dispersal event was detected, with high numbers of juveniles detected at fence lines established in terrestrial habitat away from water (these fences were part of operational activities on the site). These small juveniles were of the same cohort as those which were detected as tadpoles and metamorphs in Round 4. This highlights a possibly important aspect of this species’ life history, which is the movement of vulnerable juveniles away from their natal waterbodies when weather conditions are suitable for dispersal across terrestrial habitat.

While drier than average conditions have been a common hallmark of the *L. aurea* breeding season on Kooragang Island for the past four seasons, it is clear that an extended breeding period affords this species a greater chance of being exposed to optimal breeding conditions on at least a few occasions. As such, while adults were met with poor breeding conditions in the first half of the season, the large rainfall event/s in the latter half of the season were sufficient to trigger a large breeding event, which theoretically should allow for sufficient recruitment of individuals in the adult population in the next season for continued persistence on the island. In fact, this year saw breeding in more wetlands than any other previous season. However, what remains unclear is the impact of extended dry periods on adult survival and whether these conditions affect the acquirement of sufficient energy for breeding to occur when conditions do become optimal. The lower numbers of adult *L. aurea* detected this season compared with 2018-19 may indicate that extremely dry summers cause significant levels of adult mortality. Alternatively, adult activity in very dry periods may change in a way that makes detection especially difficult. What also remains unknown is how extended dry periods affect juveniles that have dispersed from aquatic sites, given that they are more susceptible to desiccation and are less proficient at migrating to optimal microhabitat oases than adults.

4. Longitudinal data

b. Persistence: As with previous seasons, persistence is low with most marked animals never recaptured. Of those that are, most are recaptured within six months of first capture, and only 10% are recaptured more than 12 months from first capture.

c. Movement: Most detected movements were between wetlands within the northern Industrial Zone and within the Southern Industrial Zone. In particular, most movements occurred between wetlands surrounding K105A, highlighting the strong connectivity between wetlands within this habitat mosaic. Several of these movements were made by adult females out of K29 into another wetland in the mosaic, providing support for the suggestion that *L. aurea* will move from 'refuges' (e.g. K29) to habitats that provide suitable breeding conditions at a particular time.

Most movements this season were between wetlands less than 200 metres apart. Over the past 9 years, most detected movements have been less than 500 metres, indicating that wetlands need to be within this distance to improve their connectivity within habitat mosaics. This could also be critical for promoting movements between zones, to improve gene flow between mosaics/locations across the island. Movement between the mosaic centred around K105 (referred to as the Northern Ponds mosaic) and K22/23, albeit only a small distance apart, indicates a degree of connectivity between the Industrial and Central Zone wetlands. However, there was no detection of movement between the Central and Northern Zones in 2019-20. While this has been detected in previous seasons, is it a rare occurrence and suggests that additional habitat mosaics between the Central and Northern Zones will be required to improve connectivity between these areas of the island.

A small number of larger movements greater than 500m were detected both within the current breeding season and between the current and previous season, showing movement of animals between the northern and southern Industrial Zones. In particular, movement was detected out of K100A into K105A and K42, suggesting that K100A is an important refuge, especially during dry periods. Movement was also detected between K104 to K23, indicating that while K104 is a relatively isolated wetland within the Industrial Zone, that animals are able to successfully migrate out of this wetland to other sites. It is, however, likely that animals moving from K104 will be moving to nearby wetlands prior to making extended journeys to more distant wetlands.

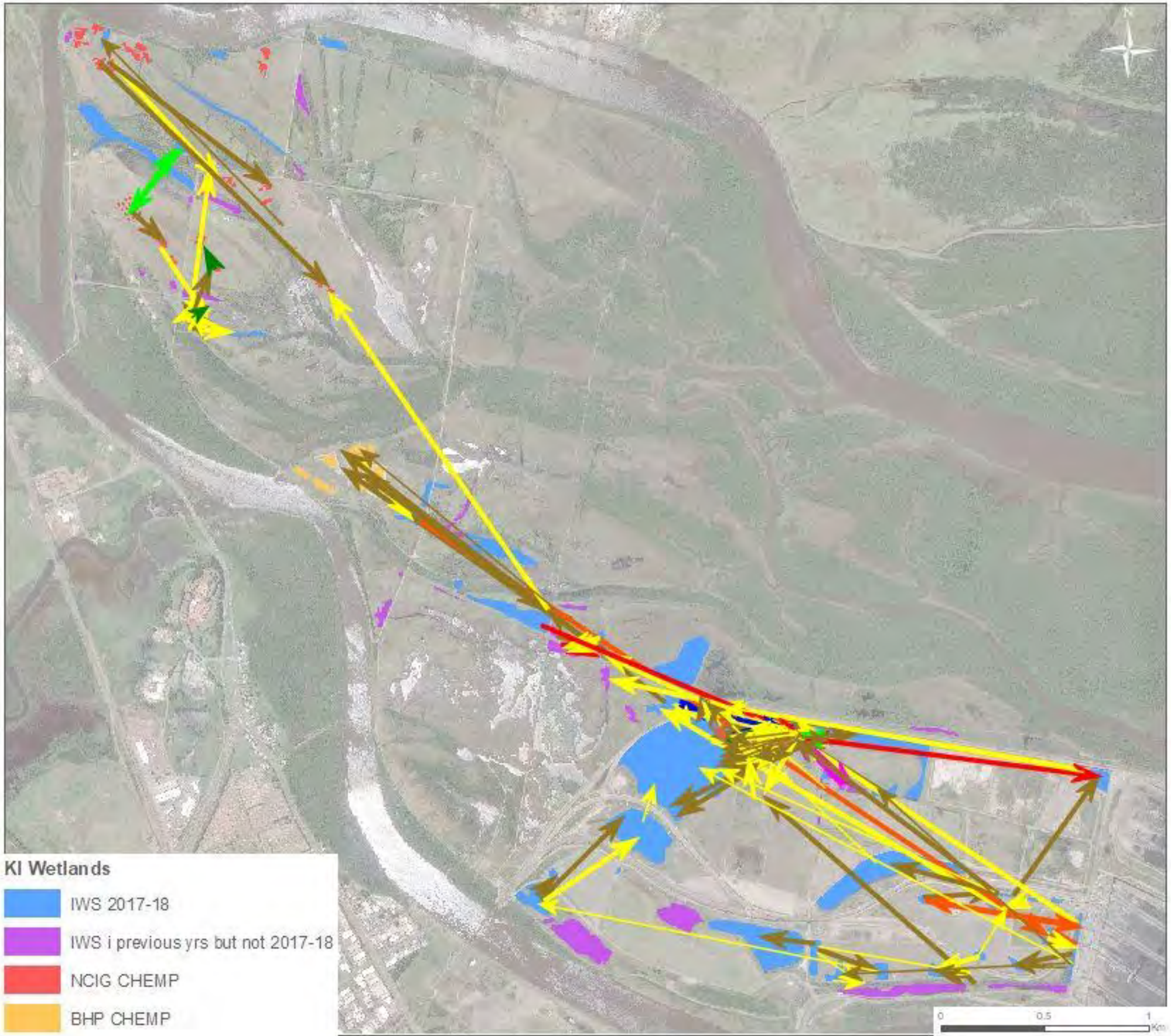


Figure 4.5.1: Detected movements of tagged *L. aurea* across Kooragang Island, 2011-20. Data combines detections from multiple datasets (see Section 3.5 for discussion).

5. Landscape use

a. Distribution: The largest number of adult detections occurred in the Industrial Zone, which is consistent with previous years, showing that this area remains a stronghold for *L. aurea* occupation/persistence. The number of frogs detected in the southern region of the Industrial Sone surpassed those of the northern region for the first time this season, which historically has always had greater frog numbers. This is likely linked to the construction of new wetlands in this southern region that has created an effective habitat mosaic that is stimulating and allowing for the capacity for such an increase. New wetlands have just recently been constructed in the northern region of the Industrial Zone prior to the current season. These have the potential to result in increased frog numbers in this region in the near future as they become established and mimic the mosaic design of the south. Adult numbers have remained the same in the northern region and increased in the southern region since the previous season, while juvenile numbers have reduced back to pre 2019-20 levels (an outlier year which saw a larger than usual amount of breeding). with A majority of breeding was also detected in the Industrial Zone, indicating that this area remains critical for breeding on the island.

   Adult numbers in the Central Zone are similar to those recorded in the previous breeding season, with a slight increase in adults detected. This is partly caused by the increase in detections at K22 and K23, which have historically been considered significant wetlands for the population but have undergone a downward trend in past years. Exemptions in the central zone include the NCIG CHEMP wetlands, which have continued to show a decline since a peak in 2018-19. There has also been a decline in detections at the BHP CHEMP wetlands, though this appears to be most related to a drop in search effort as search sensitivity remains high.

   Both densities and absolute numbers remain comparatively low in the Northern Zone, which has been the case for all breeding seasons. They have also shown a decrease from the previous two seasons, despite the construction of the NCIG-CHEMP wetlands which saw numbers increase in those seasons. Numbers in the Milliam's Pond subregion have shown a sharp decrease in particular. However, breeding was detected at both the NCIG and BHP CHEMP wetlands this year, which provides evidence that a population is persisting in the north with the capacity for breeding.

b. Landscape factors affecting distribution, abundance, and recruitment:

   b. ***Gambusia*****:** In the previous season, the majority of breeding occurred in wetlands where *Gambusia* was absent. In this season, four out of the seven ponds where breeding was detected also possessed *Gambusia*. Such co-occupation of wetlands has been recorded previously, particularly in ponds within the Industrial Zone, albeit in those where fish are not at high densities. Currently, it is unknown to what degree breeding adults are able to perceive the presence of the fish and avoid potential oviposition sites where they are present. The fact that breeding often occurs away from these sites would be indicative of this capacity. Yet, the presence of tadpoles and metamorphs at some sites where the fish is present may also suggest that successful breeding and offspring development can occur under such conditions. This is an important finding, as management strategies to remove the fish (which may not be feasible for large waterbodies and expensive) may not be needed. Instead, strategies that maintain densities at low levels could be equally effective.

      Since 2016, Gambusia has been gradually removed from a large portion of wetlands within the Industrial Zone due to repeated cycles of drying and recharging of these systems. However, this trend has reversed as a result of the arrival of a La Niña event that has prevented wetlands from drying. Gambusia is currently present within 10 wetlands within the Industrial Zone. We have also not seen evidence of ponds drying within season, which can also extirpate the fish from wetlands and open up sites for breeding for at least some months within the breeding period. The increasing presence of Gambusia within the Industrial Zone, which remains the most critical zone for *L. aurea* breeding on the island, is a cause for concern, as it could disrupt the effectiveness of the habitat mosaics that have now been established if adults avoid otherwise optimal breeding waters. It will be critical for any future drying periods to be exploited to manage Gambusia and ensure the fish do not re-invade even more sites by water run-off.

Specific management issues relevant to research partners

6. **Habitat corridor mitigation strategy**: The extent of wetland habitat, connectivity, and variation in wetland hydroperiod across the southern Industrial Zone has increased markedly in recent years, primarily as a result of the construction of nine wetlands by HCCDC since 2015. The density and abundance of *L. aurea* in this region has increased markedly over the last five seasons, and breeding now occurs frequently. As such, the strategy to improve *L. aurea* populations in the 'southern corridor' has been somewhat successful. Further, the recorded movement of adult frogs between the northern and southern Industrial Zones indicates sufficient connectivity, which could be improved by the addition of wetlands less than 500 metres apart for individuals to use as refuge while migrating across the site. This is likely to be promoted by the construction of five new wetlands in the northern industrial zone in areas previously absent in waterbodies, with evidence to suggest they are already being used for occupation and breeding by adults.

   While the southern Industrial Zone has become key habitat for the persistence of *L. aurea* on Kooragang Island, it is currently lacking in large, permanent wetlands that may be critical refuge during particularly dry periods throughout the year. Historically, this role was filled by K108, which has shown signs of decline in terms of hydroperiod and extent of open water as a result of industrial landscape changes in the vicinity. This wetland has now also been surrounded by an exclusion fence since October 2020 and is expected to be capped within the next 12 months. This will see its availability for sue by *L. aurea* drop effectively to zero until new wetlands are constructed on top of the capping in 2022. Surrounding wetlands, including K111 and K114 are large wetlands that may buffer the temporary loss of K108. In addition, three cluster ponds were installed in K10 South in 2019, in between K121 and K122 to produce additional deep permanent refuge habitat in and around the rail loop. While there is evidence that cluster ponds are used as permanent eater refuges by adult frogs, further efforts should be made to provide larger permanent wetlands in the southern Industrial Zone to ensure that this habitat mosaic is able to adequately provide all necessary resources for both local persistence all year round and breeding.

7. **Rail infrastructure mitigation strategy**: At the time that the NCIG rail infrastructure was constructed, there was (reasonable) concern that this infrastructure would reduce the extent and connectivity of wetland habitat across the southern part of the Industrial Zone. Direct impacts upon the existing wetland habitat were contained to a stretch of wetland at the east edge of K102 where the dump station is now located, and the southern part of Deep Pond that now divides K105A and K105B (Figure 4.6.1). Indirect impacts have been suggested to include change in wetland hydroperiod of the Eastern Ponds in K10 north, though this does not appear to have occurred. What is unequivocal is the separation of large parts of the southern Industrial Zone from the northern region by rail tracks and associated infrastructure.

   Although the potential for railways to impede movement of animals across the landscape is real, there is evidence to indicate that adults do not avoid traversing them. In particular, significant movements between the northern and southern Industrial Zones were detected in the previous breeding season between wetlands situated within or near the rail loop (e.g., K100A) and K105A.

Movement that required animals to go over or under rail lines was also detected in the northern zone between K105B to K105AS. Although it is not yet possible to say if railway infrastructure represents a partial hindrance to movement of *L. aurea* across the landscape, it is clear that it does not constitute an absolute barrier. However, it is also clear that most movements in the current and previous seasons have occurred between wetlands within each zone, and further research is required to determine whether assistance in movement across the rail line is needed into the future.

8. **<u>Constructed wetland strategy</u>**: Over the last decade, there have been several phases of artificial wetland construction across the island:
    i. The 'cluster ponds' installed by PWCS; in both the northern and southern regions of the Industrial Zone
    ii. The HDC wetlands constructed as part of closure works in the southern region of the Industrial Zone
    iii. The NCIG CHEMP wetlands in the Northern Zone of the island, and
    iv. The BHP CHEMP wetlands in the Central Zone of the island

    Each of these phases are now occupied by *L. aurea* at some level. Altogether these constructed wetlands appear to support nearly half of the island's *L. aurea* population.

Cluster ponds – While the grass fire of early January 2019 caused extensive damage to the C1 cluster ponds and the surrounding area, they have shown rapid recovery. These ponds are now surrounded by trees and have dense submerged vegetation that is likely optimal refuge for *L. aurea* and other frog species. A small number of *L. aurea* adults were detected in this pond set this season, along with juveniles. Note that the C1 cluster ponds were repaired through the addition of additional tanks in May 2020, after the 2019-20 breeding season. These newer ponds have less frog activity compared to the older ponds, which may be due to the slow rate at which vegetation has established itself in and around the ponds.

The number of *L. aurea* detected at the C2 cluster ponds has been steadily increasing since their first detection there in 2016-17. However, only one adult individual (sub-adult female) was captured in 2020-21. While a small number of juveniles (~30) juveniles were recorded in the first half of the 2020-21 season, C2 does not appear to provide breeding habitat. Instead, it likely provides habitat for animals that have been spawned in nearby wetlands, including K121-123, that have shown high levels of breeding activity in previous seasons. It is also likely that C2 is an important refuge of permanent water during extended dry periods within the K10 South subregion.

During the 2018-19 a fifth set of artificial wetlands based on the **cluster pond** design were installed in the Southern Industrial Zone by HDC. The purpose of these was to produce additional deep permanent, small refuge habitat in and around the rail loop, as that wetland type is currently not present in the habitat mosaic. While C3, C4 and C5 were quickly colonised by several frog species, including *L. aurea*, it appears that the C4 cluster in *K10 North* is being utilised to a greater extent compared the other two clusters and is a critical permanent water source in the subregion. This could be the result of tree stands in close proximity to the cluster that is providing favourable and long-term refuge close to water for adults, along with dense vegetation within the ponds that is providing temporary refuge for juveniles as they migrate from their natal ponds nearby. Vegetation within C5 is showing signs of becoming more established, and it is expected that frog usage here will increase in the near future.

HCCDC - All of the nine previously constructed HDC wetlands (K111-114, K117-118, K121-123) continue to be occupied by *L. aurea*. This includes the detection of large numbers of juveniles in most this breeding season. No tadpoles or metamorphs were detected at these wetlands, though they have been shown to have the capacity to be critical breeding sites for *L. aurea* on the island. In addition, five new wetlands constructed just prior to this season (K124-126 in Area 2, K127-128 near Deep Pond) have already shown occupation and breeding. Overall, the HDC wetlands continue to underlie the increased abundance of adult *L. aurea,* extent of breeding habitat, and wetland connectivity in the southern region of the Industrial Zone. Their success supports the findings of previous studies on bell frogs (e.g., Heard et al., 2018) that show the addition of new, well-designed constructed wetlands is more effective at increasing survival compared to attempts to improve existing habitat.

NCIG and BHP CHEMP - Abundance at the NCIG CHEMP wetlands has historically been low and has remained lower than other zones. While there was a marked increase in numbers in the previous season, few adults were detected in the current season, particularly at the NCIG sites. Both the NCIG and the BHP CHEMP are the focus of current research projects and detailed information is reported separately.

9. Other issues

a. **Bellfrog Way surveys**: A reduction in search effort in the previous season occurred for several reasons: i) ground fires that were ignited in January 2019 were not fully extinguished until September 2019, with access restricted until October, ii) increased safety and induction requirements by PoN prevented access further still to mid-November, and iii) we were able to survey K22-23 in early December but there were not enough suitable days at this time to complete the transect surveys as well. Both sites have since showed signs of significant recovery post fire in terms of aquatic and terrestrial vegetation. In the current season, there was an increase in the number of frogs detected, including both adults and juveniles, with numbers the highest they've been in past three seasons. This could suggest that the fires have caused the wetlands to return back to an earlier successional stage that is more favourable for *L. aurea* occupation. However, no evidence of breeding was detected this season.

Closing Statement

Litoria aurea was once both a common species and widespread in its distribution in NSW. This suggests an historical ability to occupy wide ranging habitats with frequent seasonal breeding or large breeding events. The seasonal surveys conducted across Kooragang Island over the last decade are testament to this ecology and biology, with individuals detected in almost all wetlands at one time or another provided they contain water, irrespective of the presence of the predatory *Gambusia* fish. The coastal climatic influences on Kooragang Island results in dynamic environmental conditions and *L. aurea* matches their movement and breeding in response to the complex relationship that exists between seasonal rainfall patterns, wetland physiognomy and *Gambusia* density. The mosaic of natural and created wetlands across Kooragang Island is likely playing a significant role in securing the persistence of this population in the presence of both invasive predators and disease, as well as buffering the impacts of shifting climate patterns such as increased frequency of extended dry periods by ensuring permanent wetlands exist as refuge sites.

Appendix D – KIWEF Datalogger Download Monitoring – December 2020 (Robert Carr & Associates, 2020)

RCA ref 11766E-409/0
Client ref HDC291

29 January 2021

Hunter and Central Coast Development Corporation
Level 5, 26 Honeysuckle Drive
NEWCASTLE NSW 2300

Attention Grant Moylan
CC Mike Bardsley

KIWEF DATALOGGER DOWNLOAD MONITORING
FACTUAL REPORT – ROUND 9 (DECEMBER 2020)

RCA Australia (RCA) has been engaged by Hunter and Central Coast Development Corporation (HCCDC) to undertake Datalogger Monitoring at Kooragang Island Waste Emplacement Facility (KIWEF), Newcastle NSW.

Dataloggers were collected and downloaded by RCA personnel on 15 December 2020 from locations shown on **Drawing 1**, **Attachment A**.

Nine (9) of the loggers were observed to be functioning correctly and were able to be downloaded. Of the remaining loggers:

- Deep Pond A, B-02L and SW Pond 11 were unable to be downloaded, with the cause unknown. The loggers were collected for return to the manufacturer by HCCDC. One location, Deep Pond A had a replacement logger installed during the fieldwork.
- Deep Pond B water level data appears to indicate water levels significantly higher than previous rounds indicating the data may be incorrect, with a potential issue with the logger.

A summary of relevant information, including well and water physical characteristics, data logger condition and programming, and any other relevant observations were recorded by RCA during the monitoring round and are summarised in **Attachment B**.

Graphical charts of the barometric corrected water level (mAHD), electrical conductivity (EC) data, rainfall (BOM data for Nobbys Head) and EC chytrid protection threshold levels (as advised by HCCDC) were produced by RCA and are presented in **Attachment C**.

RCA notes that survey data for well locations Deep Pond B, K114 and B-02L was not supplied. For data presentation purposes RCA have assigned a nominated RL of 3.0m AHD for each of these wells.

A summary of EC chytrid protection threshold levels (as advised by HCCDC) are detailed in **Table 1**.

Table 1 *Salinity Thresholds (as advised by HCCDC)*

No Chytrid Protection	Chytrid Protection Threshold[1]	GGBF Tadpole Health Threshold[2]	GGBF Adult Health Threshold[3]
0-1,650 μS/cm	1,650 μS/cm	2,900 μS/cm	4,100 μS/cm

1. EC levels below the Threshold present an increased risk of mortality resulting from Chytrid Fungus.
2. EC levels above the Threshold indicate conditions unsuitable for GGBF tadpole survival.
3. EC levels above the Threshold indicate conditions unsuitable for GGBF adult habitat.

A copy of all electronic data files including Solinst XLE program files, Microsoft Excel CSV data files, barometric corrected data files, and Microsoft Excel Worksheets showing calculations and graphs have been supplied to HCCDC electronically.

Yours faithfully
RCA AUSTRALIA

Richie Lamont
Environmental Scientist

Attachments

Drawing
Summary Data Table
Graph Charts

LEGEND

● Approximate data logger unit location

Aerial image taken from Nearmap, June 11 2019
(used in accordance with commercial licence)

N

0 100 200 300 400
metres

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DATA LOGGERS
KOORAGANG ISLAND WASTE
EMPLACEMENT FACILITY

CLIENT Hunter & Central Coast Development Corporation				RCA Ref	11766e-409/0
DRAWN BY	RL	SCALE	1 : 8000 (A3)	DRAWING No 1	REV 0
APPROVED BY	FB	DATE	28/01/2021	OFFICE	NEWCASTLE

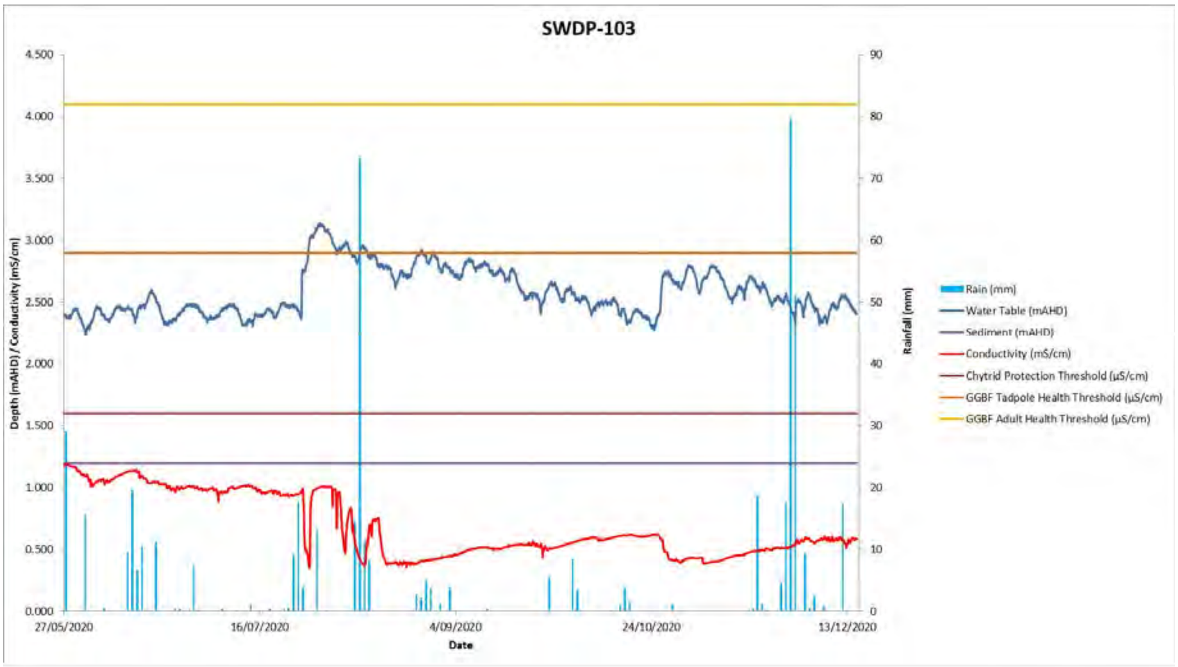
CDT–DWG–A3H–001/1

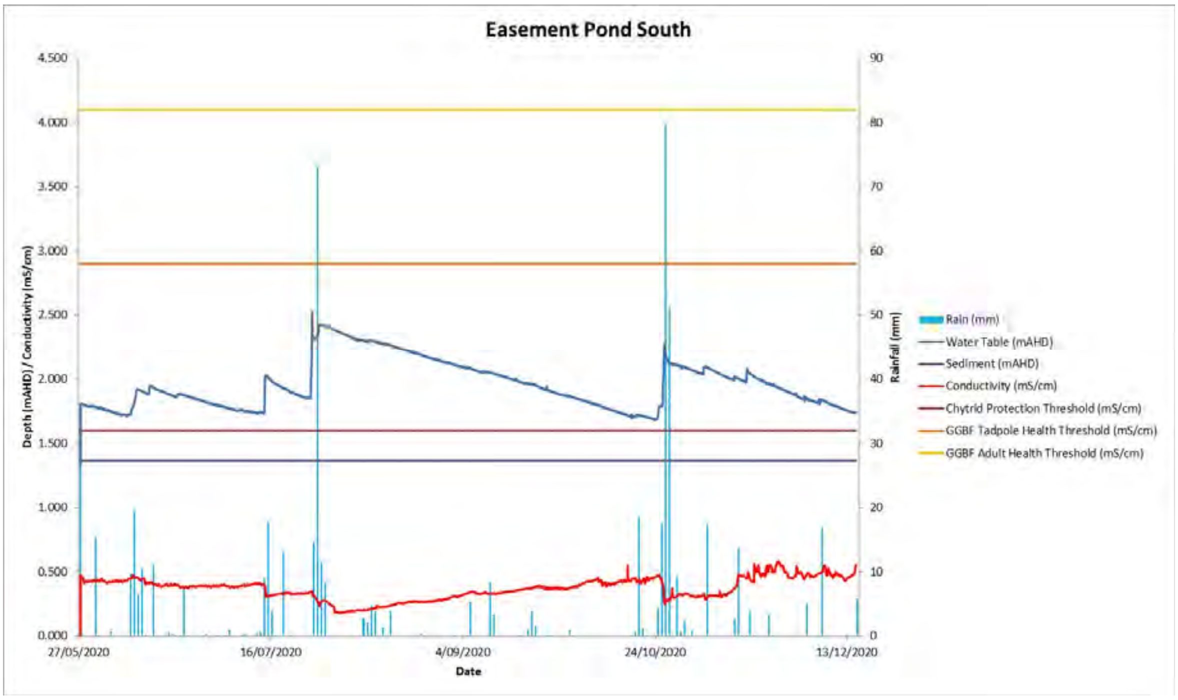
RCA summary of data logger information for KIWEF - December 2020

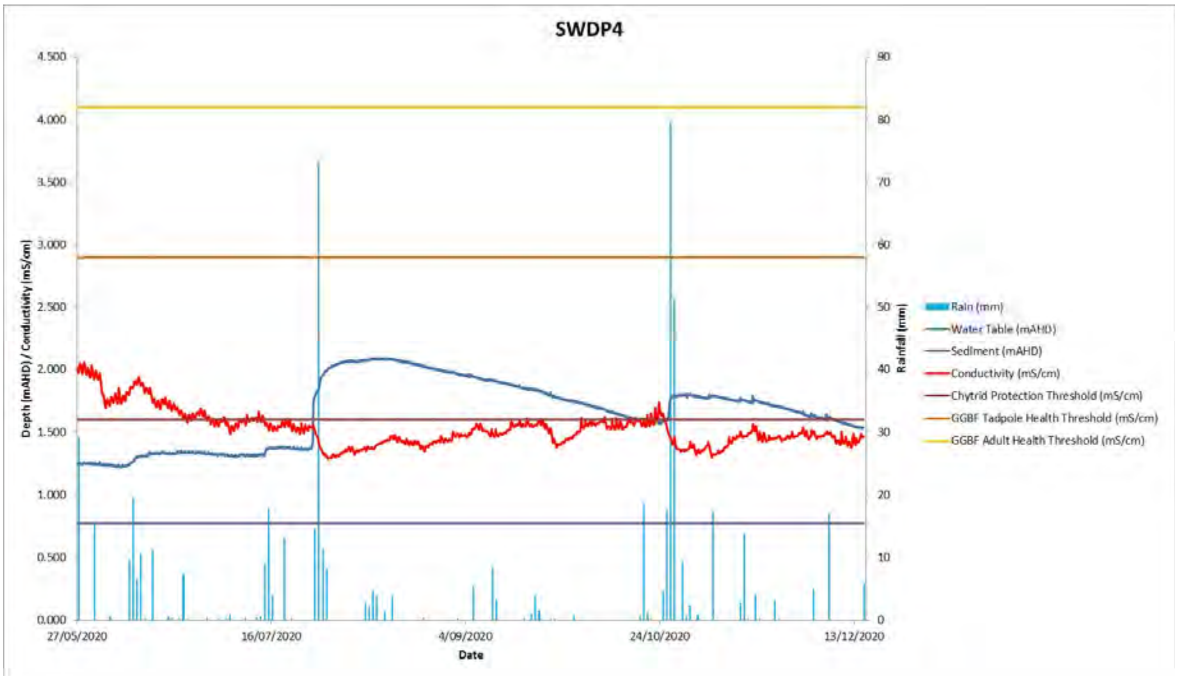
Logger Name/ Location	Logger Serial Number	Model	GPS (UTS/UPM)	Date of Retrieval	Date of Deployment	Battery	Condition	*Surveyed T.O.P (mAHD)	Top of Pipe to Water Level (m)	Water to Sediment (m)	Top of Pipe to Data Logger Tip (m)	Water level above logger	Measurement from data logger			Logger set to take new readings from	Logger Interval (mins)	Estimated Memory Capacity	Data Presented and Graphed	Notes
													* Water level above logger	Date of last reading	Logger Offest (m)					
SWDP-103	1072536	Solinst Levelogger 3001 LT F30/M10	0381402, 6361958	26/05/2020	26/05/2020	100%	Good	2.901	1.15	0.55	1.90	0.75	0.574	15/12/2020	-9.55m	26/05/2020	20	7.4 months	Yes	--
Easement Pond South	131068163	Solinst Levelogger 3001 LTC F30/M10	0381614, 6361855	26/05/2020	27/05/2020	100%	Good	2.957	1.24	0.38	1.62	0.38	0.472	15/12/2020	None	27/05/2020	20	7.4 months	Yes	--
SWDP4	1072543	Solinst Levelogger 3001 LTC F30/M10	0381778, 6362349	26/05/2020	26/05/2020	100%	Good	2.463	1.10	0.72	1.63	0.53	0.347	15/12/2020	None	26/05/2020	20	7.4 months	Yes	Minor oxidation on bottom of logger
SWSMEC-K2	121071565	Solinst Levelogger 3001 LTC F30/M10	0380330, 6362216	26/05/2020	27/05/2020	100%	Good	2.032	1.13	0.36	1.35	0.22	0.359	15/12/2020	None	27/05/2020	20	7.4 months	Yes	--
B-02L	121071574	Solinst Levelogger 3001 LTC F30/M10	0382825, 6361856	26/05/2020	27/05/2020	100%	Good	--	1.22	0.53	1.62	0.40	--	27/11/2019	None	27/05/2020	20	7.4 months	No	Logger not working. To be replaced.
GH001S	1071569	Solinst Levelogger 3001 LTC F30/M10	0382738, 6362020	26/05/2020	26/05/2020	100%	Good	--	1.13	0.11	1.29	0.16	--	15/12/2020	None	26/05/2020	20	7.4 months	Yes	--
Deep Pond B	1076043	Solinst Levelogger 3001 LTC F30/M10	0380871, 6362461	26/05/2020	26/05/2020	100%	Good	--	1.05	0.19	1.34	0.29	--	15/12/2020	None	26/05/2020	20	7.4 months	Yes	--
K114	1068452	Solinst Levelogger 3001 LTC F30/M10	0382129, 6362224	26/05/2020	26/05/2020	100%	Good	--	1.26	0.31	1.56	0.30	--	15/12/2020	None	26/05/2020	20	7.4 months	Yes	--
Deep Pond A	1071594	Solinst Levelogger 3001 LTC F30/M10	0381238, 6362908	26/05/2020	26/05/2020	100%	Good	1.799	0.48	0.48	0.89	0.41	0.005	27/11/2019	None	26/05/2020	20	7.4 months	No	Logger not working, logger replaced
SW K7	1076842	Solinst Levelogger 3001 LTC F30/M10	0381670, 6362757	26/05/2020	26/05/2020	100%	Good	2.901	0.77	0.46	1.26	0.49	0.679	15/12/2020	None	26/05/2020	20	7.4 months	Yes	--
SW Pond 11	121071570	Solinst Levelogger 3001 LTC F30/M10	0381482, 6363035	26/05/2020	27/05/2020	100%	Good	2.106	0.75	0.80	1.30	0.55	0.363	27/11/2019	None	27/05/2020	20	7.4 months	No	Logger not working. To be replaced.
Railway Pond	1071610	Solinst Levelogger 3001 LTC F30/M10	0381625, 6363051	26/05/2020	26/05/2020	100%	Good	2.053	0.72	0.47	0.97	0.25	-0.004	15/12/2020	None	26/05/2020	20	7.4 months	Yes	--
SW K7B	121071572	Solinst Levelogger 3001 LTC F30/M10	0381772, 6362754	26/05/2020	27/05/2020	100%	Good	2.318	0.40	0.66	0.90	0.50	0.545	15/12/2020	None	26/05/2020	20	7.4 months	Yes	--

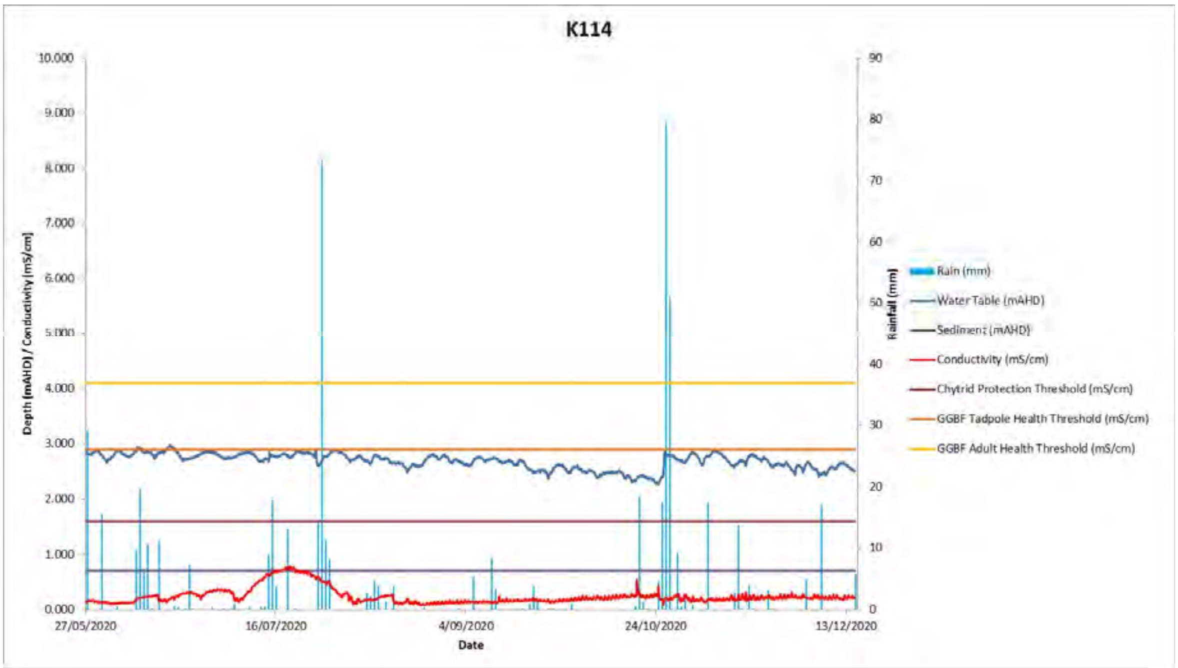
* Surveyed AHD proved by Daly Smith

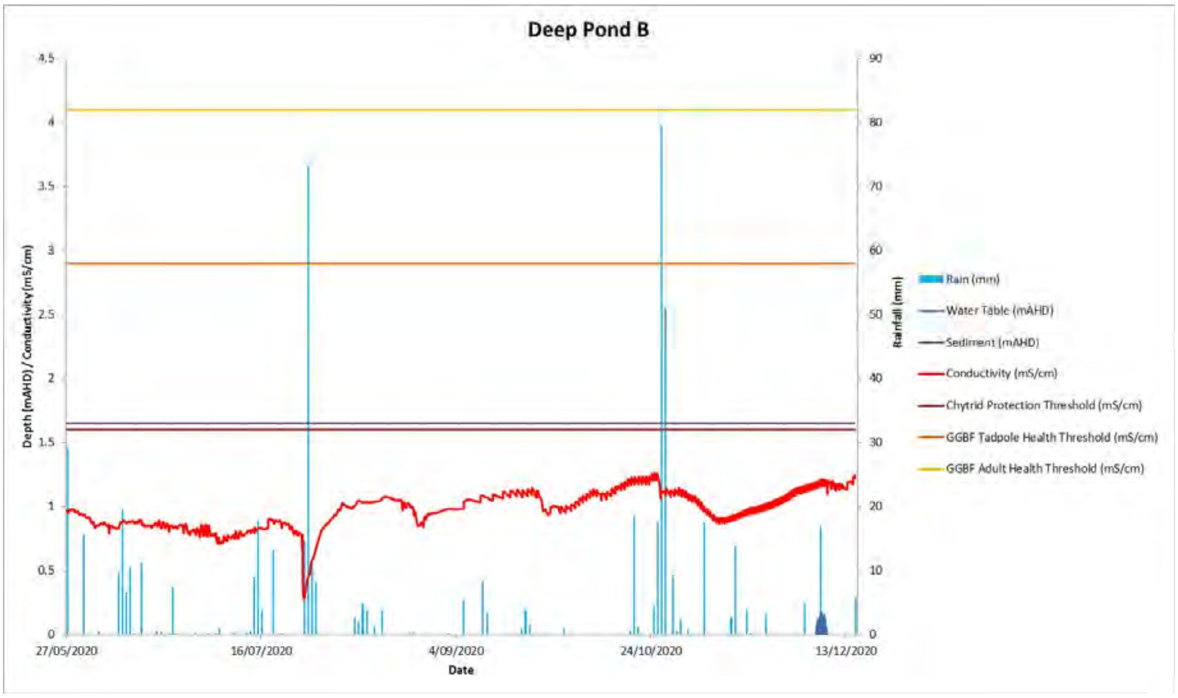
Site Barologger (SWDP-103)	12059754	Solinst Barolgger 3001 LT/M15	0381402, 6361958	26/05/2020	26/05/2020	100%	Good	--								26/05/2020	20	7.4 months	--	--

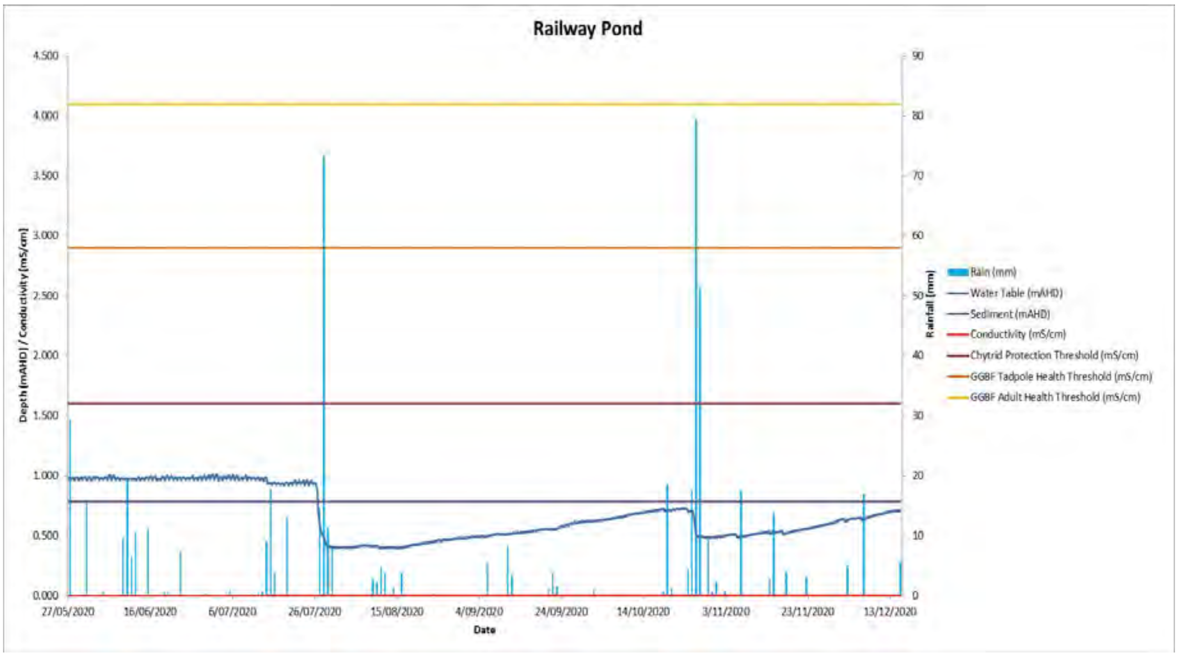

SWDP-103
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
27/05/2020
16/07/2020
4/09/2020
24/10/2020
13/12/2020
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (µS/cm)
GGBF Tadpole Health Threshold (µS/cm)
GGBF Adult Health Threshold (µS/cm)

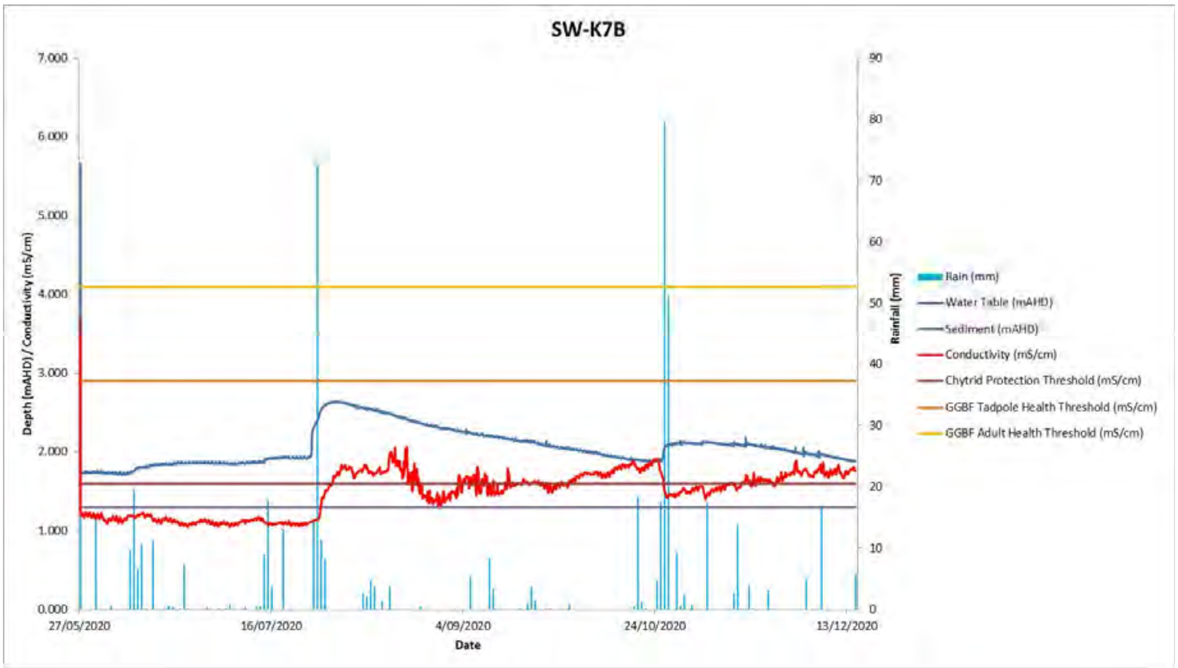

Easement Pond South
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
27/05/2020
16/07/2020
4/09/2020
24/10/2020
13/12/2020
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)

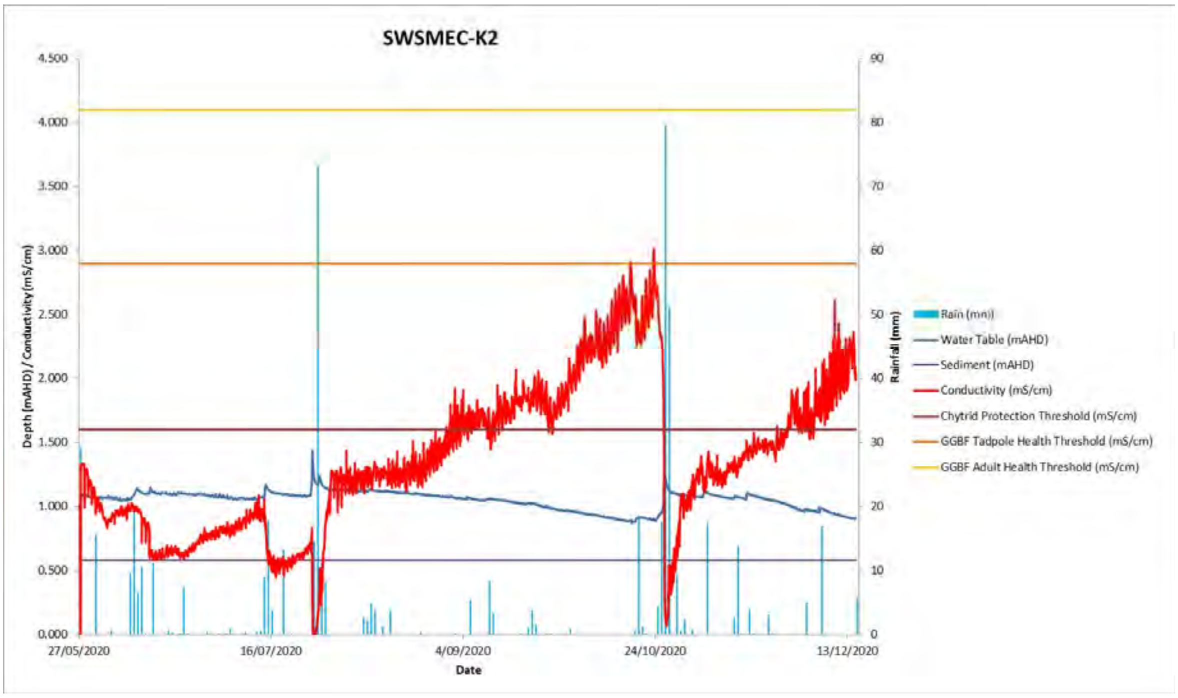

SWDP4
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
27/05/2020
16/07/2020
4/09/2020
24/10/2020
13/12/2020
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)

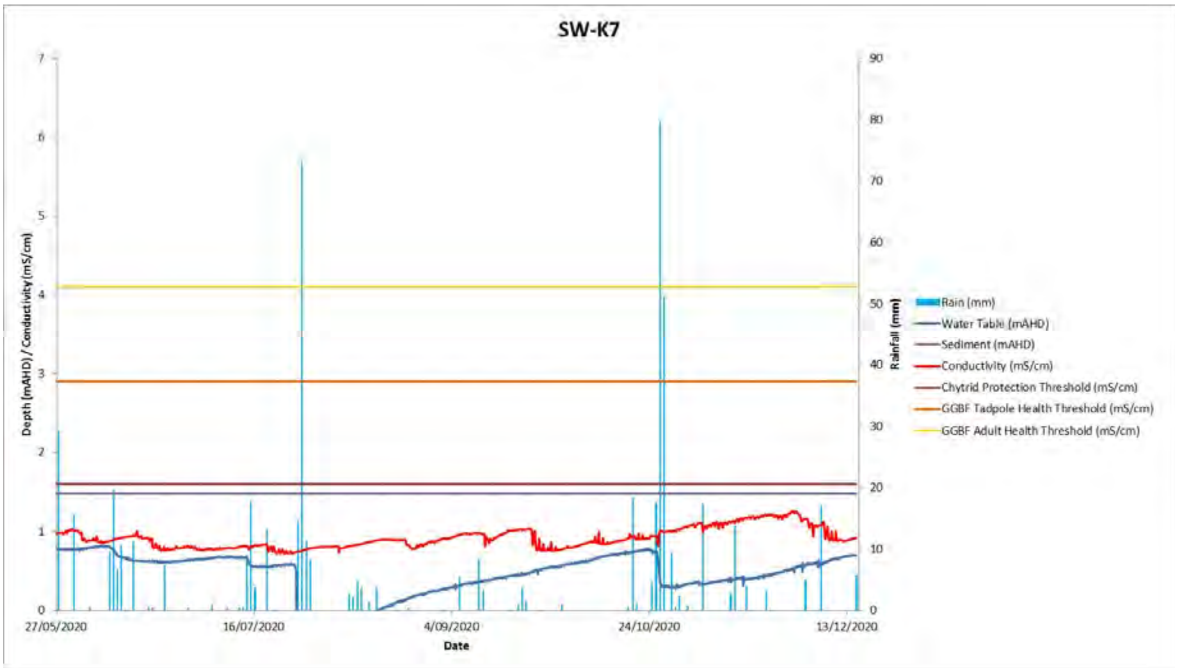

K114
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
27/05/2020
16/07/2020
4/09/2020
24/10/2020
13/12/2020
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)


Deep Pond B
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
27/05/2020
16/07/2020
4/09/2020
24/10/2020
13/12/2020
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)


Railway Pond
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
27/05/2020
16/06/2020
6/07/2020
26/07/2020
15/08/2020
4/09/2020
24/09/2020
14/10/2020
3/11/2020
23/11/2020
13/12/2020
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)


SW-K7B
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
27/05/2020
16/07/2020
4/09/2020
24/10/2020
13/12/2020
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)


SWSMEC-K2
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
27/05/2020
16/07/2020
4/09/2020
24/10/2020
13/12/2020
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)



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Appendix E – KIWEF Datalogger Download Monitoring – June 2021 (Robert Carr & Associates, 2021)

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Geotechnical Engineering
Engineering Geology
Environmental Engineering
Hydrogeology
Construction Materials Testing
Environmental Monitoring
Sound & Vibration
Occupational Hygiene

RCA ref 11766E-410/0
Client ref HDC291

24 June 2021

Hunter and Central Coast Development Corporation
Level 5, 26 Honeysuckle Drive
NEWCASTLE NSW 2300

Attention Grant Moylan
CC Mike Bardsley

KIWEF DATALOGGER DOWNLOAD MONITORING
FACTUAL REPORT – ROUND 10 (JUNE 2021)

RCA Australia (RCA) has been engaged by Hunter and Central Coast Development Corporation (HCCDC) to undertake Datalogger Monitoring at Kooragang Island Waste Emplacement Facility (KIWEF), Newcastle NSW.

Dataloggers were collected and downloaded by RCA personnel on 3 and 4 June 2021 from locations shown on **Drawing 1**, **Attachment A**.

Nine (9) of the loggers were observed to be functioning correctly and were able to be downloaded. Of the remaining loggers:

- SWDP-103, SWDP4, SWSMEC-K2 and K114 were unable to be downloaded, with the cause unknown. The loggers were collected for return to the manufacturer by HCCDC.
- GH0001S was collected during the works, with this location within a remediation area, the logger was replaced into the K114 location.
- Two (2) loggers were provided by HCCDC, with the loggers placed into SWDP103 and SWSMEC-K2 on 11 June 2021.

Of note: Three (3) loggers, Easement Pond South, B-O2L and SW Pond 11, that were replaced in February for the last download monitoring round (December 2020) were set for 3 minute intervals for data collection and therefore recorded data up to 6 March 2021. During the June 2021 collection and download, the loggers were changed to 20 minute data collection intervals.

A summary of relevant information, including well and water physical characteristics, data logger condition and programming, and any other relevant observations were recorded by RCA during the monitoring round and are summarised in **Attachment B**.

Graphical charts of the barometric corrected water level (mAHD), electrical conductivity (EC) data, rainfall (BOM data for Nobbys Head) and EC chytrid protection threshold levels (as advised by HCCDC) were produced by RCA and are presented in **Attachment C**.

RCA notes that survey data for well locations K114 and B-02L was not supplied. For data presentation purposes RCA have assigned a nominated RL of 3.0m AHD for each of these wells.

A summary of EC chytrid protection threshold levels (as advised by HCCDC) are detailed in **Table 1**.

Table 1 *Salinity Thresholds (as advised by HCCDC)*

No Chytrid Protection	Chytrid Protection Threshold[1]	GGBF Tadpole Health Threshold[2]	GGBF Adult Health Threshold[3]
0-1,650 µS/cm	1,650 µS/cm	2,900 µS/cm	4,100 µS/cm

1. EC levels below the Threshold present an increased risk of mortality resulting from Chytrid Fungus.
2. EC levels above the Threshold indicate conditions unsuitable for GGBF tadpole survival.
3. EC levels above the Threshold indicate conditions unsuitable for GGBF adult habitat.

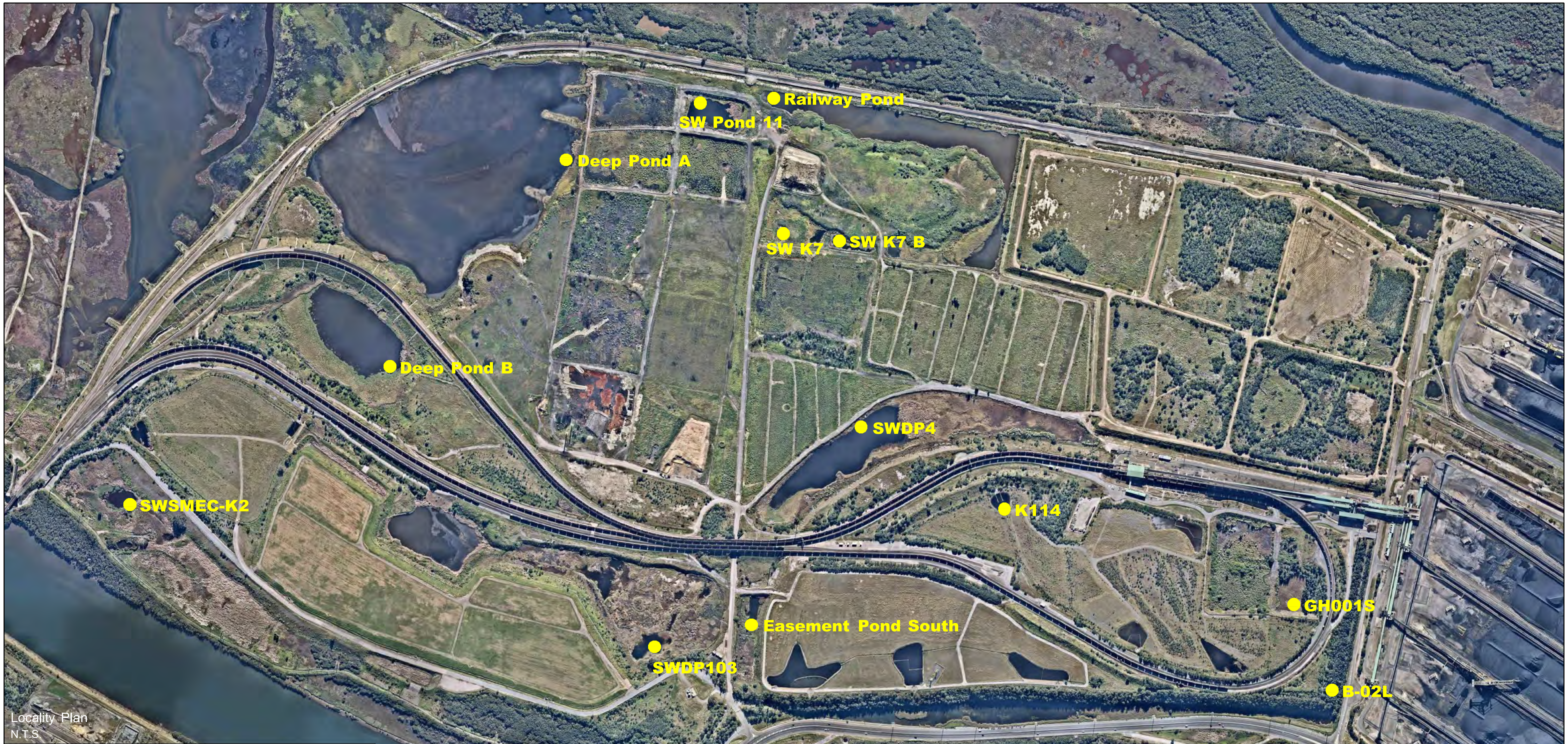
A copy of all electronic data files including Solinst XLE program files, Microsoft Excel CSV data files, barometric corrected data files, and Microsoft Excel Worksheets showing calculations and graphs have been supplied to HCCDC electronically.

Yours faithfully
RCA AUSTRALIA

Richie Lamont
Environmental Scientist

Attachments

Drawing
Summary Data Table
Graph Charts



Locality Plan
N.T.S.

LEGEND

Approximate data logger unit location

Aerial image taken from Nearmap, June 11 2019
(used in accordance with commercial licence)

0 100 200 300 400
metres

N

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

DATA LOGGERS
KOORAGANG ISLAND WASTE
EMPLACEMENT FACILITY

CLIENT Hunter & Central Coast Development Corporation				RCA Ref	11766e-410/0
DRAWN BY	RL	SCALE	1 : 8000 (A3)	DRAWING No 1	REV 0
APPROVED BY	FB	DATE	23/06/2021	OFFICE	NEWCASTLE

CDT-DWG-A3H-001/1

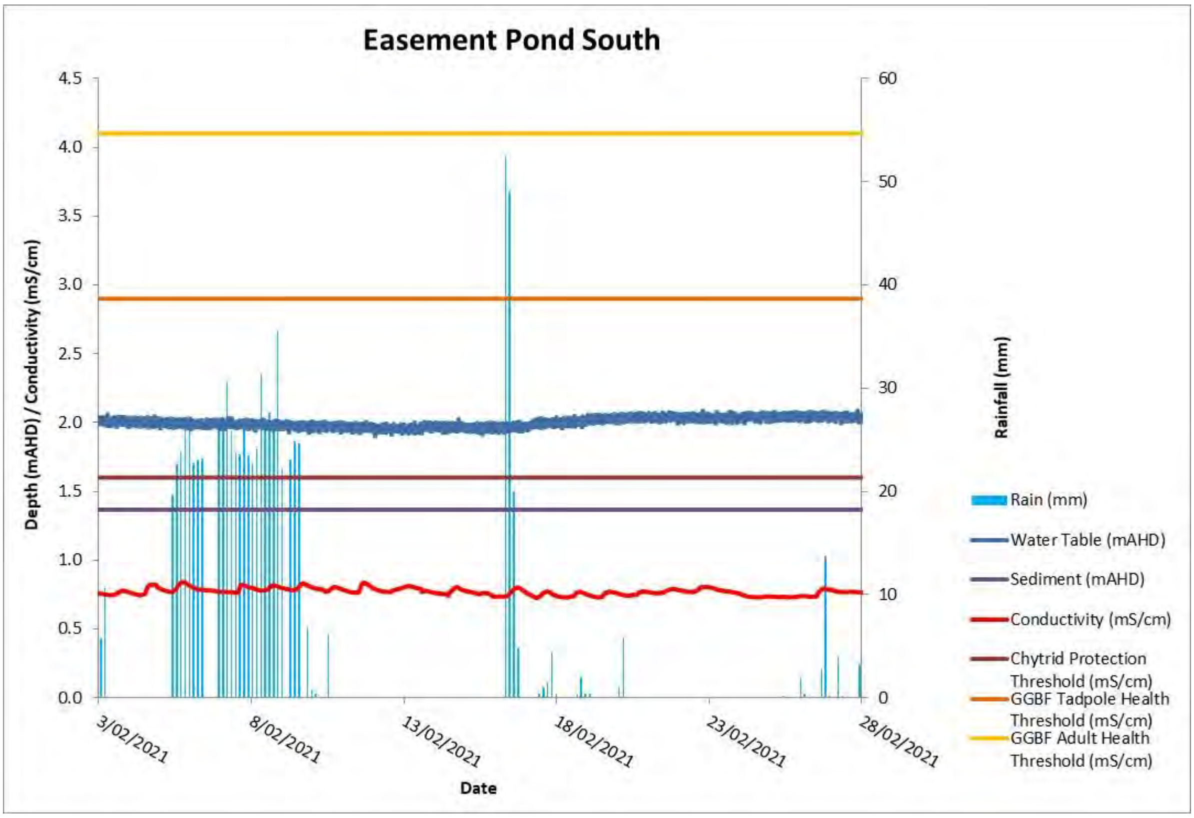
RCA summary of data logger information for KIWEF - June 2021

Logger Name/ Location	Logger Serial Number	Model	GPS (UTS/UPM)	Date of Retrieval	Date of Deployment	Battery	Condition	*Surveyed T.O.P (mAHD)	Top of Pipe to Water Level (m)	Water to Sediment (m)	Top of Pipe to Data Logger Tip (m)	Water level above logger	Measurement from data logger			Logger set to take new readings from	Logger Interval (mins)	Estimated Memory Capacity	Data Presented and Graphed	Notes
													* Water level above logger	Date of last reading	Logger Offest (m)					
SWDP-103	1072536	Solinst Levelogger 3001 LT F30/M10	0381402, 6361958	3/06/2021	11/06/2021	100%	Good	2.901	0.87	0.84	1.90	1.03	0.574	Unknown	-9.55m	11/06/2021	20	7.4 months	No	Unable to be downloaded.
Easement Pond South	131068163	Solinst Levelogger 3001 LTC F30/M10	0381614, 6361855	3/06/2021	3/06/2021	97%	Good	2.957	0.92	0.68	1.62	0.70	0.472	6/03/2021	None	3/06/2021	3	7.4 months	Yes	--
SWDP4	1072543	Solinst Levelogger 3001 LTC F30/M10	0381778, 6362349	3/06/2021	--	100%	Good	2.463	0.56	1.19	1.63	1.07	0.347	Unknown	None	--	20	7.4 months	No	Unable to be downloaded.
SWSMEC-K2	121071565	Solinst Levelogger 3001 LTC F30/M10	0380330, 6362216	3/06/2021	11/06/2021	100%	Good	2.032	0.95	0.54	1.35	0.40	0.359	Unknown	None	11/06/2021	20	7.4 months	No	Unable to be downloaded.
B-02L	121071574	Solinst Levelogger 3001 LTC F30/M10	0382825, 6361856	3/06/2021	3/06/2021	98%	Good	--	1.08	0.8	1.62	0.54	--	6/03/2021	None	3/06/2021	3	7.4 months	Yes	--
GH001S	1071569	Solinst Levelogger 3001 LTC F30/M10	0382738, 6362020	3/06/2021	--	99%	Good	--	0.92	0.28	1.29	0.37	--	3/06/2021	None	--	20	7.4 months	Yes	Taken from location, due to upcoming works, placed at K114.
Deep Pond B	1076043	Solinst Levelogger 3001 LTC F30/M10	0380871, 6362461	3/06/2021	3/06/2021	98%	Good	--	0.76	0.67	1.34	0.58	--	3/06/2021	None	3/06/2021	20	7.4 months	Yes	--
K114	1068452	Solinst Levelogger 3001 LTC F30/M10	0382129, 6362224	3/06/2021	3/06/2021	99%	Good	--	1.21	0.40	1.56	0.35	--	Unknown	None	3/06/2021	20	7.4 months	No	Unable to be downloaded.
Deep Pond A	1071594	Solinst Levelogger 3001 LTC F30/M10	0381238, 6362908	3/06/2021	3/06/2021	100%	Good	1.799	0.20	0.72	0.89	0.69	0.005	3/06/2021	None	3/06/2021	20	7.4 months	Yes	--
SW K7	1076842	Solinst Levelogger 3001 LTC F30/M10	0381670, 6362757	4/06/2021	4/06/2021	100%	Good	2.901	0.49	0.94	1.26	0.77	0.679	4/06/2021	None	4/06/2021	20	7.4 months	Yes	--
SW Pond 11	121071570	Solinst Levelogger 3001 LTC F30/M10	0381482, 6363035	3/06/2021	3/06/2021	98%	Good	2.106	0.48	1.02	1.30	0.82	0.363	6/03/2021	None	3/06/2021	3	7.4 months	Yes	--
Railway Pond	1071610	Solinst Levelogger 3001 LTC F30/M10	0381625, 6363051	3/06/2021	3/06/2021	98%	Good	2.053	0.46	0.72	0.97	0.51	-0.004	3/06/2021	None	3/06/2021	20	7.4 months	Yes	--
SW K7B	121071572	Solinst Levelogger 3001 LTC F30/M10	0381772, 6362754	3/06/2021	3/06/2021	99%	Good	2.318	0.10	1.21	0.90	0.80	0.545	3/06/2021	None	3/06/2021	20	7.4 months	Yes	--

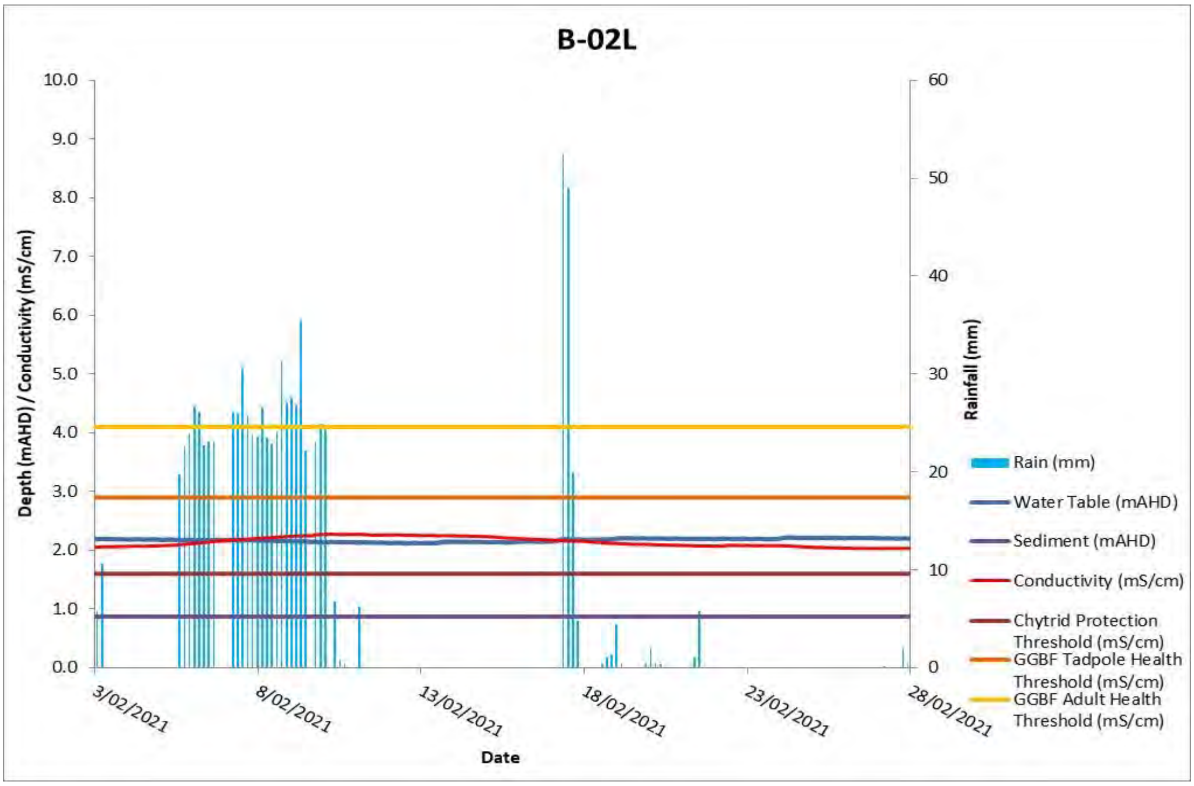
* Surveyed AHD proved by Daly Smith

Site Barologger (SWDP-103)	12059754	Solinst Barolgger 3001 LT/M15	0381402, 6361958	3/06/2021	3/06/2021	100%	Good	--								3/06/2021	20	7.4 months	--	--

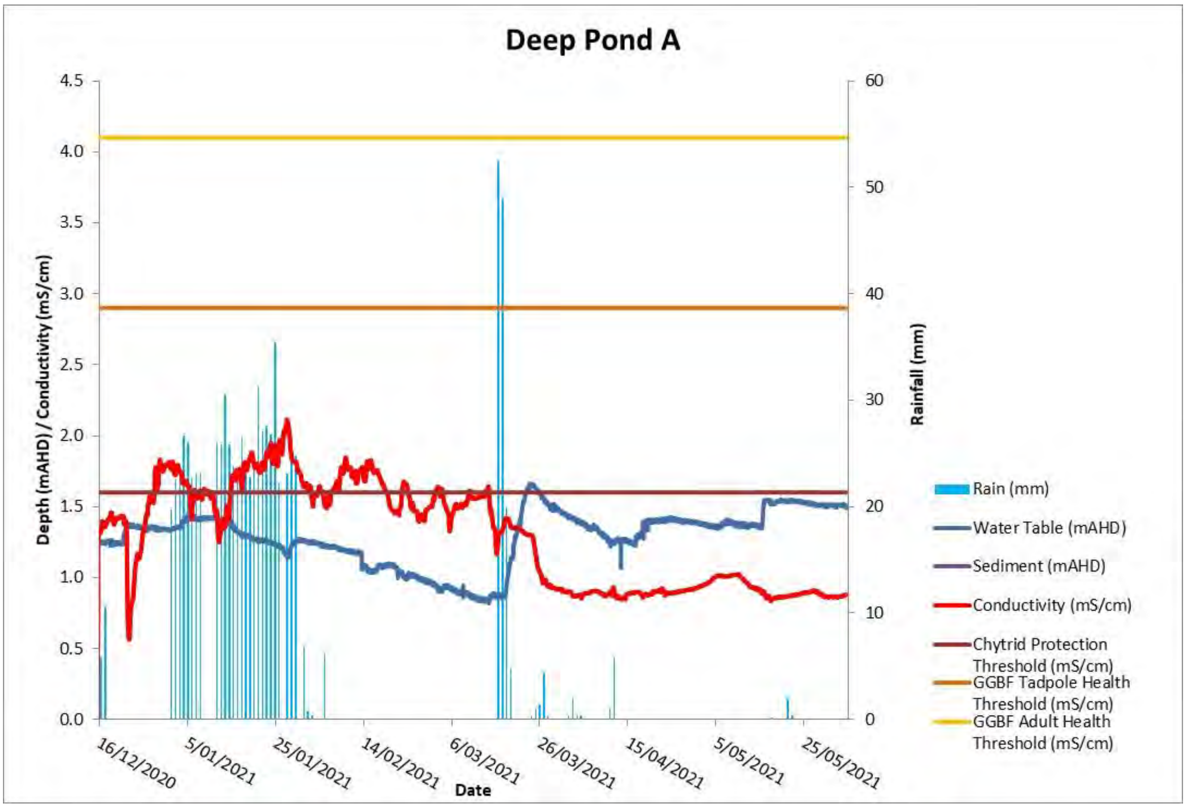
Note: Loggers from Easement Pond South, B-02L and SW Pond 11 estimated memory capacity for the for the last monitorng round was approximatley 1.1 months.



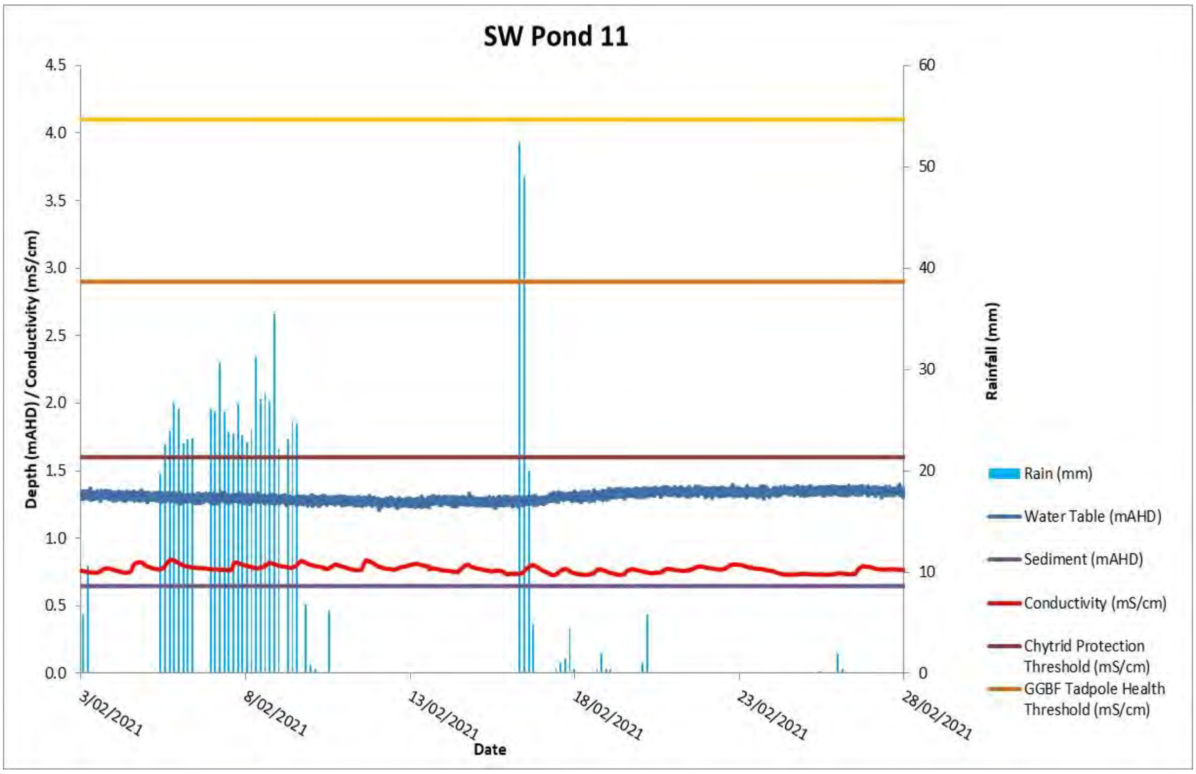
Easement Pond South
Depth (mAHD) / Conductivity (mS/cm)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Rainfall (mm)
60
50
40
30
20
10
0
3/02/2021
8/02/2021
13/02/2021
18/02/2021
23/02/2021
28/02/2021
Date
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)



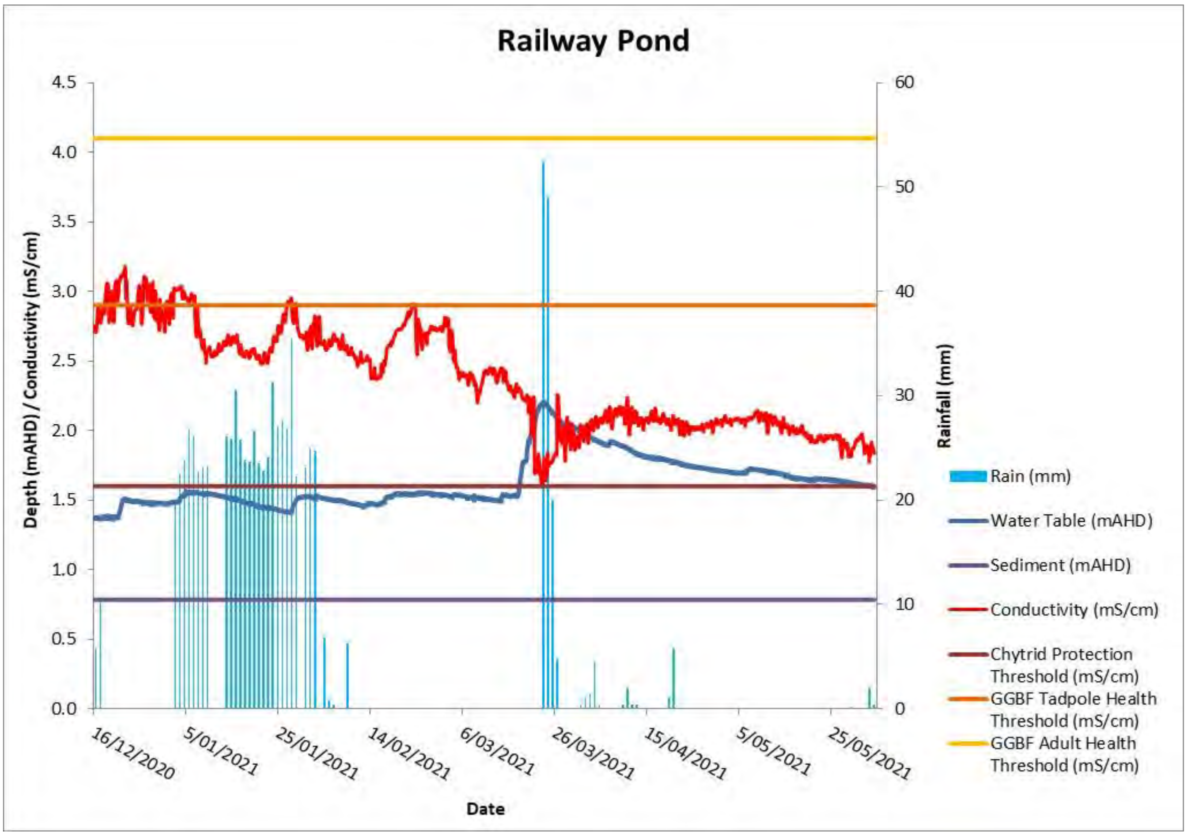
B-02L
Depth (mAHD) / Conductivity (mS/cm)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Rainfall (mm)
60
50
40
30
20
10
0
3/02/2021
8/02/2021
13/02/2021
18/02/2021
23/02/2021
28/02/2021
Date
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)

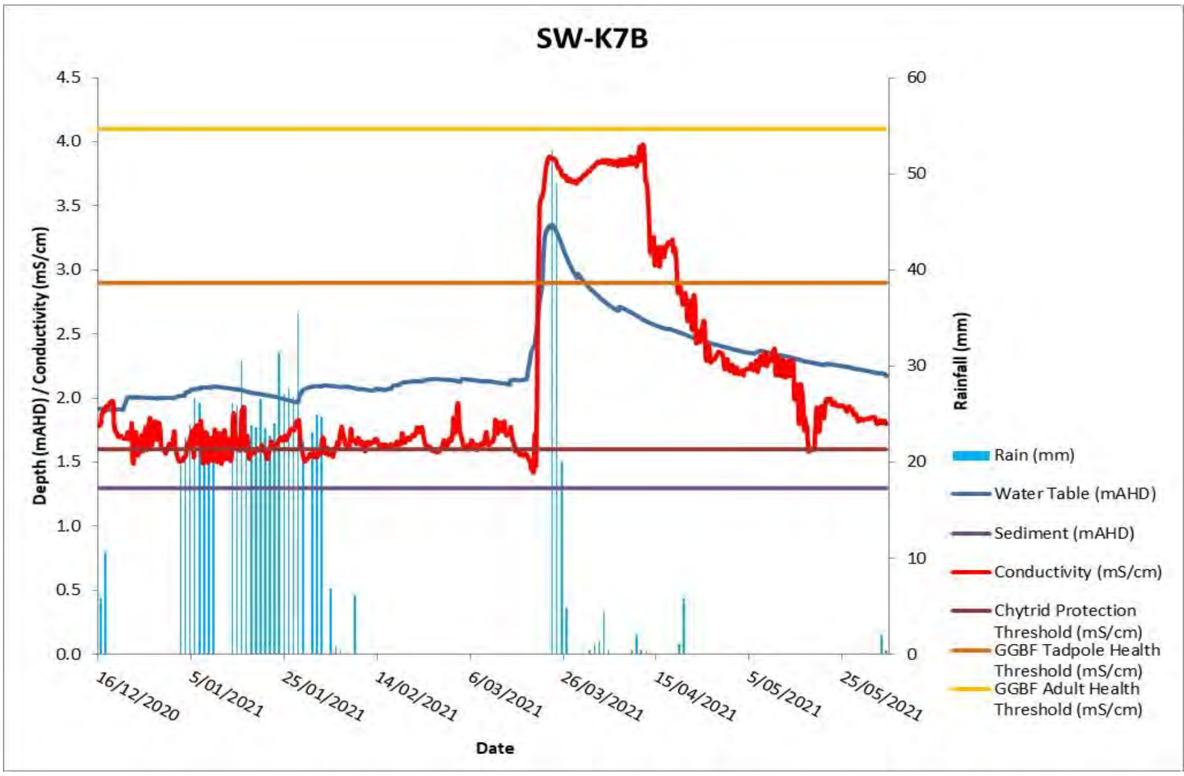


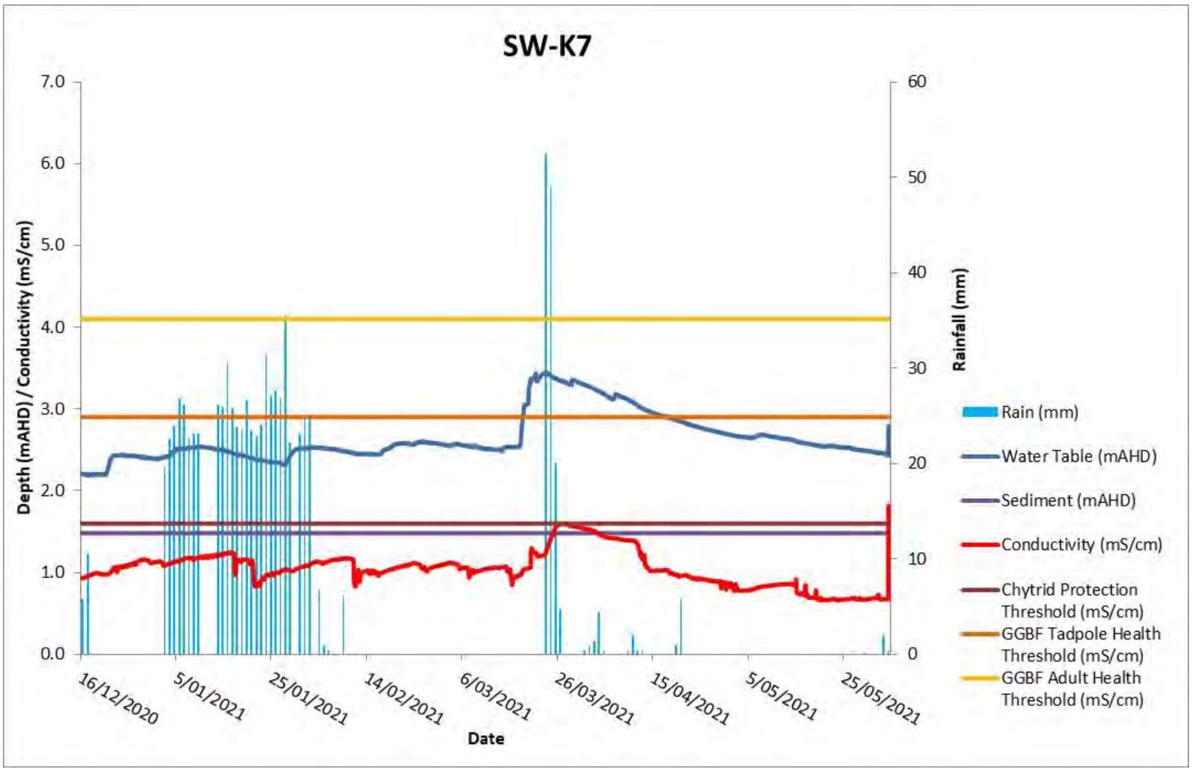
Deep Pond A
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
60
50
40
30
20
10
0
16/12/2020
5/01/2021
25/01/2021
14/02/2021
6/03/2021
26/03/2021
15/04/2021
5/05/2021
25/05/2021
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)

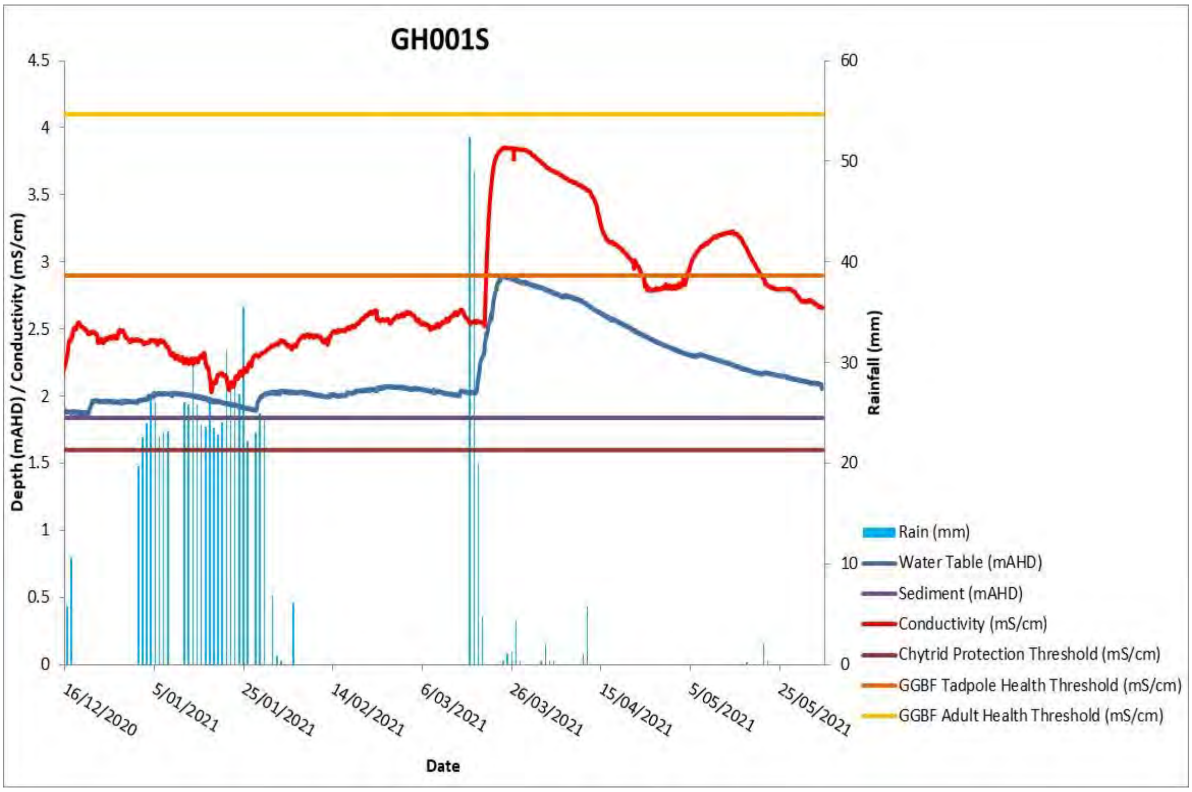


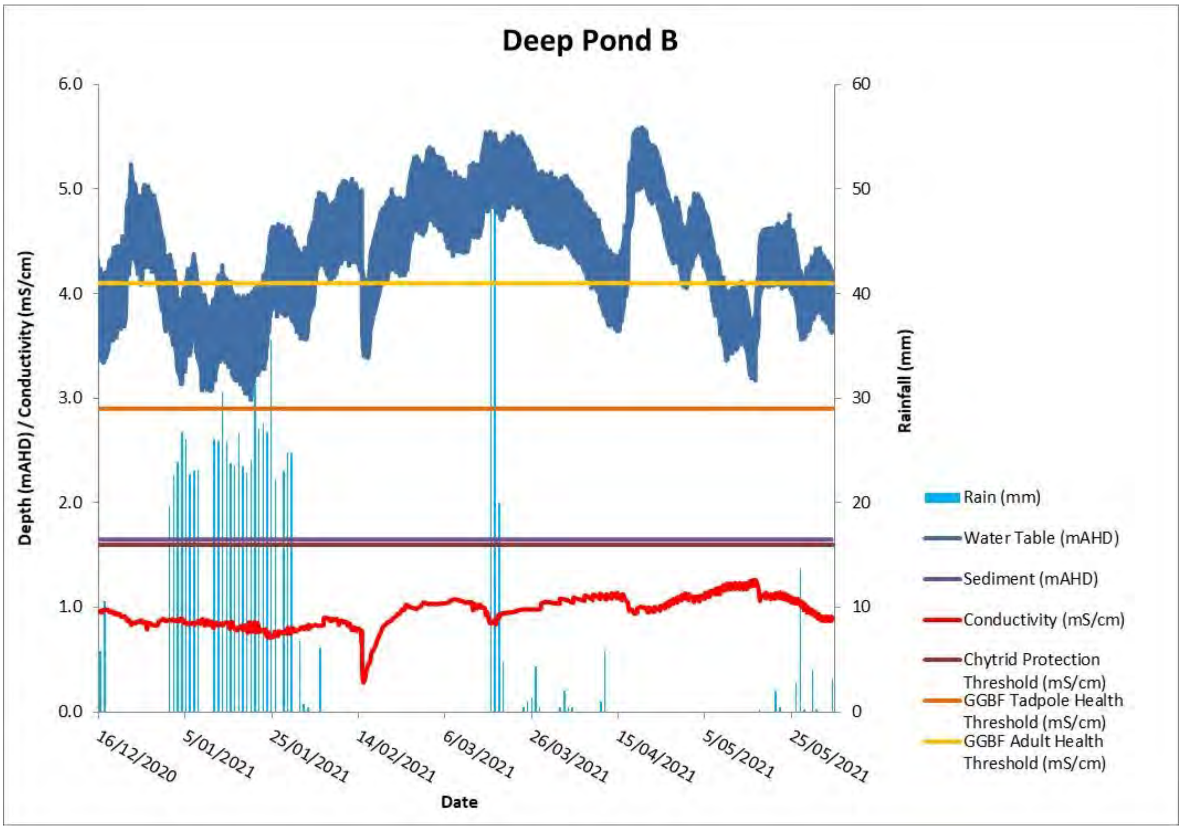
SW Pond 11
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
60
50
40
30
20
10
0
3/02/2021
8/02/2021
13/02/2021
18/02/2021
23/02/2021
28/02/2021
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)


Railway Pond
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Depth (mAHD) / Conductivity (mS/cm)
60
50
40
30
20
10
0
Rainfall (mm)
16/12/2020
5/01/2021
25/01/2021
14/02/2021
6/03/2021
26/03/2021
15/04/2021
5/05/2021
25/05/2021
Date
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)


SW-K7B
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Depth (mAHD) / Conductivity (mS/cm)
60
50
40
30
20
10
0
Rainfall (mm)
16/12/2020
5/01/2021
25/01/2021
14/02/2021
6/03/2021
26/03/2021
15/04/2021
5/05/2021
25/05/2021
Date
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)


SW-K7
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)
16/12/2020
5/01/2021
25/01/2021
14/02/2021
6/03/2021
26/03/2021
15/04/2021
5/05/2021
25/05/2021


GH001S
Depth (mAHD) / Conductivity (mS/cm)
Rainfall (mm)
Date
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)
16/12/2020
5/01/2021
25/01/2021
14/02/2021
6/03/2021
26/03/2021
15/04/2021
5/05/2021
25/05/2021


Deep Pond B
Depth (mAHD) / Conductivity (mS/cm)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Rainfall (mm)
60
50
40
30
20
10
0
16/12/2020
5/01/2021
25/01/2021
14/02/2021
6/03/2021
26/03/2021
15/04/2021
5/05/2021
25/05/2021
Date
Rain (mm)
Water Table (mAHD)
Sediment (mAHD)
Conductivity (mS/cm)
Chytrid Protection Threshold (mS/cm)
GGBF Tadpole Health Threshold (mS/cm)
GGBF Adult Health Threshold (mS/cm)

Appendix F – KIWEF Annual Groundwater & Surface Water Monitoring 2021 (Hazmat Services, 2021)

Ground and Surface Water Monitoring, Kooragang Island Waste Emplacement Facility

Annual Monitoring 2021

N4129_GME_RPT01_R1_300921

June 2021

OHS | WASTE | ENVIRONMENT

Ground and Surface Water Monitoring, Kooragang Island Waste Emplacement Facility

Annual Monitoring 2021

N4129_GME_RPT01_R1_300921

June 2021

PREPARED FOR

Hunter & Central Coast Development Corporation
6 Stewart Avenue
NEWCASTLE WEST NSW 2302

PREPARED BY

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DISCLAIMER

APPROVED COMPANY ISO 45001 Occupational Health & Safety Management Systems QMS Certification Services

APPROVED COMPANY ISO 14001 Environmental Management Systems QMS Certification Services

APPROVED COMPANY ISO 9001 Quality Management Systems QMS Certification Services

Hazmat Services Pty Ltd operates under a Health, Safety, Environment and Quality Management System which has been certified by QMS Certification Services to comply with the requirements of ISO 45001:2018 Occupational Health & Safety Management Systems, ISO 14001:2015 Environmental Management Systems and ISO 9001:2015 Quality Management Systems.
Accreditation No S1410994MA.

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DISTRIBUTION OF COPIES

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R1	Electronic (PDF)	Grant Moylan, Environmental Advisor Hunter & Central Coast Development Corporation, grant.moylan@hccdc.nsw.gov.au

ABBREVIATIONS

ANZECC	Australian and New Zealand Environment Conservation Council
ANZECC/ ARMCANZ	Australian and New Zealand Environment Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure
BoM	Bureau of Meteorology
COC	Chain of Custody
DO	Dissolved Oxygen
DQO	Data Quality Objective
EC	Electric Conductivity
EPA	NSW Environment Protection Authority
EPL	Environment Protection Licence
HCCDC	Hunter and Central Coast Development Corporation
KIWEF	Kooragang Island Waste Emplacement Facility
LOR	Limit of Reporting
NATA	National Association of Testing Authorities
OEH	NSW Office of Environment and Heritage
PID	Photo-ionisation Detector
QA/QC	Quality Assurance/Quality Control
RCA	RCA Australia
RPD	Relative Percentage Difference
SWL	Standing Water Level
VOC	Volatile Organic Compounds

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TABLES

Report Section

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FIGURES

APPENDICES

1 INTRODUCTION

Hazmat Services Pty Ltd ("Hazmat") was commissioned by Hunter & Central Coast Development Corporation ("HCCDC") to undertake ground and surface water monitoring for an additional year at the former Kooragang Island Waste Emplacement Facility ("KIWEF") located off Cormorant Drive, Kooragang Island NSW (the "Site"). The Site comprises several lots which are legally identified as Part Lot 7, Lot 10, Lot 11 and Part Lot 14 of DP11194525. The location of the Site is shown on Figure 3 in Appendix A.

The former landfill was operated by BHP under Environmental Protection Licence ("EPL") EPL6437 between 1997 and 2003 (Protection of the Environment Operations Act ("PoEO") licensing did not exist prior to 1997, and the landfill was regulated under State Pollution Control Commission and other environmental protection regulations). Under the EPL, BHP was required to undertake a range of ground and surface water monitoring. Since the closure of the steelworks and landfill, HCCDC is responsible for the ongoing monitoring of the Site on behalf of the state government, which is now the owner of the Site. The conditions for the ongoing monitoring are set out in the Approval of the Surrender of a Licence Notice (No 1111840; the "Notice") issued by the NSW Environment Protection Authority ("EPA"). The monitoring described in this report satisfies the routine regulatory requirements under Section 5 Environmental Monitoring Part c) Groundwater and Surface Water Monitoring Program, within the Notice.

1.1 Project Objectives

The objective of the surface and groundwater monitoring was to satisfy the conditions of the Notice by assessing the water quality and reporting the results to HCCDC in form of an annual report.

1.2 Scope of Works

The monitoring includes 50 established groundwater wells and five (5) surface water monitoring locations as prescribed by HCCDC in the tender documents (Env1899); the "Brief"). The groundwater wells and surface water locations are shown on the sample location map as Figure 4 in Appendix A.

Groundwater and surface water monitoring was undertaken in accordance with the requirements specified in the Services Brief. The following scope of work was undertaken:

- Review of previous monitoring data;
- Follow previously developed and implemented Data Quality Objectives ("DQO") for the investigation of groundwater;
- Prepare a site-specific health, safety and environmental plan and safe work method statement prior to commencing the works;
- Undertake fieldwork in accordance with Hazmat's standard field and quality assurance/control procedures and in consideration of relevant industry guidelines;
- Sampling and analysis for the range of specified parameters at 47 of the 50 groundwater wells and five (5) surface water monitoring locations conducted in June and July 2021, as follows;
  - Ammonia;
  - Phenols;
  - Cyanide (Total, Weak Acid Dissociable and Free);
  - Hexavalent chromium;
  - Molybdenum;
  - Lead; and
  - Total PAHs.

- Collect quality control samples in accordance with the frequency specified in the Brief and in accordance with the relevant Australian Standards; and
- Review analytical results and prepare a report detailing the methodology and outcomes of the monitoring program including conclusions regarding the Site's contamination status.

2 SITE INFORMATION

2.1 Site Identification

The Site comprises of Part Lot 7, Lot 10, Lot 11 and Part Lot 14 of DP11194525. A site map showing the study area is attached as Figure 3 in Appendix A.

2.2 Site Description

KIWEF is approximately 197 ha in area on the western portion of Kooragang Island. The site has been filled with waste materials relating to the operation of the former BHP Steel Works from the late 1960's until 2001.

The former landfill was operated by BHP under EPL6437 between 1997 and 2003 (PoEO licensing did not exist prior to 1997, and the landfill was regulated under State Pollution Control Commission and other environmental protection regulations). In 2003 the landfill was transferred to the State under an s58 License transfer, which was subsequently monitored under the EPL by the State until it was surrendered under s80 N1111840 in December 2010.

2.3 Site History

Prior to ownership by BHP, the KIWEF site was originally a series of low-lying wetlands. Over time these wetlands have been filled by mostly inert materials arising from the operations of the former BHP steel works. The site received BHP waste from the late 1960's to 2001. Currently the site comprises filled and partially filled waste emplacement cells, recent construction activity on the adjacent NCIG lease lands and various ponds and surrounding wetlands. Since closure of the landfill in 2010 the State is progressing a sequence of works to provide a suitable final landform, cap and drainage system to the site consistent with PoEO requirements. The first stages of capping have been completed and further works are being progressed in accordance with regulatory requirements.

2.4 Previous Monitoring

Prior to the Surrender of the Licence in 2010, HCCDC conducted an extensive review of the monitoring programme which was then documented in the report KIWEF Groundwater and Surface Water Rationalisation Report (GHD, 2010). The recommendations of the report formed the basis for the annual ongoing post-licence monitoring set out in the Notice.

Analytical results from previous monitoring events were provided by HCCDC and form part of this report as an electronic attachment. It is therefore assumed that all results are of good quality and obtained using standard industry practice.

The last round of monitoring was conducted by Hazmat in 2020. Hazmat sampled a total of 47 of the 50 groundwater monitoring wells and five (5) surface water bodies. A number of wells (3) were unable to be sampled due to either being destroyed, insufficient groundwater, or inaccessibility to the sample sites. Since the 2020 monitoring round some of the lost and inaccessible wells, including K7/4N, K7/4S, 344A and 344B, have been found and made accessible for sampling.

3 ASSESSMENT CRITERIA

3.1 KIWEF Annual Surface and Groundwater Monitoring Criteria

The laboratory analysis conducted as part of the 2021 KIWEF annual monitoring is as per the sample analysis requirements outlined in the Notice. Groundwater and surface water concentrations were compared to Groundwater Investigation Levels ("GIL") published in the ASC NEPM. The GIL are similar to a set of trigger values published by the Australian and New Zealand Environment Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand ("ANZECC/ARMCANZ") The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). The ANZECC (2000) trigger values were also adopted in the NSW EPA Guidelines for the Assessment and Management of Groundwater, 2007 (NSW EPA 2007).

Assessment values are established by accounting for the protection of environmental values. These values are defined in ANZECC (2000) as:

> *"…particular values or uses of the environment that are important for a healthy* ecosystem or for public benefit, welfare safety or health which require protection from *the effects of pollution, waste discharges and deposits."*

The following values will be considered when applying assessment criteria:

- Relevant aquatic ecosystems; and
- Relevant human uses (such as, potable water, agricultural water, industrial water, aquaculture and farming for human consumption, recreational, visual amenity).

The ANZECC (2000) guideline provides three grades of guideline trigger values (i.e. high, moderate or low reliability trigger values) in Section 3.4.2.3 (procedures for deriving trigger values for toxicants). The grade depends on the data available and hence the confidence or reliability of the final figures. Only high and moderate reliability trigger values are reported in Table 3.4.1 of ANZECC (2000). The GIL were adopted for a 95 % protection of aquatic species. Because of the tidal nature of the Hunter River, considered to be the receiving body, the marine values were used. These trigger values are in line with values adopted during previous monitoring. In addition, current results were compared to previous results in order to detect any trends or natural attenuation of contaminants. The adopted monitoring criteria were applied to groundwater and surface water as a screening level and are listed in Table 1. It is noted that the terms 'trigger value' and 'GIL' are used interchangeably in this report.

Table 1: Adopted Monitoring Criteria for Groundwater and Surface Water (µg/l)

Analyte	ASC NEPM GIL for Marine Waters	ANZECC (2000) Slightly – Moderately Disturbed Systems Trigger Values
Inorganics		
Chromium VI	4.4	4.4
Lead	4.4	4.4
Molybdenum	-	23*
Ammonia	910	910
Cyanide	4	4
Organics		
Naphthalene	50	70
Benzo(a)pyrene	-	-
Phenols	400	400

*- ANZECC 2000 low reliability value

3.2 Absence of Specific Criteria

In the absence of specific criteria, any analytes reported above the laboratory limit of reporting ("LOR") will be reviewed and professional judgement will be applied to assess the detrimental effects. The laboratory LOR will be at or below the adopted assessment criteria where practicable. Where specific criteria are not available the standard laboratory test, and therefore LOR, will be used. As there are no published criteria for Total PAHs, Hazmat has adopted the laboratory LOR as the assessment criteria for Total PAHs.

4 FIELDWORK METHODOLOGY

Sampling for the annual monitoring event was conducted between the 21st of June and 7th of July 2021 and included the collection of groundwater samples from 47 groundwater monitoring wells and five (5) surface water locations. Sample locations are shown in Figure 4 in Appendix A.

During the monitoring event, the majority of the wells and surface water bodies were easily located and accessed. The wells that were not sampled for the 2021 monitoring period are listed in the Table 2 below.

Table 2: List of Monitoring Wells Not Sampled – 2021 Monitoring Event

Well ID	Issue	Recommended Action
K12/9E	Well was damaged and could not be sampled.	Discussion required with EPA to confirm whether continued monitoring at location is required and if well should also be replaced.
K12/6	Well was damaged during Ash Island fires.	Discussion required with EPA to confirm whether continued monitoring at location is required and if well should also be replaced.
E61/S	Well was dry and could not be sampled.	Retry next event if undertaken.

In order to rectify the above issues, it is recommended that the EPA be consulted to determine if ongoing monitoring of these locations is required and therefore, whether they can be taken out of the next monitoring round (if to be undertaken) or that they must be repaired or replaced.

As a result of the above, 47 groundwater samples and five surface water samples were collected.

4.1 Fieldwork Guidelines

The collection of samples was undertaken in general accordance with Hazmat's Standard Operating Procedures and the following Australian Standards ("AS") and guidance documents:

- NEPC (2013) ASC NEPM Schedule B(2) Guideline on Data Collection, Sample Design and Reporting, 2013; and
- Australian Standard (AS/NZS 5667.11:1998) Water quality—Sampling Part 11: Guidance on sampling of groundwater.

4.2 Surface Water Sampling

A total of five (5) surface water samples were collected, one from each surface water location. Surface water samples were collected directly from the surface water body using a sampling arm attached to a laboratory supplied unpreserved bottle so as to avoid disturbing sediments. The unpreserved bottles were submerged just below the water surface and disposable nitrile gloves were worn for all sampling. The following water quality parameters were taken using a YSI water quality meter:

- Dissolved oxygen ("DO");
- Redox;
- Temperature;
- pH; and
- Electrical Conductivity ("EC").

The samples were then decanted into laboratory supplied and preserved bottles suitable for the chosen analytes. The water quality parameters are included in the Results Summary in Table B in Appendix D.

The calibration certificate for the water quality meter is attached in Appendix G.

4.3 Groundwater Sampling

A total of 47 groundwater monitoring wells were sampled. Prior to sampling, concentrations of Volatile Organic Compounds ("VOCs") in the wells were determined using a calibrated MiniRAE 3000 Photoionisation Detector ("PID"). Standing Water Levels ("SWL") were measured from a fixed top-of-casing mark point prior to sampling. Wells were sampled using one of the following sampling methods:

- Low flow micropurge pump – wells were purged until the field parameter readings were stabilised and measured with a YSI water quality meter as per the low flow sampling protocol; and
- Disposable hand bailers – a minimum of three well volumes were removed and purging was continued until field parameters stabilised and measured by a YSI water quality meter to ensure a representative sample was collected.

These methods were chosen for the Site due to the requirement for high integrity samples. The low flow pump was the preferred sample collection method due to the potential presence of volatile compounds. The hand bailer was only used for monitoring wells where the low flow pump did not fit inside casings and for wells which exhibited elevated sediment levels, causing blockage of the low flow pump.

At each sampling location, the following field parameters were monitored with a YSI water quality meter:

- Dissolved oxygen ("DO");
- Redox;
- Temperature;
- pH; and
- Electrical Conductivity ("EC").

The field parameters were considered stable when the pH was within 0.1 pH units of the preceding measurement and DO was within 10%. Field record sheets are attached in Appendix F. The calibration certificates for the PID and water quality meter are attached in Appendix G.

Samples which were analysed for heavy metals and hexavalent chromium were field filtered with disposable 45 micron filters before being placed into the sample bottle.

4.4 Sample Analysis

Laboratory analysis was conducted in accordance with the standard test methods outlined in Schedule B (3) of the NEPM (2013) for waters. The selected laboratories are National Association of Testing Authorities ("NATA") accredited for the analyses performed. The water samples were analysed for a suite of analytes which included:

- Ammonia;
- Phenols;
- Cyanide (Total, Weak Acid Dissociable and Free);
- Hexavalent chromium;
- Molybdenum;
- Lead; and
- Total PAHs.

Hazmat notes that, for some samples, only some of the above analytes were tested, in accordance with the Brief.

4.5 Sample Handling and Transport

Groundwater and surface water samples were placed in laboratory supplied containers suitable for the chosen analytes. Samples were placed directly into a chilled esky following collection and transported to an accredited laboratory under chain of custody ("CoC") protocols within appropriate holding times. A copy of the CoC documentation is provided in Appendix E.

Envirolab was used as the primary laboratory for the project and ALS as the secondary laboratory. Both laboratories are National Association of Testing Authorities ("NATA") accredited for the performed analysis.

4.6 Decontamination

The decontamination of sampling equipment was performed to minimise risks to health and safety, and to reduce the potential for cross-contamination between samples. For each sample, a new set of disposable nitrile gloves was used. The samples were placed into laboratory supplied sample bottles. Between each groundwater sample, the low flow pump was decontaminated. This process included a scrubbing brush and a solution of Decon 90 and tap water followed by a rinse in deionised water.

Decontamination of the sampling equipment was not required for surface water as samples were collected directly from the surface water body into the required analytical bottles. A new set of appropriately preserved sample bottles was used to collect each surface water sample.

4.7 Quality Assurance/Quality Control

Analytical data validation is the process of assessing whether the data is in compliance with method requirements and project specifications. The primary objective of this process is to ensure that data of known quality are reported, and to identify if data can be used to fulfil the overall project objectives.

The data validation guidelines adopted are based upon the following data validation guidance documents published by the United States Environmental Protection Agency (USEPA):

- USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA 540-R-10-011, dated January 2010);
- USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA 540/R-99/008, dated June 2008); and
- National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM 2013).

The process involves the checking of analytical procedure compliance and the assessment of the accuracy and precision of analytical data from a range of quality control measurements generated from both field sampling and analytical programs. Specific elements that have been checked and assessed for this project include:

- preservation and storage of samples upon collection and during transport to the laboratory;
- holding times;
- use of appropriate analytical procedures;
- required Limit of Reporting ("LOR");
- frequency of conducting quality control measurements;
- laboratory blanks;
- field duplicates;
- rinsate blanks;

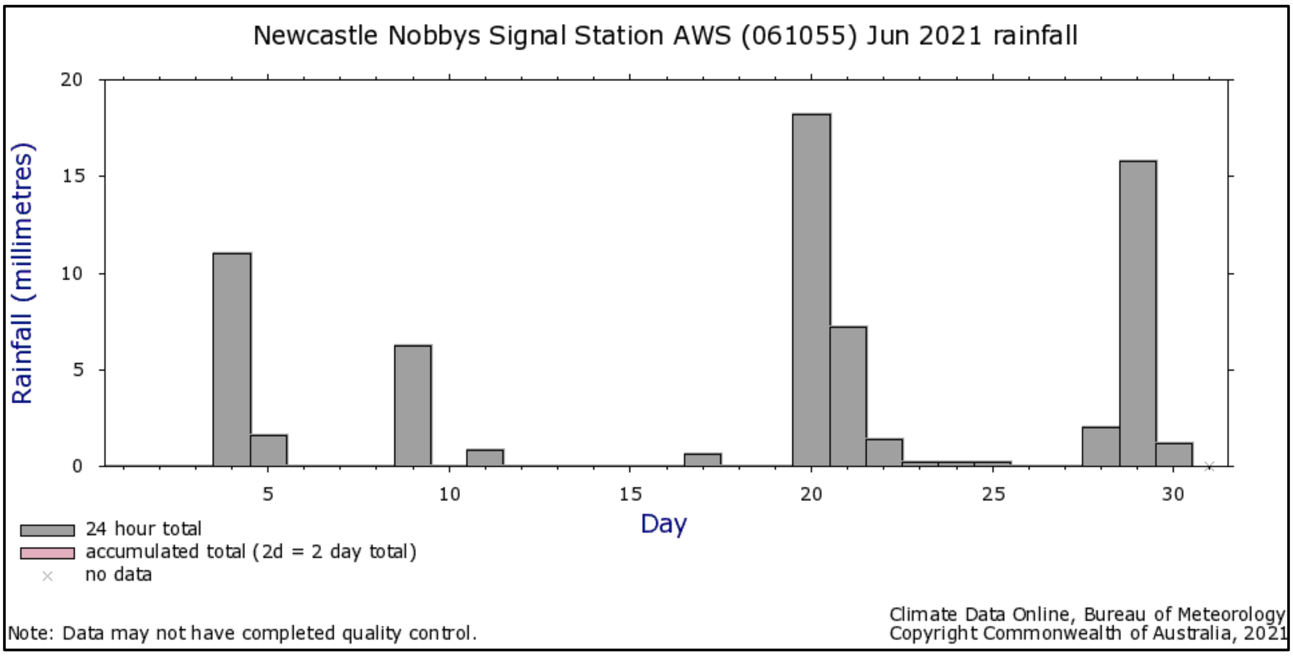
- laboratory duplicates;
- matrix spike/matrix spike duplicates (MS/MSDs);
- surrogates (or System Monitoring Compounds); and
- the occurrence of apparently unusual or anomalous results, e.g. laboratory results that appear to be inconsistent with field observations or measurements.

The description of sampling, analysis and data quality objectives and validation methods that were followed for this project are located in the quality assurance and quality control section presented in Appendix C. The outcomes are also summarised in Table 3.

4.8 Meteorological Conditions

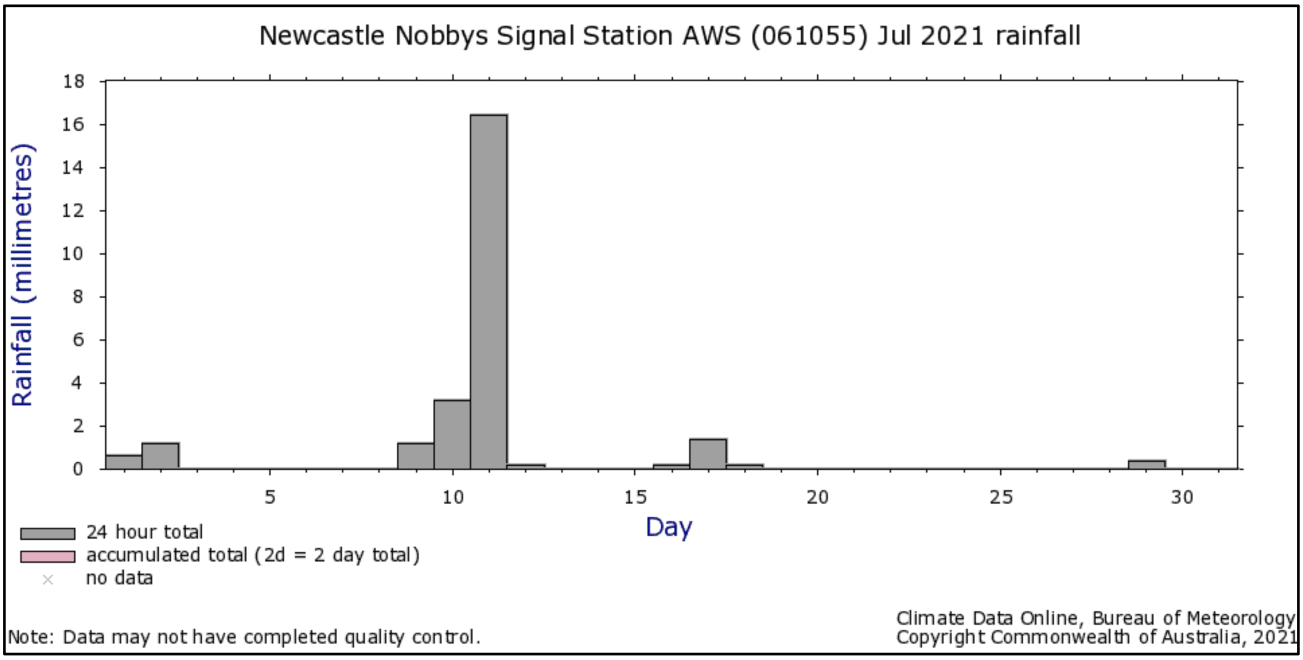
Meteorological conditions for June and July 2021 were sourced from the Bureau of Meteorology's ("BoM") Newcastle Nobbys signal station (Station 061055). The rainfall data for June and July 2021 are shown in Figure 1 and Figure 2 below. There were 14 rain events in the month of June with the highest amount of rainfall being 18.2mm. June was a generally a dry month with below average overall rainfall observed.

Up until the end of monitoring, the month of July had six rain events with the highest amount of rainfall being 16.4mm.



(Source: BoM, 2021)

Figure 1: June 2021 Rainfall Data



(Source: BoM, 2021)

Figure 2: July 2021 Rainfall Data

5 SUMMARY OF RESULTS

5.1 PID Screening

Prior to sampling of all groundwater wells, concentrations of VOCs were determined using a calibrated PID. All sampled wells reported VOC concentrations below 5 ppm.

Reported VOC concentrations for all wells sampled are presented in Table A in Appendix D. The calibration certificate for the PID is attached in Appendix G.

5.2 Field Water Quality Parameters

Reported field water quality parameters for all wells sampled are presented in Table A in Appendix D.

A summary of the field water quality parameters observed are as follows:

- Electrical conductivity readings ranged from 9.9 µs/cm to 50,143 µs/cm;
- pH readings ranged from 4.97 to 9.53;
- Dissolved oxygen readings ranged from 0.21 to 4.63 mg/L;
- Redox readings ranged from -286.5 mV to 160 mV; and
- Temperature ranged from 13.3^{0}C to 22.8^{0}C.

5.3 Groundwater

Groundwater analytical results are presented in Table B in Appendix D. A discussion on the longer-term trends of these results and what the results mean is presented in Section 6.

The following observations are made:

- The reported concentrations of ammonia exceeded the adopted ANZECC Criteria in 30 wells. The following wells were above the ANZECC Criteria: K12/1E, K12/7E, NCIG2, K7/2N, K9/2E, K9/3N, K11/1S, K11/3W, K12/4N, K11/2W, K9/4W, K12/10, K7/1, K8/5E, K12/9, NCIG1, BHe29S, E61D, K8/5W, K7/2S, K9/4E, K9/3S, GHD01S, K10/2NN, K12/10E, K11/3E, 344B and BH21S. The highest concentration of ammonia was observed at well K12/4N which reported a concentration of 61 mg/L, which is 61 times above the ANZECC Criteria. K12/4N is located outside the KIWEF footprint and is approximately 800 m northwest of the KIWEF boundary within the deep estuarine aquifer.
- The samples analysed for total phenols were detected below the ANZECC Criteria with the exception of K7/2N which reported a concentration of 4,800µg/L (4.8mg/L) which is more than 15 times above the ANZECC Criteria.
- Samples analysed for total cyanide exceeded the ANZECC Criteria in 8 samples. The following wells were above the guideline: K7/2N, K8/5E, GHD01N, K10/2N, K7/4N, K12/9, K8/5W and BH21S. The highest concentration was observed at well K7/2N which reported a concentration of 63µg/L (0.063 mg/L) which is 15 times above the ANZECC Criteria. The wells that reported a detectable total cyanide concentration also reported Weak Acid Dissociable (“WAD”) and free cyanide concentrations below the LOR.
- The reported concentrations of hexavalent chromium were below the LOR for all samples.
- Samples analysed for dissolved molybdenum exceeded ANZECC Criteria in six samples; K7/1, K8/5E, GHD01N, K10/2N, K8/5W, and BH21S. The highest concentration was observed at well BH21S which reported a concentration of 490µg/L (0.49mg/L) which is more than 15 times above the ANZECC Criteria.

- Samples analysed for dissolved lead were detected below the ANZECC Criteria with the exception of one sample;GHD01N which reported a concentration of 34µg/L (0.034mg/L) which is about 8 times above the ANZECC Criteria.
- Samples analysed for naphthalene detected concentrations below the ANZECC Criteria with the exception of wells K7/2N and BH21S. The highest concentration was detected at well K7/1 which reported a concentration of 750µg/L which is more than 10 times above the ANZECC Criteria. The samples also reported concentrations of total PAHs below the ANZECC Criteria with the exception of wells K7/2N, K11/2W, K9/4W, K7/1, K8/5E, K7/2S, GHD01, 344A, K8/5W, K9/2W, K9/4E, GHD01S and K10/2NN. K7/2N reported the highest concentration of 760µg/L which is more than 1000 times above the ANZECC Criteria.
- Samples analysed for benzo(a)pyrene detected concentrations below the LOR, with the exception of sample BH21S, which recorded a concentration of 2.2µg/L, which is equal to the adopted ANZECC Criteria for this site.

5.4 Surface Water

Surface water analytical results are shown in Table B in Appendix D. The following observations are made:

- The samples reported ammonia concentrations below the ANZECC Criteria.
- The samples reported a total phenol concentration below the LOR and adopted ANZECC Criteria.
- The results for free, WAD and total cyanide were reported below the LOR and respective ANZECC Criteria.
- The samples reported total molybdenum concentrations below the adopted ANZECC Criteria with the exception of KS7/1, which reported concentrations of 34µg/L (0.034mg/L which is approximately one and half times above the ANZECC Criteria.
- The samples reported total lead concentrations below the adopted ANZECC Criteria.
- The samples analysed for total PAH including naphthalene and benzo(a)pyrene reported concentrations below the LOR and adopted ANZECC Criteria.

5.5 Quality of Analytical Data

The outcome of the data quality assessment is summarised in Table 3. On the basis of the analytical data validation procedure employed, the overall quality of the groundwater and surface water analytical data produced is considered to be of an acceptable standard for interpretive use. Details of the methodology and outcome of the quality assurance and quality control for the project is outlined in Appendix C.

Table 3: Data Quality

Requirement	Required Frequency	Compliance	Comments
Field Duplicates (intra-laboratory duplicates)	5% (primary lab) or 1 per batch	Yes	Three duplicate samples were collected for 52 primary samples (47 groundwater and 5 surface water). Intra-laboratory duplicate samples were collected by splitting each sample into the primary and duplicate sample containers.

Requirement	Required Frequency	Compliance	Comments
Check Duplicates (inter-laboratory duplicates	5% (secondary lab) or 1 per batch	Yes	Three duplicate samples were collected for 52 primary samples (47 groundwater and 5 surface water). Inter-laboratory duplicate samples were collected by splitting each sample into the primary and duplicate sample containers.
Rinsate sample	One per day	Yes	14 rinsate samples were collected, one for each day, from the sampling equipment. The results were reported below LOR for the analytes tested.
Laboratory Duplicates	10 % (primary lab) or 1 per batch	Yes	The laboratory duplicates meet the required frequency.
Laboratory Spikes	5 % (primary lab) or 1 per batch	Yes	The laboratory spikes meet the required frequency.
Laboratory Control Samples	5 % or 1 per batch	Yes	It is noted that the Brief requires 10 % while the ASC NEPM requires 5 %.
RPDs	-	Yes	The majority of calculated RPDs fall within the acceptable range of <50 %, the exception being samples with concentrations of <10 times the LOR which can show a higher RPD. Where concentrations of either sample is <LOR or <10 times the LOR, then no limit applies. Appendix C provides details on individual RPDs.
Sampling equipment properly decontaminated	Each sample	Yes	Disposable equipment used where possible. The pump, interface probe and water quality meter were decontaminated between sampling locations.
Sample Preservation	All samples	Yes	Samples were properly preserved. Samples were compliant with required storage temperature.
Samples delivered to laboratory within sample holding times.	All samples	Yes	Confirmed from COCs and laboratory reports.
Equipment Calibration	Once per event	Yes	Refer to Appendix G.
Analytical procedures	All procedures	Yes	All procedures are NATA accredited.
SOP and competent field personnel	Always	Yes	Sampling procedures follow industry standards, and field staff are competent in sampling methods and QA/QC protocols.

6 DISCUSSION

6.1 KIWEF Annual Monitoring

Analytical results for groundwater and surface water show that, with the exception of ammonia, total cyanide, dissolved molybdenum, phenols, dissolved lead, naphthalene and total PAH's, the majority of wells did not report concentrations above the ANZECC Criteria. Results that exceed the adopted monitoring criteria were compared to historical data dating back to 1999. These are discussed in Sections 6.1.1 to 6.1.4. The results summary presented in Table B of Appendix D indicates for each sample whether it was collected from surface water or from a bore constructed in fill, shallow estuarine or deep estuarine. Historical data are provided in Appendix H.

6.1.1 Fill Bores

Five of the eleven wells in fill material (K7/1, K8/5E, K10/2N, 336A and K7/4N) reported ammonia concentrations above the ANZECC Criteria. Total cyanide was also detected at a concentration above the ANZECC Criteria in wells K8/5E, GHD01N, K10/2N and K7/4N. Concentrations of WAD and free cyanide were also detected below the LOR indicating that the cyanide present is not bio-available. Molybdenum was detected above the ANZECC Criteria in four wells (K7/1, K8/5E, GHD01N and K10/2N). Lead was detected above the ANZECC Criteria in one well (GHD01N).

A comparison to historical data for the wells where contaminants were recorded above the adopted ANZECC Criteria indicated the following:

- Ammonia concentrations were lower than the historical maximum concentrations;
- Total cyanide concentrations were lower than the historical maximum concentrations;
- Molybdenum concentrations were lower than the historical maximum concentrations; and
- Lead concentrations were also lower than the historical maximum concentration in well GHD01N.

Ongoing monitoring is recommended to observe the potential fluctuations in PAH, total cyanide, ammonia, lead and molybdenum concentrations within the fill bores, with particular attention to sample location K7/1. While fluctuating lead concentrations have historically been recorded in sample location GHD01N, the individual concentrations recorded have remained historically low, and may be representative of background conditions. Nevertheless, ongoing monitoring is recommended.

6.1.2 Shallow Estuarine Bores

A total of 22 bores were monitored in the shallow estuarine aquifer. Reported concentrations for ammonia were above the ANZECC Criteria in 13 samples. Total cyanide concentrations exceeded the adopted ANZECC Criteria in three samples. Concentrations of WAD and free cyanide were also detected below the LOR indicating that the cyanide present is not bio-available. Molybdenum concentrations exceeded the adopted ANZECC Criteria in two samples, and lead concentrations were below the adopted ANZECC Criteria. Total PAH's were recorded above the adopted laboratory LOR Criteria in six samples.

A comparison to historical data for the wells where contaminants were recorded above the adopted ANZECC Criteria indicated the following:

- Concentrations with ammonia were consistent compared to the historical maximum concentrations where the only two bores (BHe29s and K9/3S) recorded concentrations above the historical maximum which were also slightly above the adopted ANZECC Criteria. These concentrations were relatively low compared to other background wells.
- Total cyanide was either consistent with, or lower than, the historical maximum concentrations;

- Molybdenum was either consistent with, or lower than, the historical maximum concentrations;
- Lead was lower than the historical maximum concentrations;
- The high naphthalene result recorded in well BH21S is lower than the historical maximum concentrations; and

Ongoing monitoring is recommended to observe the potential fluctuations in PAH, total cyanide, ammonia, lead and molybdenum concentrations within the shallow estuarine bores. While fluctuating lead concentrations have historically been recorded in the sample locations, the individual concentrations recorded have remained historically low, and may be representative of background conditions. Nevertheless, ongoing monitoring is recommended.

6.1.3 Deep Estuarine Bores

A total of 14 bores were monitored in the deep estuarine aquifer. Reported concentrations for ammonia were above the ANZECC Criteria in 12 samples. Phenols were recorded above the adopted ANZECC Criteria in sample K7/2N. Total cyanide was recorded above the adopted ANZECC Criteria in sample K7/2N. Naphthalene was recorded above the adopted ANZECC Criteria in sample K7/2N and total PAH's were recorded above the adopted laboratory LOR Criteria in three samples.

A comparison to historical data for the wells where contaminants were recorded above the adopted ANZECC Criteria indicated the following:

- Concentrations of ammonia were either consistent with or lower than the historical maximum concentrations. The highest concentrations were detected within the deep estuarine aquifers;
- Concentrations of phenols in well K7/2N were lower with the historical maximum concentrations;
- Total cyanide was lower than the historical maximum concentrations;
- Naphthalene in well K7/2N was lower than the historical maximum concentration; and
- Total PAH's were lower than the historical maximum concentrations in well K7/2N, and consistent with the historical maximum concentrations in wells K9/4W and K11/2W.

Ongoing monitoring in line with the Notice is recommended to observe the potential fluctuations in ammonia, phenol, cyanide, naphthalene and total PAH concentrations within the deep estuarine bores. While fluctuating phenol and total PAH concentrations have historically been recorded in the sample locations, consistent low or elevated results have been recorded at individual sample locations (e.g. elevated phenol concentrations have been consistently recorded in sample location K7/2N. Ongoing monitoring is therefore recommended to assess if these trends remain consistent.

6.1.4 Surface Water

All five surface water locations were sampled and the majority of reported concentrations for all analytes were below the LOR and/or the ANZECC Criteria with the exception of sample location KS7/1 which recorded molybdenum concentrations above the ANZECC Criteria. The levels were lower than or consistent with the historical averages for molybdenum.

Compared with historical data, surface water quality is in line with previous results and concentrations appear generally lower than previously observed.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The following conclusions are made based on the reported data:

- Ammonia concentrations, although there were numerous exceedances of the adopted ANZECC Criteria, are generally lower than the historical observations. The higher concentrations were detected within background locations K12/4N and NCIG2 and these concentrations were lower than the historical maximum concentrations at these locations.
- Total cyanide concentrations in groundwater, although some exceedances of the adopted ANZECC Criteria exist, are generally at levels consistent with historical observations. Concentrations of WAD and free cyanide were also detected below the LOR indicating that the cyanide present is not bio-available.
- Concentrations for heavy metals (Pb, Mo, Cr VI), although some exceedances of the adopted ANZECC Criteria exist, are generally at levels consistent with historical observations.
- Concentrations for phenol are at levels below or consistent with historical observations.
- Concentrations of PAH are below the LOR in the majority of samples. However, a few samples exceed the adopted laboratory LOR Criteria. The PAH concentrations observed during the 2021 monitoring event are generally consistent or lower than those detected in previous recent results.
- The surface water quality observed in this round of monitoring is generally consistent with historical data and meets most of the adopted ANZECC Criteria.
- The current contaminant concentrations at the KIWEF have been detected at levels generally consistent with historical concentrations (collected since 1999). No significant reduction in concentrations have been observed and it is therefore recommended that groundwater and surface water monitoring is continued until the KIWEF closure works are completed.
- The contaminant concentrations detected at boundary monitoring points, or lack thereof, indicate that offsite migration of contaminants was not occurring.

7.2 Recommendations

The following recommendations are made based on the reported data:

- HCCDC to conduct discussion with EPA in regards to the installation or replacement monitoring wells for lost or damaged wells identified during the most recent monitoring round;
- Further investigation to identify the damage caused to wells K12/9E, and rectify;
- Ongoing groundwater and surface water monitoring in accordance with Surrender notice and; and
- Ongoing vegetation clearing and maintenance prior to next round of monitoring.

8 LIMITATIONS

Hazmat prepared this report for the purpose set out in Section 1 and as agreed to by the Client. Any advice, opinions or recommendations contained in this document should be read and relied upon only in the context of the document as a whole and are considered current to the date of this document. Any other party should satisfy themselves that the scope of work conducted and reported herein meets their specific needs. Hazmat cannot be held liable for third party reliance on this document, as Hazmat is not aware of the specific needs of the third party.

From a technical perspective, the subsurface environment at any site may present substantial uncertainty. It is a heterogeneous, complex environment, in which small subsurface features or changes in geologic conditions can have substantial impacts on water and chemical movement. Uncertainties may also affect source characterisation assessment of chemical fate and transport in the environment, assessment of exposure risks and health effects, and remedial action performance.

Hazmat professional opinions are based upon its professional judgement, experience, and training. These opinions are also based upon data derived from testing and analysis described in this document. Hazmat has limited its investigation to the scope agreed upon with its client. Hazmat believes that its options are reasonably supported by the testing and analysis that have been done, and that those opinions have been developed according to the professional standard of care for the environment consulting profession in this area at this time. That standard of care may change and new methods and practices of exploration, testing, analysis and remediation may develop in the future, which might produce different results. Hazmat professional opinions contained in this document are subject to modification if additional information is obtained, through further investigation, observations, or validation testing and analysis during remedial activities.

Finally, Hazmat does not make any other warranty, expressed or implied, as to the professional advice contained in this report.

9 REFERENCES

- Australian and New Zealand Environment Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) (2000) The Australian and New Zealand Guidelines for Fresh and Marine Water Quality;
- Australian Standard (AS/NZS 5667.11:1998) Water quality—Sampling Part 11: Guidance on sampling of groundwater;
- Australian Standard (AS4482.1-2005) Guide to the Sampling and Investigation of Potentially Contaminated Soil, Part 1: Non-volatile and semi-volatile compounds;
- Australian Standard (AS4482.2-1999) Guide to the Sampling and Investigation of Potentially Contaminated Soil, Part 2: Volatile substances;
- National Health and Medical Research Council (NHMRC) (2011) Australian Drinking Water Guidelines 6;
- NEPC (2013) ASC NEPM Schedule B(2) Guideline on Data Collection, Sample Design and Reporting, 2013;
- NSW EPA (2007) Guidelines for the Assessment and Management of Groundwater, 2007;
- NSW EPA (1995), Contaminated Sites: Sampling Design Guidelines, (NSW EPA, 1995);
- NSW EPA Environmental Protection License No. 6437; and
- RCA Australia (2014) KIWEF Groundwater and Surface Water Rationalisation Report.

APPENDIX A
Study Area and Sampling Locations

Hunter Development Corporation

NSW GOVERNMENT

Former Kooragang Island Waste Emplacement Facility Aerial Photograph April 2013

HAZMAT SERVICES

OHS | WASTE | ENVIRONMENT

Title: Former KIWEF Study Area	
Figure: 1	Project No: N4129
Date: 21/06/2021	Revision: 0

HAZMAT SERVICES

OHS | WASTE | ENVIRONMENT

Title: KIWEF Groundwater & Surface Water Monitoring Locations 2021	
Figure: 2	Project No: N4129
Date: 21/06/2021	Revision: 0

Page Size A4

APPENDIX B
EPL Surrender Notice

Section 80(1) of the Protection of the Environment Operations Act 1997

Approval of the Surrender of a Licence

Licence - 6437

Department of
Environment, Climate Change and Water NSW

HUNTER DEVELOPMENT CORPORATION ,

ABN 94 688 782 063,

PO BOX 813,

NEWCASTLE NSW 2300

Attention: Mr. Michael Bardsley

Notice Number	1111840
File Number	LIC07/20
Date	08-Dec-2010

APPROVAL OF THE SURRENDER OF LICENCE NO. 6437

BACKGROUND

A. The following licensee(s):

HUNTER DEVELOPMENT CORPORATION

94 688 782 063

applied to the Environment Protection Authority ("EPA") to surrender Environment Protection Licence No. 6437 ("the licence") issued under the *Protection of the Environment Operations Act 1997* ("the Act"). The licence authorises the carrying out of Scheduled Activity - Premises Based at KOORAGANG ISLAND, CORMORANT DRIVE, KOORAGANG, NSW.

B. The EPA received the application on 13-Jan-2010.

C. The following documents were supplied in support of the application:

a. Hunter Development Corporation – Report on KIWEF – Revised Final Landform and Capping Strategy – August 2009 – Revision 2, prepared by GHD;

b. Hunter Development Corporation – Revised Capping Strategy – Flora and Fauna Impact Assessment – January 2010 – Revision 3, prepared by GHD; and

c. Hunter Development Corporation – KI Groundwater and Surface Water Monitoring – Trend Analysis Report – January 2010 – Revision 1, prepared by GHD.

APPROVAL OF THE SURRENDER OF A LICENCE

1. The surrender of the licence is approved.

PART A GENERAL CONDITIONS

2. The approval of the surrender is subject to the following conditions:

   a) The licensee must provide the EPA with an Annual Return in relation to compliance with the conditions of the licence during the period beginning on the last licence anniversary date and ending on the date that the surrender of the licence takes effect as set out in point 5 below.

   b) The Annual Return must be supplied to the EPA within 60 days of the date from which this notice operates (see note at the end of this notice).

   c) The content and form of the Annual Return must be in accordance with the applicable reporting conditions in the licence before it was surrendered.

   d) The Annual Return must be signed in accordance with the applicable reporting conditions in the licence before it was surrendered.

3. This surrender notice applies to the following land on Kooragang Island as defined by Lot and DP numbers:

   Part Lot 7, Lot 10, Lot 11 and Part Lot 14 of DP1119752,

   and shown on map titled '*Plan of Subdivision of Lot 122 DP874949, Lot 2 DP581473, Lot 6 DP1015754 and Lots 71 and 74 in DP1119950'* date of survey 2 November 2007, Surveyors Reference HW43.01.03.00 and registered on 29 November 2007, attached to this notice.

   Note: Part Lot 14 DP1119752 refers to that area identified as Lot 14 DP 1119752 excluding land labelled as '*Extra Land Area 2*', '*Extra Land Area 4* and '*Extra Land Area 5'* shown on map titled '*Plan of Extra Land Showing Coordinates Kooragang* dated 08/06/10, attached to this notice.

PART B SITE SPECIFIC CONDITIONS

4. Final Capping

   a) The licensee shall implement the final landform and capping strategy as detailed in the document titled *Hunter Development Corporation – Report on KIWEF – Revised Final Landform and Capping Strategy – August 2009 – Revision 2, prepared by GHD,* ('the Landform and Capping Strategy') by **28 March 2013**.

   b) Three months prior to the commencement of final capping of Pond 5 (defined in Figure 4 - Areas of Contamination Hotspots – 20 May 2009, provided in the Landform and Capping Strategy) the licensee shall provide a report to the EPA, that confirms the geotechnical stability of the geosynthetic liner to withstand the additional weight of a coal washery reject capping layer as described in the Landform and Capping Strategy.

   c) The licensee shall update the Materials Management Plan provided in the Landform and Capping Strategy and provide the updated Materials Management Plan for approval to the EPA by **30 November 2011**. The updated Materials Management Plan must provide and commit to specific engineered and/or management measures to be adopted for contingency purposes if/when unknown contaminated material is encountered during the cut and fill component of the Landform and Capping Strategy.

   d) The licensee shall implement, maintain and operate erosion and sedimentation controls during the final capping process to ensure that there is no sedimentation of waterways.

   e) All activities associated with the closure, capping, rehabilitation and post-closure maintenance and monitoring at the premises must be carried out in a competent manner. This includes:

      i) The processing, handling, movement and storage of materials and substances used at the premises; and

   ii) The treatment, storage, processing, reprocessing, transport and disposal of any waste generated by the activity.

f) All plant and equipment installed at the premises or used in connection with the closure, capping, rehabilitation and post-closure maintenance and monitoring activities at the premises must be:

   i) maintained in a proper and efficient condition; and

   ii) operated in a proper and efficient manner.

g) All activities associated with the closure, capping, rehabilitation and post-closure maintenance and monitoring at the premises must be carried out in a manner that will minimise the emission of dust from the premises.

h) Within three months of completion of the installation of the final cap, the licensee must provide the EPA with a written Validation Report that includes:

   i) Advice that the final cap has been installed;

   ii) Advice from a suitably qualified and experienced person as to whether or not the cap was installed in accordance with Chapter 7 of the Landform and Capping Strategy and relevant conditions of this Notice, or future variations to this Notice;

   iii) Provision of the results of all relevant test results to validate that the permeability of the final capping layer is less than or equal to $K = 1 \times 10^{-7}$m/s. Permeability testing must be taken of the sealing layer material at a rate of not less than 1 per 2000T (or 1250m3);

   iv) Provision of information that establishes the thickness of the installed sealing and revegetation layers in the format of either:

      (i) As constructed drawings, including cross sections, of the surfaces of the coal washery reject layer; and

      (ii) The results of surveys undertaken for each capping layer by a registered surveyor.

i) The Validation Report must be prepared by a suitably qualified person who had suitable involvement in overseeing the cap's installation.

j) At the completion of the final cap, the licensee shall undertake inspections of the cap, on a six (6) monthly basis, to detect and remediate areas where the cap has eroded, degraded or slumped.

k) The licensee shall provide the EPA with a written statement of the results of the inspection required by condition 4(j) on an annual basis. The statement must describe the condition of the cap and any actions taken to remediate the cap as a result of the inspection. The first statement must be provided to the EPA by **30 September 2013** with subsequent reports provided 12 monthly following the provision of the first report.

5. Environmental Monitoring

a) The licensee shall prepare and submit a K26/32 Groundwater and Green and Golden Bell Frog Monitoring Program to the EPA for approval by **13 April 2011.** The Monitoring program shall:

   i) Document known risks associated with the contaminant hotspot located in the area known as K26/32 (defined in Figure 4 - Areas of Contamination Hotspots – 20 May 2009, provided in the Capping Strategy);

   ii) Be designed to assess the:

      (i) risk of contaminant mobilisation; and

      (ii) ongoing viability of the Green and Golden Bell Frog population in the K26/32 area; and

iii) Identify triggers for Green and Golden Bell Frog management intervention and/or actions required to address contaminant mobilisation.

b) The licensee shall prepare and submit a **Green and Golden Bell Frog Management Plan** to the EPA for approval by **13 April 2011.** The Plan shall encompass the entire premises occupied by the licensee and include, but not be limited to:

i) Management measures to be undertaken to minimise the spread of the amphibian *Chytrid* fungus including:

(i) the training of project personnel in site hygiene management; and

(ii) site hygiene procedures for project personal, mobile plant and equipment, in accordance with the NPWS Hygiene Protocol for the Control of Disease in Frogs 2001; and

ii) Measures to maintain, restore and enhance Green and Golden Bell Frog habitat, including movement corridors across the site.

c) The licensee shall undertake the groundwater monitoring program as outlined in Table 1, 2 and 3 of this notice. Monitoring locations are those groundwater bores identified in both the fill and natural aquifers as shown on the map titled '*Figure 2 - Rationalised Groundwater and Surface Water Monitoring Program*', dated 28 SEP 2010 and attached to this notice.

Table 1 – Deep Estuarine Wells being K5/5S, K5/6S, K7/2N, K9/2E, K9/3N, K9/4W, K11/1S, K11/2W, K11/3W, K12/1E, K12/3N, K12/4N, K12/7E, K12/9E and K12/10

Pollutant	Units of Measure	Frequency	Sampling Method
Ammonia	mg/L	Every 12 months	Grab sample
Phenols[1]	mg/L	Every 12 months	Grab sample
Cyanide (Total, WAD and free)	mg/L	Every 12 months	Grab sample
Chromium (hexavalent)	mg/L	Every 12 months	Grab sample
Molybdenum (dissolved)[2]	mg/L	Every 12 months	Grab sample
Lead (dissolved)[3]	mg/L	Every 12 months	Grab sample
Total PAHs	mg/L	Every 12 months	Grab sample
Conductivity	mg/L	Every 12 months	Grab sample
pH	pH	Every 12 months	Grab sample

[1] Not required to be analysed at wells K5/5S, K9/2E, K9/4W

[2] Not required to be analysed at wells K5/5S, K5/6S, K7/2N, K9/4W

[3] Not required to be analysed at wells K5/5S, K5/6S, K7/2N, K9/2E, K9/4W

Table 2 – Shallow Estuarine Wells being K3/1W, K5/6NN, K7/2S, K7/4S, K8/5W, K9/2W, K9/3S, K9/4E, K10/2NN, K11/1, K11/2E, K11/3E, K12/1W, K12/3W, K12/6, K12/7, K12/9, K12/10E, BHe29s, GHD02, E61D, 336B, 334B

Pollutant	Units of Measure	Frequency	Sampling Method
Ammonia	mg/L	Every 12 months	Grab sample
Phenols[4]	mg/L	Every 12 months	Grab sample
Cyanide (Total, WAD and free)	mg/L	Every 12 months	Grab sample
Chromium (hexavalent)	mg/L	Every 12 months	Grab sample
Molybdenum (dissolved)[5]	mg/L	Every 12 months	Grab sample
Lead (dissolved)[6]	mg/L	Every 12 months	Grab sample
Total PAHs	mg/L	Every 12 months	Grab sample
Conductivity	mg/L	Every 12 months	Grab sample
pH	pH	Every 12 months	Grab sample

Table 3 – Fill Wells being K5/4, K5/5N, K5/6N, K7/4N, K8/5E, K10/2, K10/2N, K7/1, GHD01, E61S, 336A, 344A

Pollutant	Units of Measure	Frequency	Sampling Method
Ammonia	mg/L	Every 12 months	Grab sample
Phenols[7]	mg/L	Every 12 months	Grab sample
Cyanide (Total[8], WAD and free)	mg/L	Every 12 months	Grab sample
Chromium (hexavalent)	mg/L	Every 12 months	Grab sample
Molybdenum (dissolved)[9]	mg/L	Every 12 months	Grab sample
Lead (dissolved)[10]	mg/L	Every 12 months	Grab sample
Total PAHs	mg/L	Every 12 months	Grab sample
Conductivity	mg/L	Every 12 months	Grab sample
pH	pH	Every 12 months	Grab sample

[4] Not required to be analysed at wells K7/4S, K8/3W, K9/2W, K9/4E, K10/2NN

[5] Not required to be analysed at wells K5/6NN, K7/2S, K9/4E

[6] Not required to be analysed at wells K5/6NN, K7/2S, K9/4E, K7/4S, K9/2W, K9/4E

[7] Not required to be analysed at wells K5/4, K5/5N, K7/4N, K8/5E, K10/2, K10/2N

[8] Not required to be analysed at wells K5/5N, K10/2, K10/2N

[9] Not required to be analysed at wells K5/4, K5/5N, K5/6N

[10] Not required to be analysed at wells K5/4, K5/5N, K5/6N, K7/4N

d) The licensee shall undertake the surface water monitoring program as outlined in Table 4 of this notice. Monitoring locations are those surface water monitoring locations as shown on the map titled '*Figure 2 - Rationalised Groundwater and Surface Water Monitoring Program*', dated 28 SEP 2010 and attached to this notice.

Table 4– Surface Water Monitoring at Locations KS2/1, KS1/3, K10/1, KS7/1, KS12/6

Pollutant	Units of Measure	Frequency	Sampling Method
Ammonia	mg/L	Every 12 months	Grab sample
Phenols	mg/L	Every 12 months	Grab sample
Cyanide (Total, WAD and free)	mg/L	Every 12 months	Grab sample
Chromium (hexavalent)	mg/L	Every 12 months	Grab sample
Molybdenum (dissolved)	mg/L	Every 12 months	Grab sample
Lead (dissolved)	mg/L	Every 12 months	Grab sample
Total PAHs	mg/L	Every 12 months	Grab sample
Conductivity	mg/L	Every 12 months	Grab sample
pH	pH	Every 12 months	Grab sample

e) The licensee shall provide the EPA with a written report of the results of the monitoring required by condition 5(c) and 5(d) on an annual basis. The report must be in a tabular and graphical format and the first report must be provided by **30 June 2011** with subsequent reports provided 12 monthly after the provision of the first report.

6. Except as provided by section 84(2) of the Act, the approval of the surrender of the licence by this notice operates from the date of this notice.

. . . .

Mr Grahame Clarke

Regional Manager

North East - Hunter

(by Delegation)

INFORMATION ABOUT THIS NOTICE

- On the date that the surrender of your licence takes effect the current licence fee period comes to an end. However, the surrender of your licence does not affect your liability to pay fees owing to the EPA for that licence fee period or for any earlier licence fee period.
- If you have not already paid the administrative fee for the licence fee period which has just come to an end on the surrender of your licence you must still do so. The administrative fee for a licence fee period

must be paid no later than 60 days after the beginning of that licence fee period (clause 36(1) of the *Protection of the Environment Operations (General) Regulation 2009*).

- Any load-based fees payable in relation to the licence fee period ending on the surrender of the licence must be paid no later than 90 days after the surrender of the licence takes effect (clause 37(1) of the *Protection of the Environment Operations (General) Regulation 2009*).
- Details provided in this notice will be available on the EPA's Public Register in accordance with section 308 of the Act.
- The reporting period on your Annual Return must be filled in to reflect the appropriate dates beginning on the last licence anniversary date and ending on the date that the surrender of the licence takes effect.
- The completed Annual Return must be sent by Registered Post no later than 60 days from the end of the reporting period to:

  Regulatory and Compliance Support Unit

  Department of Environment, Climate Change and Water

  PO Box A290

  SYDNEY SOUTH NSW 1232

- This notice is issued under section 80(1) of the Act.

<u>Appeals against this decision</u>

- You can appeal to the Land and Environment Court against this decision. The deadline for lodging the appeal is 21 days after you were given notice of this decision.

<u>When this notice begins to operate</u>

- The surrender of the licence specified in this notice begins to operate immediately from the date of this notice, unless another date is specified in this notice.
- If an appeal is made against this decision to approve the surrender of the licence and the Land and Environment Court directs that the decision is stayed the decision does not operate until the stay ceases to have effect or the Land and Environment Court confirms the decision or the appeal is withdrawn (whichever occurs first).

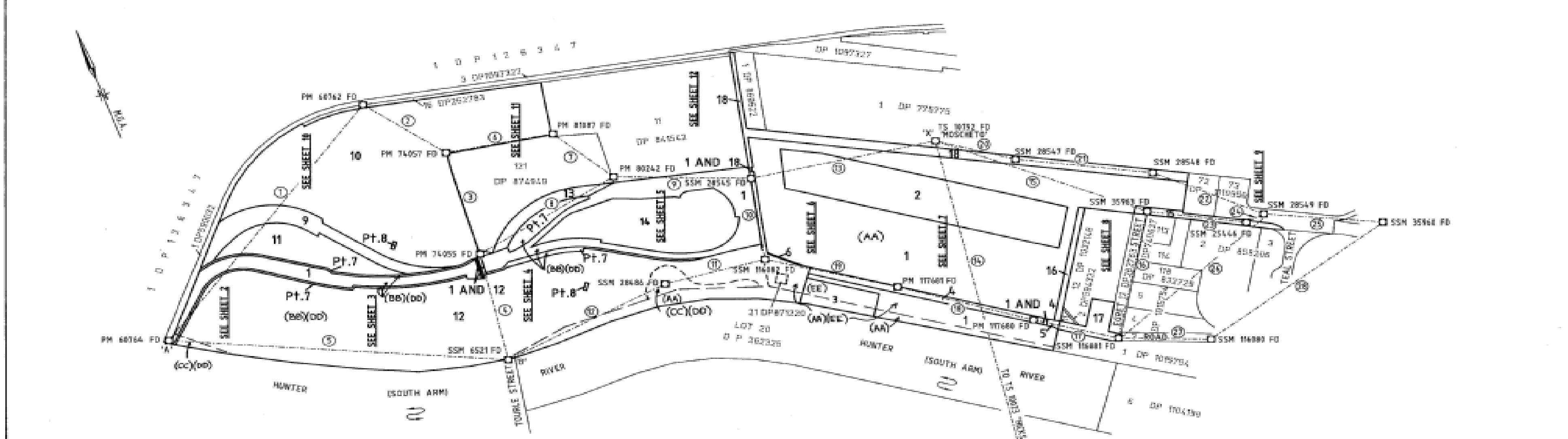
Section 80(1) of the Protection of the Environment Operations Act 1997

Approval of the Surrender of a Licence

Department of
Environment, Climate Change and Water NSW

Licence - 6437

PLAN FORM 2 (A2) WARNING : CREASING OR FOLDING WILL LEAD TO REJECTION



LINE	BY SURVEY BEARING	BY SURVEY DISTANCE	MGA GROUND BEARING	MGA GROUND DISTANCE
1	53° 43' 03"	1546.924	53° 43' 13"	1546.910
2	143° 34' 12"	456.165	143° 34' 15"	456.191
3	3° 07' 56"	566.855	–	
4	6° 29' 57"	584.4	6° 30' 09"	584.385
5	292° 50' 06"	1541.581	292° 50' 16"	1541.607
6	97° 10' 20"	495.740	97° 10' 22"	495.726
7	148° 42' 45"	361.69	148° 43' 16"	361.651
8	74° 39' 15"	736.945	74° 39' 17"	736.919
9	109° 40' 10"	632.785	109° 40' 16"	632.821
10	190° 33' 57"	440.181	–	
11	92° 48' 58"	478.56	–	
12	259° 19' 23"	828.394	–	
13	95° 28' 20"	873.08	95° 28' 26"	873.05
14	185° 44' 53"	–	185° 44' 53"	–
15	130° 07' 05"	1046.772	130° 07' 06"	1046.756
16	29° 53' 03"	696.695	–	
17	302° 53' 40"	406.18	–	
18	304° 52' 42"	650.675	304° 52' 50"	650.655
19	122° 29' 20"	628.545	122° 29' 18"	628.535
20	303° 54' 58"	381.983	–	
21	295° 31' 10"	636.96	–	
22	312° 15' 30"	555.96	–	
23	296° 21' 25"	459.96	–	
24	259° 30'	92.93	–	
25	113° 32' 58"	550.38	–	
26	63° 50' 49"	946.65	–	
27	109° 46' 07"	425.395	–	
28	258° 19'	1013.16	–	

(AA) LAND EXCLUDES MINERALS – T447400
(BB) LAND EXCLUDES MINERALS VIDE S.141 PUBLIC WORKS ACT 1912
(CC) LAND EXCLUDES MINERALS – SEE CROWN GRANT
(DD) COVENANT – R363314
(EE) BENEFITED BY EASEMENT FOR SERVICES VARIABLE WIDTH – DP849622

ALL R.L.'s ARE BASED ON A.H.D. DATUM

SURVEYING REGULATION 2006, CLAUSE 35(1)(B) AND CLAUSE 61(2)

MARK	M.G.A. CO-ORDINATES EASTING	NORTHING	ZONE	CLASS	ORDER	R.L.	CLASS	ORDER	METHOD	ORIGIN
PM 25446	384,981	6,361,217	56	U	U					
PM 60762	381,354.815	6,363,128.872	56	A	1					
PM 60764	380,108.093	6,362,213.745	56	B	2					
PM 74055	381,594.60	6,362,196.04	56	D	4	4.13	LB	L2	CLOSED LOOP LEVEL RUN	FOUND
PM 74057	381,625.65	6,362,761.91	56	D	4					
PM 80242	382,305.16	6,362,391.01	56	D	4					
PM 81087	382,117.43	6,362,780.02	56	D	4					
PM 117680	383,883.829	6,361,035.912	56	C	U	3.91	D	4	FROM SCIMS	SCIMS
PM 117681	383,350.793	6,361,407.914	56	C	U					
SSM 6521	381,528.515	6,361,615.551	56	B	2	3.780	LB	L2	FROM SCIMS	SCIMS
SSM 28486	382,362	6,361,769	56	U	U					
SSM 28545	382,900.91	6,362,178.04	56	D	4	2.850	LB	L2	CLOSED LOOP LEVEL RUN	FOUND
SSM 28547	384,087	6,361,882	56	U	U					
SSM 28548	384,661	6,361,607	56	U	U					
SSM 28549	385,033	6,361,234	56	U	U					
SSM 35960	385,577.111	6,361,013.698	56	B	2					
SSM 35963	384,570.057	6,361,420.439	56	A	1					
SSM 116080	384,650	6,360,654	56	U	U					
SSM 116081	384,196	6,360,821	56	U	U					
SSM 116082	382,820.149	6,361,745.439	56	C	U					
TS 10823	382,888.057	6,353,335.460	56	B	2					
TS 10792	383,769.775	6,362,094.777	56	B	2					

COMBINED SCALE FACTOR: 0.999765
SOURCED BY SCIMS: 16th May 2007

Surveyor: PAUL JOHN STIVANO Date of Survey: 2nd NOVEMBER 2007 Surveyor's Reference: HW43.01.03.08	PLAN OF SUBDIVISION OF LOT 122 DP874949, LOT 2 DP581473 LOT 6 DP1015754 AND LOTS 71 AND 74 IN DP1119950	LGA: NEWCASTLE Locality: KOORAGANG ISLAND Subdivision No: SUC002 Lengths are in metres. Reduction Ratio 1 : 12500	Registered 29.11.2007	DP1119752

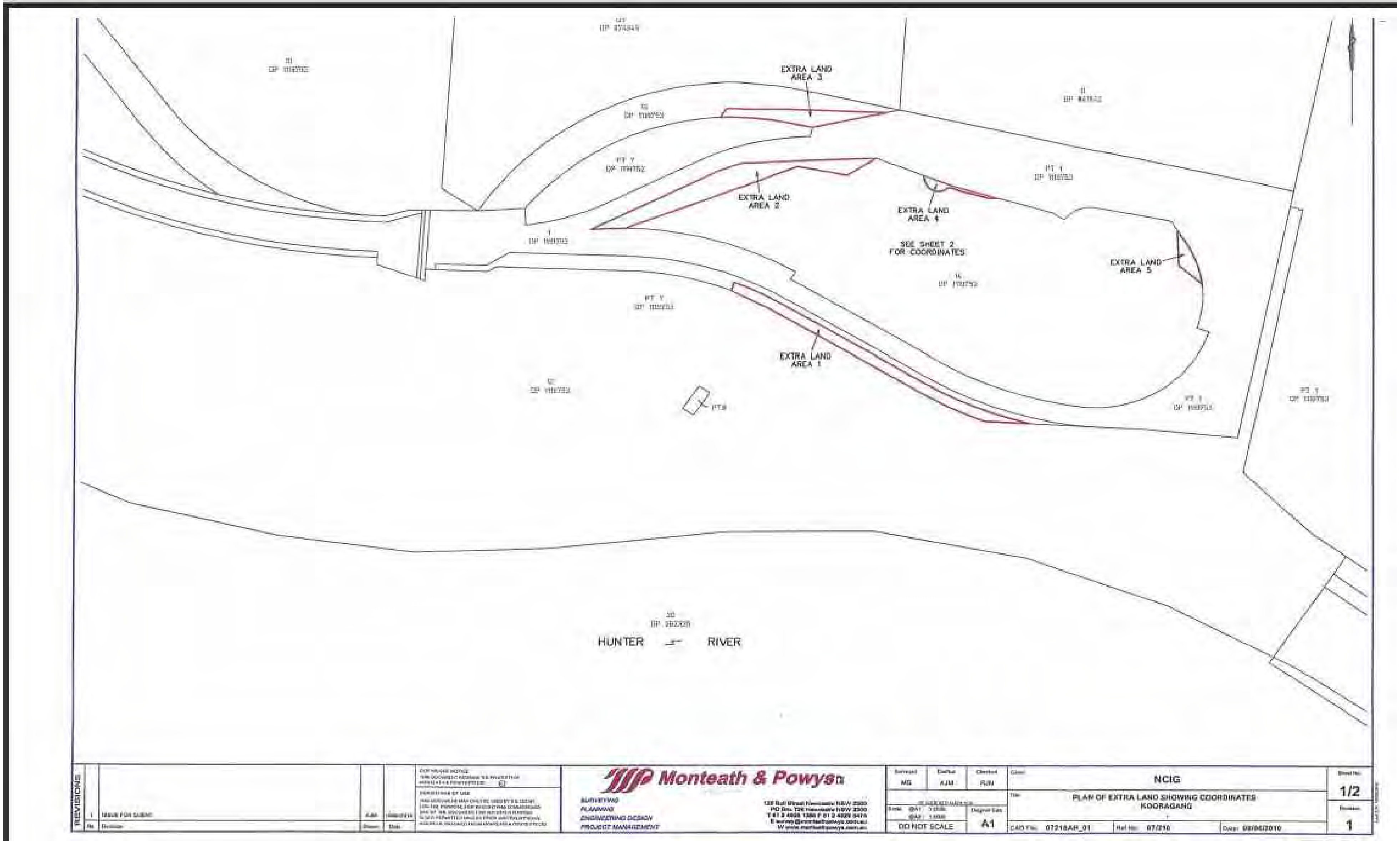
Req:R243117 /Doc:DP 1119752 P /Rev:03-Dec-2007 /Sts:SC.OK /Prt:10-Dec-2008 16:21 /Pgs:ALL /Seq:1 of 14
Ref:lee-ann /Src:T

Section 80(1) of the Protection of the Environment Operations Act 1997

Approval of the Surrender of a Licence

Department of
Environment, Climate Change and Water NSW

Licence - 6437



Section 80(1) of the Protection of the Environment Operations Act 1997

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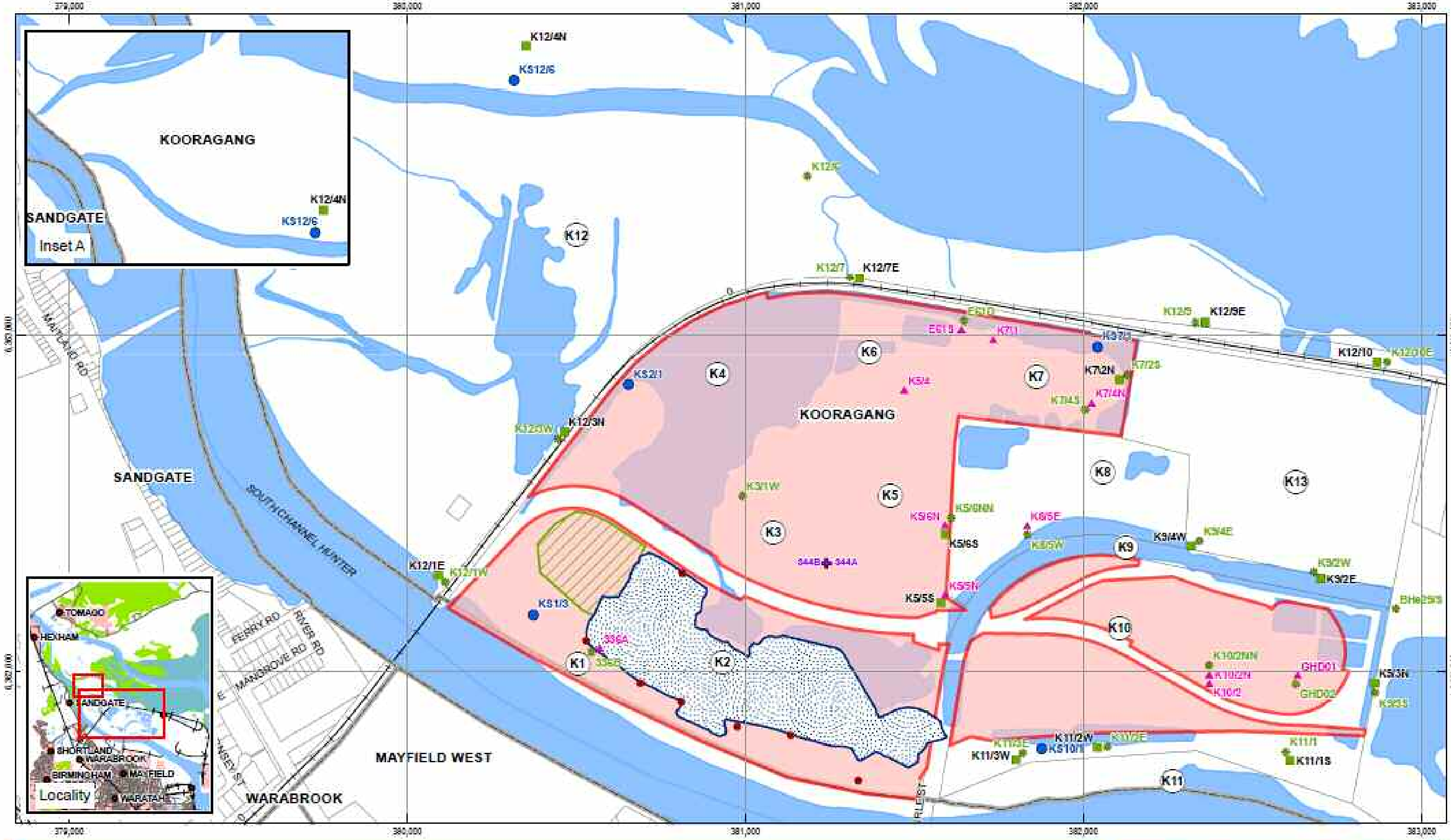


1:15,000 (at A4)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- KIWEF Licence Area
- BHPB KIEC Staging Area
- BHPB KIEC
- Cadastre
- Watercourse
- Watercourse Area
- Not Monitored
- KIEC Monitored
- Fill Acquifer
- Shallow Estuarine Acquifer
- Deep Estuarine Acquifer
- Surface Water

CLIENTS | PEOPLE | PERFORMANCE

Hunter Development Corporation
Kooragang Island Ground Water
and Surface Water Monitoring

Job Number | 22-15196
Revision | A
Date | 28 SEP 2010

Rationalised Groundwater & Surface
Water Monitoring Pogram

Figure 2

G:\22\13628\GIS\Maps\Deliverables\2215196\2215196_002_Fig2_Rationalised_Program_2010528_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geosciences Australia: Topography - 2007; Department of Lands: Cadastre - 2007; HDC: Monitoring Data - 2010. Created by: tmorton, fmackay, TMorton, gmcdiarmid

Notice to Vary a Surrender Condition

HUNTER DEVELOPMENT CORPORATION

ABN 94 688 782 063

PO BOX 813

NEWCASTLE NSW 2300

Attention: Mr Bob Hawes

Notice Number	1510956
File Number	«LicenceTrimNo»
Date	02-May-2013

VARIATION OF SURRENDER CONDITION

BACKGROUND

A. HUNTER DEVELOPMENT CORPORATION ("the licensee") is the holder of Environment Protection Licence No. 6437 ("the licence") issued under the *Protection of the Environment Operations Act 1997* ("the Act"). The licence authorised the carrying out of activities at «LocationAddress» ("the premises").

B. The licence was surrendered on **8 December 2010** by Surrender Notice number 1111840, subject to various conditions.

C. The conditions are being varied because the licensee has advised that it cannot complete the capping works required by the completion date of **28 March 2013**.

D. In a letter dated 4 February 2013, the licensee advised that it has been unable to meet the completion date referred to in paragraph B due to delays in the application to the Australian Government's Dept of Sustainability, Environment, Water, Populations and Communities relating to impacts on the threatened species, *Litorea aurea* (the Green and Golden Bell Frog).

E. The licensee has also advised would be in breach of Australian Government legislation if capping works were to commence at the premises without a determination from the Australian Government's Dept of Sustainability, Environment, Water, Populations and Communities.

VARIATION OF SURRENDER CONDITION

Notice to Vary a Surrender Condition

1. By this notice the EPA varies the condition/s of the Approval of the Surrender of licence «LinkedLicenceNo» in the following ways:

 - **Amends Condition 3** to read:

   3(a) This surrender notice applies to the following land on Kooragang Island as defined by Lot and DP numbers:

   Part Lot 7, Lot 10 and Lot 11 and Part Lot 14 of DP1119752,

   and shown on the map titled '*Plan of Subdivision of Lot 122 DP874949, Lot 2 DP581473, Lot 6 DP1015754 and Lots 71 and 74 in DP1119950'* date of survey 2 November 2007, Surveyors Reference HW43.01.03.00 and registered on 29 November 2007, attached to Surrender Notice #1111840.

   Note: Part Lot 14 DP1119752 refers to that area identified as Lot 14 DP1119752 excluding land labelled as '*Extra Land Area 2', Extra Land Area 4'* and '*Extra Land Area 5'* shown on map titled '*Plan of Extra Land Showing Coordinates Kooragang'*, dated 08/06/10, attached to Surrender Notice #1111840.

   3(b) The land defined in Condition 3(a) is divided into three Areas being:

   Area 1: Polygon ID3 and Polygon ID4 - Closure Works by HDC (K2 and K10 North);

   Area 2: Polygon ID1 and Polygon ID2 - Closure Works by PWCS (North of Rail Line);

   Area 3: Polygon ID 5 - Closure Works by PWCS (with Part Funding of State) (K10 South);

   as defined by the coordinates attached to the maps titled '*Former Kooragang Island Waste Emplacement Facility Plan of Works - Western Section* ' and '*Former Kooragang Island Waste Emplacement Facility Plan of Works - Eastern Section*' both submitted to the EPA on 15 April 2013 and attached to this Variation of Surrender Condition Notice (#1510956) .

 - **Amends Condition 4(a)** to read:

   By **30 June 2017,** the licensee shall complete implementation of the final landform and capping strategy as detailed in the documents titled:

   Hunter Development Corporation - Report on KIWEF - Revised Final Landform and Capping Strategy - August 2009 - Revision 2, prepared by GHD, ("the Landform and Capping Strategy");

   '*Green and Golden Bell Frog Management Plan – Kooragang Island Waste Emplacement Facility Closure Works*' dated 19 April 2011 and prepared by Golder Associates;

   K26/32 and K24/31 Ponds Action Plan– Kooragang Island Waste Emplacement Facility' dated 31 May 2011 and prepared by Golder Associates and

   '*Materials Management Plan - Kooragang Island Waste Emplacement Facility*' dated November 2012 prepared by RCA Australia.

 - **Removes Condition 4(b)** as the existing bentonite based geosynthetic clay liner installed over Pond 5 is consistent with the performance objectives of the agreed capping strategy as specified in the Landform and Capping Strategy referred to in Condition 4(a).

 - **Replaces Condition 4(b)** with the following new condition.

Notice to Vary a Surrender Condition

4(b) The capping and closure works as defined in Condition 4(a) are to be carried out in a staged manner in accordance with the following timeframes:

Area 1: - Capping and Closure works to be completed by **31 December 2014**

Area 2: - Capping and Closure works to be completed by **30 June 2017**

Area 3: - Capping and Closure works to be completed by **30 June 2017**

- **Removes Conditions 4(c)** as the Materials Management Plan has been updated in accordance with Condition 4(c). The updated Materials Management Plan is now referred to in Condition 4(a).
- **Replaces Condition 4(c)** with the following new condition.

4(c) Capping and Closure works, as defined in Condition 4(a), in Areas 2 and 3 may occur in synergy with the construction of the proposed Terminal 4 ('T4') project. If, by 28 February 2014, the T4 project does not obtain development consent necessary to commence construction of the T4 project, the licensee is required by this notice to complete Capping and Closure works in Areas 2 and 3, as defined in Condition 4(a).

- **Replaces Condition 4(k)** with the following new condition.

4(k) The licensee shall provide the EPA with a written statement of the results of the inspection required by condition 4(j) on an annual basis. The statement must describe the condition of the cap and any actions taken to remediate the cap as a result of the inspection. The first statement must be provided to the EPA by **30 June 2015 for Area 1** and **31 December 2017 for Areas 2 and 3**, with subsequent reports provided 12 monthly following the provision of the first report.

- **Removes Condition 5(a) and 5(b)** as these reports have been submitted to, and reviewed by the EPA. The reports required by these conditions are now referred to in Condition 4(a).
- **Conditions 5(a) and 5(b)** are to read '**Not Applicable**'.
- Adds the following new condition at **Condition 5(f)**.

Condition 5(f) If any samples collected at the monitoring locations identified in Conditions 5(c) and 5(d) show an increase in pollutant concentration at the boundary of the lands to which this notice applies, Hunter Development Corporation must commence capping works within 2 months of receiving the data. Capping works are to commence, regardless of the progress of the T4 project, unless otherwise agreed in writing by the EPA.

- Apart from amendments as detailed in this Variation Notice, all other conditions are to remain as drafted on Surrender Notice #1111840 issued on 08 December 2010.

....

Rebecca Scrivener

Acting Unit Head

North - Hunter

Notice to Vary a Surrender Condition

(by Delegation)

INFORMATION ABOUT THIS NOTICE

- This notice is issued under section 81(3) of the Act.

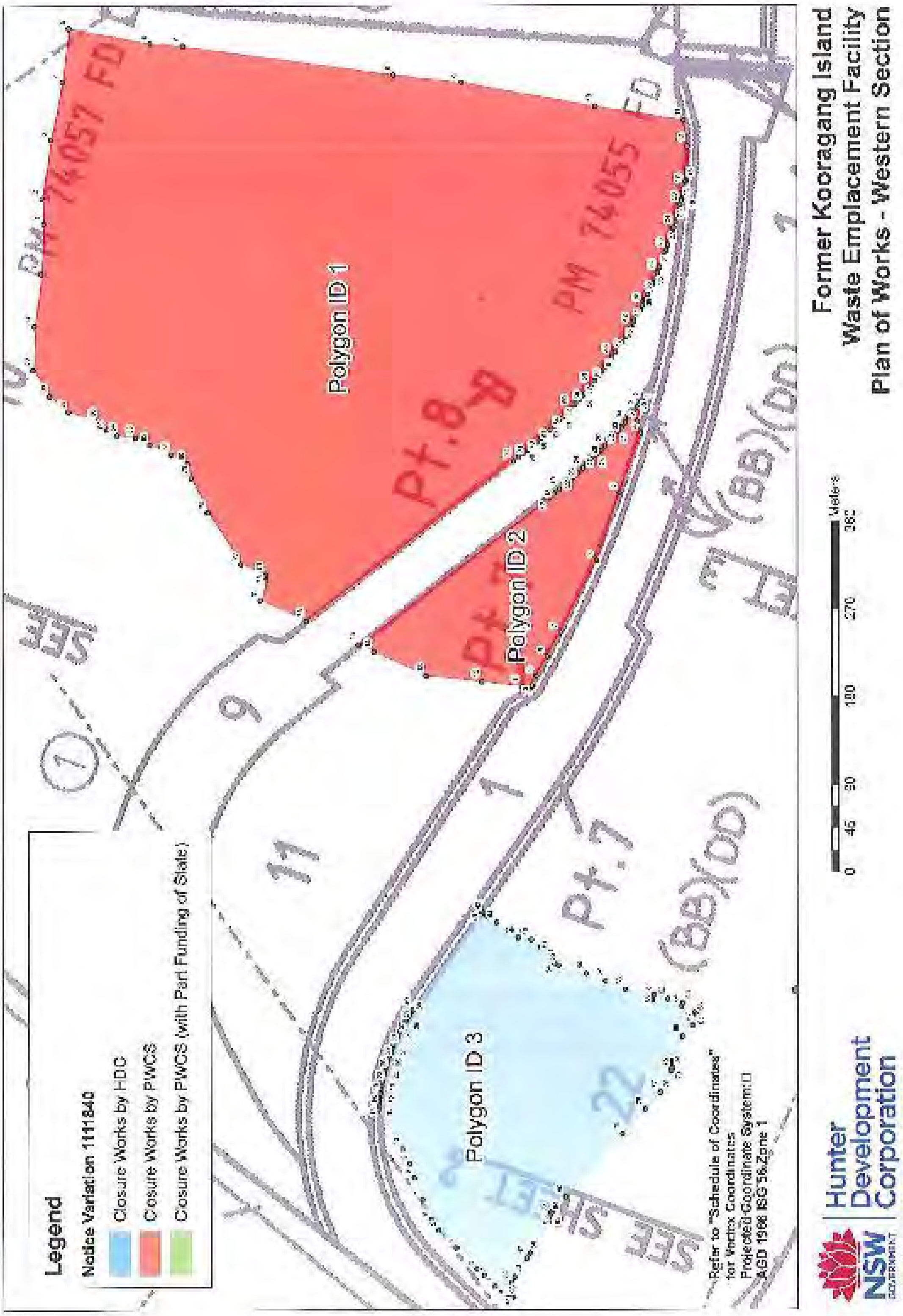
Appeals against this decision

- You can appeal to the Land and Environment Court against this decision. The deadline for lodging the appeal is 21 days after you were given notice of this decision.

When this notice begins to operate

- The variations to the Approval of the Surrender of licence specified in this notice begin to operate immediately from the date of this notice, unless another date is specified in this notice.
- If an appeal is made against this decision to vary a condition of Approval of Surrender of licence and the Land and Environment Court directs that the decision is stayed the decision does not operate until the stay ceases to have effect or the Land and Environment Court confirms the decision or the appeal is withdrawn (whichever occurs first).

Notice to Vary a Surrender Condition



Notice to Vary a Surrender Condition

Notice to Vary a Surrender Condition

Schedule of Coordinates | Polygon ID 1 | Ref NWEL Plan of Works

Reference No	X Coordinate	Y Coordinate
0	368383.145	1361891.163
1	368431.849	1361888.269
2	368461.322	1361890.336
3	368521.712	1361881.236
4	368581.276	1361869.241
5	368635.288	1361862.623
6	368620.156	1361777.828
7	368617.675	1361743.910
8	368587.893	1361525.926
9	368580.034	1361456.609
10	368555.216	1361317.042
11	368540.325	1361224.388
12	368513.853	1361220.252
13	368489.277	1361220.252
14	368483.815	1361221.215
15	368477.733	1361222.367
16	368471.667	1361223.598
17	368465.616	1361224.907
18	368459.584	1361226.295
19	368457.833	1361226.721
20	368453.569	1361227.760
21	368447.574	1361229.303
22	368441.600	1361230.923
23	368435.647	1361232.620
24	368429.716	1361234.394
25	368423.809	1361236.245
26	368417.926	1361238.172
27	368412.069	1361240.174
28	368406.238	1361242.252
29	368400.434	1361244.406
30	368394.658	1361246.634
31	368388.912	1361248.936
32	368383.196	1361251.313
33	368377.512	1361253.763
34	368371.859	1361256.287
35	368366.240	1361258.883
36	368360.654	1361261.552
37	368355.104	1361264.293
38	368349.589	1361267.105
39	368344.111	1361269.988
40	368338.671	1361272.942
41	368333.270	1361275.966
42	368327.908	1361279.059
43	368322.586	1361282.222
44	368317.306	1361285.453
45	368312.068	1361288.752
46	368306.873	1361292.118
47	368301.722	1361295.551
48	368296.616	1361299.051
49	368291.556	1361302.616
50	368286.542	1361306.246
51	368281.575	1361309.941
52	368276.656	1361313.700
53	368271.787	1361317.522
54	368266.967	1361321.406

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Notice to Vary a Surrender Condition

Schedule of Coordinates

Polygon ID 1

Ref KIWL1 Plan of Works

Reference No	X Coordinate	Y Coordinate
55	368262.198	1361325.353
56	368257.480	1361329.360
57	368252.815	1361333.429
58	368248.202	1361337.557
59	368243.643	1361341.745
60	368239.139	1361345.991
61	368234.690	1361350.295
62	368230.296	1361354.656
63	368225.960	1361359.074
64	368221.681	1361363.547
65	368217.460	1361368.075
66	368213.298	1361372.658
67	368209.196	1361377.293
68	368205.154	1361381.982
69	368201.173	1361386.722
70	368197.253	1361391.513
71	368193.396	1361396.355
72	368189.601	1361401.246
73	368025.503	1361615.613
74	368043.663	1361662.838
75	368066.717	1361657.048
76	368072.921	1361657.461
77	368083.676	1361682.698
78	368137.034	1361717.438
79	368172.607	1361734.810
80	368187.084	1361738.533
81	368196.597	1361755.492
82	368206.525	1361777.414
83	368213.970	1361792.719
84	368218.452	1361812.987
85	368222.656	1361820.026
86	368231.756	1361831.600
87	368240.856	1361852.693
88	368256.988	1361882.063
89	368284.287	1361899.022
90	368329.371	1361897.781

Notice to Vary a Surrender Condition

Schedule of Coordinates   Polygon ID 2   Ref KIWEF Plan of Works

Reference No	X Coordinate	Y Coordinate
0	368244.519	1361272.818
1	368249.694	1361268.855
2	368251.260	1361267.686
3	368230.515	1361272.370
4	368218.106	1361268.647
5	368165.609	1361291.397
6	368087.399	1361316.388
7	368013.358	1361353.028
8	367988.954	1361366.678
9	367969.100	1361378.260
10	367959.173	1361382.396
11	367957.932	1361392.737
12	367963.309	1361434.100
13	367969.100	1361491.595
14	367993.918	1361545.781
15	368001.181	1361581.838
16	368148.311	1361369.638
17	368152.304	1361364.497
18	368158.361	1361359.885
19	368160.179	1361354.384
20	368164.660	1361349.383
21	368168.901	1361344.385
22	368173.203	1361339.488
23	368177.584	1361334.645
24	368181.985	1361329.856
25	368186.464	1361325.121
26	368191.001	1361320.442
27	368195.595	1361315.819
28	368200.246	1361311.252
29	368204.952	1361306.743
30	368209.713	1361302.292
31	368214.528	1361297.900
32	368219.397	1361293.567
33	368224.319	1361289.295
34	368229.293	1361285.083
35	368234.318	1361280.932
36	368239.394	1361276.844

Notice to Vary a Surrender Condition

Schedule of Coordinates | Polygon ID 3 | Ref KIWEF Plan of Works

Reference No	X Coordinate	Y Coordinate
0	367327.507	1361409.027
1	367339.393	1361420.906
2	367351.097	1361432.131
3	367357.821	1361439.778
4	367379.838	1361460.555
5	367397.839	1361478.576
6	367408.840	1361486.404
7	367429.670	1361495.504
8	367452.378	1361504.061
9	367466.699	1361509.611
10	367481.568	1361516.379
11	367521.137	1361541.103
12	367523.673	1361540.974
13	367527.653	1361540.691
14	367531.626	1361540.329
15	367535.592	1361539.868
16	367539.546	1361539.368
17	367543.492	1361538.768
18	367547.424	1361538.090
19	367551.342	1361537.333
20	367555.243	1361536.498
21	367559.128	1361535.585
22	367562.993	1361534.595
23	367566.837	1361533.526
24	367570.660	1361532.364
25	367574.458	1361531.163
26	367578.232	1361529.867
27	367581.979	1361528.496
28	367585.698	1361527.050
29	367589.387	1361525.530
30	367593.045	1361523.937
31	367596.670	1361522.271
32	367600.261	1361520.532
33	367603.817	1361518.722
34	367607.336	1361516.842
35	367610.817	1361514.891
36	367614.250	1361512.871
37	367617.657	1361510.783
38	367621.015	1361508.627
39	367624.330	1361506.404
40	367625.819	1361505.373
41	367726.725	1361434.662
42	367724.528	1361431.918
43	367721.379	1361427.443
44	367715.818	1361418.899
45	367707.627	1361407.507
46	367700.081	1361396.781
47	367706.887	1361391.972
48	367705.176	1361389.711
49	367697.638	1361383.073
50	367689.998	1361373.173
51	367684.475	1361362.935
52	367681.775	1361362.373
53	367676.600	1361361.698
54	367673.562	1361359.223

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Notice to Vary a Surrender Condition

Schedule of Coordinates | Polygon ID 3 | Ref KIWEF Plan of Works

Reference No	X Coordinate	Y Coordinate
55	367671.200	1361355.285
56	367662.734	1361326.129
57	367655.083	1361306.216
58	367646.463	1361285.412
59	367637.090	1361263.243
60	367635.553	1361256.611
61	367640.708	1361254.968
62	367636.533	1361240.941
63	367631.884	1361225.386
64	367628.558	1361226.444
65	367622.708	1361212.381
66	367619.783	1361211.593
67	367609.208	1361215.081
68	367597.620	1361225.881
69	367571.712	1361237.406
70	367569.806	1361236.598
71	367568.430	1361236.240
72	367567.438	1361236.124
73	367565.939	1361236.136
74	367564.948	1361236.269
75	367562.230	1361237.193
76	367540.298	1361246.378
77	367539.434	1361245.870
78	367522.545	1361261.482
79	367498.844	1361288.241
80	367432.224	1361347.976
81	367418.813	1361360.559
82	367416.797	1361362.224
83	367416.002	1361362.829
84	367415.150	1361363.352
85	367412.484	1361364.729
86	367374.257	1361384.419
87	367369.094	1361388.109
88	367348.471	1361400.724
89	367343.935	1361403.458
90	367338.623	1361403.377
91	367333.047	1361402.045
92	367329.641	1361401.775
93	367328.283	1361404.180

Notice to Vary a Surrender Condition

Schedule of Coordinates

Polygon ID 4

Ref KIWEF Plan of Works

Reference No	X Coordinate	Y Coordinate
0	369074.35[illegible]	1361178.135
1	369050.409	1361179.246
2	369030.262	1361184.721
3	369019.933	1361189.562
4	369001.445	1361193.734
5	368982.822	1361197.262
6	368964.086	1361200.131
7	368945.260	1361204.388
8	369012.847	1361242.483
9	369164.511	1361301.132
10	369206.242	1361291.838
11	369212.937	1361227.497
12	369264.644	1361186.345
13	369319.262	1361164.939
14	369356.162	1361263.823
15	369370.328	1361261.352
16	369381.488	1361259.463
17	369398.417	1361259.905
18	369408.213	1361266.540
19	369471.210	1361248.567
20	369474.518	1361249.461
21	369568.818	1361225.158
22	369577.583	1361218.312
23	369563.731	1361132.119
24	369558.063	1361027.895
25	369624.600	1361026.312
26	369657.394	1361025.778
27	369681.950	1361025.379
28	369693.478	1361016.761
29	369695.929	1361012.791
30	369694.792	1361008.487
31	369696.877	1361005.744
32	369697.486	1361003.654
33	369695.762	1360998.650
34	369695.670	1360993.580
35	369698.473	1360983.923
36	369699.252	1360972.000
37	369700.828	1360965.293
38	369701.517	1360956.501
39	369700.383	1360946.504
40	369701.652	1360938.266
41	369701.027	1360933.365
42	369697.719	1360930.878
43	369695.919	1360930.139
44	369690.835	1360925.858
45	369687.096	1360924.408
46	369685.983	1360923.700
47	369680.046	1360919.080
48	369676.665	1360912.986
49	369677.606	1360908.978
50	369676.647	1360908.698
51	369672.947	1360907.704
52	369669.227	1360906.796
53	369665.489	1360905.946
54	369661.734	1360905.184

Notice to Vary a Surrender Condition

Schedule of Coordinates

Polygon ID 4

Ref XIWEF Plan of Works

Reference No	X Coordinate	Y Coordinate
55	369657.964	1360904.601
56	369654.161	1360903.898
57	369650.365	1360903.370
58	369646.580	1360902.923
59	369642.767	1360902.556
60	369638.943	1360902.267
61	369635.120	1360902.059
62	369631.291	1360901.930
63	369627.460	1360901.881
64	369623.629	1360901.912
65	369619.799	1360902.023
66	369615.972	1360902.213
67	369612.150	1360902.483
68	369608.336	1360902.833
69	369602.798	1360903.478
70	369596.016	1360904.374
71	369589.253	1360905.348
72	369582.503	1360906.402
73	369575.765	1360907.534
74	369569.041	1360908.745
75	369562.332	1360910.036
76	369555.630	1360911.403
77	369548.980	1360912.850
78	369542.300	1360914.374
79	369535.659	1360915.976
80	369529.038	1360917.656
81	369522.434	1360919.414
82	369515.852	1360921.248
83	369509.293	1360923.159
84	369502.756	1360925.147
85	369496.243	1360927.211
86	369489.755	1360929.351
87	369483.292	1360931.567
88	369476.855	1360933.858
89	369470.446	1360936.225
90	369464.065	1360938.668
91	369457.713	1360941.182
92	369451.390	1360943.772
93	369445.099	1360946.436
94	369438.839	1360949.173
95	369432.611	1360951.984
96	369426.417	1360954.866
97	369420.257	1360957.822
98	369414.132	1360960.849
99	369408.042	1360963.947
100	369401.990	1360967.117
101	369395.975	1360970.357
102	369389.998	1360973.667
103	369384.060	1360977.047
104	369378.161	1360980.497
105	369316.049	1361017.329
106	369317.910	1361020.560
107	369233.364	1361070.649
108	369186.267	1361140.362

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Notice to Vary a Surrender Condition

Schedule of Coordinates

Polygon ID 5

Ref XWH- Plan of Works

Reference No	X Coordinate	Y Coordinate
0	369453.430	1360879.085
1	369451.455	1360878.685
2	369393.221	1360881.087
3	369348.485	1360881.716
4	369291.598	1360885.917
5	369236.684	1360890.045
6	369185.216	1360893.772
7	369167.672	1360893.040
8	369086.888	1360888.672
9	369039.789	1360886.243
10	368979.195	1360881.832
11	368869.064	1360880.063
12	368766.705	1360876.490
13	368726.582	1360877.775
14	368691.027	1360879.555
15	368680.379	1360880.556
16	368675.736	1360881.365
17	368671.276	1360882.890
18	368667.111	1360885.096
19	368663.342	1360887.927
20	368660.063	1360891.312
21	368657.355	1360895.170
22	368655.285	1360899.404
23	368653.903	1360903.910
24	368657.750	1360972.563
25	368659.746	1361008.176
26	368660.020	1361011.653
27	368660.672	1361017.212
28	368661.370	1361023.166
29	368662.799	1361030.864
30	368664.477	1361037.850
31	368666.546	1361044.864
32	368669.363	1361052.857
33	368673.913	1361063.669
34	368678.651	1361074.242
35	368690.506	1361100.694
36	368692.927	1361105.412
37	368695.416	1361109.271
38	368697.761	1361112.296
39	368701.689	1361116.404
40	368705.714	1361119.915
41	368709.054	1361122.292
42	368712.406	1361124.272
43	368715.316	1361125.705
44	368718.818	1361127.069
45	368721.183	1361127.861
46	368725.114	1361129.016
47	368726.015	1361129.368
48	368726.981	1361132.896
49	368884.169	1361127.697
50	368907.320	1361126.830
51	368925.452	1361125.970
52	368937.512	1361124.930
53	368949.541	1361123.672
54	368961.530	1361121.896

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Variation to Notice N1111840

Notice to Vary a Surrender Condition

Schedule of Coordinates   Polygon ID 5   Ref KIWEF Plan of Works

Reference No	X Coordinate	Y Coordinate
55	368967.506	1361120.840
56	368979.418	1361119.789
57	368991.271	1361116.327
58	369008.916	1361112.046
59	369029.404	1361106.178
60	369043.629	1361101.405
61	369062.000	1361094.521
62	369118.003	1361066.924
63	369346.408	1360930.546
64	369361.615	1360921.598
65	369379.150	1360911.996
66	369388.046	1360907.419
67	369397.008	1360902.978
68	369415.146	1360894.553
69	369432.740	1360887.149

Notice to Vary a Surrender Condition

Notice to Vary a Surrender Condition

HUNTER DEVELOPMENT CORPORATION

ABN 94 688 782 063

PO BOX 813

NEWCASTLE NSW 2300

Attention: Mr Mike Bardsley

Notice Number	1520063
File Number	DOC14/53448 -01
Date	17-Apr-2014

VARIATION OF SURRENDER CONDITION

BACKGROUND

A. HUNTER DEVELOPMENT CORPORATION ("the licensee") is the holder of Environment Protection Licence No. 6437 ("the licence") issued under the *Protection of the Environment Operations Act 1997* ("the Act"). The licence authorised the carrying out of activities at CORMORANT DRIVE, KOORAGANG, NSW, 2304.

B. The licence was surrendered on 8 December 2010 by Surrender Notice number 1111840, subject to various conditions. The surrender notice was varied under Variation of Surrender Condition - Notice # 1510956 on 2 May 2013.

C. The licensee has requested an extension to the date provided in Condition 4(c) which acknowledges that Capping and Closure works, as defined in Condition 4(a), in Areas 2 and 3 may occur in synergy with the construction of the proposed T4 coal terminal project.

D. This notice removes this trigger date.

E. The date for the completion of capping and closure works in Areas 2 and 3 remains unchanged and the EPA expects that works will be commenced within a suitable timeframe to ensure that they are completed by the existing due date of 30 June 2017 .

Notice to Vary a Surrender Condition

VARIATION OF SURRENDER CONDITION

1. By this notice the EPA varies the condition/s of the Approval of the Surrender of Licence 6437 (Surrender Notice #1111840) in the following ways:

   - Condition 4(c) varied to read:

     Capping and Closure works, as defined in Condition 4(a), in Areas 2 and 3 may occur in synergy with the construction of the proposed terminal 4 ('T4') project.

....

Rebecca Scrivener

Acting Unit Head

North - Hunter

(by Delegation)

INFORMATION ABOUT THIS NOTICE

- This notice is issued under section 81(3) of the Act.

<u>Appeals against this decision</u>

- You can appeal to the Land and Environment Court against this decision. The deadline for lodging the appeal is 21 days after you were given notice of this decision.

<u>When this notice begins to operate</u>

- The variations to the Approval of the Surrender of licence specified in this notice begin to operate immediately from the date of this notice, unless another date is specified in this notice.
- If an appeal is made against this decision to vary a condition of Approval of Surrender of licence and the Land and Environment Court directs that the decision is stayed the decision does not operate until the stay ceases to have effect or the Land and Environment Court confirms the decision or the appeal is withdrawn (whichever occurs first).

APPENDIX C
Quality Assurance /Quality Control Report

1 LABORATORY REPORTS

Primary results and QAQC results were reported in the Envirolab certificates of analysis 274162, 273750, 273167, 272960, 272599,273751 and 272373, and ALS reports ES2125985, ES2125281 and ES2123157. The data quality assessment detailed below refers to the data provided in these laboratory reports.

2 DATA QUALITY INDICATORS

Data Quality Indicators ("DQI") are typically developed to provide goals for the quality of data required to sufficiently meet the site-specific objectives of environmental site assessments and validation assessments. Precision, sensitivity, accuracy, representativeness, comparability and completeness (PSARCC parameters) are all indicators of data quality. The DQIs used to assess the PSARCC parameters for this assessment are detailed in Table A. The DQIs in Table A are in accordance with the ASC NEPM and are adopted by NSW EPA (2006).

Table A: Data Quality Indicators

Data Quality Indicator	Data Quality Indicator Limits	Non-Conformance Action
Precision		
Field Duplicate RPDs (inter-laboratory and intra-laboratory).	Hazmat has developed the following DQIs for field duplicates: • Less than 10 times LOR: no limit • Greater than 10 times LOR: <50% RPD Collected at a frequency of 5% for intra-lab and 5% for inter-lab duplicates.	Assess sample matrix. Request lab confirmation and if necessary re-analysis.
Laboratory Duplicate RPDs	Laboratory specified limits (expected to be similar to field duplicate DQIs).	Request lab confirmation
Method Blanks	Not detected above LOR.	Request lab confirmation
Sensitivity		
Practical Quantitation Limit (PQL) or LOR	Typically, this is achieved when PQLs is at least 3 times lower than the adopted screening levels.	Request more sensitive analysis from lab.
Accuracy		
Laboratory Control Samples	The laboratory sets their own limits for organic and inorganic compounds which are generally between 70% and 130% recovery. Recovery limits for each analyte are specified in the laboratory reports in Appendix E.	Request Lab Confirmation
Single Control Spikes (organics)	Specified by the laboratory within the quality control report or the certificates of analysis.	Request Lab Confirmation
Matrix Spikes (MS)	DQI provided by laboratory and varies between laboratories and surrogates.	Request Lab Confirmation
MS Duplicates and Duplicate Control Spikes	DQI provided by laboratory and varies between laboratories and surrogates.	Request Lab Confirmation

Data Quality Indicator	Data Quality Indicator Limits	Non-Conformance Action
Surrogate Spikes	DQI provided by laboratory and varies between laboratories and surrogates.	Request Lab Confirmation
Representativeness		
Rinsates	Not detected above LOR	Reassess decontamination procedure during sample collection
	All fieldwork including decontamination procedures to be undertaken in accordance with industry best practice.	
	Samples analysed for the analytes requested on the COC.	Refer any non-conformances to lab request explanation
	Sample handling, storage and transport to be in accordance with ASC NEPM.	
	Samples to be extracted and analysed within appropriate holding times.	Refer any non-conformances to lab request explanation
	Samples to be transported under full chain of custody documentation. The laboratory to return a copy of the signed CoC acknowledging the receipt data and time and identity of samples included in the shipment.	
	Include laboratory certificates of analysis which detail any standard and non-standard methods used.	
Completeness		
	100% of results requested for analysis to be reported by analytical laboratory.	Request confirmation
	Total representative data set to be >95% complete after data validation procedures.	
Comparability		
	Samples to be collected by experienced professional staff.	
	Where possible, analysis to be undertaken at NATA accredited laboratories utilising NATA accredited methods.	
	Detailed sample logs to be completed for each sample location noting any observed variations between conditions and signs of potential contamination.	
	Transported under the same conditions and analysed by one laboratory using consistent methods for each analysis suite.	

Data Quality Indicator	Data Quality Indicator Limits	Non-Conformance Action
	Primary samples to be stored and handled.	
	DQIs to indicate acceptable Precision and Accuracy.	

3 PRECISION

The precision of a duplicate determination was measured as Relative Percentage Difference ("RPD"), calculated from the following equation:

$$RPD = \left[\frac{X1 - X2}{\left(\frac{X1 + X2}{2} \right)} \right] \times 100$$

where: X1 is the primary sample analyte value
X2 is the duplicate sample analyte value

3.1 Field Precision

Intra-laboratory field duplicates are taken and analysed as an indicator of the effect of the field sampling protocol on the precision of analytical results. These duplicates also provide an indication of the nature of the field samples in terms of their relative heterogeneity and media variance. Intra-laboratory duplicate samples are required to be collected at a rate of one per 20 samples (5%) in accordance with ASC NEPM and the Brief.

Inter-laboratory field duplicates are taken and analysed as an indicator of the precision between different laboratories, as well as field sampling protocol and the nature of the field sample heterogeneity. Inter-laboratory duplicate samples are also required to be collected at a rate of one per 20 samples (5%) in accordance with ASC NEPM and the Brief.

Three intra-laboratory duplicates and three inter-laboratory duplicates were submitted representing 52 primary samples. The frequency between intra-lab and inter-lab samples averages at 6.7% and 6.7% respectively which is within the DQI shown in Table A for intra-laboratory and inter-laboratory duplicates.

RPDs were only calculated were both the primary and the duplicate sample reported a result above LOR. The majority of calculated RPD were within stipulated limits. RPDs are shown in Table B below.

Table B: Summary of QA/QC Samples and RPDs

ANALYTES			Ammonia	Phenols	Free Cyanide	Weak Acid Disociable Cyanide	Total Cyanide	Cr VI - Dissolved	Mo - Dissolved	Pb - Dissolved	BTEX	TRH	Total PAHs	Naphthalene	Benzo(a)pyrene
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L			µg/L	µg/L	µg/L
LOR			0.01	1	0.004	0.004	0.004	0.01	0.001	0.001			0.5	0.2	0.5
Sample ID	Duplicate Type	Batch ID													
KS10/1		272373	0.008	<50	<0.004	<0.004	<0.004	<0.005	0.001	<0.001	-	-	<0.1	<0.2	<0.1
QC1		272373	0.043	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	-	-	<0.1	<0.2	<0.1
RPD A	Intra-lab		137%	-	-	-	-	-	-	-	-	-	-	-	-
KS10/1		272373	0.008	<50	<0.004	<0.004	<0.004	<0.005	0.001	<0.001	-	-	<0.1	<0.2	<0.1
QC1A		ES2123157	0.05	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	-	-	<0.5	<0.1	<0.5
RPD A	Inter-lab		145%	-	-	-	-	-	-	-	-	-	-	-	-
RCA2		273751	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	<0.1
QC2		273751	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	<0.1
RPD A	Intra-lab		-	-	-	-	-	-	-	-	-	-	-	-	-
RCA2		273751	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	<0.1
QC2A		ES2125281	-	-	-	-	-	-	-	-	-	-	<0.5	<0.1	<0.5
RPD A	Inter-lab		-	-	-	-	-	-	-	-	-	-	-	-	-
K12/7		274162	<0.005	<50	<0.004	<0.004	<0.004	<0.005	0.001	0.002	-	-	<0.1	<0.2	<0.1
QC3		274162	<0.005	<50	<0.004	<0.004	<0.004	<0.005	<0.001	0.002	-	-	<0.1	<0.2	<0.1
RPD A	Intra-lab		0%	-	-	-	-	-	-	-	-	-	-	-	-
K12/7		274162	1	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	-	-	<0.1	<0.2	<0.1
QC3A		ES2125985	0.12	<50	<0.004	<0.004	<0.004	<0.005	<0.010	<0.010	-	-	<0.5	<1	<0.5
RPD A	Inter-lab		157%	-	-	-	-	-	-	-	-	-	-	-	-

3.2 Laboratory Precision

Precision is a measure of the variation in results from a laboratory method. The laboratory measures the precision of the analyses performed on a particular batch of samples using laboratory duplicates. Acceptable RPDs for parameters are specified by the testing laboratory.

Each RPD was in accordance with the stipulated DQIs.

3.3 Sensitivity

The LOR is at least 3 times below the adopted investigation limit for all analytes with the exception of hexavalent chromium. Hexavalent chromium was reported at concentrations below the LOR and is therefore considered to be close to the adopted guideline values. Overall, the data is considered sufficiently sensitive for interpretative use.

4 ACCURACY

Accuracy is a measure of the closeness of the analytical result obtained by a method to the 'true' value. The laboratory measures accuracy using matrix spikes, laboratory control samples, control spikes, method blanks and surrogate spikes.

4.1 Matrix Spikes

Matrix spikes are prepared by spiking a field sample with a known concentration of a recommended spiking compound in order to ascertain the effects of the specific sample matrix on the recovery of analytes.

Accuracy as indicated by matrix spikes is measured in terms of percentage recovery as defined by the following equation:

– $$\%R = \frac{SSR - SR}{SA} X\,100$$

where: %R = percentage recovery of the spike
SSR = spiked sample result
SR = sample result (native)
SA = spike added

All matrix spike recoveries in all work orders were within stipulated limits.

4.2 Laboratory Control Spikes

Laboratory Control Spikes (“LCS”) are prepared by spiking a clean matrix (i.e. a matrix with the target analytes below the LOR), with known quantities of an organic or inorganic compound. Laboratory control samples are analysed at a rate of one per analytical batch for analytes.

Accuracy as indicated by laboratory control samples is measured in terms of percentage recovery as defined by the following equation:

%R = LCSR/LCSC

where:	%R	= percentage recovery of the laboratory control sample
	LCSR	= laboratory control sample result
	LCSC	= laboratory control sample concentration

The quality control analyte specific acceptance criterion is three times the standard deviation of the historical mean for each analyte. The range for each analyte is specified in the certificate of analysis.

No LCS outliers occurred.

4.3 Method Blanks

Method blanks monitor the externally introduced contaminants, which potentially derive from glassware, cleaning reagents and digestion reagents during the analysis process. The laboratory blank is treated as a sample in the laboratory, going through the same sample preparation and analysis procedures as corresponding samples.

All method blank results were reported below the LOR.

4.4 Surrogate Spikes

Both primary and QAQC samples analysed for organic parameters are spiked prior to extraction with surrogate compounds that are representative of the target analysis, but are not commonly found in samples taken from the natural environment.

Accuracy as indicated by surrogate spikes is measured in terms of percentage recovery as defined by the following equation:

%R = SSR/Sa x 100

where:	%R = percentage recovery of the spike
	SSR = spiked sample result
	SA = spike added

The DQIs used for the assessment are based on USEPA surrogate recovery limits. No surrogate spike outliers occurred.

5 REPRESENTATIVENESS

Representativeness expresses the degree to which sample data accurately and precisely represents a characteristic of a population, parameter variations at a sample point or an environmental condition. Representativeness is a qualitative parameter, which is most concerned with the proper design and implementation of the sampling program.

5.1 Rinsate Samples

A total of 14 rinsate samples were collected and analysed for the primary sample analysis. Results are reported below the LOR for the majority of analytes. Analytical results are provided in Table C and in the certificates of analysis in Appendix E.

Table C: Rinsate Blank Analytical Results

QC sample	Batch No	Date	Analysis Results
Rinsate 01	272373	21/06/2021	All below laboratory LOR
Rinsate 02	272599	23/06/2021	All below laboratory LOR
Rinsate 03	272599	23/06/2021	All below laboratory LOR
Rinsate 04	272960	24/06/2021	All below laboratory LOR
Rinsate 05	272960	25/06/2021	All below laboratory LOR
Rinsate 06	272960	28/06/2021	All below laboratory LOR
Rinsate 07	273167	30/06/2021	All below laboratory LOR
Rinsate 08	273167	01/07/2021	All below laboratory LOR
Rinsate 09	273750	06/07/2021	All below laboratory LOR
Rinsate 10	273750	07/07/2021	All below laboratory LOR
Rinsate 11	273750	08/07/2021	All below laboratory LOR
Rinsate 12	274162	09/07/2021	All below laboratory LOR
Rinsate 13	274162	13/07/2021	All below laboratory LOR
Rinsate 14	274162	14/07/2021	All below laboratory LOR

5.2 General Parameters

Other general parameters were employed to ensure representativeness, including:

- The sampling and analysis program was developed by experienced professionals based on adequate site history and a thorough understanding of the sampling objective.
- Samples were placed in clean, preserved/unpreserved laboratory supplied containers suitable for the target analytes. Samples were stored, transported and handled at a temperature of less than 4 °C and in accordance with NEPM 2013.
- Samples were transported under full chain of custody documentation including the sampler, nature of the sample, collection date, analyses to be performed, sample preservation method and departure time from the site. The laboratory returned a copy of the signed chain of custody acknowledging the receipt data and time and identity of samples included in the shipment. The chain of custody documentation is included in each of site contamination assessment reports.
- All fieldwork was undertaken in general accordance with Hazmat's standard operating procedures.

6 COMPARABILITY

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. Data comparability was maintained by undertaking the validation as follows:

- The samples were collected by Hazmat professional field personnel in general accordance with Hazmat's standard operation procedures;
- Primary samples were stored, handled and transported under the same conditions and analysed by the same laboratory using consistent methods; and
- DQIs indicated acceptable precision and accuracy.

7 COMPLETENESS

Completeness is defined as the percentage of measurements made which are judged to be valid measurements. The DQI for completeness is that valid data is generated for all critical samples and that, overall, the data is valid. This is considered to be the case for the data set presented in this assessment.

7.1 Laboratory Accreditation

Envirolab and ALS are NATA accredited for the requested analyses and conducted all the requested analyses in accordance with the guidelines outlined in NEPM (2013). Extraction and analysis methods and the LORs are provided in the certificates of analysis provided in Appendix E.

8 CONCLUSIONS

The majority of PSARCC parameters were within the specified DQIs and, overall, the data is considered to be of sufficient quality to meet the objectives of the investigation.

APPENDIX D
Results Table and Sample Log

Table A: Sample Log 2021

Ref	Sample ID	GPS Coordinates, Lat and Long	a. Depth to water (m from TOC)	b. Well Stickup (m)	Depth to Water (m BGS)	Depth of Well	RL to top of casing (mAHD)	Inferred Groundwater RL (mAHD)	Volume purged	pH	Conductivity (us/cm)	Dissolved Oxygen (mg/L)	Redox (mV)	Temperature (^{0}C)	VOC Concentration	Observations
1	**K5/4**	@-32.866196525,151.733088180556	4.6	0.76	4	5.6			2	6.41	9.9	4.35	11.7	21	0	Clear
2	**K8/5E**	@-32.8700999194444,151.736928847222	4.39	1.78	2.61	5.37	6.203	3.593	10	4.97	2424	-	14.1	19.4	0	Clear
3	**K10/2**	@-32.8739240083333,151.742615269444	7.26	0.89	6.37	9.93	9.949	3.579	5	7.56	793	3.82	-185.1	19.8	0	Grey,organic odour
4	**K10/2N**	@-32.8739010138889,151.742616533333	18.1	0.89	17.21	10.1			5	9.57	1184	2.71	-286.5	18.2	0	Grey, organic odour
5	**K5/5N**	@-32.871887975,151.734181980556	3.15	0.7	2.45	3.73			2	8.62	997	1.99	-154.1	19.6	0	Turbid, organic matter
6	**K5/6N**	@-32.86981455,151.734329236111	2.8	0.48	2.32	3.55	4.54	2.22	15	8.87	678	2.89	-2104	18.2	0	Cloudy, organic odour
7	**K7/4N**	@-32.866774825,151.738804752778	5	0.91	4.09	9.01			12	5.61	46.1	0.27	-141.1	22.8	0	Clear, slight odour
8	**K10/2NN**	@-32.8738900583333,151.742619713889	8.69	1.03	7.66	14.11	10.151	2.491	13	6.11	611	1.48	-283.3	20.1	0	Clear
9	**K7/2S**	@-32.8659912833333,151.739893777778	8.68	0.66	8.02	11.48	7.569	-0.451	15	5.89	236.2	0.28	-76.4	22	0	Black, grey
10	**K8/5W**	@-32.8701029638889,151.736928872222	5.01	1.7	3.31	8.05	6.251	2.941	10	5.2	2435	3.58	-118.3	20.1	0	Clear,slight odour
11	**K5/5S**	@-32.8719091722222,151.734169858333	3.88	0.87	3.01	9.5	5.09	2.08	12	6.2	3319	1.78	-113.5	20.1	0	Cloudy, grey, organic odour
12	**K5/6S**	@-32.8698296694444,151.73432795	3.27	0.79	2.48	9.75	4.73	2.25	10	7.11	3170	2.05	-131	20	0	Clear, slightly cloudy
13	**K5/6NN**	@-32.8698023361111,151.734331180556	3.15	0.54	2.61	5.5	4.39	1.78	10	6.88	3423	0.8	-194	20.2	0	Clear, organic odour
14	**K7/4S**	@-32.8667824805556,151.738801986111	6.04	0.78	5.26	13.75			10	5.98	820	0.08	-30.3	21.7	0	Grey, foamy
15	**K9/2E**	@-32.8711932138889,151.745977766667	1.82	0.23	1.59	11.8	2.85	1.26	20	5.69	325.9	1.47	-39.4	19.8	0	Clear, some sediment
16	**K9/2W**	@-32.8711919638889,151.745961819444	2.03	0.1	1.93	4.01	2.86	0.93	8	5.73	12.4	1.8	-29	17	0	Muddy, brown
17	**K9/4E**	@-32.8704616777778,151.742101736111	1.66	0.24	1.42	5.27	3.13	1.71	15	5.84	321.9	3.04	-52.5	17.4	0	Brown, muddy
18	**K9/4W**	@-32.870457775,151.742094986111	2.26	0.24	2.02	11.7	3.09	1.07	15	6	15066	3.13	-33.2	18.6	0	Slightly murky
19	**K11/3E**	@-32.8761161888889,151.736490888889	1.28	0.54	0.74	5.54	2.436	1.696	5	5.59	43	2.31	-101.1	18.5	0	Grey, no odour
20	**K11/3W**	@-32.876119975,151.736482647222	1.81	0.61	1.2	12.6	2.593	1.393	10	6.67	328.5	4.42	-96.1	19.8	0	Clear, slightly murky
21	**K12/4N**	@-32.8568868944444,151.721287152778	1.08	0.5	0.58	12.72	1.415	0.835	10	6.81	740	1.64	-20.1	17.3	0	Clear, slightly brown
22	**K12/6**	@-32.8604496388889,151.730110666667	**Well damaged during Ash Island Fire**													
23	**K11/1**	@-32.8762061194444,151.745137916667	1.97	0.66	1.31	3.98	2.938	1.628	10	5.4	16	2.43	-210.4	17.3	0	Brown, murky
24	**K11/1S**	@-32.8762269555556,151.745147841667	4.23	0.77	3.46	9.32	3.707	0.247	15	6.01	392.2	2.18	-208.2	19.4	0	Clear, organic odour
25	**K11/2E**	@-32.8757992194444,151.739075363889	1.42	0.72	0.7	5.49		-0.7	5	7.72	792	1.54	160	17.3	0	brown/orange, murky
26	**K11/2W**	@-32.8758008861111,151.739066211111	1.63	0.41	1.22	11.46		-1.22	30	7.69	7033	0.36	-313	18.3	0	murky, organic odour
27	**K9/3N**	@-32.8741753777778,151.747846636111	2.82	0	2.82	10.19	3.83	1.01	15	5.83	283.3	2.51	-163.8	20.6	0	Grey, odour
28	**K9/3S**	@-32.8741838277778,151.747842611111	2.78	0	2.78	3.41	4.09	1.31	1	6.09	163.3	2.4	-146.2	18.1	0	Grey, black
29	**K12/1W**	@-32.8710135361111,151.718306388889	0.99	0.34	0.65	3.69	1.8	1.15	5	7.3	6819	1.78	-54.4	17.6	0	Brown, murky, orange
30	**K12/1E**	@-32.8710068805556,151.718298030556	1.28	0.46	0.82	8.73	1.81	0.99	15	6.79	622	3.6	-45.7	19.4	0	Brown, murky
31	**K12/7**	@-32.863187625,151.731627994444	0.77	0.36	0.41	3.94	1.816	1.406	10	6.12	793	2.24	168.7	15.7	0	Clear
32	**K12/7E**	@-32.8631926916667,151.731713938889	1.24	0.31	0.93	12	1.76	0.83	14.5	6.74	47154	5.1	4.1	18.9	0	Clear, organic odour
33	**K12/9**	@-32.864467975,151.741461905556	1.13	0.8	0.33	5.37	1.939	1.609	10	6.41	779	1.83	43	17.9	0	Clear, yellowish
34	**K12/9E**	@-32.8644670416667,151.742649177778	**Well damaged**													Pale brown, cloudy, organic odour
35	**K12/10**	@-32.8656095555556,151.748294761111	0.97	0.7	0.27	19.2	2.134	1.864	15	5.91	47822	0.48	-29.3	18.3	0	Black, organic odour
36	**K12/10E**	@-32.8656093083333,151.748347552778	1.14	0.47	0.67	3.05	1.818	1.148	10	6.28	50143	1.47	-153	15.5	0	Brown, sediment odour
37	**E61D**	@-32.8645866583333,151.734909161111	5.77	0.5	5.27	23.58	6.338	1.068	15	6.95	48081	0.88	-171.3	21.1	0	Black, strong odour
38	**E61S**	@-32.8645983305556,151.734904794444	**Well dry**													
39	**336A**	@-32.8728012583333,151.722970138889	5.41	0.72	4.69	6.83	6.72	2.03	10	6.18	64.1	1.72	-17	19.9	0	Clear, slightly murky
40	**336B**	@-32.8727923027778,151.722959380556	6.85	0.72	6.13	12.45	6.71	0.58	10	6.11	64.6	1.85	-58.6	19.5	0	Grey
41	**KS1/3**	@-32.8716136194444,151.720904211111	Not Applicable - Surface Water Location							8.68	1368	1.32	-75.9	11.9	0	Muddy brown, turbid
42	**KS7/1**	@-32.8651573555556,151.739212786111	Not Applicable - Surface Water Location							8.03	2130	4.63	-4.4	10.8	0	Murky, sediments, fish
43	**KS12/6**	@-32.8575162972222,151.721228333333	Not Applicable - Surface Water Location							7.51	14335	0.21	-184.3	7.6	0	Blackish brown, strong organic odour
44	**KS10/1**	@-32.8759084805556,34.0080794222222	Not Applicable - Surface Water Location							7.48	1064	6.17	66	16.7	0	Cloudy, no odour
45	**K7/2N**	@-32.8659912138889,151.739894025	6.24	0.65	5.59	9.96	7.569	1.979	5	7.26	3320	1.27	-233.9	21.5	0	Brown, balck, strong odour
46	**K7/1**	@-32.8648820777778,151.73590725	4.7	0.57	4.13	6.68	6.376	2.246	8	5.81	1093	4.07	-100	20.5	0	Greyish brown, slight odour
47	**BHe29s**	@-32.8727340305556,151.748208691667	2.84	0.73	2.11	3.41	3.417	1.307	10	7.91	1137	1.29	-219.5	17.5	0	Murky brown/grey
48	**GHD01N**	@-32.8741675833333,151.745355408333	6.66	0.27	6.39	9.48	10.051	3.661	10	5.85	86	2.85	-117.3	21.3	0	Clear
49	**GHD01S**	@-32.8741774972222,151.745352797222	9.32	0.58	8.74	20.1	10.109	1.369	10	5.58	6400	2.47	-162.8	20	0	Clear
50	**KS2/1**	@-32.8658496111111,151.730459036111	Not Applicable - Surface Water Location							9.53	1369	-	-86.6	13.3	0	Clear, no odour
51	**NCIG/1**	@-32.8654273361111,151.724129322222	1.34	0.73	0.61	6.74	0	-0.61	10	6.77	230.3	-	-89.5	18.9	0	Clear, organic odour
52	**NCIG/2**	@-32.8653673,151.724219438889	1.66	0.88	0.78	12.99	0	-0.78	12.99	6.33	3314	2.6	-84	19.2	0	Grey, no odour
53	**BH21S**	@-32.8701522416667,151.726858402778	5.21	0.74	4.47	6.4			10	5.03	84	1.5	-198.5	21.6	0	Grey, organic odour
54	**344A**		5.78	0.76	5.02	8.03			15	5.26	83.9	2.3	-167.8	20.9	0	Grey, strong odour
55	**344B**		8.32	0.79	7.53	11.27			3	6.07	190	2.42	-167.8	18.7	0	Grey/black

Ground and Surface Water Monitoring, Kooragang Island Waste Emplacement Facility
Annual Monitoring 2021

Table B: Results Summary 2021

ANALYTES				pH	Conductivity	Ammonia	Phenols	Free Cyanide	Weak Acid Dissociable Cyanide	Total Cyanide	Cr VI - Dissolved	Mo - Dissolved*	Pb - Dissolved*	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)&(k)fluoranthene	Benzo(a)pyrene	Indeno(1.2.3-cd)pyrene	Dibenzo(ah)anthracene	Benzo(ghi)perylene	TotalPAH's
				pH units	µs/cm	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
LOR						0.01	1	0.004	0.004	0.004	0.01	0.001	0.001	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.5
ASC NEPM GIL for Marine Waters Criteria				-	-	0.91	400µg/L	-	-	0.004mg/L	0.0044mg/L	-	0.0044mg/L	50µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANZECC Criteria				-	-	0.91	400µg/L	-	-	0.004mg/L	0.0044mg/L	0.023 (L)	0.0044mg/L	70µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample ID	Type of Bore	Batch ID	Date																										
K12/1E	deep	273750	6/07/2021	6.79	622	1.3	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K12/7E	deep	273750	8/07/2021	6.74	47154	9.9	<50	<0.004	<0.004	<0.004	<0.005	0.003	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
NCIG/2	deep	273750	6/07/2021	6.33	3314	43	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K5/5S	deep	273273	22/06/2021	6.2	3319	0.71	-	<0.004	<0.004	<0.004	<0.005	-	-	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K5/6S	deep	272373	22/06/2021	7.11	3170	0.46	<50	<0.004	<0.004	<0.004	<0.005	-	-	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K7/2N	deep	274162	14/07/2021	7.26	3320	10	4800	<0.004	<0.004	0.063	<0.005	-	-	750	<0.1	12	2.1	0.3	0.2	0.2	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	760
K9/2E	deep	272599	24/06/2021	5.96	325.9	3.8	-	<0.004	<0.004	<0.004	<0.005	0.001	-	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K9/3N	deep	273167	30/06/2021	5.83	283.3	3.6	<50	<0.004	<0.004	<0.004	<0.005	<0.001	0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K11/1S	deep	273167	1/07/2021	6.01	392.2	4.7	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K11/3W	deep	273167	1/07/2021	6.67	328.5	5.8	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K12/4N	deep	273750	6/07/2021	6.81	740	61	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K11/2W	deep	272373	21/06/2021	7.69	7033	4.4	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	<0.2	0.3	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	0.86
K9/4W	deep	272599	23/06/2021	6	15066	1.6	-	<0.004	<0.004	<0.004	<0.005	-	-	<0.2	<0.1	0.8	0.8	1.3	0.2	0.2	0.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	3.4
K12/10	deep	273750	8/07/2021	5.91	47822	5.3	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K5/6N	fill	272373	22/06/2021	8.87	678	0.32	<50	<0.004	<0.004	<0.004	<0.005	-	-	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K7/1	fill	272599	23/06/2021	5.81	1093	6.4	<50	<0.004	<0.004	<0.004	<0.005	0.38	<0.001	17	<0.1	0.4	<0.1	0.2	<0.1	0.2	0.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	17
K10/2	fill	273750	7/07/2021	9.57	1184	0.016	-	-	-	-	<0.005	0.005	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K8/5E	fill	272599	23/06/2021	4.97	2424	1.5	<50	<0.004	<0.004	0.017	<0.005	0.055	0.002	2.4	<0.1	1.7	0.8	1.2	0.3	0.4	1.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	8
GHD01N	fill	273750	7/07/2021	5.85	85	0.22	<50	<0.004	<0.004	0.007	<0.005	0.13	0.034	0.3	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	0.64
344A	fill	272599	24/06/2021	5.26	83.9	0.62	<50	<0.004	<0.004	<0.004	<0.005	0.004	<0.001	<0.2	<0.1	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	0.17
K5/5N	fill	272373	22/06/2021	8.62	997	0.008	<50	<0.004	-	-	<0.005	-	-	<0.2	<0.1	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K10/2N	fill	273750	7/07/2021	9.57	1184	1.8	<50	<0.004	<0.004	0.021	<0.005	0.029	<0.001	<0.2	<0.1	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
336A	fill	272960	25/06/2021	6.18	64.1	1.4	<50	<0.004	<0.004	<0.004	<0.005	0.004	<0.001	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	0.27
K5/4	fill	274162	13/07/2021	6.41	9.9	0.021	-	<0.004	<0.004	<0.004	<0.005	-	-	<0.2	<0.1	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K7/4N	fill	274162	14/07/2021	5.61	46.1	9	<50	<0.004	<0.004	0.023	<0.005	0.015	<0.001	<0.2	<0.1	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K12/7	shallow	274162	9/07/2021	6.12	793	<0.005	<50	<0.004	<0.004	<0.004	<0.005	0.001	0.002	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K12/9	shallow	274162	9/07/2021	6.41	779	2.7	<50	<0.004	<0.004	0.005	<0.005	0.003	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
NCIG/1	shallow	273750	6/07/2021	6.77	230.3	0.95	<50	<0.004	<0.004	<0.004	<0.005	0.01	<0.001	0.2	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
336B	shallow	272960	25/06/2021	6.11	64.6	0.6	<50	<0.004	<0.004	<0.004	<0.005	0.002	<0.001	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	0.27
K5/6NN	shallow	272373	22/06/2021	6.88	3423	0.69	<50	<0.004	<0.004	<0.004	<0.005	-	-	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
BHe29S	shallow	273167	30/06/2021	7.91	1137	1.7	<50	<0.004	<0.004	<0.004	<0.005	0.005	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
E61D	shallow	272373	22/06/2021	6.95	48081	2.8	<50	<0.004	<0.004	<0.004	<0.005	<0.001	0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K8/5W	shallow	272599	23/06/2021	5.2	2435	2.9	<50	<0.004	<0.004	0.012	<0.005	0.025	<0.001	39	0.2	270	140	150	13	14	901	0.2	0.2	<0.2	<0.1	<0.1	<0.1	<0.1	640
K7/2S	shallow	274162	13/07/2021	5.89	236.2	6.1	<50	<0.004	<0.004	<0.004	<0.005	-	-	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	0.29
K9/2W	shallow	272599	24/06/2021	5.73	12.4	0.69	-	<0.004	<0.004	<0.004	<0.005	0.019	-	0.2	<0.1	0.4	0.2	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	0.85
K9/4E	shallow	272599	23/06/2021	5.84	321.9	2.8	-	<0.004	<0.004	<0.004	<0.005	-	-	<0.2	<0.1	0.5	0.4	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	1.3
K11/1	shallow	273167	1/07/2021	5.4	16	0.085	<50	<0.004	<0.004	<0.004	<0.005	0.003	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K9/3S	shallow	273167	30/06/2021	6.09	163.3	1.8	<50	<0.004	<0.004	<0.004	<0.01	0.023	<0.001	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	0.28
GHD01S	shallow	273750	7/07/2021	5.58	6400	3.5	<50	<0.004	<0.004	<0.004	<0.005	0.001	<0.001	7.7	1	0.3	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	9.2
K10/2NN	shallow	273750	7/07/2021	6.11	611	6.4	-	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	21	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	21
K11/2E	shallow	272373	21/06/2021	7.72	792	0.14	<50	<0.004	<0.004	<0.004	<0.005	0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K12/10E	shallow	273750	8/07/2021	6.28	50143	1.5	<50	<0.004	<0.004	<0.004	<0.005	<0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K12/1W	shallow	273750	6/07/2021	7.3	6819	0.007	<50	<0.004	<0.004	<0.004	<0.01	<0.001	0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
K11/3E	shallow	273167	1/07/2021	5.59	43	0.84	<50	<0.004	<0.004	<0.004	<0.005	0.002	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
344B	shallow	272599	24/06/2021	6.07	190	2.6	<50	<0.004	<0.004	<0.004	<0.005	0.003	0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
BH21S	shallow	272960	24/06/2021	5.03	84	7.6	<50	<0.004	<0.004	0.065	<0.005	0.49	<0.001	220	1.8	1.9	3	10	2.4	7.5	6	2.3	2	3.8	2.2	1.1	0.3	1.4	270
K7/4S	shallow	274162	14/07/2021	5.98	820	0.69	<50	<0.004	<0.004	<0.004	<0.005	<0.001	0.001	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	0.29
KS12/6	surface	273750	6/07/2021	7.51	14335	0.34	<50	<0.004	<0.004	<0.004	<0.050	<0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
KS1/3	surface	272960	28/06/2021	8.68	1368	0.18	<50	<0.004	<0.004	<0.004	<0.005	0.003	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
KS2/1	surface	272960	28/06/2021	13.3	1369	0.014	<50	<0.004	<0.004	<0.004	<0.005	0.016	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
KS7/1	surface	272960	28/06/2021	8.03	2130	<0.005	<50	<0.004	<0.004	<0.004	<0.005	0.034	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE
KS10/1	surface	272373	21/06/2021	7.48	1064	0.008	<50	<0.004	<0.004	<0.004	<0.005	0.001	<0.001	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE

Exceed KIWEF trigger values

APPENDIX E
Laboratory Report Sheets and Chain of Custody

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CERTIFICATE OF ANALYSIS 244613

Client Details	
Client	Hazmat Services
Attention	Damien Hendrickx
Address	PO Box 118, Carrington, NSW, 2294

Sample Details	
Your Reference	**Water samples**
Number of Samples	6 WATER
Date samples received	11/06/2020
Date completed instructions received	11/06/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details	
Date results requested by	18/06/2020
Date of Issue	18/06/2020

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Results Approved By

Diego Bigolin, Team Leader, Inorganics
Giovanni Agosti, Group Technical Manager
Josh Williams, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

PAHs in Water - Low Level						
Our Reference		244613-1	244613-2	244613-3	244613-4	244613-5
Your Reference	UNITS	KS1/3	336A	336B	KS10/1	K11/2E
Date Sampled		09/06/2020	09/06/2020	09/06/2020	09/06/2020	10/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	12/06/2020	12/06/2020	12/06/2020	12/06/2020	12/06/2020
Date analysed	-	15/06/2020	15/06/2020	15/06/2020	15/06/2020	15/06/2020
Naphthalene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	84	105	94	78	114

PAHs in Water - Low Level		
Our Reference		244613-6
Your Reference	UNITS	K11/2W
Date Sampled		10/06/2020
Type of sample		WATER
Date extracted	-	12/06/2020
Date analysed	-	15/06/2020
Naphthalene	µg/L	<0.2
Acenaphthylene	µg/L	<0.1
Acenaphthene	µg/L	<0.1
Fluorene	µg/L	<0.1
Phenanthrene	µg/L	<0.1
Anthracene	µg/L	<0.1
Fluoranthene	µg/L	<0.1
Pyrene	µg/L	<0.1
Benzo(a)anthracene	µg/L	<0.1
Chrysene	µg/L	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2
Benzo(a)pyrene	µg/L	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5
Total +ve PAH's	µg/L	<0.1
Surrogate p-Terphenyl-d14	%	108

Total Phenolics in Water						
Our Reference		244613-1	244613-2	244613-3	244613-4	244613-5
Your Reference	UNITS	KS1/3	336A	336B	KS10/1	K11/2E
Date Sampled		09/06/2020	09/06/2020	09/06/2020	09/06/2020	10/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	12/06/2020	12/06/2020	12/06/2020	12/06/2020	12/06/2020
Date analysed	-	12/06/2020	12/06/2020	12/06/2020	12/06/2020	12/06/2020
Total Phenolics (as Phenol)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05

Total Phenolics in Water		
Our Reference		244613-6
Your Reference	UNITS	K11/2W
Date Sampled		10/06/2020
Type of sample		WATER
Date extracted	-	12/06/2020
Date analysed	-	12/06/2020
Total Phenolics (as Phenol)	mg/L	<0.05

HM in water - dissolved						
Our Reference		244613-1	244613-2	244613-3	244613-4	244613-5
Your Reference	UNITS	KS1/3	336A	336B	KS10/1	K11/2E
Date Sampled		09/06/2020	09/06/2020	09/06/2020	09/06/2020	10/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	12/06/2020	12/06/2020	12/06/2020	12/06/2020	12/06/2020
Date analysed	-	12/06/2020	12/06/2020	12/06/2020	12/06/2020	12/06/2020
Lead-Dissolved	μg/L	<1	<1	<1	<1	<1
Molybdenum-Dissolved	μg/L	3	2	<1	12	3

HM in water - dissolved		
Our Reference		244613-6
Your Reference	UNITS	K11/2W
Date Sampled		10/06/2020
Type of sample		WATER
Date prepared	-	12/06/2020
Date analysed	-	12/06/2020
Lead-Dissolved	μg/L	<1
Molybdenum-Dissolved	μg/L	<1

Miscellaneous Inorganics						
Our Reference		244613-1	244613-2	244613-3	244613-4	244613-5
Your Reference	UNITS	KS1/3	336A	336B	KS10/1	K11/2E
Date Sampled		09/06/2020	09/06/2020	09/06/2020	09/06/2020	10/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	11/06/2020	11/06/2020	11/06/2020	11/06/2020	11/06/2020
Date analysed	-	11/06/2020	11/06/2020	11/06/2020	11/06/2020	11/06/2020
Ammonia as N in water	mg/L	0.066	1.4	0.64	<0.005	0.14
Total Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Free Cyanide in Water	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.050	<0.005	<0.005	<0.005	<0.01

Miscellaneous Inorganics		
Our Reference		244613-6
Your Reference	UNITS	K11/2W
Date Sampled		10/06/2020
Type of sample		WATER
Date prepared	-	11/06/2020
Date analysed	-	11/06/2020
Ammonia as N in water	mg/L	5.1
Total Cyanide	mg/L	<0.004
Free Cyanide in Water	mg/L	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005

Method ID	Methodology Summary
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjsuted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hyperchlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Metals-022	Determination of various metals by ICP-MS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.

Client Reference: Water samples

QUALITY CONTROL: PAHs in Water - Low Level						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			12/06/2020	2	12/06/2020	12/06/2020		12/06/2020	[NT]
Date analysed	-			15/06/2020	2	15/06/2020	15/06/2020		15/06/2020	[NT]
Naphthalene	µg/L	0.2	Org-022/025	<0.2	2	<0.2	<0.2	0	85	[NT]
Acenaphthylene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Acenaphthene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Fluorene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	78	[NT]
Phenanthrene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	79	[NT]
Anthracene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Fluoranthene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	74	[NT]
Pyrene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	91	[NT]
Benzo(a)anthracene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Chrysene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	110	[NT]
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025	<0.2	2	<0.2	<0.2	0	[NT]	[NT]
Benzo(a)pyrene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	71	[NT]
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	123	2	105	93	12	118	[NT]

QUALITY CONTROL: Total Phenolics in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	244613-2
Date extracted	-			12/06/2020	1	12/06/2020	12/06/2020		12/06/2020	12/06/2020
Date analysed	-			12/06/2020	1	12/06/2020	12/06/2020		12/06/2020	12/06/2020
Total Phenolics (as Phenol)	mg/L	0.05	Inorg-031	<0.05	1	<0.05	<0.05	0	100	97

Client Reference: Water samples

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W4	[NT]
Date prepared	-			12/06/2020	[NT]	[NT]	[NT]	[NT]	12/06/2020	[NT]
Date analysed	-			12/06/2020	[NT]	[NT]	[NT]	[NT]	12/06/2020	[NT]
Lead-Dissolved	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Molybdenum-Dissolved	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	92	[NT]

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	244613-2
Date prepared	-			11/06/2020	1	11/06/2020	11/06/2020		11/06/2020	11/06/2020
Date analysed	-			11/06/2020	1	11/06/2020	11/06/2020		11/06/2020	11/06/2020
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	0.066	0.067	2	92	107
Total Cyanide	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	101	[NT]
Free Cyanide in Water	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	93	[NT]
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	104	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	<0.005	1	<0.050	<0.050	0	108	97

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

ENVIROLAB GROUP

CHAIN OF CUSTODY - Client

ENVIROLAB GROUP - National phone number 1300 42 43 44

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Ph 02 9910 6200 / sydney@envirolab.com.au

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Client: Hazmat Services
Contact Person: Damien Hendrickx
Project Mgr: Damien Hendrickx
Sampler: TG/HR
Address: Level 1 45C Fitzroy Street Carrington NSW 2294
Phone: 02 49611887 **Mob:** 0431433791
Email: damien@hazmat-services.com.au

Client Project Name / Number / Site etc (ie report title):
PO No.: 4880
Envirolab Quote No. : 16SY078
Date results required:
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Report format: esdat / equis /
Lab Comments:

Sample information					Tests Required															Comments
Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Ammonia	Phenols	Free Cyanide/Total cyanide/dissolved cyanide	Hexavalent Chromium	Molybdenum	Lead	PAH	Free Cyanide/Dissolved Cyanide	BTEX							Provide as much information about the sample as you can
1	KS1/3		9/06/2020	Water	X	X	X	X	X	X	X									
2	336A		9/06/2020	Water	X	X	X	X	X	X	X									
3	336B		9/06/2020	Water	X	X	X	X	X	X	X									
4	KS10/1		9/06/2020	Water	X	X	X	X	X	X	X									
5	K11/2E		10/06/2020	Water	X	X	X	X	X	X	X									
6	K11/2W		10/06/2020	Water	X	X	X	X	X	X	X									

ENVIROLAB GROUP
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 244613
Date Received: 11-6-20
Time Received: [illegible]
Received by:
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Relinquished by (Company): Hazmat Services
Print Name: Damien Hendrickx
Date & Time: 10-6-20
Signature:

Received by (Company): ELS.
Print Name: C. WEIR
Date & Time: 11-6-20 11:10
Signature:

Lab use only:
Samples Received: Cool or Ambient (circle one)
Temperature Received at: 13.7. (if applicable)
Transported by: Hand delivered / courier

White - Lab copy / Blue - Client copy / Pink - Retain in Book Page No:

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 244740

Client Details

Client	Hazmat Services
Attention	Damien Hendrickx
Address	PO Box 118, Carrington, NSW, 2294

Sample Details

Your Reference	**4882**
Number of Samples	2 water
Date samples received	12/06/2020
Date completed instructions received	12/06/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	19/06/2020
Date of Issue	18/06/2020

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Results Approved By
Diego Bigolin, Team Leader, Inorganics
Josh Williams, Senior Chemist
Loren Bardwell, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

PAHs in Water			
Our Reference		244740-1	244740-2
Your Reference	UNITS	K12/1E	K12/1W
Date Sampled		11/06/2020	11/06/2020
Type of sample		water	water
Date extracted	-	15/06/2020	15/06/2020
Date analysed	-	16/06/2020	16/06/2020
Naphthalene	µg/L	<1	<1
Acenaphthylene	µg/L	<1	<1
Acenaphthene	µg/L	<1	<1
Fluorene	µg/L	<1	<1
Phenanthrene	µg/L	<1	<1
Anthracene	µg/L	<1	<1
Fluoranthene	µg/L	<1	<1
Pyrene	µg/L	<1	<1
Benzo(a)anthracene	µg/L	<1	<1
Chrysene	µg/L	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2
Benzo(a)pyrene	µg/L	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	122	113

Total Phenolics in Water			
Our Reference		244740-1	244740-2
Your Reference	UNITS	K12/1E	K12/1W
Date Sampled		11/06/2020	11/06/2020
Type of sample		water	water
Date extracted	-	15/06/2020	15/06/2020
Date analysed	-	15/06/2020	15/06/2020
Total Phenolics (as Phenol)	mg/L	<0.05	<0.05

Miscellaneous Inorganics			
Our Reference		244740-1	244740-2
Your Reference	UNITS	K12/1E	K12/1W
Date Sampled		11/06/2020	11/06/2020
Type of sample		water	water
Date prepared	-	12/06/2020	12/06/2020
Date analysed	-	12/06/2020	12/06/2020
Total Cyanide	mg/L	<0.004	<0.004
Free Cyanide in Water	mg/L	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005
Ammonia as N in water	mg/L	0.95	<0.005

HM in water - dissolved			
Our Reference		244740-1	244740-2
Your Reference	UNITS	K12/1E	K12/1W
Date Sampled		11/06/2020	11/06/2020
Type of sample		water	water
Date prepared	-	15/06/2020	15/06/2020
Date analysed	-	15/06/2020	15/06/2020
Molybdenum-Dissolved	µg/L	<2	5
Lead-Dissolved	µg/L	<2	<2

Method ID	Methodology Summary
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjsuted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hyperchlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Metals-022	Determination of various metals by ICP-MS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.

QUALITY CONTROL: PAHs in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			15/06/2020	[NT]	[NT]	[NT]	[NT]	15/06/2020	[NT]
Date analysed	-			16/06/2020	[NT]	[NT]	[NT]	[NT]	16/06/2020	[NT]
Naphthalene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	88	[NT]
Acenaphthylene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Acenaphthene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluorene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	116	[NT]
Phenanthrene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	77	[NT]
Anthracene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluoranthene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	72	[NT]
Pyrene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	86	[NT]
Benzo(a)anthracene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chrysene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	118	[NT]
Benzo(b,j+k)fluoranthene	µg/L	2	Org-022/025	<2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(a)pyrene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	74	[NT]
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	1	Org-022/025	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	120	[NT]	[NT]	[NT]	[NT]	118	[NT]

QUALITY CONTROL: Total Phenolics in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			15/06/2020	[NT]	[NT]	[NT]	[NT]	15/06/2020	[NT]
Date analysed	-			15/06/2020	[NT]	[NT]	[NT]	[NT]	15/06/2020	[NT]
Total Phenolics (as Phenol)	mg/L	0.05	Inorg-031	<0.05	[NT]	[NT]	[NT]	[NT]	102	[NT]

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date prepared	-			12/06/2020	[NT]	[NT]	[NT]	[NT]	12/06/2020	[NT]
Date analysed	-			12/06/2020	[NT]	[NT]	[NT]	[NT]	12/06/2020	[NT]
Total Cyanide	mg/L	0.004	Inorg-014	<0.004	[NT]	[NT]	[NT]	[NT]	95	[NT]
Free Cyanide in Water	mg/L	0.004	Inorg-014	<0.004	[NT]	[NT]	[NT]	[NT]	97	[NT]
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	<0.004	[NT]	[NT]	[NT]	[NT]	100	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	<0.005	[NT]	[NT]	[NT]	[NT]	108	[NT]
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	[NT]	[NT]	[NT]	[NT]	108	[NT]

QUALITY CONTROL: HM in water - dissolved						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date prepared	-			15/06/2020	[NT]	[NT]	[NT]	[NT]	15/06/2020	[NT]
Date analysed	-			15/06/2020	[NT]	[NT]	[NT]	[NT]	15/06/2020	[NT]
Molybdenum-Dissolved	μg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	95	[NT]
Lead-Dissolved	μg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	103	[NT]

Result Definitions	
NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

8 HM in water - dissolved - The PQL for 244740-1 & 244740-2 has been raised due to the sample matrix requiring a dilution.

CHAIN OF CUSTODY - Client

ENVIROLAB GROUP - National phone number 1300 42 43 44

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Perth Lab - MPL Laboratories
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Ph 0406 350 706 / adelaide@envirolab.com.au

Client: Hazmat Services
Contact Person: Damien Hendrickx
Project Mgr: Damien Hendrickx
Sampler: TG/HR
Address: Level 1 45C Fitzroy Street Carrington NSW 2294
Phone: 02 49611887 **Mob:** 0431433791
Email: damien@hazmat-services.com.au

Client Project Name / Number / Site etc (ie report title):
PO No.: 4882
Envirolab Quote No. : 16SY078
Date results required:
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Report format: esdat / equis /
Lab Comments:

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Ammonia	Phenols	Free Cyanide/Total cyanide/dissolved cyanide	Hexavalent Chromium	Molybdenum	Lead	PAH	Free Cyanide/Dissovled Cyanide	BTEX							Provide as much information about the sample as you can
1	K12/1E		11/06/2020	Water	X	X	X	X	X	X	X									
2	K12/1W		11/06/2020	Water	X	X	X	X	X	X	X									

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: ~~244700~~ 244700
Date Received: 12/6/2020
Time Received: 1109
Received by: R
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Relinquished by (Company): Hazmat Services
Print Name: Damien Hendrickx
Date & Time: 11/06/2020
Signature:

Received by (Company): ELS
Print Name: Rles
Date & Time: 12/6/2020 1109
Signature: R

Lab use only:
Samples Received: Cool or Ambient (circle one)
Temperature Received at: 14.1 (if applicable)
Transported by: Hand delivered / courier

White - Lab copy / Blue - Client copy / Pink - Retain in Book Page No:

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 245143

Client Details

Client	Hazmat Services
Attention	Damien Hendrickx
Address	PO Box 118, Carrington, NSW, 2294

Sample Details

Your Reference	**N2490-03**
Number of Samples	17 WATER
Date samples received	18/06/2020
Date completed instructions received	18/06/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	25/06/2020
Date of Issue	25/06/2020

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Diego Bigolin, Team Leader, Inorganics
Josh Williams, Senior Chemist
Loren Bardwell, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

PAHs in Water - Low Level						
Our Reference	UNITS	245143-6	245143-7	245143-8	245143-9	245143-10
Your Reference		K7/2S	E61D	K5/6S	K5/6N	K5/6NN
Date Sampled		15/06/2020	15/06/2020	15/06/2020	15/06/2020	15/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	23/06/2020	23/06/2020	23/06/2020	23/06/2020	23/06/2020
Date analysed	-	23/06/2020	23/06/2020	23/06/2020	23/06/2020	23/06/2020
Naphthalene	µg/L	2	<0.2	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	2.0	<0.1	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	119	104	97	119	110

PAHs in Water - Low Level						
Our Reference		245143-11	245143-12	245143-13	245143-14	245143-15
Your Reference	UNITS	K7/1	K7/2N	K9/4E	K9/4W	K9/2E
Date Sampled		15/06/2020	15/06/2020	16/06/2020	16/06/2020	16/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	23/06/2020	23/06/2020	23/06/2020	23/06/2020	23/06/2020
Date analysed	-	23/06/2020	23/06/2020	23/06/2020	23/06/2020	23/06/2020
Naphthalene	µg/L	320	230	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	0.4	0.2	<0.1	<0.1	<0.1
Acenaphthene	µg/L	5.0	11	<0.1	<0.1	<0.1
Fluorene	µg/L	1.5	1.4	<0.1	<0.1	<0.1
Phenanthrene	µg/L	1.9	0.2	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	0.4	<0.1	<0.1	<0.1
Fluoranthene	µg/L	0.4	0.6	<0.1	<0.1	<0.1
Pyrene	µg/L	0.4	0.6	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	0.2	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	0.2	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	330	240	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	100	82	96	96	112

PAHs in Water - Low Level			
Our Reference		245143-16	245143-17
Your Reference	UNITS	K9/2W	KS7/1
Date Sampled		16/06/2020	16/06/2020
Type of sample		WATER	WATER
Date extracted	-	23/06/2020	23/06/2020
Date analysed	-	23/06/2020	23/06/2020
Naphthalene	µg/L	0.4	<0.2
Acenaphthylene	µg/L	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5
Total +ve PAH's	µg/L	0.37	<0.1
Surrogate p-Terphenyl-d14	%	79	84

Total Phenolics in Water						
Our Reference		245143-6	245143-7	245143-8	245143-9	245143-10
Your Reference	UNITS	K7/2S	E61D	K5/6S	K5/6N	K5/6NN
Date Sampled		15/06/2020	15/06/2020	15/06/2020	15/06/2020	15/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	19/06/2020	19/06/2020	19/06/2020	19/06/2020	19/06/2020
Date analysed	-	19/06/2020	19/06/2020	19/06/2020	19/06/2020	19/06/2020
Total Phenolics (as Phenol)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05

Total Phenolics in Water				
Our Reference		245143-11	245143-12	245143-17
Your Reference	UNITS	K7/1	K7/2N	KS7/1
Date Sampled		15/06/2020	15/06/2020	16/06/2020
Type of sample		WATER	WATER	WATER
Date extracted	-	19/06/2020	19/06/2020	19/06/2020
Date analysed	-	19/06/2020	19/06/2020	19/06/2020
Total Phenolics (as Phenol)	mg/L	<0.05	6.2	<0.05

HM in water - dissolved						
Our Reference	UNITS	245143-1	245143-2	245143-3	245143-4	245143-5
Your Reference		RB-1	RB-2	RB-3	RB-4	RB-5
Date Sampled		09/06/2020	10/06/2020	11/06/2020	15/06/2020	16/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	19/06/2020	19/06/2020	19/06/2020	19/06/2020	19/06/2020
Date analysed	-	19/06/2020	19/06/2020	19/06/2020	19/06/2020	19/06/2020
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	<1	<1	<1	<1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	<1	<1	<1	<1	<1
Molybdenum-Dissolved	µg/L	<1	<1	<1	<1	<1

HM in water - dissolved						
Our Reference	UNITS	245143-7	245143-11	245143-15	245143-16	245143-17
Your Reference		E61D	K7/1	K9/2E	K9/2W	KS7/1
Date Sampled		15/06/2020	15/06/2020	16/06/2020	16/06/2020	16/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	19/06/2020	19/06/2020	19/06/2020	19/06/2020	19/06/2020
Date analysed	-	19/06/2020	19/06/2020	19/06/2020	19/06/2020	19/06/2020
Lead-Dissolved	µg/L	<2	<1	[NA]	[NA]	<1
Molybdenum-Dissolved	µg/L	<2	590	<2	5	88

Miscellaneous Inorganics						
Our Reference		245143-6	245143-7	245143-8	245143-9	245143-10
Your Reference	UNITS	K7/2S	E61D	K5/6S	K5/6N	K5/6NN
Date Sampled		15/06/2020	15/06/2020	15/06/2020	15/06/2020	15/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	18/06/2020	18/06/2020	18/06/2020	18/06/2020	18/06/2020
Date analysed	-	18/06/2020	18/06/2020	18/06/2020	18/06/2020	18/06/2020
Ammonia as N in water	mg/L	3.9	2.8	0.56	0.37	0.85
Total Cyanide	mg/L	0.010	0.006	0.006	0.008	0.006
Free Cyanide in Water	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005	<0.50	<0.005	<0.01

Miscellaneous Inorganics						
Our Reference		245143-11	245143-12	245143-13	245143-14	245143-15
Your Reference	UNITS	K7/1	K7/2N	K9/4E	K9/4W	K9/2E
Date Sampled		15/06/2020	15/06/2020	16/06/2020	16/06/2020	16/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	18/06/2020	18/06/2020	18/06/2020	18/06/2020	18/06/2020
Date analysed	-	18/06/2020	18/06/2020	18/06/2020	18/06/2020	18/06/2020
Ammonia as N in water	mg/L	8.8	11	5.8	1.9	4.1
Total Cyanide	mg/L	0.10	0.28	<0.004	<0.004	<0.004
Free Cyanide in Water	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005	<0.005	<0.050	<0.005

Miscellaneous Inorganics			
Our Reference		245143-16	245143-17
Your Reference	UNITS	K9/2W	KS7/1
Date Sampled		16/06/2020	16/06/2020
Type of sample		WATER	WATER
Date prepared	-	18/06/2020	18/06/2020
Date analysed	-	18/06/2020	18/06/2020
Ammonia as N in water	mg/L	2.8	0.016
Total Cyanide	mg/L	<0.004	<0.004
Free Cyanide in Water	mg/L	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005

Method ID	Methodology Summary
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjsuted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hyperchlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.

QUALITY CONTROL: PAHs in Water - Low Level						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	245143-14
Date extracted	-			23/06/2020	13	23/06/2020	23/06/2020		[NT]	23/06/2020
Date analysed	-			23/06/2020	13	23/06/2020	23/06/2020		[NT]	23/06/2020
Naphthalene	µg/L	0.2	Org-022/025	<0.2	13	<0.2	<0.2	0	[NT]	86
Acenaphthylene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	[NT]
Acenaphthene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	[NT]
Fluorene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	86
Phenanthrene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	88
Anthracene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	[NT]
Fluoranthene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	82
Pyrene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	88
Benzo(a)anthracene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	[NT]
Chrysene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	70
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025	<0.2	13	<0.2	<0.2	0	[NT]	[NT]
Benzo(a)pyrene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	92
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025	<0.1	13	<0.1	<0.1	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	89	13	96	110	14	[NT]	91

QUALITY CONTROL: PAHs in Water - Low Level						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-			[NT]	15	23/06/2020	23/06/2020		[NT]	[NT]
Date analysed	-			[NT]	15	23/06/2020	23/06/2020		[NT]	[NT]
Naphthalene	µg/L	0.2	Org-022/025	[NT]	15	<0.2	<0.2	0	[NT]	[NT]
Acenaphthylene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Acenaphthene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Fluorene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Phenanthrene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Anthracene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Fluoranthene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Pyrene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Benzo(a)anthracene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Chrysene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025	[NT]	15	<0.2	<0.2	0	[NT]	[NT]
Benzo(a)pyrene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025	[NT]	15	<0.1	<0.1	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	[NT]	15	112	70	46	[NT]	[NT]

QUALITY CONTROL: Total Phenolics in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	245143-7
Date extracted	-			19/06/2020	6	19/06/2020	19/06/2020		19/06/2020	19/06/2020
Date analysed	-			19/06/2020	6	19/06/2020	19/06/2020		19/06/2020	19/06/2020
Total Phenolics (as Phenol)	mg/L	0.05	Inorg-031	<0.05	6	<0.05	<0.05	0	100	97

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W5	[NT]
Date prepared	-			19/06/2020	1	19/06/2020	19/06/2020		19/06/2020	[NT]
Date analysed	-			19/06/2020	1	19/06/2020	19/06/2020		19/06/2020	[NT]
Arsenic-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	91	[NT]
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	102	[NT]
Chromium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	108	[NT]
Copper-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	109	[NT]
Lead-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	112	[NT]
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	1	<0.05	[NT]		87	[NT]
Nickel-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	101	[NT]
Zinc-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	102	[NT]
Molybdenum-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	91	[NT]

QUALITY CONTROL: Miscellaneous Inorganics						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	245143-6
Date prepared	-			18/06/2020	6	18/06/2020	18/06/2020		18/06/2020	18/06/2020
Date analysed	-			18/06/2020	6	18/06/2020	18/06/2020		18/06/2020	18/06/2020
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	6	3.9	3.9	0	103	#
Total Cyanide	mg/L	0.004	Inorg-014	<0.004	6	0.010	0.009	11	112	[NT]
Free Cyanide in Water	mg/L	0.004	Inorg-014	<0.004	6	<0.004	<0.004	0	97	[NT]
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	<0.004	6	<0.004	<0.004	0	105	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	<0.005	6	<0.005	[NT]		105	[NT]

QUALITY CONTROL: Miscellaneous Inorganics						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	245143-7
Date prepared	-			[NT]	8	18/06/2020	18/06/2020		[NT]	18/06/2020
Date analysed	-			[NT]	8	18/06/2020	18/06/2020		[NT]	18/06/2020
Ammonia as N in water	mg/L	0.005	Inorg-057	[NT]	8	0.56	[NT]		[NT]	[NT]
Total Cyanide	mg/L	0.004	Inorg-014	[NT]	8	0.006	[NT]		[NT]	105
Free Cyanide in Water	mg/L	0.004	Inorg-014	[NT]	8	<0.004	[NT]		[NT]	89
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	[NT]	8	<0.004	[NT]		[NT]	97
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	[NT]	8	<0.50	<0.50	0	[NT]	[NT]

QUALITY CONTROL: Miscellaneous Inorganics						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	245143-8
Date prepared	-			[NT]	11	18/06/2020	18/06/2020		[NT]	18/06/2020
Date analysed	-			[NT]	11	18/06/2020	18/06/2020		[NT]	18/06/2020
Ammonia as N in water	mg/L	0.005	Inorg-057	[NT]	11	8.8	8.7	1	[NT]	[NT]
Total Cyanide	mg/L	0.004	Inorg-014	[NT]	11	0.10	[NT]		[NT]	[NT]
Free Cyanide in Water	mg/L	0.004	Inorg-014	[NT]	11	<0.004	[NT]		[NT]	[NT]
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	[NT]	11	<0.004	[NT]		[NT]	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	[NT]	11	<0.005	<0.005	0	[NT]	102

QUALITY CONTROL: Miscellaneous Inorganics						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	16	18/06/2020	18/06/2020		[NT]	[NT]
Date analysed	-			[NT]	16	18/06/2020	18/06/2020		[NT]	[NT]
Ammonia as N in water	mg/L	0.005	Inorg-057	[NT]	16	2.8	[NT]		[NT]	[NT]
Total Cyanide	mg/L	0.004	Inorg-014	[NT]	16	<0.004	<0.004	0	[NT]	[NT]
Free Cyanide in Water	mg/L	0.004	Inorg-014	[NT]	16	<0.004	<0.004	0	[NT]	[NT]
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	[NT]	16	<0.004	<0.004	0	[NT]	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	[NT]	16	<0.005	[NT]		[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

MISC_INORG: Hexavalent Chromium PQL has been raised due to matrix interferences, samples were diluted and reanalysed however same results were achieved.

MISC_INORG:AMMONIA # Percent recovery is not possible to report due to the high concentration of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.

Dissolved Metals: no filtered, preserved sample was received for samples #13-17, therefore the unpreserved sample was filtered through 0.45µm filter at the lab.
Note: there is a possibility some elements may be underestimated.

8 HM in water - dissolved - The PQL has been raised for samples #7 and #15 due to the sample matrix requiring dilution.

CHAIN OF CUSTODY - Client

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7a The Parade, Norwood, SA 5067
Ph 0406 350 706 / adelaide@envirolab.com.au

Client: Hazmat Services	**Client Project Name / Number / Site etc (ie report title):** N2490-03
Contact Person: Damien Hendrickx	
Project Mgr: Damien Hendrickx	**PO No.:** 4906
Sampler: TG/HR	**Envirolab Quote No. :** 16SY078
Address: Level 1 45C Fitzroy Street Carrington NSW 2294	**Date results required:** **Or choose:** standard / same day / 1 day / 2 day / 3 day *Note: Inform lab in advance if urgent turnaround is required - surcharges apply*
Phone: 02 49611887 **Mob:** 0431433791	**Report format:** esdat / equis /
Email: damien@hazmat-services.com.au	**Lab Comments:**

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Ammonia	Phenols	Free Cyanide/Total cyanide/dissolved cyanide	Hexavalent Chromium	Molybdenum	Lead	PAH	Free Cyanide/Dissolved Cyanide	BTEX	Metals (Standard 8 + Molybdenum)						Comments: Provide as much information about the sample as you can
1	RB-1		9/06/2020	Water										X						
2	RB-2		10/06/2020	Water										X						
3	RB-3		11/06/2020	Water										X						
4	RB-4		15/06/2020	Water										X						
5	RB-5		16/06/2020	Water										X						
6	K7/2S		15/06/2020	Water	X	X	X	X			X									
7	E61D		15/06/2020	Water	X	X	X	X	X	X	X									
8	K5/6S		15/06/2020	Water	X	X	X	X			X									
9	K5/6N		15/06/2020	Water	X	X	X	X			X									
10	K5/6NN		15/06/2020	Water	X	X	X	X			X									
11	K7/1		15/06/2020	Water	X	X	X	X	X	X	X									
12	K7/2N		15/06/2020	Water	X	X	X	X			X									
13	K9/4E		16/06/2020	Water	X		X	X			X									Please filter from unpreserved bottle for metals analysis
14	K9/4W		16/06/2020	Water	X		X	X			X									Please filter from unpreserved bottle for metals analysis

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 245143
Date Received: 18·06·20
Time Received: 1054
Received by: KG
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Relinquished by (Company): Hazmat Services	**Received by (Company):** ELS Syd	***Lab use only:***
Print Name: Damien Hendrickx	**Print Name:** K-Gore	**Samples Received:** Cool or Ambient (circle one)
Date & Time: 17/06/2020	**Date & Time:** 18·06·2020 1054	**Temperature Received at:** 10·4 (if applicable)
Signature:	**Signature:**	**Transported by:** Hand delivered / courier

245143.

CHAIN OF CUSTODY - Client

ENVIROLAB

ENVIROLAB GROUP - National phone number 1300 42 43 44

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Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
Ph 0406 350 706 / adelaide@envirolab.com.au

Client: Hazmat Services	Client Project Name / Number / Site etc (ie report title): N2490-03
Contact Person: Damien Hendrickx	
Project Mgr: Damien Hendrickx	PO No.: 4906
Sampler: TG/HR	Envirolab Quote No. : 16SY078
Address: Level 1 45C Fitzroy Street Carrington NSW 2294	Date results required: Or choose: standard / same day / 1 day / 2 day / 3 day *Note: Inform lab in advance if urgent turnaround is required - surcharges apply*
Phone: 02 49611887 Mob: 0431433791	Report format: esdat / equis /
Email: damien@hazmat-services.com.au	Lab Comments:

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Ammonia	Phenols	Free Cyanide/Total cyanide/dissolved cyanide	Hexavalent Chromium	Molybdenum	Lead	PAH	Free Cyanide/Dissovled Cyanide	BTEX	Metals (Standard 8 + Molybdenum)						Comments: Provide as much information about the sample as you can
15	K9/2E		16/06/2020	Water	X		X	X	X		X									Please filter from unpreserved bottle for metals analysis
16	K9/2W		16/06/2020	Water	X		X	X	X		X									Please filter from unpreserved bottle for metals analysis
17.	KS7/1		16/06/2020	Water	X	X	X	X	X	X	X									Please filter from unpreserved bottle for metals analysis

Relinquished by (Company): Hazmat Services	Received by (Company): ELS Syd	*Lab use only:*
Print Name: Damien Hendrickx	Print Name: K-Core	Samples Received: Cool or Ambient (circle one)
Date & Time: 17/06/2020	Date & Time: 18·06·2020 1054·	Temperature Received at: 10·4 (if applicable)
Signature:	Signature:	Transported by: Hand delivered / courier

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CERTIFICATE OF ANALYSIS 245731

Client Details

Client	Hazmat Services
Attention	Damien Hendrickx
Address	PO Box 118, Carrington, NSW, 2294

Sample Details

Your Reference	**N249003**
Number of Samples	9 WATER
Date samples received	26/06/2020
Date completed instructions received	26/06/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	03/07/2020
Date of Issue	01/07/2020

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Diego Bigolin, Team Leader, Inorganics
Loren Bardwell, Senior Chemist
Steven Luong, Organics Supervisor

Authorised By

Nancy Zhang, Laboratory Manager

PAHs in Water - Low Level						
Our Reference		245731-1	245731-2	245731-3	245731-4	245731-5
Your Reference	UNITS	NCIG1	K12/7E	NCIG2	K12/7	K12/4N
Date Sampled		23/06/2020	23/06/2020	23/06/2020	23/06/2020	24/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	29/06/2020	29/06/2020	29/06/2020	29/06/2020	29/06/2020
Date analysed	-	30/06/2020	30/06/2020	30/06/2020	30/06/2020	30/06/2020
Naphthalene	µg/L	0.2	<0.2	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	0.34	<0.1	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	100	91	76	92	123

PAHs in Water - Low Level					
Our Reference		245731-6	245731-7	245731-8	245731-9
Your Reference	UNITS	KS12/6	K8/5E	QCA	QC2
Date Sampled		24/06/2020	24/06/2020	23/06/2020	24/06/2020
Type of sample		WATER	WATER	WATER	WATER
Date extracted	-	29/06/2020	29/06/2020	29/06/2020	29/06/2020
Date analysed	-	30/06/2020	30/06/2020	30/06/2020	30/06/2020
Naphthalene	µg/L	<0.2	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	0.2	<0.1	<0.1
Pyrene	µg/L	<0.1	0.3	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	<0.1	0.45	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	112	71	78	86

Total Phenolics in Water						
Our Reference		245731-1	245731-2	245731-3	245731-4	245731-5
Your Reference	UNITS	NCIG1	K12/7E	NCIG2	K12/7	K12/4N
Date Sampled		23/06/2020	23/06/2020	23/06/2020	23/06/2020	24/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	30/06/2020	30/06/2020	30/06/2020	30/06/2020	30/06/2020
Date analysed	-	30/06/2020	30/06/2020	30/06/2020	30/06/2020	30/06/2020
Total Phenolics (as Phenol)	mg/L	<0.05	<0.05	0.08	<0.05	<0.05

Total Phenolics in Water					
Our Reference		245731-6	245731-7	245731-8	245731-9
Your Reference	UNITS	KS12/6	K8/5E	QCA	QC2
Date Sampled		24/06/2020	24/06/2020	23/06/2020	24/06/2020
Type of sample		WATER	WATER	WATER	WATER
Date extracted	-	30/06/2020	30/06/2020	30/06/2020	30/06/2020
Date analysed	-	30/06/2020	30/06/2020	30/06/2020	30/06/2020
Total Phenolics (as Phenol)	mg/L	<0.05	0.09	<0.05	<0.05

HM in water - dissolved						
Our Reference		245731-1	245731-2	245731-3	245731-4	245731-5
Your Reference	UNITS	NCIG1	K12/7E	NCIG2	K12/7	K12/4N
Date Sampled		23/06/2020	23/06/2020	23/06/2020	23/06/2020	24/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	29/06/2020	29/06/2020	29/06/2020	29/06/2020	29/06/2020
Date analysed	-	29/06/2020	29/06/2020	29/06/2020	29/06/2020	29/06/2020
Lead-Dissolved	μg/L	<1	<1	<1	<1	<1
Molybdenum-Dissolved	μg/L	27	3	<1	9	<1

HM in water - dissolved					
Our Reference		245731-6	245731-7	245731-8	245731-9
Your Reference	UNITS	KS12/6	K8/5E	QCA	QC2
Date Sampled		24/06/2020	24/06/2020	23/06/2020	24/06/2020
Type of sample		WATER	WATER	WATER	WATER
Date prepared	-	29/06/2020	29/06/2020	29/06/2020	29/06/2020
Date analysed	-	29/06/2020	29/06/2020	29/06/2020	29/06/2020
Lead-Dissolved	μg/L	<1	<1	<1	<1
Molybdenum-Dissolved	μg/L	<1	57	27	<1

Miscellaneous Inorganics						
Our Reference		245731-1	245731-2	245731-3	245731-4	245731-5
Your Reference	UNITS	NCIG1	K12/7E	NCIG2	K12/7	K12/4N
Date Sampled		23/06/2020	23/06/2020	23/06/2020	23/06/2020	24/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	26/06/2020	26/06/2020	26/06/2020	26/06/2020	26/06/2020
Date analysed	-	26/06/2020	26/06/2020	26/06/2020	26/06/2020	26/06/2020
Ammonia as N in water	mg/L	1.7	5.8	44	3.5	53
Total Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Free Cyanide in Water	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics					
Our Reference		245731-6	245731-7	245731-8	245731-9
Your Reference	UNITS	KS12/6	K8/5E	QCA	QC2
Date Sampled		24/06/2020	24/06/2020	23/06/2020	24/06/2020
Type of sample		WATER	WATER	WATER	WATER
Date prepared	-	26/06/2020	26/06/2020	26/06/2020	26/06/2020
Date analysed	-	26/06/2020	26/06/2020	26/06/2020	26/06/2020
Ammonia as N in water	mg/L	1.0	2.6	1.7	0.94
Total Cyanide	mg/L	<0.004	0.004	<0.004	<0.004
Free Cyanide in Water	mg/L	<0.004	<0.004	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005	<0.005	<0.005

Method ID	Methodology Summary
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjsuted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hyperchlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Metals-022	Determination of various metals by ICP-MS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.

QUALITY CONTROL: PAHs in Water - Low Level						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			29/06/2020	[NT]	[NT]	[NT]	[NT]	29/06/2020	[NT]
Date analysed	-			30/06/2020	[NT]	[NT]	[NT]	[NT]	30/06/2020	[NT]
Naphthalene	µg/L	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	128	[NT]
Acenaphthylene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Acenaphthene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluorene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	110	[NT]
Phenanthrene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	93	[NT]
Anthracene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluoranthene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	95	[NT]
Pyrene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	102	[NT]
Benzo(a)anthracene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chrysene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	72	[NT]
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(a)pyrene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	96	[NT]
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	122	[NT]	[NT]	[NT]	[NT]	96	[NT]

QUALITY CONTROL: Total Phenolics in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	245731-2
Date extracted	-			30/06/2020	1	30/06/2020	30/06/2020		30/06/2020	30/06/2020
Date analysed	-			30/06/2020	1	30/06/2020	30/06/2020		30/06/2020	30/06/2020
Total Phenolics (as Phenol)	mg/L	0.05	Inorg-031	<0.05	1	<0.05	<0.05	0	102	103

QUALITY CONTROL: HM in water - dissolved						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	245731-2
Date prepared	-			29/06/2020	1	29/06/2020	29/06/2020		29/06/2020	29/06/2020
Date analysed	-			29/06/2020	1	29/06/2020	29/06/2020		29/06/2020	29/06/2020
Lead-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	92	83
Molybdenum-Dissolved	µg/L	1	Metals-022	<1	1	27	27	0	90	104

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	245731-1
Date prepared	-			26/06/2020	1	26/06/2020	26/06/2020		26/06/2020	26/06/2020
Date analysed	-			26/06/2020	1	26/06/2020	26/06/2020		26/06/2020	26/06/2020
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	1.7	1.7	0	85	[NT]
Total Cyanide	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	95	[NT]
Free Cyanide in Water	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	107	[NT]
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	96	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	<0.005	1	<0.005	[NT]		105	93

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	245731-2
Date prepared	-			[NT]	8	26/06/2020	26/06/2020		[NT]	26/06/2020
Date analysed	-			[NT]	8	26/06/2020	26/06/2020		[NT]	26/06/2020
Ammonia as N in water	mg/L	0.005	Inorg-057	[NT]	8	1.7	[NT]		[NT]	#
Total Cyanide	mg/L	0.004	Inorg-014	[NT]	8	<0.004	[NT]		[NT]	80
Free Cyanide in Water	mg/L	0.004	Inorg-014	[NT]	8	<0.004	[NT]		[NT]	81
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	[NT]	8	<0.004	[NT]		[NT]	98
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	[NT]	8	<0.005	<0.005	0	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

MISC_INORG:AMMONIA # Percent recovery is not possible to report due to the high concentration of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.

CHAIN OF CUSTODY - Client

ENVIROLAB GROUP - National phone number 1300 42 43 44

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Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
Ph 0406 350 706 / adelaide@envirolab.com.au

Client: Hazmat Services	**Client Project Name / Number / Site etc (ie report title):** N249003
Contact Person: Damien Hendrickx	**PO No.:** 4932
Project Mgr: Damien Hendrickx	**Envirolab Quote No. :** 16SY078
Sampler: TG/HR	**Date results required:** Standard TAT
Address: Level 1 45C Fitzroy Street Carrington NSW 2294	**Or choose:** standard / same day / 1 day / 2 day / 3 day *Note: Inform lab in advance if urgent turnaround is required - surcharges apply*
Phone: 02 49611887 **Mob:** 0431433791	**Report format:** esdat / equis /
Email: damien@hazmat-services.com.au	**Lab Comments:**

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Ammonia	Phenols	Free Cyanide/Total cyanide/dissolved cyanide	Hexavalent Chromium	Molybdenum	Lead	PAH	Free Cyanide/Dissolved Cyanide	BTEX							Comments: Provide as much information about the sample as you can
1	NCIG1		23/06/2020	Water	X	X	X	X	X	X	X									
2	K12/7E		23/06/2020	Water	X	X	X	X	X	X	X									
3	NCIG2		23/06/2020	Water	X	X	X	X	X	X	X									
4	K12/7		23/06/2020	Water	X	X	X	X	X	X	X									
5	K12/4N		24/06/2020	Water	X	X	X	X	X	X	X									
6	KS12/6		24/06/2020	Water	X	X	X	X	X	X	X									
7	K8/5E		24/06/2020	Water	X	X	X	X	X	X	X									
8	QCA		23/06/2020	Water	X	X	X	X	X	X	X									
9	QC2		24/06/2020	Water	X	X	X	X	X	X	X									

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 245731
Date Received: 26/06/2020
Time Received: 10:55
Received by: MT
Temp: Cool/Ambient 7-2
Cooling: Ice/Icepack
Security: Intact/Broken/None

Relinquished by (Company): Hazmat Services	**Received by (Company):** ELS Sydney	***Lab use only:***
Print Name: Damien Hendrickx	**Print Name:** Ming Yan To	**Samples Received:** Cool or Ambient (circle one)
Date & Time: 24/06/2020	**Date & Time:** 26/06/2020 10:55	**Temperature Received at:** 7-2 (if applicable)
Signature:	**Signature:** MT	**Transported by:** Hand delivered / courier

White - Lab copy / Blue - Client copy / Pink - Retain in Book Page No:

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 246114

Client Details

Client	Hazmat Services
Attention	Damien Hendrickx
Address	PO Box 118, Carrington, NSW, 2294

Sample Details

Your Reference	**N249003**
Number of Samples	10 WATER
Date samples received	02/07/2020
Date completed instructions received	02/07/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	09/07/2020
Date of Issue	08/07/2020

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Results Approved By
Diego Bigolin, Team Leader, Inorganics
Dragana Tomas, Senior Chemist
Jaimie Loa-Kum-Cheung, Metals Supervisor

Authorised By

Nancy Zhang, Laboratory Manager

PAHs in Water - Low Level						
Our Reference		246114-5	246114-6	246114-7	246114-8	246114-9
Your Reference	UNITS	BHe29S	K10/2NN	K10/2	K9/3S	K9/3N
Date Sampled		29/06/2020	29/06/2020	30/06/2020	30/06/2020	30/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	06/07/2020	06/07/2020	06/07/2020	06/07/2020	06/07/2020
Date analysed	-	06/07/2020	06/07/2020	06/07/2020	06/07/2020	06/07/2020
Naphthalene	µg/L	<0.2	14	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	<0.1	14	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	89	98	86	94	85

PAHs in Water - Low Level		
Our Reference		246114-10
Your Reference	UNITS	K11/3W
Date Sampled		30/06/2020
Type of sample		WATER
Date extracted	-	06/07/2020
Date analysed	-	06/07/2020
Naphthalene	µg/L	<0.2
Acenaphthylene	µg/L	<0.1
Acenaphthene	µg/L	<0.1
Fluorene	µg/L	<0.1
Phenanthrene	µg/L	<0.1
Anthracene	µg/L	<0.1
Fluoranthene	µg/L	<0.1
Pyrene	µg/L	<0.1
Benzo(a)anthracene	µg/L	<0.1
Chrysene	µg/L	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2
Benzo(a)pyrene	µg/L	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5
Total +ve PAH's	µg/L	<0.1
Surrogate p-Terphenyl-d14	%	83

Total Phenolics in Water					
Our Reference		246114-5	246114-8	246114-9	246114-10
Your Reference	UNITS	BHe29S	K9/3S	K9/3N	K11/3W
Date Sampled		29/06/2020	30/06/2020	30/06/2020	30/06/2020
Type of sample		WATER	WATER	WATER	WATER
Date extracted	-	03/07/2020	03/07/2020	03/07/2020	03/07/2020
Date analysed	-	03/07/2020	03/07/2020	03/07/2020	03/07/2020
Total Phenolics (as Phenol)	mg/L	<0.05	<0.05	<0.05	<0.05

HM in water - dissolved						
Our Reference	UNITS	246114-1	246114-2	246114-3	246114-4	246114-5
Your Reference		RB6	RB7	RB8	RB9	BHe29S
Date Sampled		23/06/2020	24/06/2020	29/06/2020	30/06/2020	29/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	03/07/2020	03/07/2020	03/07/2020	03/07/2020	03/07/2020
Date analysed	-	03/07/2020	03/07/2020	03/07/2020	03/07/2020	03/07/2020
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	[NA]
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	[NA]
Chromium-Dissolved	µg/L	<1	<1	<1	<1	[NA]
Copper-Dissolved	µg/L	<1	<1	<1	2	[NA]
Lead-Dissolved	µg/L	<1	<1	<1	<1	11
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	[NA]
Nickel-Dissolved	µg/L	<1	<1	<1	<1	[NA]
Zinc-Dissolved	µg/L	<1	<1	1	4	[NA]
Molybdenum-Dissolved	µg/L	<1	<1	<1	<1	9

HM in water - dissolved						
Our Reference	UNITS	246114-6	246114-7	246114-8	246114-9	246114-10
Your Reference		K10/2NN	K10/2	K9/3S	K9/3N	K11/3W
Date Sampled		29/06/2020	30/06/2020	30/06/2020	30/06/2020	30/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	03/07/2020	03/07/2020	03/07/2020	03/07/2020	03/07/2020
Date analysed	-	03/07/2020	03/07/2020	03/07/2020	03/07/2020	03/07/2020
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Molybdenum-Dissolved	µg/L	<1	9	22	<1	<1

Miscellaneous Inorganics						
Our Reference		246114-5	246114-6	246114-7	246114-8	246114-9
Your Reference	UNITS	BHe29S	K10/2NN	K10/2	K9/3S	K9/3N
Date Sampled		29/06/2020	29/06/2020	30/06/2020	30/06/2020	30/06/2020
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	02/07/2020	02/07/2020	02/07/2020	02/07/2020	02/07/2020
Date analysed	-	02/07/2020	02/07/2020	02/07/2020	02/07/2020	02/07/2020
Ammonia as N in water	mg/L	0.85	5.6	0.13	0.78	3.3
Total Cyanide	mg/L	<0.004	<0.004	[NA]	<0.004	<0.004
Free Cyanide in Water	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.050	<0.005	<0.005	<0.005

Miscellaneous Inorganics		
Our Reference		246114-10
Your Reference	UNITS	K11/3W
Date Sampled		30/06/2020
Type of sample		WATER
Date prepared	-	02/07/2020
Date analysed	-	02/07/2020
Ammonia as N in water	mg/L	6.1
Total Cyanide	mg/L	0.006
Free Cyanide in Water	mg/L	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005

Method ID	Methodology Summary
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjsuted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hyperchlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.

QUALITY CONTROL: PAHs in Water - Low Level						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date extracted	-			06/07/2020	6	06/07/2020	06/07/2020		06/07/2020	[NT]
Date analysed	-			06/07/2020	6	06/07/2020	06/07/2020		06/07/2020	[NT]
Naphthalene	µg/L	0.2	Org-022/025	<0.2	6	14	15	7	104	[NT]
Acenaphthylene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Acenaphthene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Fluorene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	110	[NT]
Phenanthrene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	74	[NT]
Anthracene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Fluoranthene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	70	[NT]
Pyrene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	76	[NT]
Benzo(a)anthracene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Chrysene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	72	[NT]
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025	<0.2	6	<0.2	<0.2	0	[NT]	[NT]
Benzo(a)pyrene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	84	[NT]
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	104	6	98	114	15	71	[NT]

QUALITY CONTROL: Total Phenolics in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date extracted	-			03/07/2020	5	03/07/2020	03/07/2020		03/07/2020	[NT]
Date analysed	-			03/07/2020	5	03/07/2020	03/07/2020		03/07/2020	[NT]
Total Phenolics (as Phenol)	mg/L	0.05	Inorg-031	<0.05	5	<0.05	<0.05	0	102	[NT]

QUALITY CONTROL: HM in water - dissolved						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	246114-2
Date prepared	-			03/07/2020	1	03/07/2020	03/07/2020		03/07/2020	03/07/2020
Date analysed	-			03/07/2020	1	03/07/2020	03/07/2020		03/07/2020	03/07/2020
Arsenic-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	91	90
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	97	96
Chromium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	107	98
Copper-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	104	96
Lead-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	106	92
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	1	<0.05	[NT]		101	[NT]
Nickel-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	97	97
Zinc-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	95	97
Molybdenum-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	97	95

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	246114-6
Date prepared	-			02/07/2020	5	02/07/2020	02/07/2020		02/07/2020	02/07/2020
Date analysed	-			02/07/2020	5	02/07/2020	02/07/2020		02/07/2020	02/07/2020
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	5	0.85	0.97	13	93	107
Total Cyanide	mg/L	0.004	Inorg-014	<0.004	5	<0.004	<0.004	0	94	[NT]
Free Cyanide in Water	mg/L	0.004	Inorg-014	<0.004	5	<0.004	<0.004	0	98	[NT]
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	<0.004	5	<0.004	<0.004	0	94	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	<0.005	5	<0.005	<0.005	0	104	99

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

MISC_INORG: Hexavalent Chromium PQL has been raised due to matrix interferences, samples were diluted and reanalysed however same results were achieved.

CHAIN OF CUSTODY - Client

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Client: Hazmat Services	**Client Project Name / Number / Site etc (ie report title):** N249003
Contact Person: Damien Hendrickx	
Project Mgr: Damien Hendrickx	**PO No.:** 4948
Sampler: TG/HR	**Envirolab Quote No. :** 16SY078
Address: Level 1 45C Fitzroy Street Carrington NSW 2294	**Date results required:** Standard TAT **Or choose:** standard / same day / 1 day / 2 day / 3 day *Note: Inform lab in advance if urgent turnaround is required - surcharges apply*
Phone: 02 49611887 **Mob:** 0431433791	**Report format:** esdat / equis /
Email: damien@hazmat-services.com.au	**Lab Comments:**

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Ammonia	Phenols	Free Cyanide/Total cyanide/dissolved cyanide	Hexavalent Chromium	Molybdenum	Lead	PAH	Free Cyanide/Dissovled Cyanide	BTEX	Metals (Standard 8 + Molybdenum)					Comments: Provide as much information about the sample as you can
1	RB6		23/06/2020	Water										x					
2	RB7		24/06/2020	Water										x					
3	RB8		29/06/2020	Water										x					
4	RB9		30/06/2020	Water										x					
5	BHe29S		29/06/2020	Water	x	x	x	x	x	x	x								
6	K10/2NN		29/06/2020	Water	x		x	x	x	x	x								
7	K10/2		30/06/2020	Water	x			x	x	x	x	x							
8	K9/3S		30/06/2020	Water	x	x	x	x	x	x	x								
9	K9/3N		30/06/2020	Water	x	x	x	x	x	x	x								
	~~K11/3E~~		~~30/06/2020~~	~~Water~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~								
10	K11/3W		30/06/2020	Water	x	x	x	x	x	x	x								

ENVIROLAB Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 246114
Date Received: 2/7/20
Time Received: 10:30
Received By: 82
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Relinquished by (Company): Hazmat Services	**Received by (Company):** ELS	*Lab use only:*
Print Name: Damien Hendrickx	**Print Name:** [illegible]	**Samples Received:** Cool or Ambient (circle one)
Date & Time: 30/06/2020	**Date & Time:** 2/7/20	**Temperature Received at:** (if applicable)
Signature: [signature]	**Signature:** 82	**Transported by:** Hand delivered / courier

White - Lab copy / Blue - Client copy / Pink - Retain in Book Page No:

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 246213

Client Details

Client	Hazmat Services
Attention	Damien Hendrickx
Address	PO Box 118, Carrington, NSW, 2294

Sample Details

Your Reference	N249003
Number of Samples	3 WATER
Date samples received	03/07/2020
Date completed instructions received	03/07/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	10/07/2020
Date of Issue	09/07/2020

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Results Approved By
Diego Bigolin, Team Leader, Inorganics
Dragana Tomas, Senior Chemist
Jaimie Loa-Kum-Cheung, Metals Supervisor

Authorised By

Nancy Zhang, Laboratory Manager

PAHs in Water - Low Level			
Our Reference		246213-2	246213-3
Your Reference	UNITS	K5/5S	K8/5W
Date Sampled		2/07/2020	2/07/2020
Type of sample		WATER	WATER
Date extracted	-	06/07/2020	06/07/2020
Date analysed	-	06/07/2020	06/07/2020
Naphthalene	µg/L	0.3	50
Acenaphthylene	µg/L	<0.1	0.2
Acenaphthene	µg/L	0.5	190
Fluorene	µg/L	0.3	120
Phenanthrene	µg/L	0.3	130
Anthracene	µg/L	<0.1	9.8
Fluoranthene	µg/L	<0.1	16
Pyrene	µg/L	<0.1	11
Benzo(a)anthracene	µg/L	<0.1	0.6
Chrysene	µg/L	<0.1	0.3
Benzo(b,j+k)fluoranthene	µg/L	<0.2	0.4
Benzo(a)pyrene	µg/L	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5
Total +ve PAH's	µg/L	1.3	530
Surrogate p-Terphenyl-d14	%	105	80

Total Phenolics in Water		
Our Reference		246213-3
Your Reference	UNITS	K8/5W
Date Sampled		2/07/2020
Type of sample		WATER
Date extracted	-	06/07/2020
Date analysed	-	06/07/2020
Total Phenolics (as Phenol)	mg/L	<0.05

HM in water - dissolved			
Our Reference		246213-1	246213-3
Your Reference	UNITS	RB-10	K8/5W
Date Sampled		2/07/2020	2/07/2020
Type of sample		WATER	WATER
Date prepared	-	06/07/2020	06/07/2020
Date analysed	-	06/07/2020	06/07/2020
Arsenic-Dissolved	μg/L	<1	[NA]
Cadmium-Dissolved	μg/L	<0.1	[NA]
Chromium-Dissolved	μg/L	<1	[NA]
Copper-Dissolved	μg/L	<1	[NA]
Lead-Dissolved	μg/L	<1	<1
Mercury-Dissolved	μg/L	<0.05	[NA]
Nickel-Dissolved	μg/L	<1	[NA]
Zinc-Dissolved	μg/L	<1	[NA]
Molybdenum-Dissolved	μg/L	<1	43

Miscellaneous Inorganics			
Our Reference		246213-2	246213-3
Your Reference	UNITS	K5/5S	K8/5W
Date Sampled		2/07/2020	2/07/2020
Type of sample		WATER	WATER
Date prepared	-	03/07/2020	03/07/2020
Date analysed	-	03/07/2020	03/07/2020
Ammonia as N in water	mg/L	1.1	4.7
Total Cyanide	mg/L	<0.004	0.012
Free Cyanide in Water	mg/L	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005

Method ID	Methodology Summary
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjsuted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hyperchlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.

QUALITY CONTROL: PAHs in Water - Low Level					Duplicate					Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			06/07/2020	[NT]	[NT]	[NT]	[NT]	06/07/2020	[NT]
Date analysed	-			06/07/2020	[NT]	[NT]	[NT]	[NT]	06/07/2020	[NT]
Naphthalene	µg/L	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	104	[NT]
Acenaphthylene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Acenaphthene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluorene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Phenanthrene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	88	[NT]
Anthracene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluoranthene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	88	[NT]
Pyrene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	98	[NT]
Benzo(a)anthracene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chrysene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	74	[NT]
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(a)pyrene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	98	[NT]
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	84	[NT]	[NT]	[NT]	[NT]	85	[NT]

QUALITY CONTROL: Total Phenolics in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date extracted	-			06/07/2020	[NT]	[NT]	[NT]	[NT]	06/07/2020	[NT]
Date analysed	-			06/07/2020	[NT]	[NT]	[NT]	[NT]	06/07/2020	[NT]
Total Phenolics (as Phenol)	mg/L	0.05	Inorg-031	<0.05	[NT]	[NT]	[NT]	[NT]	102	[NT]

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date prepared	-			06/07/2020	[NT]	[NT]	[NT]	[NT]	06/07/2020	[NT]
Date analysed	-			06/07/2020	[NT]	[NT]	[NT]	[NT]	06/07/2020	[NT]
Arsenic-Dissolved	μg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	98	[NT]
Cadmium-Dissolved	μg/L	0.1	Metals-022	<0.1	[NT]	[NT]	[NT]	[NT]	103	[NT]
Chromium-Dissolved	μg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	108	[NT]
Copper-Dissolved	μg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Lead-Dissolved	μg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Mercury-Dissolved	μg/L	0.05	Metals-021	<0.05	[NT]	[NT]	[NT]	[NT]	97	[NT]
Nickel-Dissolved	μg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Zinc-Dissolved	μg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
Molybdenum-Dissolved	μg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate					Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date prepared	-			03/07/2020	[NT]	[NT]	[NT]	[NT]	03/07/2020	[NT]
Date analysed	-			03/07/2020	[NT]	[NT]	[NT]	[NT]	03/07/2020	[NT]
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	[NT]	[NT]	[NT]	[NT]	100	[NT]
Total Cyanide	mg/L	0.004	Inorg-014	<0.004	[NT]	[NT]	[NT]	[NT]	97	[NT]
Free Cyanide in Water	mg/L	0.004	Inorg-014	<0.004	[NT]	[NT]	[NT]	[NT]	97	[NT]
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	<0.004	[NT]	[NT]	[NT]	[NT]	101	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	<0.005	[NT]	[NT]	[NT]	[NT]	103	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

CHAIN OF CUSTODY - Client

ENVIROLAB GROUP

ENVIROLAB GROUP - National phone number 1300 42 43 44

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
Ph 02 9910 6200 / sydney@envirolab.com.au

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7a The Parade, Norwood, SA 5067
Ph 0406 350 706 / adelaide@envirolab.com.au

Client: Hazmat Services	**Client Project Name / Number / Site etc (ie report title):** N249003
Contact Person: Damien Hendrickx	**PO No.:** 4958
Project Mgr: Damien Hendrickx	**Envirolab Quote No. :** 16SY078
Sampler: TG/HR	**Date results required:** Standard TAT
Address: Level 1 45C Fitzroy Street Carrington NSW 2294	**Or choose:** standard / same day / 1 day / 2 day / 3 day *Note: Inform lab in advance if urgent turnaround is required - surcharges apply*
Phone: 02 49611887 **Mob:** 0431433791	**Report format:** esdat / equis /
Email: damien@hazmat-services.com.au	**Lab Comments:**

Sample information | **Tests Required** | **Comments**

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Ammonia	Phenols	Free Cyanide/Total cyanide/dissolved cyanide	Hexavalent Chromium	Molybdenum	Lead	PAH	Free Cyanide/Dissolved Cyanide	BTEX	Metals (Standard 8 + Molybdenum)						Provide as much information about the sample as you can
1	RB-10		2/07/2020	Water										X						
2	K5/5S		2/07/2020	Water	X		X	X			X									
3	K8/5W		2/07/2020	Water	X	X	X	X	X	X	X									

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 246213
Date Received: 3/7/20
Time Received: 1101
Received by: CM
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Relinquished by (Company): Hazmat Services	**Received by (Company):** ELS SYD	***Lab use only:***
Print Name: Damien Hendrickx	**Print Name:** C.MUCM	**Samples Received: Cool or Ambient (circle one)**
Date & Time: 2/07/2020	**Date & Time:** 3/7/20 1101	**Temperature Received at:** 14.2 **(if applicable)**
Signature:	**Signature:** CM	**Transported by: Hand delivered / courier**

White - Lab copy / Blue - Client copy / Pink - Retain in Book Page No:

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 246440

Client Details

Client	Hazmat Services
Attention	Damien Hendrickx
Address	PO Box 118, Carrington, NSW, 2294

Sample Details

Your Reference	**N249003**
Number of Samples	7 Water
Date samples received	07/07/2020
Date completed instructions received	07/07/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	14/07/2020
Date of Issue	13/07/2020

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Results Approved By
Diego Bigolin, Team Leader, Inorganics
Dragana Tomas, Senior Chemist
Jaimie Loa-Kum-Cheung, Metals Supervisor
Priya Samarawickrama, Senior Chemist
Steven Luong, Organics Supervisor

Authorised By

Nancy Zhang, Laboratory Manager

vTRH(C6-C10)/BTEXN in Water				
Our Reference		246440-2	246440-3	246440-5
Your Reference	UNITS	K11/1	K11/1S	QC5
Date Sampled		05/07/2020	05/07/2020	05/07/2020
Type of sample		Water	Water	Water
Date extracted	-	08/07/2020	08/07/2020	08/07/2020
Date analysed	-	08/07/2020	08/07/2020	08/07/2020
TRH C_6 - C_9	µg/L	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10
Benzene	µg/L	<1	<1	<1
Toluene	µg/L	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2
o-xylene	µg/L	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1
Surrogate Dibromofluoromethane	%	112	116	115
Surrogate toluene-d8	%	97	97	95
Surrogate 4-BFB	%	97	97	97

svTRH (C10-C40) in Water				
Our Reference		246440-2	246440-3	246440-5
Your Reference	UNITS	K11/1	K11/1S	QC5
Date Sampled		05/07/2020	05/07/2020	05/07/2020
Type of sample		Water	Water	Water
Date extracted	-	08/07/2020	08/07/2020	08/07/2020
Date analysed	-	08/07/2020	08/07/2020	08/07/2020
TRH C_{10} - C_{14}	µg/L	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	120	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	120	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100
Surrogate o-Terphenyl	%	128	127	122

PAHs in Water - Low Level						
Our Reference		246440-1	246440-2	246440-3	246440-4	246440-5
Your Reference	UNITS	K11/3E	K11/1	K11/1S	QC4	QC5
Date Sampled		04/07/2020	05/07/2020	05/07/2020	04/07/2020	05/07/2020
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	08/07/2020	08/07/2020	08/07/2020	08/07/2020	08/07/2020
Date analysed	-	08/07/2020	08/07/2020	08/07/2020	08/07/2020	08/07/2020
Naphthalene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	101	109	115	109	108

Total Phenolics in Water					
Our Reference		246440-1	246440-2	246440-3	246440-4
Your Reference	UNITS	K11/3E	K11/1	K11/1S	QC4
Date Sampled		04/07/2020	05/07/2020	05/07/2020	04/07/2020
Type of sample		Water	Water	Water	Water
Date extracted	-	07/07/2020	07/07/2020	07/07/2020	07/07/2020
Date analysed	-	07/07/2020	07/07/2020	07/07/2020	07/07/2020
Total Phenolics (as Phenol)	mg/L	<0.05	<0.05	<0.05	<0.05

HM in water - dissolved						
Our Reference		246440-1	246440-2	246440-3	246440-4	246440-6
Your Reference	UNITS	K11/3E	K11/1	K11/1S	QC4	RB-12
Date Sampled		04/07/2020	05/07/2020	05/07/2020	04/07/2020	04/07/2020
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	08/07/2020	08/07/2020	08/07/2020	08/07/2020	08/07/2020
Date analysed	-	08/07/2020	08/07/2020	08/07/2020	08/07/2020	08/07/2020
Arsenic-Dissolved	μg/L	[NA]	[NA]	[NA]	[NA]	<1
Cadmium-Dissolved	μg/L	[NA]	[NA]	[NA]	[NA]	<0.1
Chromium-Dissolved	μg/L	[NA]	[NA]	[NA]	[NA]	<1
Copper-Dissolved	μg/L	[NA]	[NA]	[NA]	[NA]	<1
Lead-Dissolved	μg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	μg/L	[NA]	[NA]	[NA]	[NA]	<0.05
Nickel-Dissolved	μg/L	[NA]	[NA]	[NA]	[NA]	<1
Zinc-Dissolved	μg/L	[NA]	[NA]	[NA]	[NA]	<1
Molybdenum-Dissolved	μg/L	<1	4	<1	<1	<1

HM in water - dissolved		
Our Reference		246440-7
Your Reference	UNITS	RB-13
Date Sampled		05/07/2020
Type of sample		Water
Date prepared	-	08/07/2020
Date analysed	-	08/07/2020
Arsenic-Dissolved	μg/L	<1
Cadmium-Dissolved	μg/L	<0.1
Chromium-Dissolved	μg/L	<1
Copper-Dissolved	μg/L	<1
Lead-Dissolved	μg/L	<1
Mercury-Dissolved	μg/L	<0.05
Nickel-Dissolved	μg/L	<1
Zinc-Dissolved	μg/L	<1
Molybdenum-Dissolved	μg/L	<1

Miscellaneous Inorganics					
Our Reference		246440-1	246440-2	246440-3	246440-4
Your Reference	UNITS	K11/3E	K11/1	K11/1S	QC4
Date Sampled		04/07/2020	05/07/2020	05/07/2020	04/07/2020
Type of sample		Water	Water	Water	Water
Date prepared	-	07/07/2020	07/07/2020	07/07/2020	07/07/2020
Date analysed	-	07/07/2020	07/07/2020	07/07/2020	07/07/2020
Ammonia as N in water	mg/L	5.2	0.40	5.1	5.2
Total Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004
Free Cyanide in Water	mg/L	<0.004	<0.004	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005	<0.005	<0.005

Method ID	Methodology Summary
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjsuted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hyperchlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-023	Water samples are analysed directly by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date extracted	-			08/07/2020	[NT]	[NT]	[NT]	[NT]	08/07/2020	[NT]
Date analysed	-			08/07/2020	[NT]	[NT]	[NT]	[NT]	08/07/2020	[NT]
TRH C_6 - C_9	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	110	[NT]
TRH C_6 - C_{10}	µg/L	10	Org-023	<10	[NT]	[NT]	[NT]	[NT]	110	[NT]
Benzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Toluene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	109	[NT]
Ethylbenzene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	112	[NT]
m+p-xylene	µg/L	2	Org-023	<2	[NT]	[NT]	[NT]	[NT]	115	[NT]
o-xylene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	116	[NT]
Naphthalene	µg/L	1	Org-023	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	101	[NT]	[NT]	[NT]	[NT]	91	[NT]
Surrogate toluene-d8	%		Org-023	98	[NT]	[NT]	[NT]	[NT]	101	[NT]
Surrogate 4-BFB	%		Org-023	96	[NT]	[NT]	[NT]	[NT]	112	[NT]

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	246440-3
Date extracted	-			08/07/2020	2	08/07/2020	08/07/2020		08/07/2020	08/07/2020
Date analysed	-			08/07/2020	2	08/07/2020	08/07/2020		08/07/2020	08/07/2020
TRH C_{10} - C_{14}	µg/L	50	Org-020	<50	2	<50	<50	0	118	106
TRH C_{15} - C_{28}	µg/L	100	Org-020	<100	2	120	<100	18	105	122
TRH C_{29} - C_{36}	µg/L	100	Org-020	<100	2	<100	<100	0	108	103
TRH >C_{10} - C_{16}	µg/L	50	Org-020	<50	2	<50	<50	0	118	106
TRH >C_{16} - C_{34}	µg/L	100	Org-020	<100	2	120	<100	18	105	122
TRH >C_{34} - C_{40}	µg/L	100	Org-020	<100	2	<100	<100	0	108	103
Surrogate o-Terphenyl	%		Org-020	104	2	128	115	11	99	112

QUALITY CONTROL: PAHs in Water - Low Level					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	246440-3
Date extracted	-			08/07/2020	2	08/07/2020	08/07/2020		08/07/2020	08/07/2020
Date analysed	-			08/07/2020	2	08/07/2020	08/07/2020		08/07/2020	08/07/2020
Naphthalene	µg/L	0.2	Org-022/025	<0.2	2	<0.2	<0.2	0	110	110
Acenaphthylene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Acenaphthene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Fluorene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	102	104
Phenanthrene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	108	98
Anthracene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Fluoranthene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	106	108
Pyrene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	124	110
Benzo(a)anthracene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Chrysene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	92	86
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025	<0.2	2	<0.2	<0.2	0	[NT]	[NT]
Benzo(a)pyrene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	112	108
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025	<0.1	2	<0.1	<0.1	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	99	2	109	102	7	111	94

QUALITY CONTROL: Total Phenolics in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date extracted	-			07/07/2020	[NT]	[NT]	[NT]	[NT]	07/07/2020	[NT]
Date analysed	-			07/07/2020	[NT]	[NT]	[NT]	[NT]	07/07/2020	[NT]
Total Phenolics (as Phenol)	mg/L	0.05	Inorg-031	<0.05	[NT]	[NT]	[NT]	[NT]	103	[NT]

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date prepared	-			08/07/2020	2	08/07/2020	08/07/2020		08/07/2020	[NT]
Date analysed	-			08/07/2020	2	08/07/2020	08/07/2020		08/07/2020	[NT]
Arsenic-Dissolved	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	96	[NT]
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Chromium-Dissolved	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Copper-Dissolved	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	111	[NT]
Lead-Dissolved	µg/L	1	Metals-022	<1	2	<1	<1	0	112	[NT]
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	[NT]	[NT]	[NT]	[NT]	98	[NT]
Nickel-Dissolved	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
Zinc-Dissolved	µg/L	1	Metals-022	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
Molybdenum-Dissolved	µg/L	1	Metals-022	<1	2	4	3	29	96	[NT]

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate					Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	246440-2
Date prepared	-			07/07/2020	1	07/07/2020	07/07/2020		07/07/2020	07/07/2020
Date analysed	-			07/07/2020	1	07/07/2020	07/07/2020		07/07/2020	07/07/2020
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	5.2	5.2	0	94	84
Total Cyanide	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	96	[NT]
Free Cyanide in Water	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	105	[NT]
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	103	[NT]
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	<0.005	1	<0.005	<0.005	0	104	100

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Dissolved Metals: no filtered, preserved sample was received for sample #1-4, therefore the unpreserved sample was filtered through 0.45μm filter at the lab.
Note: there is a possibility some elements may be underestimated.

CHAIN OF CUSTODY - Client

ENVIROLAB

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Client: Hazmat Services
Contact Person: Damien Hendrickx
Project Mgr: Damien Hendrickx
Sampler: DH
Address: Level 1 45C Fitzroy Street Carrington NSW 2294
Phone: 02 49611887 **Mob:** 0431433791
Email: damien@hazmat-services.com.au

Client Project Name / Number / Site etc (ie report title): N249003
PO No.: 4962
Envirolab Quote No. : 16SY078
Date results required: Standard TAT
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Report format: esdat / equis /
Lab Comments:

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Ammonia	Phenols	Free Cyanide/Total cyanide/dissolved cyanide	Hexavalent Chromium	Molybdenum	Lead	PAH	Free Cyanide/Dissolved Cyanide	BTEX	Metals (Standard 8 + Molybdenum)	TRH					Comments: Provide as much information about the sample as you can
1	K11/3E		4/07/2020	Water	x	x	x	x	x	x	x									Please filter from unpreserved bottle for metals analysis
2	K11/1		5/07/2020	Water	x	x	x	x	x	x	x		x		x					Please filter from unpreserved bottle for metals analysis
3	K11/1S		5/07/2020	Water	x	x	x	x	x	x	x		x		x					Please filter from unpreserved bottle for metals analysis
4	QC4		4/07/2020	Water	x	x	x	x	x	x	x									Please filter from unpreserved bottle for metals analysis
5	QC5		5/07/2020	Water							x		x		x					
6	RB-12		4/07/2020	Water										x						
7	RB-13		5/07/2020	Water										x						

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 248440
Date Received: 7/7/20
Time Received: 1105
Received by: JD
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Relinquished by (Company): Hazmat Services
Print Name: Damien Hendrickx
Date & Time: 6/07/2020
Signature:

Received by (Company): ELS SYD
Print Name: Jason Day
Date & Time: 7/7/20 1105
Signature: JDAY

Lab use only:
Samples Received: Cool or Ambient (circle one)
Temperature Received at: 10.9 (if applicable)
Transported by: Hand delivered / courier

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 246645

Client Details

Client	Hazmat Services
Attention	Damien Hendrickx
Address	PO Box 118, Carrington, NSW, 2294

Sample Details

Your Reference	**N249003**
Number of Samples	9 Water
Date samples received	09/07/2020
Date completed instructions received	09/07/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	16/07/2020
Date of Issue	16/07/2020

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Diego Bigolin, Team Leader, Inorganics
Dragana Tomas, Senior Chemist
Loren Bardwell, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

vTRH(C6-C10)/BTEXN in Water					
Our Reference		246645-6	246645-7	246645-8	246645-9
Your Reference	UNITS	RCA1	RCA2	GHD01S	GHD01N
Date Sampled		07/07/2020	07/07/2020	07/07/2020	07/07/2020
Type of sample		Water	Water	Water	Water
Date extracted	-	10/07/2020	10/07/2020	10/07/2020	10/07/2020
Date analysed	-	11/07/2020	11/07/2020	11/07/2020	11/07/2020
TRH C_6 - C_9	µg/L	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10
Benzene	µg/L	<1	<1	2	<1
Toluene	µg/L	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	59	<1
Surrogate Dibromofluoromethane	%	119	120	123	119
Surrogate toluene-d8	%	96	96	98	97
Surrogate 4-BFB	%	101	105	102	101

svTRH (C10-C40) in Water					
Our Reference		246645-6	246645-7	246645-8	246645-9
Your Reference	UNITS	RCA1	RCA2	GHD01S	GHD01N
Date Sampled		07/07/2020	07/07/2020	07/07/2020	07/07/2020
Type of sample		Water	Water	Water	Water
Date extracted	-	13/07/2020	13/07/2020	13/07/2020	13/07/2020
Date analysed	-	14/07/2020	14/07/2020	14/07/2020	14/07/2020
TRH C_{10} - C_{14}	µg/L	<50	51	100	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	<50	74	130	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	74	70	<50
TRH >C_{16} - C_{34}	µg/L	<100	120	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100
Surrogate o-Terphenyl	%	91	75	95	72

PAHs in Water - Low Level						
Our Reference		246645-1	246645-2	246645-3	246645-4	246645-5
Your Reference	UNITS	K12/10E	KS2/1	K12/9	K12/10	K12/9E
Date Sampled		06/07/2020	06/07/2020	07/07/2020	07/07/2020	07/07/2020
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	13/07/2020	13/07/2020	13/07/2020	13/07/2020	13/07/2020
Date analysed	-	13/07/2020	13/07/2020	13/07/2020	13/07/2020	13/07/2020
Naphthalene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	81	85	73	84	80

PAHs in Water - Low Level					
Our Reference		246645-6	246645-7	246645-8	246645-9
Your Reference	UNITS	RCA1	RCA2	GHD01S	GHD01N
Date Sampled		07/07/2020	07/07/2020	07/07/2020	07/07/2020
Type of sample		Water	Water	Water	Water
Date extracted	-	13/07/2020	15/07/2020	13/07/2020	13/07/2020
Date analysed	-	13/07/2020	15/07/2020	13/07/2020	13/07/2020
Naphthalene	µg/L	<0.2	0.4	41	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	1.8	<0.1
Acenaphthene	µg/L	<0.1	0.2	2.3	<0.1
Fluorene	µg/L	<0.1	<0.1	0.7	<0.1
Phenanthrene	µg/L	<0.1	0.6	0.8	0.3
Anthracene	µg/L	<0.1	0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	0.4	0.2	<0.1
Pyrene	µg/L	<0.1	0.3	0.2	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	<0.1	2.1	48	0.29
Surrogate p-Terphenyl-d14	%	83	86	75	70

Total Phenolics in Water						
Our Reference		246645-1	246645-2	246645-3	246645-4	246645-5
Your Reference	UNITS	K12/10E	KS2/1	K12/9	K12/10	K12/9E
Date Sampled		06/07/2020	06/07/2020	07/07/2020	07/07/2020	07/07/2020
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	09/07/2020	09/07/2020	09/07/2020	09/07/2020	09/07/2020
Date analysed	-	09/07/2020	09/07/2020	09/07/2020	09/07/2020	09/07/2020
Total Phenolics (as Phenol)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05

Total Phenolics in Water			
Our Reference		246645-8	246645-9
Your Reference	UNITS	GHD01S	GHD01N
Date Sampled		07/07/2020	07/07/2020
Type of sample		Water	Water
Date extracted	-	09/07/2020	09/07/2020
Date analysed	-	09/07/2020	09/07/2020
Total Phenolics (as Phenol)	mg/L	<0.05	<0.05

HM in water - dissolved						
Our Reference		246645-1	246645-2	246645-3	246645-4	246645-5
Your Reference	UNITS	K12/10E	KS2/1	K12/9	K12/10	K12/9E
Date Sampled		06/07/2020	06/07/2020	07/07/2020	07/07/2020	07/07/2020
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	13/07/2020	13/07/2020	13/07/2020	13/07/2020	13/07/2020
Date analysed	-	13/07/2020	13/07/2020	13/07/2020	13/07/2020	13/07/2020
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Molybdenum-Dissolved	µg/L	<1	50	<1	<1	<1

HM in water - dissolved			
Our Reference		246645-8	246645-9
Your Reference	UNITS	GHD01S	GHD01N
Date Sampled		07/07/2020	07/07/2020
Type of sample		Water	Water
Date prepared	-	13/07/2020	13/07/2020
Date analysed	-	13/07/2020	13/07/2020
Lead-Dissolved	µg/L	<1	6
Molybdenum-Dissolved	µg/L	37	110

Miscellaneous Inorganics						
Our Reference		246645-1	246645-2	246645-3	246645-4	246645-5
Your Reference	UNITS	K12/10E	KS2/1	K12/9	K12/10	K12/9E
Date Sampled		06/07/2020	06/07/2020	07/07/2020	07/07/2020	07/07/2020
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	09/07/2020	09/07/2020	09/07/2020	09/07/2020	09/07/2020
Date analysed	-	09/07/2020	09/07/2020	09/07/2020	09/07/2020	09/07/2020
Ammonia as N in water	mg/L	1.4	0.033	1.6	6.5	0.49
Total Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Free Cyanide in Water	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics			
Our Reference		246645-8	246645-9
Your Reference	UNITS	GHD01S	GHD01N
Date Sampled		07/07/2020	07/07/2020
Type of sample		Water	Water
Date prepared	-	09/07/2020	09/07/2020
Date analysed	-	09/07/2020	09/07/2020
Ammonia as N in water	mg/L	5.4	0.46
Total Cyanide	mg/L	0.007	0.021
Free Cyanide in Water	mg/L	<0.004	<0.004
Weak Acid Dissociable Cyanide	mg/L	<0.004	<0.004
Hexavalent Chromium, Cr^{6+}	mg/L	<0.005	<0.005

Method ID	Methodology Summary
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjsuted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hyperchlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-024	Hexavalent Chromium (Cr6+) - determined colourimetrically. Waters samples are filtered on receipt prior to analysis.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Metals-022	Determination of various metals by ICP-MS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-023	Water samples are analysed directly by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date extracted	-			10/07/2020	8	10/07/2020	10/07/2020		10/07/2020	[NT]
Date analysed	-			11/07/2020	8	11/07/2020	11/07/2020		11/07/2020	[NT]
TRH C_6 - C_9	µg/L	10	Org-023	<10	8	<10	<10	0	110	[NT]
TRH C_6 - C_{10}	µg/L	10	Org-023	<10	8	<10	<10	0	110	[NT]
Benzene	µg/L	1	Org-023	<1	8	2	2	0	98	[NT]
Toluene	µg/L	1	Org-023	<1	8	<1	<1	0	102	[NT]
Ethylbenzene	µg/L	1	Org-023	<1	8	<1	<1	0	111	[NT]
m+p-xylene	µg/L	2	Org-023	<2	8	<2	<2	0	119	[NT]
o-xylene	µg/L	1	Org-023	<1	8	<1	<1	0	118	[NT]
Naphthalene	µg/L	1	Org-023	<1	8	59	56	5	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	108	8	123	110	11	99	[NT]
Surrogate toluene-d8	%		Org-023	96	8	98	97	1	98	[NT]
Surrogate 4-BFB	%		Org-023	102	8	102	107	5	122	[NT]

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	246645-9
Date extracted	-			13/07/2020	6	13/07/2020	13/07/2020		13/07/2020	13/07/2020
Date analysed	-			14/07/2020	6	14/07/2020	14/07/2020		14/07/2020	14/07/2020
TRH C_{10} - C_{14}	µg/L	50	Org-020	<50	6	<50	<50	0	82	90
TRH C_{15} - C_{28}	µg/L	100	Org-020	<100	6	<100	<100	0	70	74
TRH C_{29} - C_{36}	µg/L	100	Org-020	<100	6	<100	<100	0	87	103
TRH >C_{10} - C_{16}	µg/L	50	Org-020	<50	6	<50	<50	0	82	90
TRH >C_{16} - C_{34}	µg/L	100	Org-020	<100	6	<100	<100	0	70	74
TRH >C_{34} - C_{40}	µg/L	100	Org-020	<100	6	<100	<100	0	87	103
Surrogate o-Terphenyl	%		Org-020	91	6	91	89	2	92	100

QUALITY CONTROL: PAHs in Water - Low Level						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W4	246645-7
Date extracted	-			13/07/2020	6	13/07/2020	13/07/2020		13/07/2020	13/07/2020
Date analysed	-			13/07/2020	6	13/07/2020	13/07/2020		13/07/2020	13/07/2020
Naphthalene	µg/L	0.2	Org-022/025	<0.2	6	<0.2	<0.2	0	112	78
Acenaphthylene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Acenaphthene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Fluorene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	100	74
Phenanthrene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	94	66
Anthracene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Fluoranthene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	96	70
Pyrene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	102	70
Benzo(a)anthracene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Chrysene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	82	70
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025	<0.2	6	<0.2	<0.2	0	[NT]	[NT]
Benzo(a)pyrene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	98	74
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025	<0.1	6	<0.1	<0.1	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	93	6	83	87	5	90	119

QUALITY CONTROL: Total Phenolics in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	246645-2
Date extracted	-			09/07/2020	1	09/07/2020	09/07/2020		09/07/2020	09/07/2020
Date analysed	-			09/07/2020	1	09/07/2020	09/07/2020		09/07/2020	09/07/2020
Total Phenolics (as Phenol)	mg/L	0.05	Inorg-031	<0.05	1	<0.05	<0.05	0	102	84

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	246645-2
Date prepared	-			13/07/2020	3	13/07/2020	13/07/2020		13/07/2020	13/07/2020
Date analysed	-			13/07/2020	3	13/07/2020	13/07/2020		13/07/2020	13/07/2020
Lead-Dissolved	µg/L	1	Metals-022	<1	3	<1	<1	0	100	87
Molybdenum-Dissolved	µg/L	1	Metals-022	<1	3	<1	<1	0	96	101

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate					Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	246645-2
Date prepared	-			09/07/2020	1	09/07/2020	09/07/2020		09/07/2020	09/07/2020
Date analysed	-			09/07/2020	1	09/07/2020	09/07/2020		09/07/2020	09/07/2020
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	1.4	1.4	0	109	105
Total Cyanide	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	89	97
Free Cyanide in Water	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	96	92
Weak Acid Dissociable Cyanide	mg/L	0.004	Inorg-014	<0.004	1	<0.004	<0.004	0	96	87
Hexavalent Chromium, Cr^{6+}	mg/L	0.005	Inorg-024	<0.005	1	<0.005	<0.005	0	106	112

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Dissolved Metals: no filtered, preserved sample was received for samples #1 & 9, therefore the unpreserved sample was filtered through 0.45μm filter at the lab.
Note: there is a possibility some elements may be underestimated.

CHAIN OF CUSTODY - Client

ENVIROLAB GROUP - National phone number 1300 42 43 44

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DA→1-5, 8,

Client: Hazmat Services
Contact Person: Damien Hendrickx
Project Mgr: Damien Hendrickx
Sampler: TG/HR
Address: Level 1 45C Fitzroy Street Carrington NSW 2294
Phone: 02 49611887 **Mob:** 0431433791
Email: damien@hazmat-services.com.au

Client Project Name / Number / Site etc (ie report title): N249003
PO No.: 4981
Envirolab Quote No. : 16SY078
Date results required: Standard TAT
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Report format: esdat / equis /
Lab Comments:

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Ammonia	Phenols	Free Cyanide/Total cyanide/dissolved cyanide	Hexavalent Chromium	Molybdenum	Lead	PAH	Free Cyanide/Dissolved Cyanide	BTEX	Metals (Standard 8 + Molybdenum)	TRH					Comments: Provide as much information about the sample as you can
1	K12/10E		6/07/2020	Water	x	x	x	x	x	x	x									Please filter from unpreserved bottle for metals analysis.
2	KS2/1		6/07/2020	Water	x	x	x	x	x	x	x									
3	K12/9		7/07/2020	Water	x	x	x	x	x	x	x									
4	K12/10		7/07/2020	Water	x	x	x	x	x	x	x									
5	K12/9E		7/07/2020	Water	x	x	x	x	x	x	x									
6	RCA1		7/07/2020	Water							x		x		x					
7	RCA2		7/07/2020	Water							x		x		x					
8	GHD01S		7/07/2020	Water	x	x	x	x	x	x	x		x		x					
9	GHD01N		7/07/2020	Water	x	x	x	x	x	x	x		x		x					Please filter from unpreserved bottle for metals analysis
NR	RB-14		6/07/2020	Water										x						
NR	RB-15		7/07/2020	Water										x						

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 246045
Date Received: 9/7/20
Time Received: 1104
Received By: CM
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Relinquished by (Company): Hazmat Services	**Received by (Company):** ELS Syd	*Lab use only:*	
Print Name: Damien Hendrickx	**Print Name:** C-McKenz	**Samples Received:** Cool or Ambient (circle one)	
Date & Time: 8/07/2020	**Date & Time:** 9/7/20 1104	**Temperature Received at:** 6.5 (if applicable)	
Signature:	**Signature:** CM	**Transported by:** Hand delivered / courier	

White - Lab copy / Blue - Client copy / Pink - Retain in Book

Page No:

CERTIFICATE OF ANALYSIS

Work Order	: **ES2022017**	Page	: 1 of 5
Client	: **HAZMAT SERVICES PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR DAMIEN HENDRICKX	Contact	: Customer Services ES
Address	:	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4961 1887	Telephone	: +61-2-8784 8555
Project	: N249003	Date Samples Received	: 25-Jun-2020 19:30
Order number	: 4933	Date Analysis Commenced	: 26-Jun-2020
C-O-C number	: ----	Issue Date	: 02-Jul-2020 15:58
Sampler	: TG/HR		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ashesh Patel	Senior Chemist	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	QCA1	QCA2	----	----	----
			Client sampling date / time	23-Jun-2020 00:00	24-Jun-2020 00:00	----	----	----
Compound	CAS Number	LOR	Unit	ES2022017-001	ES2022017-002	--------	--------	--------
				Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.017**	<0.001	----	----	----
EG050F: Dissolved Hexavalent Chromium								
Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	<0.01	----	----	----
EK025SF: Free CN by Segmented Flow Analyser								
Free Cyanide	----	0.004	mg/L	<0.004	<0.004	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	----	----	----
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser								
Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	<0.004	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**1.46**	**0.88**	----	----	----
EP035SF: Total Phenol by Segmented Flow Analyser								
Phenols (Total)	----	0.05	mg/L	<0.05	<0.05	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	----	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	----	----	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	----	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	----	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	----	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	----	----	----
^ **Sum of polycyclic aromatic hydrocarbons**	----	0.5	µg/L	<0.5	<0.5	----	----	----
^ **Benzo(a)pyrene TEQ (zero)**	----	0.5	µg/L	<0.5	<0.5	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	QCA1	QCA2	----	----	----
			Client sampling date / time	23-Jun-2020 00:00	24-Jun-2020 00:00	----	----	----
Compound	CAS Number	LOR	Unit	ES2022017-001	ES2022017-002	--------	--------	--------
				Result	Result	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates - Continued								
Phenol-d6	13127-88-3	1.0	%	**20.2**	**26.4**	----	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%	**50.8**	**54.4**	----	----	----
2.4.6-Tribromophenol	118-79-6	1.0	%	**43.6**	**41.4**	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	**72.6**	**71.5**	----	----	----
Anthracene-d10	1719-06-8	1.0	%	**92.7**	**82.2**	----	----	----
4-Terphenyl-d14	1718-51-0	1.0	%	**90.2**	**74.2**	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	Recovery Limits (%) High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	44
2-Chlorophenol-D4	93951-73-6	14	94
2.4.6-Tribromophenol	118-79-6	17	125
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	20	104
Anthracene-d10	1719-06-8	27	113
4-Terphenyl-d14	1718-51-0	32	112

QUALITY CONTROL REPORT

Work Order	: **ES2022017**	Page	: 1 of 6
Client	: **HAZMAT SERVICES PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR DAMIEN HENDRICKX	Contact	: Customer Services ES
Address	:	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4961 1887	Telephone	: +61-2-8784 8555
Project	: N249003	Date Samples Received	: 25-Jun-2020
Order number	: 4933	Date Analysis Commenced	: 26-Jun-2020
C-O-C number	: ----	Issue Date	: 02-Jul-2020
Sampler	: TG/HR		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ashesh Patel	Senior Chemist	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP035SF: Total Phenol by Segmented Flow Analyser (QC Lot: 3102478)									
ES2021565-001	Anonymous	EP035SF: Phenols (Total)	----	0.05	mg/L	<0.05	<0.05	0.00	No Limit
ES2021905-003	Anonymous	EP035SF: Phenols (Total)	----	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 3107935)									
EW2002895-001	Anonymous	EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EW2002930-001	Anonymous	EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EG050F: Dissolved Hexavalent Chromium (QC Lot: 3111988)									
ES2022017-001	QCA1	EG050G-F: Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK025SF: Free CN by Segmented Flow Analyser (QC Lot: 3102473)									
ES2021987-014	Anonymous	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
ES2021988-008	Anonymous	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK025SF: Free CN by Segmented Flow Analyser (QC Lot: 3102477)									
ES2022017-002	QCA2	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 3102475)									
ES2021987-017	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit
ES2021988-008	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser (QC Lot: 3102474)									
ES2021987-014	Anonymous	EK028SF: Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
ES2021988-008	Anonymous	EK028SF: Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser (QC Lot: 3102476)									
ES2022017-002	QCA2	EK028SF: Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 3105322)									

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 3105322) - continued									
ES2022017-002	QCA2	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.88	0.91	3.35	0% - 20%
ES2021787-004	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.32	0.32	0.00	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EP035SF: Total Phenol by Segmented Flow Analyser (QCLot: 3102478)								
EP035SF: Phenols (Total)	----	0.05	mg/L	<0.05	0.2 mg/L	97.0	70.9	123
EG020F: Dissolved Metals by ICP-MS (QCLot: 3107935)								
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	90.1	83.0	111
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	93.7	79.0	113
EG050F: Dissolved Hexavalent Chromium (QCLot: 3111988)								
EG050G-F: Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	0.05 mg/L	99.9	86.0	112
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 3102473)								
EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	102	88.0	128
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 3102477)								
EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	108	88.0	128
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 3102475)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	125	73.0	133
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser (QCLot: 3102474)								
EK028SF: Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	118	93.0	127
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser (QCLot: 3102476)								
EK028SF: Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	113	93.0	127
EK055G: Ammonia as N by Discrete Analyser (QCLot: 3105322)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	1 mg/L	106	90.0	114
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 3102662)								
EP075(SIM): Naphthalene	91-20-3	1	µg/L	<1.0	5 µg/L	66.2	50.0	94.0
EP075(SIM): Acenaphthylene	208-96-8	1	µg/L	<1.0	5 µg/L	82.9	63.6	114
EP075(SIM): Acenaphthene	83-32-9	1	µg/L	<1.0	5 µg/L	83.6	62.2	113
EP075(SIM): Fluorene	86-73-7	1	µg/L	<1.0	5 µg/L	86.8	63.9	115
EP075(SIM): Phenanthrene	85-01-8	1	µg/L	<1.0	5 µg/L	74.5	62.6	116
EP075(SIM): Anthracene	120-12-7	1	µg/L	<1.0	5 µg/L	80.9	64.3	116
EP075(SIM): Fluoranthene	206-44-0	1	µg/L	<1.0	5 µg/L	95.8	63.6	118
EP075(SIM): Pyrene	129-00-0	1	µg/L	<1.0	5 µg/L	100	63.1	118
EP075(SIM): Benz(a)anthracene	56-55-3	1	µg/L	<1.0	5 µg/L	69.6	64.1	117
EP075(SIM): Chrysene	218-01-9	1	µg/L	<1.0	5 µg/L	79.6	62.5	116
EP075(SIM): Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	5 µg/L	74.9	61.7	119
EP075(SIM): Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	5 µg/L	99.4	63.0	115
EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	5 µg/L	75.6	63.3	117

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	High
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 3102662) - continued								
EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	5 µg/L	68.8	59.9	118
EP075(SIM): Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	5 µg/L	71.0	61.2	117
EP075(SIM): Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	5 µg/L	71.2	59.1	118
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 3103203)								
EP075(SIM): Naphthalene	91-20-3	1	µg/L	<1.0	5 µg/L	72.1	50.0	94.0
EP075(SIM): Acenaphthylene	208-96-8	1	µg/L	<1.0	5 µg/L	77.0	63.6	114
EP075(SIM): Acenaphthene	83-32-9	1	µg/L	<1.0	5 µg/L	80.3	62.2	113
EP075(SIM): Fluorene	86-73-7	1	µg/L	<1.0	5 µg/L	81.7	63.9	115
EP075(SIM): Phenanthrene	85-01-8	1	µg/L	<1.0	5 µg/L	74.0	62.6	116
EP075(SIM): Anthracene	120-12-7	1	µg/L	<1.0	5 µg/L	84.0	64.3	116
EP075(SIM): Fluoranthene	206-44-0	1	µg/L	<1.0	5 µg/L	73.0	63.6	118
EP075(SIM): Pyrene	129-00-0	1	µg/L	<1.0	5 µg/L	71.9	63.1	118
EP075(SIM): Benz(a)anthracene	56-55-3	1	µg/L	<1.0	5 µg/L	70.3	64.1	117
EP075(SIM): Chrysene	218-01-9	1	µg/L	<1.0	5 µg/L	76.4	62.5	116
EP075(SIM): Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	5 µg/L	72.1	61.7	119
EP075(SIM): Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	5 µg/L	82.4	63.0	115
EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	5 µg/L	75.4	63.3	117
EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	5 µg/L	85.3	59.9	118
EP075(SIM): Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	5 µg/L	82.5	61.2	117
EP075(SIM): Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	5 µg/L	75.6	59.1	118

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	High
EP035SF: Total Phenol by Segmented Flow Analyser (QCLot: 3102478)							
ES2021565-001	Anonymous	EP035SF: Phenols (Total)	----	0.2 mg/L	95.0	65.1	128
EG020F: Dissolved Metals by ICP-MS (QCLot: 3107935)							
ES2022012-001	Anonymous	EG020A-F: Lead	7439-92-1	1 mg/L	128	70.0	130
EG050F: Dissolved Hexavalent Chromium (QCLot: 3111988)							
ES2022017-001	QCA1	EG050G-F: Hexavalent Chromium	18540-29-9	0.05 mg/L	85.8	70.0	130
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 3102473)							
ES2021987-017	Anonymous	EK025SF: Free Cyanide	----	0.2 mg/L	106	70.0	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 3102477)							
ES2022017-002	QCA2	EK025SF: Free Cyanide	----	0.2 mg/L	104	70.0	130
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 3102475)							
ES2021987-017	Anonymous	EK026SF: Total Cyanide	57-12-5	0.2 mg/L	107	70.0	130
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser (QCLot: 3102474)							
ES2021987-017	Anonymous	EK028SF: Weak Acid Dissociable Cyanide	----	0.2 mg/L	107	70.0	130
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser (QCLot: 3102476)							
ES2022017-002	QCA2	EK028SF: Weak Acid Dissociable Cyanide	----	0.2 mg/L	102	70.0	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 3105322)							
ES2021787-004	Anonymous	EK055G: Ammonia as N	7664-41-7	1 mg/L	96.0	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ES2022017**	Page	: 1 of 7
Client	: **HAZMAT SERVICES PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR DAMIEN HENDRICKX	Telephone	: +61-2-8784 8555
Project	: N249003	Date Samples Received	: 25-Jun-2020
Site	: ----	Issue Date	: 02-Jul-2020
Sampler	: TG/HR	No. of samples received	: 2
Order number	: 4933	No. of samples analysed	: 2

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type / Method	Count QC	Count Regular	Rate (%) Actual	Rate (%) Expected	Quality Control Specification
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	0	22	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
PAH/Phenols (GC/MS - SIM)	0	22	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) QCA1	**23-Jun-2020**	**----**	----	----	**29-Jun-2020**	20-Dec-2020	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) QCA2	**24-Jun-2020**	**----**	----	----	**29-Jun-2020**	21-Dec-2020	✓
EG050F: Dissolved Hexavalent Chromium							
Clear Plastic Bottle - NaOH (EG050G-F) QCA1	**23-Jun-2020**	**----**	----	----	**01-Jul-2020**	21-Jul-2020	✓
Clear Plastic Bottle - NaOH (EG050G-F) QCA2	**24-Jun-2020**	**----**	----	----	**01-Jul-2020**	22-Jul-2020	✓
EK025SF: Free CN by Segmented Flow Analyser							
Opaque plastic bottle - NaOH (EK025SF) QCA1	**23-Jun-2020**	**----**	----	----	**26-Jun-2020**	07-Jul-2020	✓
Opaque plastic bottle - NaOH (EK025SF) QCA2	**24-Jun-2020**	**----**	----	----	**26-Jun-2020**	08-Jul-2020	✓
EK026SF: Total CN by Segmented Flow Analyser							
Opaque plastic bottle - NaOH (EK026SF) QCA1	**23-Jun-2020**	**----**	----	----	**26-Jun-2020**	07-Jul-2020	✓
Opaque plastic bottle - NaOH (EK026SF) QCA2	**24-Jun-2020**	**----**	----	----	**26-Jun-2020**	08-Jul-2020	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser							
Opaque plastic bottle - NaOH (EK028SF) QCA1	**23-Jun-2020**	**----**	----	----	**26-Jun-2020**	07-Jul-2020	✓
Opaque plastic bottle - NaOH (EK028SF) QCA2	**24-Jun-2020**	**----**	----	----	**26-Jun-2020**	08-Jul-2020	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK055G) QCA1	**23-Jun-2020**	**----**	----	----	**27-Jun-2020**	21-Jul-2020	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) QCA2	**24-Jun-2020**	**----**	----	----	**27-Jun-2020**	22-Jul-2020	✓
EP035SF: Total Phenol by Segmented Flow Analyser							
Clear Plastic Bottle - Sulfuric Acid (EP035SF) QCA1	**23-Jun-2020**	**----**	----	----	**26-Jun-2020**	21-Jul-2020	✓
Clear Plastic Bottle - Sulfuric Acid (EP035SF) QCA2	**24-Jun-2020**	**----**	----	----	**26-Jun-2020**	22-Jul-2020	✓
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons							
Amber Glass Bottle - Unpreserved (EP075(SIM)) QCA1	**23-Jun-2020**	**26-Jun-2020**	30-Jun-2020	✓	**27-Jun-2020**	05-Aug-2020	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) QCA2	**24-Jun-2020**	**26-Jun-2020**	01-Jul-2020	✓	**29-Jun-2020**	05-Aug-2020	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Ammonia as N by Discrete analyser	EK055G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	3	21	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	22	**0.00**	**10.00**	✗	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phenol by Segmented Flow Analyser	EP035SF	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	3	21	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N by Discrete analyser	EK055G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	2	22	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phenol by Segmented Flow Analyser	EP035SF	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	2	22	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phenol by Segmented Flow Analyser	EP035SF	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	22	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
Total Phenol by Segmented Flow Analyser	EP035SF	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	WATER	In house: Referenced to APHA 3500 Cr-A & B. Samples are 0.45µm filtered prior to analysis. Hexavalent chromium is determined directly on water sample by Descrete Analyser as received by pH adjustment and colour development using dephenylcarbazide. Each run of samples is measured against a five-point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Free CN by Segmented Flow Analyser	EK025SF	WATER	In house: Referenced to ASTM D7237: Using an automated segmented flow analyser, a sample at high pH (sodium hydroxide preserved) is buffered to pH 6.0. The hydrogen cyanide present passes across a gas dialysis membrane into an acceptor stream consisting of 0.01 M sodium hydroxide. The acceptor stream mixes with a buffer at pH 5.2 and reacts with chloramine-T to form cyanogen chloride. Cyanogen chloride reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour, measured at 600nm. This method is compliant with NEPM (2013) Schedule B(3)
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	In house: Referenced to APHA 4500-CN C / ASTM D7511. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (2013) Schedule B(3)
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	WATER	In house: Referenced to APHA 4500-CN C&O. Samples preserved with sodium hydroxide are introduced into an automated segmented flow analyser. Hydrogen cyanide is liberated from a slightly acidified (pH 4.5) and is dialysed. Tight cyanide complexes that would not be amenable to oxidation by chlorine are not converted. Iron cyanide complexes are precipitated with zinc acetate. Liberated HCN diffuses through a membrane into a stream of sodium hydroxide where it is carried as CN- The cyanide in caustic solution is buffered to pH 5.2 and further converted to cyanogen chloride by reaction with chloramine-T. Cyanogen chloride subsequently reacts with 4 ¿pyridine carboxylic and 1,3 - dimethylbarbituric acids to give a red colour complex. This colour is measured at 600 nm. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Phenol by Segmented Flow Analyser	EP035SF	WATER	In house: Referenced to ISO 14402. The sample is in-line-distilled at pH 1- 4. The distillate, containing steam-volatile phenolic compounds is then oxidised by hexacyanoferrate(III). The resulting quinones react with 4-aminoantipyrine forming red condensation products, which are measured spectrometrically in a flow spectrometer at 505 nm.. This method is compliant with NEPM (2013) Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270E Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.

LAB OF ORIGIN:
NEWCASTLE

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle**: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ **Brisbane**: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville**: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ **Melbourne**: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide**: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Perth**: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston**: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: Hazmat Services
OFFICE: Level 1, 45C Fitzroy Street, Carrington NSW 2294
PROJECT: N249003
ORDER NUMBER: 4933
PROJECT MANAGER: Damien Hendrickx — **CONTACT PH:** 02 4911887
SAMPLER: TG/HR — **SAMPLER MOBILE:**
COC Emailed to ALS? (YES / NO) — **EDD FORMAT (or default):**
Email Reports to : damien@hazmat-services.com.au
Email Invoice to: admin@hazmat-services.com.au; damien@hazmat-services.com.au

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: SYBQ/478
COUNTRY OF ORIGIN:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt:
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Tim Grundy	MM 3.10pm		AS
DATE/TIME: 24/6/20	DATE/TIME: 25/06/20	DATE/TIME:	DATE/TIME: 7.30am 25/6/20

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).									Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	Ammonia	Phenols	Free Cyanide/ Total Cyanide/ dissolved Cyanide	Hexavalent Chromiun	Molybdenum	Lead	Total PAH	BTEX	TPH	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	QCA1	23/06/2020	Water			X	X	X	X	X	X	X			
2	QCA2	24/06/2020	Water			X	X	X	X	X	X	X			
				TOTAL											

Environmental Division
Sydney
Work Order Reference
ES2022017
Telephone : + 61-2-8784 8555

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

CERTIFICATE OF ANALYSIS

Work Order	: **ES2023180**	Page	: 1 of 6
Client	: **HAZMAT SERVICES PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR DAMIEN HENDRICKX	Contact	: Customer Services ES
Address	:	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4961 1887	Telephone	: +61-2-8784 8555
Project	: N249003	Date Samples Received	: 06-Jul-2020 11:37
Order number	: 4963	Date Analysis Commenced	: 07-Jul-2020
C-O-C number	: ----	Issue Date	: 13-Jul-2020 12:11
Sampler	: DH		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ashesh Patel	Senior Chemist	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG050G: LOR raised for Hexavalent Chromium due to sample matrix.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	QCA3	QCA4	QCA5	----	----
			Client sampling date / time	03-Jul-2020 00:00	04-Jul-2020 00:00	05-Jul-2020 00:00	----	----
Compound	CAS Number	LOR	Unit	ES2023180-001	ES2023180-002	ES2023180-003	--------	--------
				Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS								
Lead	7439-92-1	0.001	mg/L	----	<0.001	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	----	**0.006**	----	----	----
EG050F: Dissolved Hexavalent Chromium								
Hexavalent Chromium	18540-29-9	0.01	mg/L	----	<0.05	----	----	----
EK025SF: Free CN by Segmented Flow Analyser								
Free Cyanide	----	0.004	mg/L	----	<0.004	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	----	<0.004	----	----	----
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser								
Weak Acid Dissociable Cyanide	----	0.004	mg/L	----	<0.004	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	----	**0.32**	----	----	----
EP035SF: Total Phenol by Segmented Flow Analyser								
Phenols (Total)	----	0.05	mg/L	----	<0.05	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	<1.0	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	<0.5	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	<0.5	----	----
EP080/071: Total Petroleum Hydrocarbons								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	QCA3	QCA4	QCA5	----	----
			Client sampling date / time	03-Jul-2020 00:00	04-Jul-2020 00:00	05-Jul-2020 00:00	----	----
Compound	CAS Number	LOR	Unit	ES2023180-001	ES2023180-002	ES2023180-003	--------	--------
				Result	Result	Result	----	----
EP080/071: Total Petroleum Hydrocarbons - Continued								
C6 - C9 Fraction	----	20	µg/L	<20	----	<20	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	<50	----	----
C15 - C28 Fraction	----	100	µg/L	**870**	----	<100	----	----
C29 - C36 Fraction	----	50	µg/L	**330**	----	<50	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	**1200**	----	<50	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	<20	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	<20	----	----
>C10 - C16 Fraction	----	100	µg/L	**530**	----	<100	----	----
>C16 - C34 Fraction	----	100	µg/L	**620**	----	<100	----	----
>C34 - C40 Fraction	----	100	µg/L	**250**	----	<100	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	**1400**	----	<100	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	**530**	----	<100	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	<1	----	----
Toluene	108-88-3	2	µg/L	<2	----	<2	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	<2	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	<2	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	<2	----	----
^ Total Xylenes	----	2	µg/L	<2	----	<2	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	<1	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	<5	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	**23.4**	**19.3**	**21.2**	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%	**45.1**	**47.5**	**46.3**	----	----
2.4.6-Tribromophenol	118-79-6	1.0	%	**66.7**	**43.1**	**39.3**	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	**71.2**	**62.4**	**73.8**	----	----
Anthracene-d10	1719-06-8	1.0	%	**89.4**	**65.0**	**82.2**	----	----
4-Terphenyl-d14	1718-51-0	1.0	%	**64.9**	**65.6**	**89.3**	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**83.3**	----	**106**	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	QCA3	QCA4	QCA5	----	----
			Client sampling date / time	03-Jul-2020 00:00	04-Jul-2020 00:00	05-Jul-2020 00:00	----	----
Compound	CAS Number	LOR	Unit	ES2023180-001	ES2023180-002	ES2023180-003	--------	--------
				Result	Result	Result	----	----
EP080S: TPH(V)/BTEX Surrogates - Continued								
Toluene-D8	2037-26-5	2	%	**96.2**	**----**	**117**	**----**	**----**
4-Bromofluorobenzene	460-00-4	2	%	**90.3**	**----**	**115**	**----**	**----**

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	*CAS Number*	*Recovery Limits (%)* Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	44
2-Chlorophenol-D4	93951-73-6	14	94
2.4.6-Tribromophenol	118-79-6	17	125
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	20	104
Anthracene-d10	1719-06-8	27	113
4-Terphenyl-d14	1718-51-0	32	112
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

QUALITY CONTROL REPORT

Work Order	: **ES2023180**	Page	: 1 of 7
Client	: **HAZMAT SERVICES PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR DAMIEN HENDRICKX	Contact	: Customer Services ES
Address	:	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4961 1887	Telephone	: +61-2-8784 8555
Project	: N249003	Date Samples Received	: 06-Jul-2020
Order number	: 4963	Date Analysis Commenced	: 07-Jul-2020
C-O-C number	: ----	Issue Date	: 13-Jul-2020
Sampler	: DH		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ashesh Patel	Senior Chemist	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP035SF: Total Phenol by Segmented Flow Analyser (QC Lot: 3122541)									
ES2023178-001	Anonymous	EP035SF: Phenols (Total)	----	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 3122804)									
ES2022820-013	Anonymous	EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.007	0.006	0.00	No Limit
ES2023041-001	Anonymous	EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EG050F: Dissolved Hexavalent Chromium (QC Lot: 3128596)									
ES2023180-002	QCA4	EG050G-F: Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.05	<0.05	0.00	No Limit
EK025SF: Free CN by Segmented Flow Analyser (QC Lot: 3122539)									
ES2023180-002	QCA4	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 3122537)									
ES2023180-002	QCA4	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser (QC Lot: 3122538)									
ES2023180-002	QCA4	EK028SF: Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 3124448)									
ES2023169-001	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.03	0.04	34.0	No Limit
ES2023228-011	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.02	0.02	0.00	No Limit
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QC Lot: 3123028)									
ES2023212-001	Anonymous	EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EP075(SIM): Naphthalene	91-20-3	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Acenaphthylene	208-96-8	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Acenaphthene	83-32-9	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Fluorene	86-73-7	1	µg/L	<1.0	<1.0	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QC Lot: 3123028) - continued									
ES2023212-001	Anonymous	EP075(SIM): Phenanthrene	85-01-8	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Anthracene	120-12-7	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Fluoranthene	206-44-0	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Pyrene	129-00-0	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Benz(a)anthracene	56-55-3	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Chrysene	218-01-9	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	<1.0	0.00	No Limit
		EP075(SIM): Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	<1.0	0.00	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 3123027)									
ES2023212-001	Anonymous	EP071: C15 - C28 Fraction	----	100	µg/L	<100	<100	0.00	No Limit
		EP071: C10 - C14 Fraction	----	50	µg/L	<50	<50	0.00	No Limit
		EP071: C29 - C36 Fraction	----	50	µg/L	<50	<50	0.00	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 3124662)									
ES2023212-004	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
ES2023250-001	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 3123027)									
ES2023212-001	Anonymous	EP071: >C10 - C16 Fraction	----	100	µg/L	<100	<100	0.00	No Limit
		EP071: >C16 - C34 Fraction	----	100	µg/L	<100	<100	0.00	No Limit
		EP071: >C34 - C40 Fraction	----	100	µg/L	<100	<100	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 3124662)									
ES2023212-004	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
ES2023250-001	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EP080: BTEXN (QC Lot: 3124662)									
ES2023212-004	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit
ES2023250-001	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP080: BTEXN (QC Lot: 3124662) - continued									
ES2023250-001	Anonymous	EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EP035SF: Total Phenol by Segmented Flow Analyser (QCLot: 3122541)								
EP035SF: Phenols (Total)	----	0.05	mg/L	<0.05	0.2 mg/L	98.5	70.9	123
EG020F: Dissolved Metals by ICP-MS (QCLot: 3122804)								
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	93.6	83.0	111
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	100	79.0	113
EG050F: Dissolved Hexavalent Chromium (QCLot: 3128596)								
EG050G-F: Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	0.05 mg/L	99.6	86.0	112
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 3122539)								
EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	110	88.0	128
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 3122537)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	107	73.0	133
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser (QCLot: 3122538)								
EK028SF: Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	117	93.0	127
EK055G: Ammonia as N by Discrete Analyser (QCLot: 3124448)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	1 mg/L	102	90.0	114
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 3123028)								
EP075(SIM): Naphthalene	91-20-3	1	µg/L	<1.0	5 µg/L	75.1	50.0	94.0
EP075(SIM): Acenaphthylene	208-96-8	1	µg/L	<1.0	5 µg/L	79.2	63.6	114
EP075(SIM): Acenaphthene	83-32-9	1	µg/L	<1.0	5 µg/L	81.4	62.2	113
EP075(SIM): Fluorene	86-73-7	1	µg/L	<1.0	5 µg/L	79.0	63.9	115
EP075(SIM): Phenanthrene	85-01-8	1	µg/L	<1.0	5 µg/L	71.6	62.6	116
EP075(SIM): Anthracene	120-12-7	1	µg/L	<1.0	5 µg/L	95.8	64.3	116
EP075(SIM): Fluoranthene	206-44-0	1	µg/L	<1.0	5 µg/L	98.8	63.6	118
EP075(SIM): Pyrene	129-00-0	1	µg/L	<1.0	5 µg/L	92.8	63.1	118
EP075(SIM): Benz(a)anthracene	56-55-3	1	µg/L	<1.0	5 µg/L	72.0	64.1	117
EP075(SIM): Chrysene	218-01-9	1	µg/L	<1.0	5 µg/L	72.6	62.5	116
EP075(SIM): Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	5 µg/L	77.4	61.7	119
EP075(SIM): Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	5 µg/L	82.8	63.0	115
EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	5 µg/L	69.2	63.3	117
EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	5 µg/L	77.2	59.9	118
EP075(SIM): Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	5 µg/L	67.2	61.2	117
EP075(SIM): Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	5 µg/L	73.3	59.1	118
EP080/071: Total Petroleum Hydrocarbons (QCLot: 3123027)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	High
EP080/071: Total Petroleum Hydrocarbons (QCLot: 3123027) - continued								
EP071: C10 - C14 Fraction	----	50	µg/L	<50	400 µg/L	75.5	55.8	112
EP071: C15 - C28 Fraction	----	100	µg/L	<100	600 µg/L	96.0	71.6	113
EP071: C29 - C36 Fraction	----	50	µg/L	<50	400 µg/L	74.7	56.0	121
EP080/071: Total Petroleum Hydrocarbons (QCLot: 3124662)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	260 µg/L	84.9	75.0	127
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 3123027)								
EP071: >C10 - C16 Fraction	----	100	µg/L	<100	500 µg/L	84.7	57.9	119
EP071: >C16 - C34 Fraction	----	100	µg/L	<100	700 µg/L	89.7	62.5	110
EP071: >C34 - C40 Fraction	----	100	µg/L	<100	300 µg/L	85.7	61.5	121
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 3124662)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	310 µg/L	85.1	75.0	127
EP080: BTEXN (QCLot: 3124662)								
EP080: Benzene	71-43-2	1	µg/L	<1	10 µg/L	89.1	70.0	122
EP080: Toluene	108-88-3	2	µg/L	<2	10 µg/L	95.2	69.0	123
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	10 µg/L	93.7	70.0	120
EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	10 µg/L	92.4	69.0	121
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	10 µg/L	91.6	72.0	122
EP080: Naphthalene	91-20-3	5	µg/L	<5	10 µg/L	86.1	70.0	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	High
EP035SF: Total Phenol by Segmented Flow Analyser (QCLot: 3122541)							
ES2023178-001	Anonymous	EP035SF: Phenols (Total)	----	0.2 mg/L	98.5	65.1	128
EG020F: Dissolved Metals by ICP-MS (QCLot: 3122804)							
ES2022871-017	Anonymous	EG020A-F: Lead	7439-92-1	1 mg/L	121	70.0	130
EG050F: Dissolved Hexavalent Chromium (QCLot: 3128596)							
ES2023180-002	QCA4	EG050G-F: Hexavalent Chromium	18540-29-9	0.05 mg/L	103	70.0	130
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 3122539)							
ES2023180-002	QCA4	EK025SF: Free Cyanide	----	0.2 mg/L	97.6	70.0	130
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 3122537)							
ES2023180-002	QCA4	EK026SF: Total Cyanide	57-12-5	0.2 mg/L	98.7	70.0	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	High
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser (QCLot: 3122538)							
ES2023180-002	QCA4	EK028SF: Weak Acid Dissociable Cyanide	----	0.2 mg/L	105	70.0	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 3124448)							
ES2023169-001	Anonymous	EK055G: Ammonia as N	7664-41-7	1 mg/L	102	70.0	130
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 3123028)							
ES2023212-004	Anonymous	EP075(SIM): Acenaphthene	83-32-9	20 µg/L	75.7	70.0	130
		EP075(SIM): Pyrene	129-00-0	20 µg/L	90.6	70.0	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 3123027)							
ES2023212-004	Anonymous	EP071: C10 - C14 Fraction	----	200 µg/L	91.7	70.0	130
		EP071: C15 - C28 Fraction	----	250 µg/L	126	71.0	130
		EP071: C29 - C36 Fraction	----	200 µg/L	83.2	67.0	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 3124662)							
ES2023212-004	Anonymous	EP080: C6 - C9 Fraction	----	325 µg/L	84.8	70.0	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 3123027)							
ES2023212-004	Anonymous	EP071: >C10 - C16 Fraction	----	250 µg/L	96.9	70.0	130
		EP071: >C16 - C34 Fraction	----	350 µg/L	98.7	75.0	130
		EP071: >C34 - C40 Fraction	----	150 µg/L	87.5	67.0	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 3124662)							
ES2023212-004	Anonymous	EP080: C6 - C10 Fraction	C6_C10	375 µg/L	82.0	70.0	130
EP080: BTEXN (QCLot: 3124662)							
ES2023212-004	Anonymous	EP080: Benzene	71-43-2	25 µg/L	73.6	70.0	130
		EP080: Toluene	108-88-3	25 µg/L	83.6	70.0	130
		EP080: Ethylbenzene	100-41-4	25 µg/L	76.7	70.0	130
		EP080: meta- & para-Xylene	108-38-3 106-42-3	25 µg/L	80.5	70.0	130
		EP080: ortho-Xylene	95-47-6	25 µg/L	77.6	70.0	130
		EP080: Naphthalene	91-20-3	25 µg/L	76.9	70.0	130

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ES2023180**	Page	: 1 of 7
Client	: **HAZMAT SERVICES PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR DAMIEN HENDRICKX	Telephone	: +61-2-8784 8555
Project	: N249003	Date Samples Received	: 06-Jul-2020
Site	: ----	Issue Date	: 13-Jul-2020
Sampler	: DH	No. of samples received	: 3
Order number	: 4963	No. of samples analysed	: 3

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method Container / Client Sample ID(s)	Extraction / Preparation Date extracted	Due for extraction	Days overdue	Analysis Date analysed	Due for analysis	Days overdue
EG050F: Dissolved Hexavalent Chromium						
Amber Glass Bottle - Unpreserved QCA4	----	----	----	09-Jul-2020	05-Jul-2020	**4**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation Date extracted	Due for extraction	Evaluation	Analysis Date analysed	Due for analysis	Evaluation
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) QCA4	**04-Jul-2020**	**----**	----	----	**07-Jul-2020**	31-Dec-2020	✓
EG050F: Dissolved Hexavalent Chromium							
Amber Glass Bottle - Unpreserved (EG050G-F) QCA4	**04-Jul-2020**	**----**	----	----	**09-Jul-2020**	05-Jul-2020	✘
EK025SF: Free CN by Segmented Flow Analyser							
Opaque plastic bottle - NaOH (EK025SF) QCA4	**04-Jul-2020**	**----**	----	----	**07-Jul-2020**	18-Jul-2020	✓
EK026SF: Total CN by Segmented Flow Analyser							
Opaque plastic bottle - NaOH (EK026SF) QCA4	**04-Jul-2020**	**----**	----	----	**07-Jul-2020**	18-Jul-2020	✓
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser							
Opaque plastic bottle - NaOH (EK028SF) QCA4	**04-Jul-2020**	**----**	----	----	**07-Jul-2020**	18-Jul-2020	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK055G) QCA4	**04-Jul-2020**	**----**	----	----	**07-Jul-2020**	01-Aug-2020	✓
EP035SF: Total Phenol by Segmented Flow Analyser							
Clear Plastic Bottle - Sulfuric Acid (EP035SF) QCA4	**04-Jul-2020**	**----**	----	----	**07-Jul-2020**	01-Aug-2020	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons							
Amber Glass Bottle - Unpreserved (EP075(SIM)) QCA3	**03-Jul-2020**	**07-Jul-2020**	10-Jul-2020	✓	**10-Jul-2020**	16-Aug-2020	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) QCA4	**04-Jul-2020**	**07-Jul-2020**	11-Jul-2020	✓	**10-Jul-2020**	16-Aug-2020	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) QCA5	**05-Jul-2020**	**07-Jul-2020**	12-Jul-2020	✓	**10-Jul-2020**	16-Aug-2020	✓
EP080/071: Total Petroleum Hydrocarbons							
Amber Glass Bottle - Unpreserved (EP071) QCA3	**03-Jul-2020**	**07-Jul-2020**	10-Jul-2020	✓	**10-Jul-2020**	16-Aug-2020	✓
Amber Glass Bottle - Unpreserved (EP071) QCA5	**05-Jul-2020**	**07-Jul-2020**	12-Jul-2020	✓	**10-Jul-2020**	16-Aug-2020	✓
Clear glass VOC vial - HCl (EP080) QCA3	**03-Jul-2020**	**09-Jul-2020**	17-Jul-2020	✓	**09-Jul-2020**	17-Jul-2020	✓
Clear glass VOC vial - HCl (EP080) QCA5	**05-Jul-2020**	**09-Jul-2020**	19-Jul-2020	✓	**09-Jul-2020**	19-Jul-2020	✓
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions							
Amber Glass Bottle - Unpreserved (EP071) QCA3	**03-Jul-2020**	**07-Jul-2020**	10-Jul-2020	✓	**10-Jul-2020**	16-Aug-2020	✓
Amber Glass Bottle - Unpreserved (EP071) QCA5	**05-Jul-2020**	**07-Jul-2020**	12-Jul-2020	✓	**10-Jul-2020**	16-Aug-2020	✓
Clear glass VOC vial - HCl (EP080) QCA3	**03-Jul-2020**	**09-Jul-2020**	17-Jul-2020	✓	**09-Jul-2020**	17-Jul-2020	✓
Clear glass VOC vial - HCl (EP080) QCA5	**05-Jul-2020**	**09-Jul-2020**	19-Jul-2020	✓	**09-Jul-2020**	19-Jul-2020	✓
EP080: BTEXN							
Clear glass VOC vial - HCl (EP080) QCA3	**03-Jul-2020**	**09-Jul-2020**	17-Jul-2020	✓	**09-Jul-2020**	17-Jul-2020	✓
Clear glass VOC vial - HCl (EP080) QCA5	**05-Jul-2020**	**09-Jul-2020**	19-Jul-2020	✓	**09-Jul-2020**	19-Jul-2020	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Ammonia as N by Discrete analyser	EK055G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	6	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phenol by Segmented Flow Analyser	EP035SF	1	9	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	6	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N by Discrete analyser	EK055G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	2	3	**66.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phenol by Segmented Flow Analyser	EP035SF	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phenol by Segmented Flow Analyser	EP035SF	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
Ammonia as N by Discrete analyser	EK055G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phenol by Segmented Flow Analyser	EP035SF	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Hexavalent Chromium by Discrete Analyser - Dissolved	EG050G-F	WATER	In house: Referenced to APHA 3500 Cr-A & B. Samples are 0.45µm filtered prior to analysis. Hexavalent chromium is determined directly on water sample by Descrete Analyser as received by pH adjustment and colour development using dephenylcarbazide. Each run of samples is measured against a five-point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Free CN by Segmented Flow Analyser	EK025SF	WATER	In house: Referenced to ASTM D7237: Using an automated segmented flow analyser, a sample at high pH (sodium hydroxide preserved) is buffered to pH 6.0. The hydrogen cyanide present passes across a gas dialysis membrane into an acceptor stream consisting of 0.01 M sodium hydroxide. The acceptor stream mixes with a buffer at pH 5.2 and reacts with chloramine-T to form cyanogen chloride. Cyanogen chloride reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour, measured at 600nm. This method is compliant with NEPM (2013) Schedule B(3)
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	In house: Referenced to APHA 4500-CN C / ASTM D7511. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (2013) Schedule B(3)
Weak Acid Dissociable Cyanide by Segmented Flow Analyser	EK028SF	WATER	In house: Referenced to APHA 4500-CN C&O. Samples preserved with sodium hydroxide are introduced into an automated segmented flow analyser. Hydrogen cyanide is liberated from a slightly acidified (pH 4.5) and is dialysed. Tight cyanide complexes that would not be amenable to oxidation by chlorine are not converted. Iron cyanide complexes are precipitated with zinc acetate. Liberated HCN diffuses through a membrane into a stream of sodium hydroxide where it is carried as CN- The cyanide in caustic solution is buffered to pH 5.2 and further converted to cyanogen chloride by reaction with chloramine-T. Cyanogen chloride subsequently reacts with 4 ¿pyridine carboxylic and 1,3 - dimethylbarbituric acids to give a red colour complex. This colour is measured at 600 nm. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Phenol by Segmented Flow Analyser	EP035SF	WATER	In house: Referenced to ISO 14402. The sample is in-line-distilled at pH 1- 4. The distillate, containing steam-volatile phenolic compounds is then oxidised by hexacyanoferrate(III). The resulting quinones react with 4-aminoantipyrine forming red condensation products, which are measured spectrometrically in a flow spectrometer at 505 nm.. This method is compliant with NEPM (2013) Schedule B(3)

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
TRH - Semivolatile Fraction	EP071	WATER	In house: Referenced to USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270E Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
TRH Volatiles/BTEX	EP080	WATER	In house: Referenced to USEPA SW 846 - 8260D Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. Alternatively, a sample is equilibrated in a headspace vial and a portion of the headspace determined by GCMS analysis. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney:** 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ **Brisbane:** 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ **Melbourne:** 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Perth:** 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston:** 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: Hazmat Services
OFFICE: Level 1, 45C Fitzroy Street, Carrington NSW 2294
PROJECT: N249003
ORDER NUMBER: 4963
PROJECT MANAGER: Damien Hendrickx **CONTACT PH:** 02 4911887
SAMPLER: DH **SAMPLER MOBILE:**
COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**
Email Reports to : damien@hazmat-services.com.au
Email Invoice to: admin@hazmat-services.com.au; damien@hazmat-services.com.au

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☑ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: SYBQ/478
COUNTRY OF ORIGIN:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: 6.9 °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Damien Hendrickx	MM 11:37am	MM 5pm	Andrew 7:27 pm
DATE/TIME: 06/7/20 ; 11:35am	DATE/TIME: 06/07/20	DATE/TIME: 06/07/20	DATE/TIME: 06/07/20

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).									Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	Ammonia	Total Phenolics	Free Cyanide/ Total Cyanide/ dissolved Cyanide	Hexavalent Chromium	Molybdenum	Lead	Total PAH	BTEX	TPH	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	QCA3	3/07/2020	Water		4							x	x	x	
2	QCA4	4/07/2020	Water		5	x	x	x	x	x	x	x			Please filter from unpreserved bottle for metals analysis
3	QCA5	5/07/2020	Water		4							x	x	x	
				TOTAL	13	1	1	1	1	1	1	3	2	2	

Environmental Division
Sydney
Work Order Reference
ES2023180
Telephone : + 61-2-8784 8555

LAB OF ORIGIN: [illegible]

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

APPENDIX F
Field Sheets

Entered + Resulted x 2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	~~KS~~ KS1/3
Client:		**Date:**	9/6/20
Site:		**Field Team:**	TG HR
Weather:	Cloudy - Rain		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):		NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)			
c. Total Well Length:		NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:	Micro purge	Purge Depth:	
Field Equipment:	YSI meter	Start Time:	3:00

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (μS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
3:00	~~1500~~ 4L	15.4	7.96	-5.6	1269	3.30	dirty in colour, cloudy.
							Surface water
							sample.

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (μS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + Plotted x2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	Well ID:	336A
Client:		Date:	9/6/20
Site:		Field Team:	TG HR
Weather:	Cloudy & rainy		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	5.46m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.76m		
c. Total Well Length:	6.63m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):	5.48 ~~5.17~~	Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	Micro purge	Purge Depth:	6.0m
Field Equipment:	YSI meter	Start Time:	1215

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1228	2.5L	20.4	6.64	-136.0	3580	0.15	cloudy organic odour
1232	3.0L	20.5	6.46	-127.8	3537	0.22	" "
1236	3.5L	20.5	6.41	-125.0	3503	0.50	" "
1242	4.5L	20.5	6.41	-126.0	2495	0.56	clear no odour "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

2.5L 1m

Exceed + resulted x 2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	336B
Client:		**Date:**	9/6/20
Site:		**Field Team:**	TG HR
Weather:	cloudy		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	6.0m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.75m		
c. Total Well Length:	11.38m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):	6.0m	Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	Micro purge	Purge Depth:	10.5m
Field Equipment:	YSI meter	Start Time:	11:14

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (μS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
11:20	2.5L	19.6	6.98	-129.4	17046	~~2.50~~ 0.36	Cloudy organic smell
11:29	5.0L	19.6	6.98	-133.2	17356	1.01	" "
1138	7.5L	19.7	6.98	-135.1	17831	0.97	" "
1145	10.0L	19.5	6.98	-136.2	17940	0.10	" "
1150	12.5L	19.5	6.98	-136.1	17989	0.05	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (μS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + Resultsx2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	1CS10/1
Client:		**Date:**	9/6/20
Site:		**Field Team:**	TG HR
Weather:	cloudy		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):		NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)			
c. Total Well Length:		NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:	YSI meter	Start Time:	1536

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O2 (ppm)	Comments (colour, odour, turbidity, etc.
1540	4.0L	16.7	7.48	66.0	1064	6.17	cloudy no odour
							surface water sample

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + Resultsx2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	249063	**Well ID:**	KII / 2W
Client:		**Date:**	10/6/20
Site:	KIWEF	**Field Team:**	TG HR
Weather:	Raining		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.7M	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.69m		
c. Total Well Length:	11.35m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi\frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	Micro purge	Purge Depth:	10m
Field Equipment:	YSI meter WQM	Start Time:	10:55

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
11:08	3L	19	7.54	-284	9960	no reading	Cloudy, smells
1116	6L	19.1	7.51	-287.2	10084	" "	" 0.0 not reading "
11:29	11L	19.1	7.49	-297.1	10044		" "
11:40	14L	19.1	7.49	-304.5	10039	" "	" "
1255	19L	19.0	7.49	-310.4	10280	0.01	" "
1207	24L	19.1	7.48	-318.2	10205	0.05	" "
1212	26.5	19.1	7.47	-323.9	10195	0.07	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:	1215	Depth to Water Table:	1.65m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

~~Entered~~ + Results x 2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	249063	**Well ID:**	K11/2E
Client:		**Date:**	10/6/20
Site:	KIWEF	**Field Team:**	HR +G
Weather:	~~[illegible]~~ raining		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	~~0.57m~~ 1.53m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.57m		
c. Total Well Length:	5.44m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):	2.29m	Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	10:15

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
10:22	2.5L	18.6	7.19	-129.9	1717	1.00	organic smell, brown. cloudy water
10:30	5L	18.7	7.12	-155.5	1709	0.31	organic smell, brown cloudy water
10:38	7.5L	18.8	7.14	-161.5	1705	0.20	organic, brown, cloudy

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + resulted x 2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	249003	**Well ID:**	K12/1E
Client:		**Date:**	11/6/20
Site:	KIWEF	**Field Team:**	HR TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	~~0.28m~~ 1.15m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.28m		
c. Total Well Length:	8.69m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi\frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:	451 WQM	Start Time:	2:00

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
2:13	5L	19.8	6.55	-46.7	~~26~~25955	0.69	cloudy, no smell
2:20	10L	19.9	6.44	-65.5	26294	1.83	cloudy. no smell
2:30	15L	19.9	6.43	-78.7	26188	0.43	cloudy no smell
2:31	17L	19.9	6.38	-77.5	26048	0.23	cloudy, no smell

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:	2:47	Depth to Water Table:	1.17m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Resubmitted x 2

Entered

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N24900X3	**Well ID:**	K12/1W
Client:		**Date:**	11/6/20
Site:	KIWEF	**Field Team:**	HR ta ✓
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	0.98m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.27m		
c. Total Well Length:	3.74m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	40mm		

Well Purge Information

Purge Method:	Bailers	Purge Depth:	
Field Equipment:		Start Time:	1:20

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*
1:25	2.5L	19	7.78	-34.5	35104	2.09	cloudy, brown orange colour
1:30	5L	18.3	9.00	-55.4	35687	2.70	cloudy, brown orange colour
1:32	7.5L	19.0	7.91	-46.8	35565	2.96	cloudy, brown orange colour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:	1:35	Depth to Water Table:	1.02m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered - Resulted x2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K7/25
Client:		**Date:**	
Site:	KIWEF	**Field Team:**	TG MR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	6.66m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.64		
c. Total Well Length:	11.43m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	~~WQM YSI~~ Micropurge	Purge Depth:	
Field Equipment:	WQM YSI	Start Time:	1440

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
3:05	3L	22.7	5.92	-89.9	7296	1.79	black strong odour
3:15	6L	22.7	5.97	-89.6	8652	1.99	black strong odour
3:20	8L	22.7	5.98	-89.7	8757	1.84	black strong odour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	6.56m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

Entered + Resulted x 2

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	E610
Client:		**Date:**	15/6/20
Site:	KIWEF	**Field Team:**	HK TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	5.96m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	~~[illegible]~~ 0.70m		
c. Total Well Length:	29.36m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	40mm		

Well Purge Information

Purge Method:	Bailer	Purge Depth:	
Field Equipment:	40mm Bailer	Start Time:	12:00

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*
12:28	10L	21.2	7.23	-119.1	50189	4.82	Clear, no odour
1:06	20L	21.4	7.43	-116.3	~~[illegible]~~ 53137	3.57	Clear. " "
1:36	30L	23	7.31	-105.6	51926	3.92	clear " "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	5.97m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + Resulted × 2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	E61S
Client:		**Date:**	15/6/20
Site:	KIWEF	**Field Team:**	HR JG
Weather:	Clear		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	Dry	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.72m		
c. Total Well Length:	4.60 m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	40 mm		

Well Purge Information

Purge Method:	Bailer	Purge Depth:	Dry
Field Equipment:	Bailer	Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	Dry

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + Reonked x2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K5/65
Client:		**Date:**	15/6/20
Site:	KIWEF	**Field Team:**	HR TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	3·46m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0·60m		
c. Total Well Length:	9·77m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:		Start Time:	1055

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1105	2.5	20.0	6.41	-109.8	4321	1.66	cloudy organic odour
1110	5L	20.0	6.07	-76.3	4172	0.70	cloudy, orga odour.
1120	7.5L	20.1	6.04	-69.1	4159	2.01	" "
1127	10.5L	20.1	6.08	-70.2	4138	1.67	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	3·46m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

Entered + Resultedx2

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	KS16N
Client:		**Date:**	15/6/20
Site:	KIWEF	**Field Team:**	HR TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	2.26m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.64m		
c. Total Well Length:	3.53m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:	WQM YSI	Start Time:	1018

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
1028	1.5L	18.6	6.45	-224	1102	2.39	cloudy organic odour
1034	3.0L	18.4	5.93	-174.9	793	2.83	" "
1038	4.5	18.4	5.78	-133.5	633	3.49	" "
1042	6.0L	18.3	5.79	-124.6	593	4.7	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:	1050	Depth to Water Table:	2.26m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

Intertek - Resulted x2

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	KS/6NN
Client:		**Date:**	15/6/20
Site:	Kiwet	**Field Team:**	HR TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	3.33m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.52m		
c. Total Well Length:	5.5m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	micro purge	Purge Depth:	5.0m
Field Equipment:	YSI, WQM	Start Time:	0930

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*
0938	3L	19.8	6.53	-187.4	4270	4.99	clear organic odour
0948	6L	19.9	6.57	-179.5	4306	1.61	" "
0952	7.5	20.0	6.57	-176.4	4342	1.45	

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	3.33m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + resultedx 2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K7 I1
Client:		**Date:**	15/6/20
Site:	KIWEF	**Field Team:**	HE TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	5.01m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.49m		
c. Total Well Length:	6.65m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi\frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:	microPurge	Purge Depth:	
Field Equipment:		Start Time:	13:32

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O2 (ppm)	Comments (colour, odour, turbidity, etc.
13:42	1.57	21.8	7.07	-198.4	1802	2.08	clear odour
1:47	3L	21.8	6.170	-185.7	2222	1.36	clear " "
1:53	4.5L	21.7	6.35	-169.5	2515	2.60	clear " "
1402	6.0L	21.7	6.55	-189.9	2640	2.55	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	6.01m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

entered + resulted x 2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N2349003	**Well ID:**	K7/2N
Client:		**Date:**	15/6/20
Site:	Kwef	**Field Team:**	HR JG
Weather:	sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	6.59 m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.66m		
c. Total Well Length:	8.92m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	40 mm		

Well Purge Information

Purge Method:	Bailer	Purge Depth:	
Field Equipment:		Start Time:	2:20

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
2:30	3L	23.2	7.46	-274.6	6619	5.71	cloudy, strong odour
2:36	4L	21.5	7.70	-265.0	6285	3.60	black strong odour
							abstruction in well
							no further water from
							well.

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	8.81m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered results L

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K9 /4E
Client:		**Date:**	16/6/20
Site:	KIWEF	**Field Team:**	HK JG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1·60cm	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	23cm		
c. Total Well Length:	5·23m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi\frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:		Start Time:	12:30

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
12:40	2.5L	19.6	6.34	-239.5	9061	4.30	dark brown strong odour
12:45	5L.	19.5	6.28	-237.8	8201	6.07	" "
12:50	7.5L	19.6	6.24	-239.6	14965	5.55	" "
12:55	10L	19.5	6.20	-239.3	14561	6.29	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	1·57cm.

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

Entered + resulted x2

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K9/4W
Client:		**Date:**	16/6/20
Site:		**Field Team:**	TG HK
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	2.26m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	20cm		
c. Total Well Length:	11.62m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1145	2.5	18.9	6.29	-120.6	16093	1.77	cloudy organic odour
1158	5.0L	18.9	6.43	-133.4	7800	1.65	" "
1210	7.5L	18.9	6.38	-141.1	15111	1.46	" "
1220	10.0L	18.9	6.40	-144.6	15066	1.49	" "
							Had to retrieve previous
							hosing from 1m down well
							0.5hrs spent

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	2.25cm

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + resulted x2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K9/2E
Client:		**Date:**	16/6/20
Site:	KIWEF	**Field Team:**	HK TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.94m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.27m		
c. Total Well Length:	11.64m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi\frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:		Start Time:	10:26

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
10:40	2.5L	20.0	6.00	-178.0	34141	3.48	clear organic odour
10:45	5L	19.9	6.10	-186.6	33405	3.38	" "
10:54	7.5L	20.0	6.13	-192.3	33976	3.26	" "
11:02	10L	20.0	6.04	-192.6	33874	3.84	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	1.96m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + resulted x2

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	K9 lzw
Client:		**Date:**	16/6/20
Site:		**Field Team:**	HK TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.97m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.3m		
c. Total Well Length:	3.92m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	80mm		

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:		Start Time:	9:48

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
9:50	2.5L	19	6.17	-150.0	8517	2.60	cloudy organic smell
10:00	4L	18.7	5.97	-119.0	4660	1.84	cloudy organic smell
10:05	5L	18.2	5.99	-109.1	4686	1.38	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	3.55m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

Entered + resulted x2

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	KS7 / I
Client:		**Date:**	16/6/20
Site:		**Field Team:**	HK TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):		NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)			
c. Total Well Length:		NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	9:20

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O2 (ppm)	Comments (colour, odour, turbidity, etc.
9:24	8L	13.7	8.30	15.3	3228	16.35	~~yellow~~ clear no odour
							Surface water

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K12/7
Client:		**Date:**	23/6/20
Site:		**Field Team:**	TG HR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	0.93m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.456m		
c. Total Well Length:	5.63m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1518	2.5L	18.9	6.68	-46.2	40826	6.69	Brown cloudy
1525	5.0L	18.8	6.70	-45.0	34097	3.21	" "
1530	7.5L	18.7	6.66	-23.0	28661	4.74	" "
1535	10L	18.7	6.64	-42.5	26398	4.26	" "
1540	12L	18.7	6.54	-48.7	25765	3.1	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	2.33m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	NC1G/2
Client:		**Date:**	23/6/20
Site:		**Field Team:**	TG HR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.71m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.79m		
c. Total Well Length:	12.93m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:		Start Time:	12:20

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
12:24	2.5L	19.4	6.64	-1[illegible].6	51670	1.16	dark grey, organic smell
12:30	5L	19.5	6.47	-152.1	51745	1.64	" "
12:37	7.5L	19.5	6.41	-149.3	51592	3.89	" "
12:47	10L	19.6	6.39	-150	51580	4.72	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	8.24m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K12/7E
Client:		**Date:**	23/6/20
Site:		**Field Team:**	TG HR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.24m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.31m		
c. Total Well Length:	12m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:	micro purge	Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1357	2.5L	18.8	6.81	-63.7	46888	1.30	cloudy organic odour
14:02	5L	18.8	6.78	-65.1	48764	0.68	" "
1408	7.5L	18.9	6.82	-26.5	46430	1.28	" "
1415	9.5L	18.9	6.87	-11.0	46446	3.46	Clear organic odour
1420	12L	18.9	6.78	3.0	46673	4.31	" "
14:30	14.5L	18.9	6.74	4.1	47154	5.1	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	8.19m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	Well ID:	NC16/1
Client:		Date:	23/6/20
Site:		Field Team:	TG HR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.56m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.86m		
c. Total Well Length:	6.69m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
10:54	2.5L	19.8	5.77	-223.7	31033	4.23	Organic odour, cloudy
11:05	5L	20.1	6.08	-200.5	11127	1.68	" "
11:11	7.5L	20.1	5.94	-190.9	6741	1.32	" "
11:16	10L	20.1	5.88	-185.8	5037	2.80	" "
11:32	12.5L	19.4	6.03	-184.1	5467	2.56	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	1.56m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID
QCA	QCA I	

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49008	**Well ID:**	K8/SE
Client:		**Date:**	24/6/20
Site:		**Field Team:**	TA HR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	4.94m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	1.54 m		
c. Total Well Length:	5.30m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1.50	500mL	19.5	5.42	-89.4	591	2.45	~~Dry~~ Sampled ~~wasted~~ &
							Ran dry
							~~clear~~ no colour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	DRY – 5.13m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	KS12 16
Client:		**Date:**	24/6/20
Site:		**Field Team:**	TG HR
Weather:	Sunny, windy		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):		NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)			
c. Total Well Length:		NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1210	5	13.4	4.24	229.9	31480	19.81	clear no odour
							SURFACE
							WATER

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID
QC2	QCA2	

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	K12 14N
Client:		**Date:**	24/6/20
Site:		**Field Team:**	TG HR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.46m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.45m		
c. Total Well Length:	12.64m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
10:50	2.5L	17.3	6.91	-117.8	52064	5.16	Clear, no odour
10:57	5L	17.3	6.99	-137.5	52333	1.28	" "
11:06	7.5L	17.3	7.31	-160.5	52418	0.40	" "
11:16	10L	17.3	7.12	-136.3	52184	2.39	" "
11:25	12.5L	17.3	7.50	-138.2	52494	2.54	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	9.10m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	~~BH29~~ BHE295
Client:		**Date:**	29/6/20
Site:		**Field Team:**	TG
Weather:	Cloudy		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	2-72m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.68		
c. Total Well Length:	4.53m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	40mm		

Well Purge Information

Purge Method:	Bailer	Purge Depth:	
Field Equipment:		Start Time:	1015

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1022	3.0L	18.3	8.41	-222.8	1653	9.15	organic odour. cloudy
1032	6L	16.8	8.25	-221.9	1619	7.11	" "
1045	9L	17.7	8.26	-223.0	1594	8.68	" "
1055	12L	18.2	8.23	-227.8	1615	7.62	" "
1105	15L	18.2	8.26	-224.1	1633	7.83	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	2.93m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	K10/2NN
Client:		**Date:**	29/6/20
Site:		**Field Team:**	TG
Weather:	cloudy		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	10.30m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.74m		
c. Total Well Length:	14.02m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	Micropurge	Purge Depth:	
Field Equipment:		Start Time:	1245

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1300	2.5	20.9	6.07	-249.4	20416	6.30	cloudy - black
1308	5L	20.8	6.03	-242.2	18766	6.95	cloudy - brown
1317	7.5L	20.8	6.00	-252.5	20586	9.53	" "
1326	10.0L	20.8	5.96	-266.1	20596	7.10	Gassy - fumes strong
1330	12.5L	20.8	5.98	-273.1	21298	8.77	odour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	10.32m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K10/2N
Client:		**Date:**	29/6/20
Site:		**Field Team:**	TG
Weather:	Cloudy		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	7.43m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.79		
c. Total Well Length:	10.03	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (μS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
							Blockage - hosing
							in sight when
							light shone in
							well

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (μS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K9/3N
Client:		**Date:**	30/6/20
Site:		**Field Team:**	TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	2.92m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	Ground level		
c. Total Well Length:	10.18m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	1130

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1140	2.5L	20.6	7.16	-219.2	24238	3.02	clear organic odour
1147	5L	20.7	7.11	-233.4	23879	2.79	" "
1154	7.5L	20.7	7.09	-240.5	23757	3.09	" "
12:00	10L	20.8	7.09	-245.0	23713	3.23	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	2.92m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	K9/35
Client:		**Date:**	30/6/20
Site:		**Field Team:**	TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.88m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	Ground level		
c. Total Well Length:	3.37m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
1230	1.5L	19.1	7.89	-223.4	5889	1.33	Black - organic odour
1237	3L	19.0	7.93	-255.3	5346	1.86	Cloudy organic odour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	1.87m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K11/3W
Client:		**Date:**	30/6/20
Site:		**Field Team:**	TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.99m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.60		
c. Total Well Length:	12.44m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	1350

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1400	2.0	19.9	7.19	-148.0	16331	1.92	Cloudy organic odour
1410	5L	20.4	7.16	-159.8	15921	2.59	" "
1414	7.5L	20.1	7.14	-154.4	15718	3.20	" "
1418	10L	20.2	7.18	-158.1	16027	3.15	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	1.99m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K10/2
Client:		**Date:**	30/6/20
Site:		**Field Team:**	TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	7.93m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.60m		
c. Total Well Length:	9.76m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	microPurge	Purge Depth:	
Field Equipment:		Start Time:	10:20

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1030	2.5L	19.2	6.71	35.9	724	12.75	Cloudy No odour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	8.68m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N299003	**Well ID:**	KS155
Client:		**Date:**	2/7/20
Site:		**Field Team:**	TG HK
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	4.09m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.59m		
c. Total Well Length:	9.48m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*
13:33	2.5L	20.9	6.72	-136.6	4719	2.26	clear
13:39	5L	20.6	6.41	-140.0	4257	2.82	" "
13:45	7.5L	20.7	6.28	-142.3	3958	2.86	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	4.08

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49063	**Well ID:**	KS 15N
Client:		**Date:**	2/7/20
Site:		**Field Team:**	TG HR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	3.45m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.66m		
c. Total Well Length:	3.69m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:	DRY WELL	Purge Depth:	
Field Equipment:		Start Time:	

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
							DRY WELL
							Unable to be purged
							Only 24 cm of water.

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N 249003	**Well ID:**	K8 / SW
Client:		**Date:**	2/7/20
Site:		**Field Team:**	TG HR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	5·26m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	1·77m		
c. Total Well Length:	8m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi\frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
12:33	2.5L	21.2	10·85	-360·5	3280	1·95	Clear & ~~odour~~. ~~Strong~~ Strong organic odour
12:41	5L	21.1	10·80	-366·4	3383	0·21	" "
12:46	7·5L	21.1	10·73	-332·4	3479	3·12	" "
12:52	9L	21.1	10·70	-333·5	2022	2.68	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	5·87

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K11/3E
Client:	HCCDC	**Date:**	4-7-20
Site:	KIWEF	**Field Team:**	DW
Weather:	Fine, sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.57	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	~~5~~ 0.38		
c. Total Well Length:	5.43	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):	3.86	Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	~~Micropurge~~ Bailer	Purge Depth:	~~3~~
Field Equipment:	YSI Meter	Start Time:	1405

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1415	2.5	17.9	7.38	-132.6	1872	3.29	Clear, no odour
1420	5.0	18.2	7.30	-114.3	1852	1.20	" " "
1430	7.5	20.3	7.29	-79.1	1901	1.92	" " "
1440	10.0	19.9	7.30	-77.8	1904	1.98	" " "
1445	12.0	19.8	7.28	-76.5	1906	1.96	" " "
							Switched to skinny bailer - obstruction in well

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1445	12.0	19.8	7.28	-76.5	1906	1.96	Clear, no odour

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID
K11/3E	QC4 ~~A~~	~~A~~ QCA4

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K11/1
Client:	HCCDC	**Date:**	5-7-20
Site:	KIWE	**Field Team:**	DH
Weather:	Fine, sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	2.15	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.76		
c. Total Well Length:	3.76	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):	~~3~~ 1.61	Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	Micropurge	Purge Depth:	2.50
Field Equipment:	YSI Meter	Start Time:	10:00

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*
1015	2.5	17.0	7.48	-31.2	1899	2.65	Clear, no odour
1020	5.0	17.6	7.45	-49.0	1794	2.12	" "
1030	7.5	17.5	7.43	-39.8	1752	2.12	" "
1040	10.0	17.5	7.42	-36.2	1722	2.10	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*
1055	10.0	17.5	7.42	-36.2	1722	2.10	Clear, no odour

End Time:	11:00	Depth to Water Table:	2.15

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID
K11/1	QCS	QCAS
	(EPAP only)	(EPAP only)

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K11/1S
Client:	HCCDC	**Date:**	5-7-20
Site:	KIWEF	**Field Team:**	DH
Weather:	Fine, sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	3.10	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.83		
c. Total Well Length:	9.35	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):	6.25	Well Volume: $V = \pi\frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	Micropurge	Purge Depth:	~~9.~~ 6.50
Field Equipment:	YSI Meter	Start Time:	11:10

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1115	2.5	18.2	7.93	-151.7	3728	1.16	Clear, no odour
1120	5.0	18.9	7.82	-271.8	9366	1.14	" "
1125	10.0	19.2	7.83	-279.4	9550	1.04	" "
1130	15.0	19.3	7.82	-294.6	9653	0.77	" "
1135	20.0	19.3	7.83	-295.8	9658	0.76	" "
1140	25.0	19.4	7.84	-296.6	9672	0.74	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1140	25.0	19.4	7.84	-296.6	9672	0.74	Clear, no odour

End Time:		Depth to Water Table:	3.12

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID
K11/1S	–	–

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	KL12/10E
Client:		**Date:**	6/7/20
Site:		**Field Team:**	TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.21m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.51m		
c. Total Well Length:	4.47m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	micropurge	Purge Depth:	
Field Equipment:		Start Time:	1540

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1548	2.5L	16.3	6.72	-256.6	64581	11.16	Dark brown organic odour
1556	5L	16.1	6.55	-259.1	64566	14.68	" "
1600	7.5	16.4	6.52	-256.7	62066	12.71	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	1.21m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	KS14
Client:		**Date:**	6/7/20
Site:		**Field Team:**	TG HK
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	5.12m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.10m		
c. Total Well Length:	5.57m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*
							Dry could not extract
							enough water to
							Sample.
							Fill around top of well.

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O₂ (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	KS2/1
Client:		**Date:**	6/7/20
Site:		**Field Team:**	TG HR
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):		NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)			
c. Total Well Length:		NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:	Surface water	Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O2 (ppm)	Comments (colour, odour, turbidity, etc.
		14.2	6.97	35.9	6890	16.67	clear, no odour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	344A
Client:		**Date:**	6/7/20
Site:		**Field Team:**	TG HK
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.40 m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)			
c. Total Well Length:		NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
							Inspected well in area
							located in this location.
							NO well ID on well
							NO sample

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	344B
Client:		**Date:**	6/7/20
Site:		**Field Team:**	TG MR
Weather:	Sun		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.56m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)			
c. Total Well Length:		NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
							Blockage in well
							Inspected well in
							area. located in
							this location. No well
							ID on well.
							No sample.

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	BH215
Client:		**Date:**	6/7/20
Site:		**Field Team:**	TG HR
Weather:	Sun		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):		NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)			
c. Total Well Length:		NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*
							Inspected well in area
							located in this location.
							No well ID on well.
							Sighted in PVC approx
							1m down. Bend in pipe.
							NO sample

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	*Volume Removed (L)*	*Temp (°C)*	*pH*	*Redox (mV)*	*EC (µS/cm)*	*Diss.O_2 (ppm)*	*Comments (colour, odour, turbidity, etc.*

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	KI2/9
Client:		**Date:**	7/7/20
Site:		**Field Team:**	TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	0.74m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.62m		
c. Total Well Length:	14.06m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	Micropurge	Purge Depth:	13m
Field Equipment:	YSI, WQM	Start Time:	0940

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
09:55	2.5	18.1	6.31	-126.9	53785	11.09	Black organic odour
1002	5L	18.0	6.18	-130.7	53941	11.01	Cloudy Black organic odour
1008	7.5L	18.1	6.24	-137.9	53950	11.49	"
1015	10L	18.2	6.28	-144.2	53747	11.20	Clear-cloudy organic odour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	0.76m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K12/10
Client:		**Date:**	6/7/20
Site:		**Field Team:**	TG
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	1.05m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.72m		
c. Total Well Length:	19.13m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	Micropurge	Purge Depth:	
Field Equipment:		Start Time:	1435

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1442	2.5L	17.7	6.20	-54.8	3343	1.75	Black organic odour
1454	6L	15.6	6.16	-101.2	3041	3.63	" "
1500	8L	17.8	6.37	-152.1	3039	4.45	" "
1504	10L	17.8	6.35	-157.4	4,314	6.25	" "
1508	13L	18.0	6.28	-147.8	35698	6.48	Light Grey cloudy organic odour
1512	16L	17.9	6.25	-146.2	42271	6.57	" "
1516	19L	18.8	6.29	-241.7	53069	10.29	Black organic odour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1520	22L	18.2	6.35	-216.0	54049	11.54	" "
1525	25L	18.1	6.38	-210.3	53042	12.17	Light Grey cloudy organic odour

End Time:		Depth to Water Table:	1.06M

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	K12/9E
Client:		**Date:**	7/7/20
Site:		**Field Team:**	TK
Weather:	Sunny		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	0.26m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.10m		
c. Total Well Length:	4.49m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:	50mm		

Well Purge Information

Purge Method:	Micropurge	Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
1040	2.5	18.2	6.71	-131.8	27500	10.40	Light brown cloudy organic odour
1045	5L	18.3	7.19	-143.1	27844	13.81	" "
1050	7.5	18.3	7.25	-157.3	27958	12.44	" "
1057	10L	18.3	7.29	-162.5	15340	6.29	" "
1103	12.5L	18.3	7.22	-161.8	22031	5.96	" "

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	0.37m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	NZ49003	**Well ID:**	GH0015
Client:		**Date:**	7/7/20
Site:		**Field Team:**	TG HR
Weather:	Sun		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	9.34m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)	0.27m		
c. Total Well Length:	20.02m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:		Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
13:55	2.5L	20.3	5.52	-159.6	6179	13.19	dark colour organic odour.
2:00	5L	20.8	5.81	-215.7	4588	13.31	" "
14 06	7.5	20.7	5.78	-232.6	4375	12.59	" "
1410	10L	20.7	5.74	-231.8	4240	14.91	" "
1415	12.5L	20.7	5.72	-233.1	6045	15.30	" "
1420	15L	20.7	5.88	-238.0	5535	14.24	" "
1425	17.5L	20.7	5.87	-240.6	5616	15.51	cloudy dark greay organic odour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	9.38m

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

HAZMAT SERVICES

SITE CONTAMINATION ANALYSIS – GROUND WATER SAMPLING

Project No.	N249003	**Well ID:**	GH001N
Client:		**Date:**	7/7/20
Site:		**Field Team:**	TG HR
Weather:	Sun		

Water Level Data (measured as metres from Top of Casing [ToC])

a. Depth to Water Table (ToC):	7.48m	NAPL present?	☐Yes ☐No
b. Well Stickup (ToC to ground level)			
c. Total Well Length:	9.43m	NAPL Interphase Depth:	
d. Depth of Water Column (c-a):		Well Volume: $V = \pi \frac{d^2}{4} \times c =$	
e. Casing Diameter:			

Well Purge Information

Purge Method:		Purge Depth:	
Field Equipment:	Bailer.	Start Time:	

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.
15:00		20.5	8.19	-198.4	3142	15.17	dark colour (black) no odour

Purging should continue for a minimum of three bore volumes and stabilised measurements are achieved or until the bore purges dry and stabilised measurements are achieved. Stabilised measurements for pH are within 0.1 pH units; EC, redox and dissolved oxygen are within 10 % and temperature is within 0.5 °C over two successive measurements.

Well Sampling Information

Time	Volume Removed (L)	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	Diss.O_2 (ppm)	Comments (colour, odour, turbidity, etc.

End Time:		Depth to Water Table:	

Sample Collection Summary

Primary Sample ID	Intra-lab Sample ID	Inter-lab Sample ID

APPENDIX G
Calibration Certificates

Oil / Water Interface Meter

Instrument Geotech Interface Meter (60m)
Serial No. 3954

airmet
Air-Met Scientific Pty Ltd
1300 137 067

Item	Test	Pass	Comments
Battery	Compartment	✓	
	Capacity	✓	
Probe	Cleaned/Decon.	✓	
	Operation	✓	
Connectors	Condition	✓	
Tape Check	Cleaned	✓	
Connectors	Checked for cuts	✓	
Instrument Test	At surface level	✓	

Certificate of Calibration

This is to certify that the above instrument has been cleaned and tested.

Calibrated by: Sarah Lian

Calibration date: 04-Jun-20

Next calibration due: 03-Aug-20

Multi Parameter Water Meter

airmet

Air-Met Scientific Pty Ltd
1300 137 067

Instrument YSI Quatro Pro Plus
Serial No. 18L102023

Item	Test	Pass	Comments
Battery	Charge Condition	✓	
	Fuses	✓	
	Capacity	✓	
Switch/keypad	Operation	✓	
Display	Intensity	✓	
	Operation (segments)	✓	
Grill Filter	Condition	✓	
	Seal	✓	
PCB	Condition	✓	
Connectors	Condition	✓	
Sensor	1. pH	✓	
	2. mV	✓	
	3. EC	✓	
	4. D.O	✓	
	5. Temp	✓	
Alarms	Beeper		
	Settings		
Software	Version		
Data logger	Operation		
Download	Operation		
Other tests:			

Certificate of Calibration

This is to certify that the above instrument has been calibrated to the following specifications:

Sensor	Serial no	Standard Solutions	Certified	Solution Bottle Number	Instrument Reading
1. pH 10.00		pH 10.00		352607	pH 9.68
2. pH 7.00		pH 7.00		330737	pH 6.90
3. pH 4.00		pH 4.00		330734	pH 4.08
4. mV		234mV		346052/342074	233.8mV
5. EC		2.76mS		333787	2.75mS
6. D.O		0.00ppm		1904288592	0.00ppm
7. Temp		20.4°C		MultiTherm	19.9°C

Calibrated by: Sarah Lian

Calibration date: 4/06/2020

Next calibration due: 4/07/2020

APPENDIX H
Historical Data

Appendix G – KIWEF Area 2 Cap Maintenance Summaries (Ecological Australia, 2021)

Level 7, Suites 28 & 29
19 Bolton Street
Newcastle NSW 2300

4 August 2021

Our ref: 20NEW-19606

Cheslyn Africa
Project Manager
Daracon Group
PO Box 201
Beresfield NSW 2322

Dear Ches,

19606 Kooragang Cap Maintenance – Pre-clearance summary report 23 – 30 July 2021

This report summarises daily fieldwork undertaken between Friday, 23 July to Friday 30 July.

Daracon undertook cap maintenance works across Kooragang Island comprising of the removal of vegetation (*Acacia sp*.). Vegetation was removed individually by hand cutting and sprayed with herbicide directly onto the stump. ELA ecologist, Dee Ryder was present to complete Green and Golden Bell Frog (GGBF) pre-clearance surveys prior to the commencement of works and was present throughout the vegetation removal works.

No GGBF were sighted during this period of the vegetation removal works. The attached photographs show vegetation removal being undertaken after pre-clearance and during supervision.

Please contact me if you have any questions regarding this report.

Regards,

Dee Ryder
Ecologist

0415 207 072

Appendix A Photographs

Plate 1: Works area during vegetation removal

Plate 2: Works area after vegetation removal

Level 7, Suites 28 & 29
19 Bolton Street
Newcastle NSW 2300

6 August 2021

Our ref: 20NEW-19606

Cheslyn Africa
Project Manager
Daracon Group
PO Box 201
Beresfield NSW 2322

Dear Ches,

19606 Kooragang Cap Maintenance – Pre-clearance summary report 2 – 6 August 2021

This report summarises daily fieldwork undertaken between Monday, 2 August and Friday, 6 August.

Daracon undertook cap maintenance works across Kooragang Island comprising of the removal of vegetation (*Acacia sp*.). Vegetation was removed individually by hand cutting and sprayed with herbicide directly onto the stump. ELA ecologist, Dee Ryder was present to complete Green and Golden Bell Frog (GGBF) pre-clearance surveys prior to the commencement of works and was present throughout the vegetation removal works.

One juvenile GGBF was located inside the works area on Tuesday, 3 August, the frog was relocated to a suitable water body outside the works area. The attached photographs show the juvenile GGBF during relocation to water body.

Please contact me if you have any questions regarding this report.

Regards,

Dee Ryder
Ecologist

0415 207 072

Appendix A Photographs

Plate 1: Juvenile GGBF relocated on 3 August

Plate 2: Juvenile GGBF near water body outside works area

Level 7, Suites 28 & 29
19 Bolton Street
Newcastle NSW 2300

13 August 2021

Our ref: 20NEW-19606

Cheslyn Africa
Project Manager
Daracon Group
PO Box 201
Beresfield NSW 2322

Dear Ches,

19606 Kooragang Cap Maintenance – Pre-clearance summary report 10 – 13 August 2021

This report summarises daily fieldwork undertaken between Tuesday, 10 August and Friday, 13 August.

Daracon undertook cap maintenance works across Kooragang Island comprising of the removal of vegetation (*Acacia sp*.). Vegetation was removed individually by hand cutting and sprayed with herbicide directly onto the stump. An ELA ecologist was present to undertake Green and Golden Bell Frog (GGBF) pre-clearance surveys prior to the commencement of works and for the duration of the vegetation removal works (Table 1).

Table 1: Summary of GGBF relocated to 13 August 2021

Ecologist	10/08	11/08	12/08	13/08	
Liam Scanlan	0	0			
Sophie Montgomery			0		
Shawn Ryan				0	
			Number of GGBF relocated		0

No GGBF were encountered in the works area, however two non-threatened frogs *Litoria fallax* (Eastern Dwarf Tree Frog) were relocated to a suitable water body outside the works area. The attached photographs show a portion of the works area before and after vegetation removal during this survey period.

Please contact me if you have any questions regarding this report.

Regards,

Dee Ryder
Ecologist

0415 207 072

Appendix A Photographs

Plate 1: Works area prior to vegetation removal (juvenile *Acacia sp*.)

Plate 2: Works area after vegetation removal

Level 7, Suites 28 & 29
19 Bolton Street
Newcastle NSW 2300

20 August 2021

Our ref: 20NEW-19606

Cheslyn Africa
Project Manager
Daracon Group
PO Box 201
Beresfield NSW 2322

Dear Ches,

19606 Kooragang Cap Maintenance – Pre-clearance summary report 16-20 August 2021

This report summarises daily fieldwork undertaken between Monday, 16 August and Friday, 20 August 2021.

Daracon undertook cap maintenance works across Kooragang Island comprising of the removal of vegetation (*Acacia sp*.). Vegetation was removed individually by hand cutting and sprayed with herbicide directly onto the stump. An ELA ecologist was present to undertake Green and Golden Bell Frog (GGBF) pre-clearance surveys prior to the commencement of works and for the duration of the vegetation removal works (Table 1).

Table 1: Summary of GGBF relocated to 20 August 2021

Ecologist	16/08	17/08	18/08	19/08	20/08	
Liam Scanlan	0	0				
Dee Ryder			0			
Sophie Montgomery				0	0	
				Number of GGBF relocated		0

No GGBF were encountered in the works area, however four non-threatened common frog species were relocated to a suitable water body outside the works area. The attached photographs show the vegetation removal method using individual hand cutting and treatment of vegetation within the works area.

Please contact me if you have any questions regarding this report.

Regards,

Dee Ryder
Ecologist

0415 207 072

Appendix A Photographs

Plate 1: Vegetation removal by hand (juvenile *Acacia sp*.)

Plate 2: Herbicide treatment of individual vegetation stumps