



TOXIC HABITAT

Heavy metal impacts on water birds near
NSW coal fired power stations

Cover Images: Rebecca Citroni

Lead Author: Paul Winn

Contributors: Naomi Jones, Jo Lynch, George Woods

Illustrators:

Maira Wilke (Black Swan, Pied Cormorant)

Alison Ellis (Bioaccumulation flow-chart)

Photos:

If not supplied by HCEC courtesy of Steve Merrett, Rob Palazzi, Rebecca Citroni and Dawn Riggett, Hunter Bird Observers Club – Bird Image Library

Many thanks to all those who have assisted us with this report, including experts willing to share advice and insights, all those who pitched in for your efforts and contributions.

Special thank you goes to Mick Roderick and the Hunter Bird Observers Club for its efforts in support of bird life in the Hunter region, and its contribution to this report.

The Hunter Community Environment Centre is a not-for-profit community group funded by grants, donations and independent of government and corporate funding. We established in 2004 to encourage and facilitate environmental and social justice advocacy and education in the Hunter region, NSW, Australia. The objectives of the Hunter Community Environment Centre are:

- To maintain a community environment information, resource and advocacy centre.
- To educate and inform the community about biodiversity and the need to protect it.
- To provide and promote the dissemination of information and views regarding environmental matters.
- To promote and assist cooperation, sharing of resources and coordination of activities amongst environment and community groups.
- To protect and conserve ecological processes, genetic diversity and the natural environment.

For further information on this report please contact

Johanna Lynch, Coordinator

Hunter Community Environment Centre coordinator@hcec.org.au

(02) 4962 5316 167 Parry St, Hamilton East, 2303 www.hcec.org.au

Produced & published by Hunter Community Environment Centre

ABN 40826463714

Publication date: September 2021

ISBN: 978-0-6452693-0-7

TOXIC HABITAT

Heavy metal impacts on water birds near
NSW coal fired power stations

Contents

| | |
|---|----|
| Foreword | 2 |
| Executive Summary | 4 |
| Introduction | 9 |
| Methodology | 12 |
| Results and discussion | 13 |
| Metals of concern | 15 |
| ARSENIC | 17 |
| CADMIUM | 18 |
| LEAD | 19 |
| SELENIUM | 20 |
| MERCURY | 22 |
| Major regional heavy metal sources | 24 |
| Lake Macquarie | 25 |
| Vales Point Environmental Site Assessment | 29 |
| Metals in Wyee Bay crabs | 29 |
| Mannering Bay sediment core | 31 |
| Eraring power station Environmental Site Assessment | 32 |
| HCEC sediment analysis | 32 |
| Lake Wallace | 35 |
| HCEC sediment analysis | 38 |

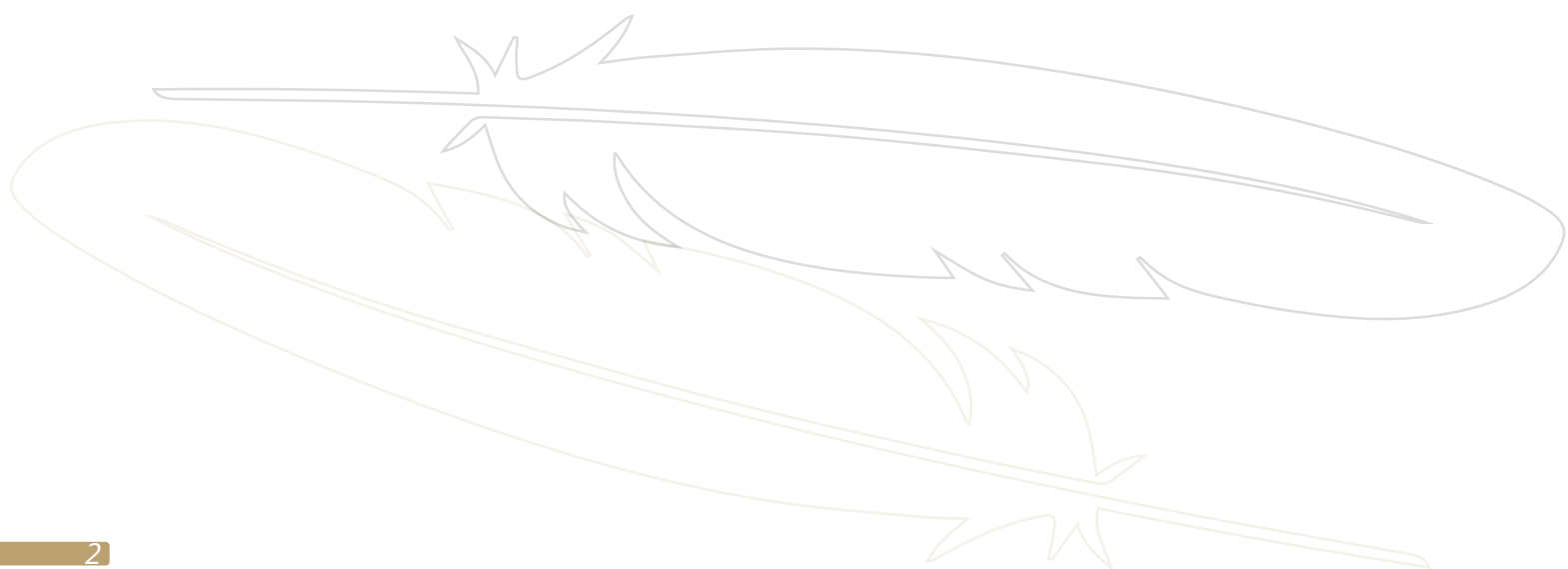
| | |
|---|-----|
| Lake Liddell | 39 |
| Bayswater Environmental Site Assessment | 43 |
| HCEC sediment analysis | 43 |
| Port Stephens – Myall Lakes | 44 |
| Mercury source | 47 |
| Conclusion | 50 |
| References | 54 |
| Appendix 1: Laboratory Reports | 62 |
| Lake Macquarie | 62 |
| Lake Liddell | 77 |
| Lake Wallace | 95 |
| Appendix 2: Photos of collected feathers | 123 |
| Myall Lakes National Park | 123 |
| Lake Macquarie | 132 |
| Lake Wallace | 138 |
| Lake Liddell | 142 |
| Appendix 3: Photos of Lake Macquarie crab | 148 |
| Appendix 4: Australia Museum feather identification | 149 |

Foreword

Hunter Bird Observers Club Inc. (HBOC) is the largest bird interest group in the Hunter Valley, was established in 1976 and currently has a membership of over 400 members. They have been involved with bird monitoring projects for over 30 years and are a well-respected stakeholder group on local conservation issues. Their key concern for bird conservation in the Hunter Valley is the continual loss and alteration of habitat, particularly woodlands and shorebird habitat.

Woodland birds and migratory shorebirds are the two groups facing the most threat in the Hunter Valley due to habitat loss and fragmentation. Beach-nesting birds, including Little Terns, Australian Pied Oystercatchers and Beach Stone-curlews, all threatened in NSW, are also under threat due to conflicts with recreational vehicles on beaches and other threats to their nesting habitat such as altered hydrology due to climate change.

Annually, the Hunter's Lake Liddell sees an incredibly high volume of birds. It has suitable foraging and nesting habitat for a range of water birds and some shorebirds, and importantly is a large waterbody with areas of fringe vegetation and reed beds which support breeding, roosting and foraging.



Lake Liddell holds a significant proportion of the Hunter's population of some species including the Eurasian Coot, Great Crested Grebe, Hoary-headed Grebe, Black Swan and Musk Duck. In HBOC's estimation, it could hold the highest number of Eurasian Coots and possibly Black Swans of any site in the Hunter Valley. BirdLife Australia atlas data shows 118 species of birds recorded on and around Lake Liddell. Terrestrial birds listed as threatened in NSW include Little Eagle, Spotted Harrier, White-bellied Sea-Eagle, Brown Treecreeper, Grey-crowned Babbler and Diamond Firetail. The dam is also likely to hold Blue-billed Ducks (listed vulnerable in NSW) from time to time and HBOC notes that overall, Lake Liddell is poorly surveyed so we do not have a full understanding of the birds using it. Both woodland birds and shorebirds – two guilds of species recognised as being nationally threatened – face direct impacts from the coal industry in the Hunter Valley. The initial loss of woodlands at the extraction site, followed by further loss and degradation of habitat along the coal-supply chain; an example being the migratory shorebird habitat of the Hunter Estuary, juxtaposed with Newcastle's export coal terminal.

The continuing destruction of habitat, the intensifying and unpredictable impacts of global climate change and the added threat to birdlife in the Hunter of coal-ash contamination revealed by the HCEC in this paper, is deeply troubling.

Daniel Williams

President Hunter Bird Observers Club



Hunter Bird
Observers Club

Affiliated with BirdLife Australia

Hunter Bird Observers Club Inc
PO Box 24, New Lambton, NSW 2305
www.hboc.org.au
ABN 62 415 889 446

Executive Summary

This is the third report the Hunter Community Environment Centre (HCEC) has released on heavy metal contamination of NSW waterways by coal-fired power stations.

In this report, we reveal bioaccumulation of metals and metalloids in waterbird populations from three Lakes contaminated by coal-fired power stations, as well as areas within the Port Stephens Great Lakes Marine Park.

We collected 40 feathers from 12 genera of waterbird and four terrestrial bird species, from southern Lake Macquarie, Lake Liddell, Lake Wallace, and control sites in Port Stephens and Myall Lakes.

Feathers are indicators of heavy metals in birds because feathers can store and eliminate metals, especially into the growing feathers during the moulting process. Authors such as Burger (1993, 2008), Burger and Gochfeld (1993; 1994; 2000a; 2000b) and Burger et al. (2009), among others, have provided estimates of threshold concentrations of metals in feathers that could prove harmful to the health and reproductive success of the birds.

The report focuses on the metals which pose the greatest concern for bird life and toxicity impacts including: arsenic, cadmium, lead, mercury and selenium.

We have applied these thresholds to results of laboratory analysis of the feathers collected and found more than half, including those from the control sites, contained metals above concentrations shown to adversely affect health and reproductive success. Feathers from three birds - one Cormorant from Lake Macquarie, and two Black Swans from Lake Liddell - exceeded health thresholds for at least three metals/metalloids.

Of the 40 feathers collected from Lake Macquarie, Lake Wallace, and Lake Liddell;

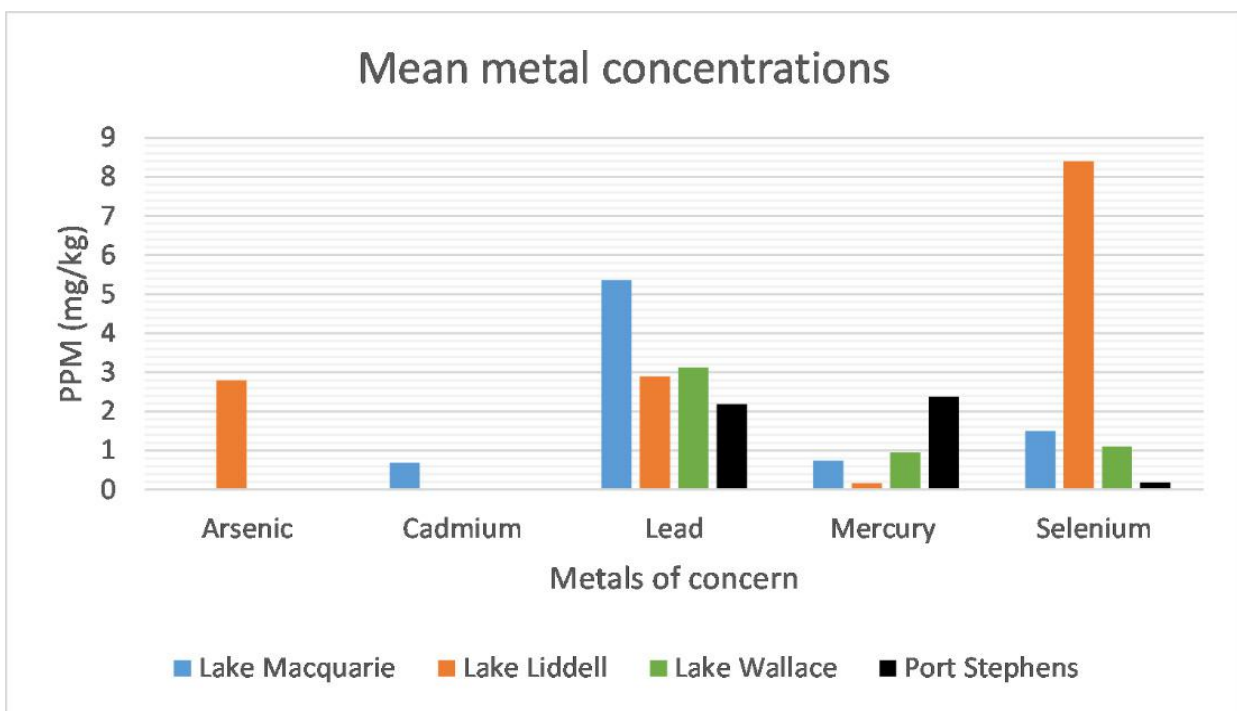
- 85 percent exceeded thresholds for selenium (1.8 mg/kg). The area of greatest concern for selenium was Lake Liddell, where all the feathers collected had concentrations above health and reproduction impacts thresholds.
- 30 percent exceeded published thresholds for lead (4 mg/kg). All but six feathers (85%) contained detectable lead. Cormorant feathers from Lake Macquarie and Lake Wallace contained 2 and 4 times threshold health.

In addition;

- 40 percent of the feathers collected from Lake Liddell contained arsenic concentrations in the range of possible adverse health effects (1.3 mg/kg to 13 mg/kg).
- One third of the feathers collected from Lake Macquarie contained detectable cadmium. In one Cormorant feather (>0.4 mg/kg) cadmium was almost three times the concentrations shown to adversely affect health and reproductive success (2 mg/kg).

We conclude that the following heavy metals are at concentrations that may pose a risk to the health and reproductive success of bird;

- Arsenic, lead and selenium in Lake Liddell.
- Cadmium, lead, mercury and selenium in Lake Macquarie.
- Lead, mercury, and selenium in Lake Wallace.



Over half the feathers collected for the study contained mercury above the laboratory's detection limit (0.1 mg/kg). Of great concern was that two feathers from the Marine Park were found to be above published adverse health thresholds (8.6 mg/kg and 7.7 mg/kg). We believe the concentrations of mercury in feathers collected from the Port Stephens Great Lakes Marine Park, as well as mercury contamination found generally, are largely the result of atmospheric deposition of mercury emitted by NSW coal fired power stations, the closest of which are Bayswater and Liddell.

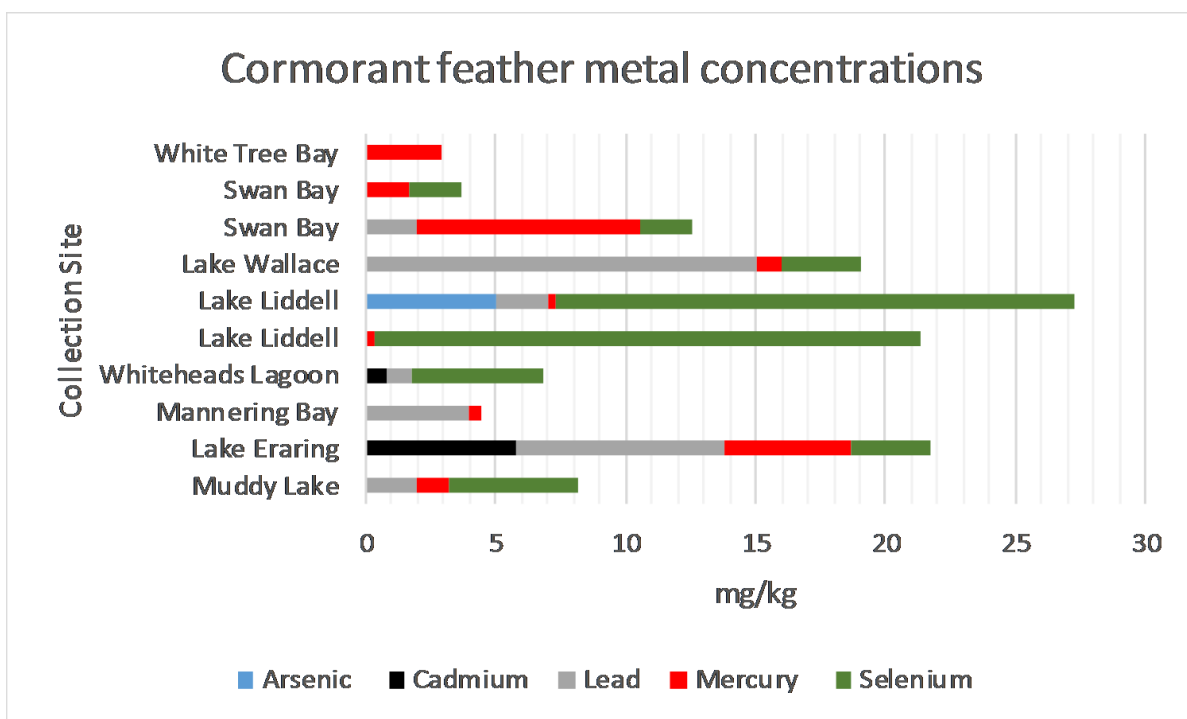
Recent studies have confirmed that the main driver of increased metal concentrations in Lakes close to NSW power stations is the combustion of coal. This mirrors experiences in other parts of the world, where metal contamination has markedly increased in water bodies close to operating coal-fired power stations.

Coal-fired power stations pollute waterways by emitting heavy metals into the atmosphere, which are then deposited in catchments and into waterways, into waterways directly via discharge, and coal ash leachate contaminating groundwater.

According to the National Pollutant Inventory, coal fired power stations emit almost 40 percent of NSW industrial point source air emissions of mercury and selenium, as well as 15 percent of arsenic and eight percent of cadmium. Most of this pollution could be reduced through the installation of flue gas desulphurisation technology (wet scrubbers) at operating power stations.

The clearest example of heavy metal contamination in birds is Lake Liddell. All the feathers collected from Lake Liddell contained concentrations of between one and three heavy metals shown to cause adverse health and reduce reproductive success.

The large Black Swan population of Lake Liddell is exposed to the toxic effects of a number of heavy metals. One of the feathers, taken from the decaying carcass of an adult Black Swan, had concentrations of arsenic at three times, lead three times, and selenium five times published health impact thresholds. Selenium concentrations in two of the Cormorant feathers were acutely toxic. The selenium contamination of Lake Liddell is largely the result of discharge and leachate from the Liddell power station ash dam.



Lead concentrations in feathers from Lake Wallace correlate with the very high sediment concentrations in the Lake directly attributable to the coal mines and power station ash dams upstream.

Lake Macquarie contamination is more complex, as the former lead smelter was a major contributor to the lead, selenium, and cadmium contamination, at least in northern Lake Macquarie. However, sediment cores taken by HCEC from southern Lake Macquarie suggest a causal link between the power stations and the elevated metals and metalloids found in Lake waterbirds and regularly caught and consumed seafood.

Nevertheless, all operating NSW coal-fired power stations are contributing to the concentrations of heavy metals afflicting our waterbirds. Many of which are also facing the significant challenges of climate change and habitat destruction.

In light of the findings presented in this study, an investigation by the NSW EPA into the full extent of health impacts that may be afflicting water bird and their habitat contaminated by coal-power stations must take place.





Introduction

The Hunter Community Environment Centre (HCEC) has been analysing water and sediment samples taken from areas surrounding NSW power station coal ash dumps since 2018.

Our findings, published in two reports,¹ have been confirmed by previously unpublished assessments commissioned by the NSW Government between 2013 and 2015. These Environmental Site Assessments (ESAs) identified significant contamination at all NSW coal-fired power station sites - largely attributed to the very large coal ash waste dumps - and concluded that the concentrations of metals and metalloids identified in soil, sediment, surface water and groundwater represent a potential risk to human health and the environment.

Because of their high solubility in water, metals and metalloids (“metals” will be used for convenience) can be absorbed by living organisms. Concentrations of metals can multiply as they accumulate in successive organisms along the food chain; from water to

sediment, to algae, seagrass, and invertebrates, to fish, birds, and mammals. If the metals ingested accumulate beyond threshold concentration, they can cause serious health disorders and significant environmental harm.

Metal pollution has likely played an important role in global biodiversity decline.² Long-term exposure to metals in the environment, even at low doses with chronic exposure, represents a major threat to wildlife populations and biodiversity.³

Sediment-dwelling organisms can accumulate metals above concentrations in the sediment⁴ exposing consumers of these organisms to the now-mobilised metals. Some metals bio-concentrate in the tissues of organisms at much higher levels than the waters and sediments in which they live.⁵ This is why birds feeding in shoreline habitats often accumulate higher levels of heavy metals and other trace elements than those in terrestrial environments.⁶

1 Winn et al, 2019. Winn et al, 2020.

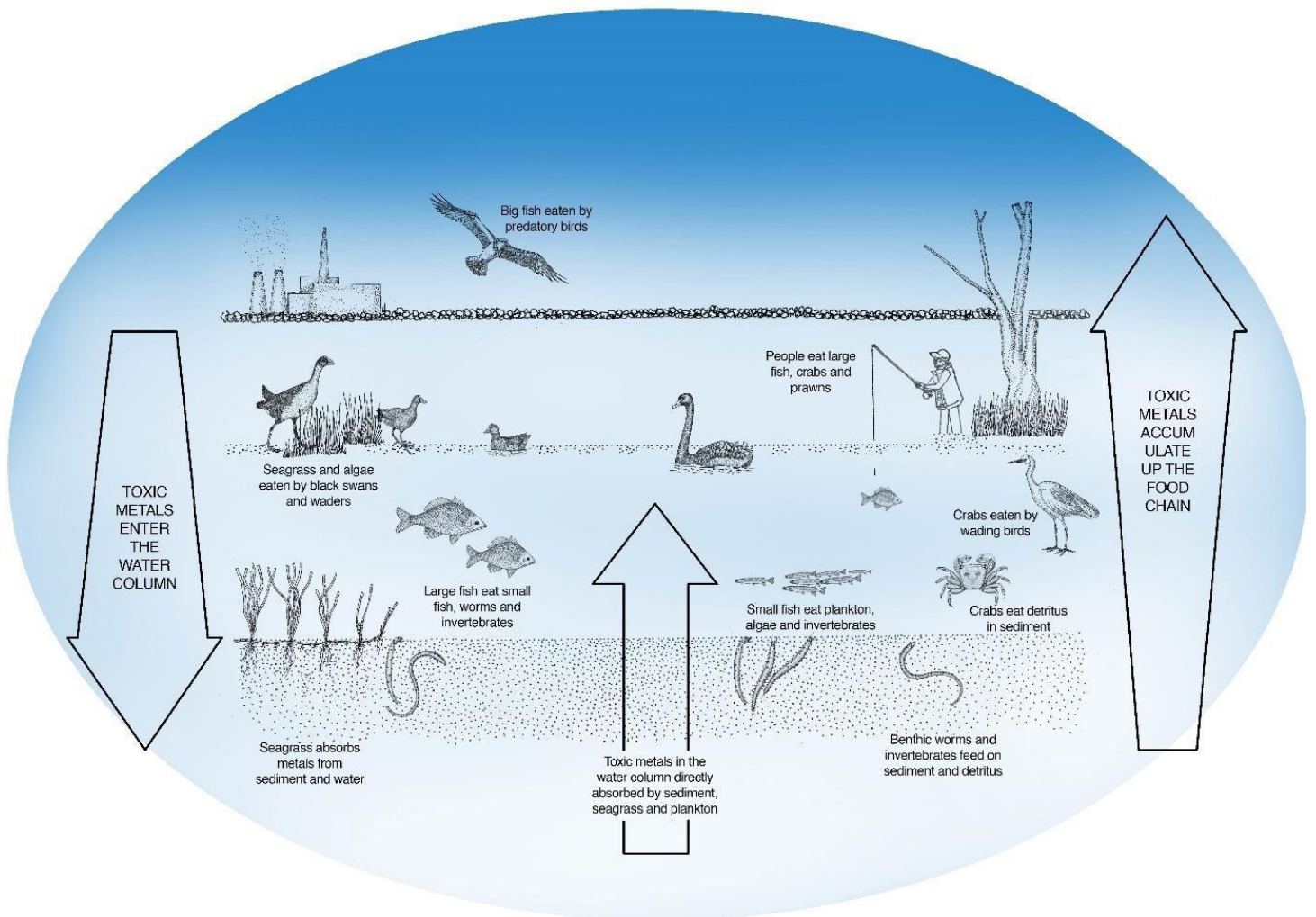
2 Tovar-Sánchez, et al, 2018.

3 Tovar-Sánchez, et al, 2018..

4 Tessier & Campbell, 1987; Thomas, Bendell-Young, 1998.

5 Burger J. 2008.

6 Burger J, 1993; Lucia et al, 2010; Wayland & Scheuhammer, 2011.



Metals bioaccumulation in the food-web. Alison Ellis.

Waterbirds have the capacity to significantly accumulate metals above environmental pollution levels,¹ which can influence the waterbird physiology, adversely affecting their feeding habits, growth, age, reproduction, moulting, migration and distribution.²

Waterbirds suffer severe health impairment or death when subjected to high concentrations of some metals.³ Chronic exposure can also cause mortality and other acute effects.⁴

The main consequences for birds exposed to chronic sub-lethal concentrations are reproductive dysfunction, increased susceptibility to disease, and behavioural changes.^{5 6} In addition, eggs of waterbirds exposed to heavy metals may have an impact on early growth and nestling survival.⁷ At the population level, heavy metal contamination can lead to dramatic declines in the number of water birds, which can lead to regional extinctions.⁸

1 Salzano & Angelone, 2013; Ullah et al, 2014.

2 Custer et al, 2003; Johansen et al, 2004; Mansouri, et al, 2012.

3 Wei Zhang & Jian Zhang, 2011

4 Jayakumar & Muralidharana, 2011.

5 .Scheuhammer. 1987.

6 Janssens et al, 2003; Dauwea et al, 2004.

7 Bize et al, 2002.

8 Wei Zhang & Jian Zhang, 2011



Two Black Swans and nest on Lake Liddell. July 2020. HCEC

Feathers are indicators of metals in birds because feathers can store and eliminate metals, especially into the growing feathers during the moulting process.⁹ While the concentrations increase with age and differ between feather types and function, concentrations are proportional to the body mass of animals and reflect the local contamination of a particular habitat,¹⁰ and represent long-term exposure.¹¹ Analysing metal content of feathers has been proven to be a reliable, non-invasive method of monitoring the potential ecological consequences of contamination. As they represent structures of the body in which metal deposition occurs, feathers can be as useful as internal organs in this respect and can be applied as bioindicators of metal pollution.^{12 13}

This report sets out laboratory analyses of metal concentrations in 40 randomly collected feathers discarded from a range of bird species and genera from the shores of three Lakes that are downstream from five NSW power station coal ash dumps shown to contaminate nearby sediment, as well as 14 feathers from background sites in Port Stephens and Myall Lakes National Park. We correlate these findings with known sediment concentrations, suggest likely pollution sources, and apply published health threshold concentrations to laboratory analyses of the feathers collected and identify possible impacts these metal concentrations may be having on waterbird species and local populations.

9 *Naccari, et al, 2009.*

10 *Naccari, et al, 2009.*

11 *Kim & Koo, 2007.*

12 *Markowski, et al 2013.*

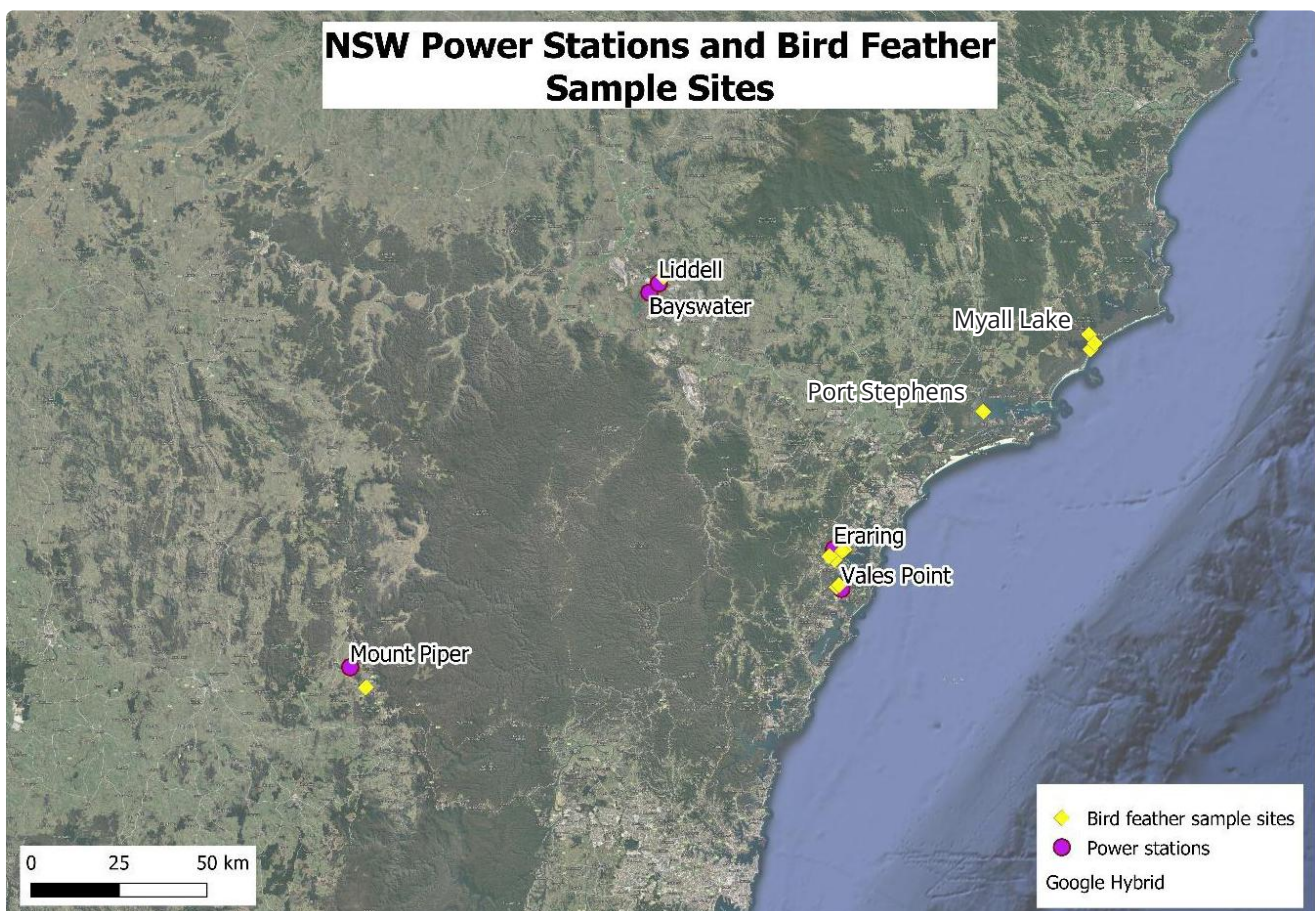
13 *Burger, 1993.*

Methodology

With the appropriate National Parks and Wildlife Research Licence, we collected 40 feathers discarded by a range of birds from the shores of southern Lake Macquarie, eastern Lake Wallace, and northern Lake Liddell, and Port Stephens and Myall Lake as control sites (see Map 1).

We washed the feathers in warm water, photographed them, and sent representative feathers to Envirolabs in Sydney for metal analyses (see Appendix 1 for laboratory reports).

We sent replica feather samples and photographs to the Australian Museum for identification (see Appendix 2 for digital records of feathers and Appendix 4 for Australian Museum identification).



Map 1: Feather collection sites



Results and discussion

Clear differences are apparent in the metal concentrations found in feathers from the four general areas.

- **Mercury** was above detection limits (0.1 mg/kg) in feathers from all areas. However, maximum and mean concentrations were highest in the control area (Port Stephens/Myall Lake).
- **Lead** was above detection limits (1 mg/kg) in feathers from all areas. Mean and maximum lead concentrations were highest in those collected from southern Lake Macquarie.
- **Selenium** was above detection limits (2 mg/kg) in feathers from all areas, but the maximum and mean concentrations were highest in those collected from Lake Liddell.
- **Cadmium** was only found above detection limits (0.4 mg/kg) in feathers collected from southern Lake Macquarie.
- **Arsenic** was only found above detection limits (4 mg/kg) in feathers collected from Lake Liddell.

Cumulative metals - all feathers

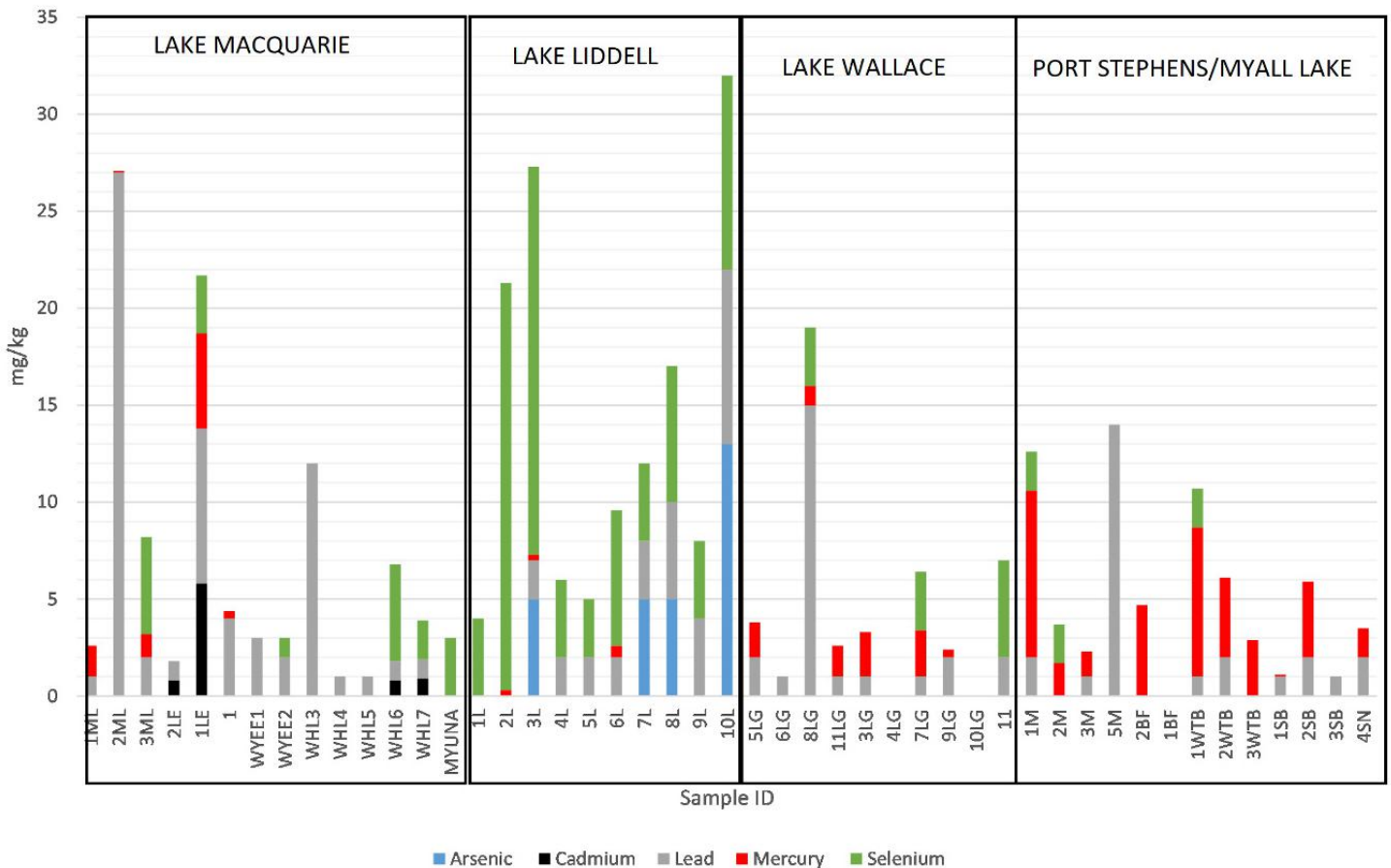


Chart 1: Metal concentrations found in feathers from all four collection areas.

As will be discussed below, metal concentrations in feathers will differ for species with different foraging behaviour, dispersal, size, and longevity. However, estimates made through thorough field and laboratory study by a number of authors can be applied to suggest critical concentrations in feathers that have the potential to adversely affect health and reproductive success of birds. These thresholds concentrations and their sources are set out under the metals of concern below.

When applied to the concentrations found in the feathers we collected for this study the following is the result.

- **Selenium:** 85 percent (18/21) of the feathers collected from the contaminated areas exceeded published threshold concentrations (1.8 mg/kg), compared to 23 percent from the control areas (3/13).

- **Lead:** Almost 30 percent of the feathers from the contaminated areas had concentrations of lead with the potential to adversely affect the birds' health and reproductive success (4 mg/kg), compared to only one of the 13 feathers (8%) from the control area.
- **Mercury:** None of the feathers collected from the contaminated areas had mercury concentrations above the published threshold level of 5 mg/kg. However, one feather from southern Lake Macquarie was just below this threshold (4.9 mg/kg). Two feathers from the control area contained mercury above adverse health threshold concentrations (8.6 mg/kg and 7.7 mg/kg).

- **Arsenic:** Arsenic was only detected in feathers from Lake Liddell where it was detected in four of the ten feathers. All were found to contain concentrations in the range of possible adverse health effects (1.3 mg/kg to 13 mg/kg).
- **Cadmium:** Cadmium was only detected in feathers from Lake Macquarie where it was detected in four feathers. Concentrations were above adverse health and reproductive effects thresholds (2 mg/kg) in one feather (5.9 mg/kg).

In total, 24 of the 44 (55%) feathers collected contained concentrations of metals above health thresholds - 20/31 (65%) of these were from the contaminated sites. Feathers from three of these birds – one Cormorant from Lake Macquarie, and two Black Swans from Lake Liddell - were found to contain concentrations of at least three metals above published adverse health and reproductive success thresholds (See published feather thresholds for metals of concern below).

Metals of concern

Several metals can impact the health of wild populations of waterbirds. In general, mercury, cadmium and lead are of primary concern,¹ they are non-essential, and toxic² Lead and cadmium, in particular, have been shown to adversely affect embryogenesis, hatching success and viability of water birds.³ Cadmium, mercury, and selenium have been shown to adversely affect the condition of birds by reducing their growth or body weight.⁴

Differences in metal concentration between bird species from various locations can be due to differences in foraging location, prey types and prey size.⁵ Cormorants prey on fish and marine invertebrates, and do not travel far from their colonies (<20 km).⁶ Cormorant feathers were collected from all the lakes and waterways sampled. Metal concentrations found in feathers of Cormorants from all collection sites are set out in Chart 2 below.

1 Mailman, 1980; Thompson and Furness, 1998.

2 Elliott et al, 1992.

3 Virág Kertész, 2006.

4 Takekawa et al, 2002.

5 Solgi, Eisa & Mirzaei-Rajeouni, Elham & Zamani, Abbas. (2020).

6 Millener, 1972.

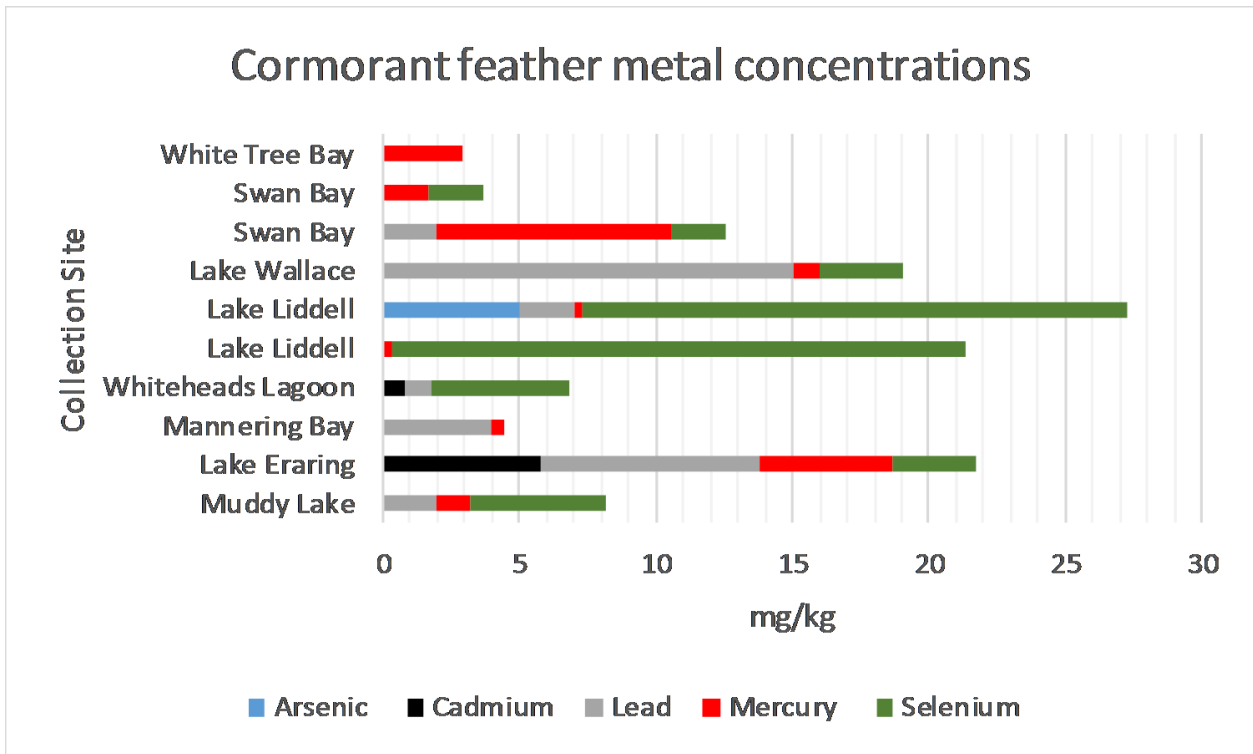


Chart 2: Metal concentrations in Cormorant feathers from all areas

When we apply the thresholds set out below, that data suggests the following toxic metals are at concentrations high enough to cause adverse health and reproductive success in birds residing in these areas;

- Arsenic, lead and selenium in Lake Liddell.
- Cadmium, lead, mercury and selenium in Lake Macquarie.
- Lead, mercury, and selenium in Lake Wallace.
- Lead and mercury in Port Stephens/Myall Lake.

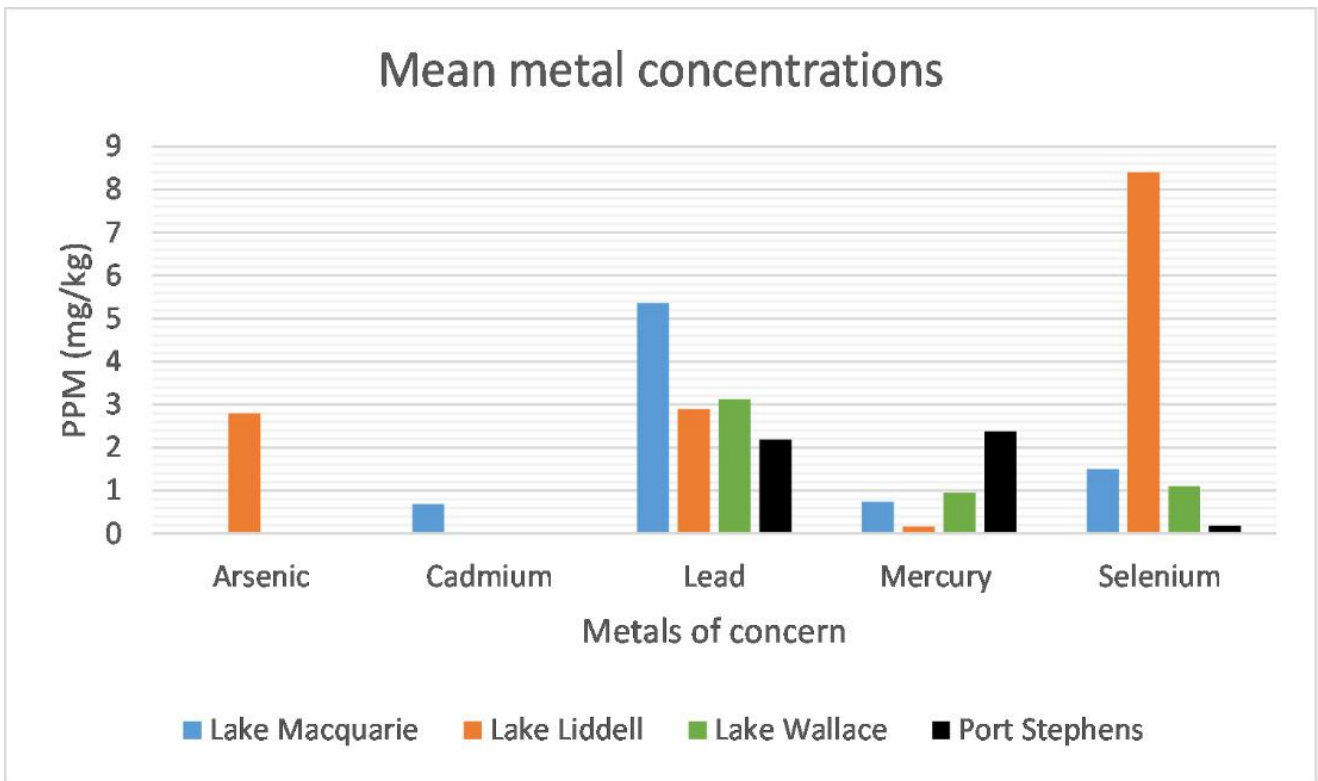


Chart 3: Mean metal concentration in feathers from all collection areas

ARSENIC

- Four of the ten feathers collected from Lake Liddell contained between 5 to 13 mg/kg arsenic. Mean concentration of the ten feathers (samples below the detectable limit were treated as zero) was 2.8 mg/kg.
- None of the feathers analysed from Lake Macquarie, Lithgow, and Port Stephens contained any detectable arsenic.
- Detectable arsenic concentrations were found in one Cormorant feather (5 mg/kg) and all four Black Swan feathers (three at 5 mg/kg, and one at 13 mg/kg). The feather with the highest arsenic concentration (13 mg/kg) was taken from a Black Swan carcass.
- Elevated arsenic concentrations were found in the flesh and organs of the crabs from southern Lake Macquarie (Wye Bay – max. 9 mg/kg). Mannering Bay sediment core sampling suggests a two- to threefold enrichment of arsenic since Vales Point A was commissioned.

Thresholds

Wildlife can be exposed to a variety of forms of inorganic and organic arsenic which may vary in their bioavailability and toxicity, although all forms seem hazardous.⁷ Overall, arsenic acts as a toxin inactivating enzymes, and it can deplete the major antioxidants of cells,⁸ and be carcinogenic.⁹ In birds, high doses of more than 24 mg/kg arsenic are fatal, and

7 Mandal & Suzuki, 2002.

8 Koivula & Eeva, 2010.

9 Sánchez-Virosta et al, 2015.

sublethal effects range across reproductive, behavioural and physiological categories.¹⁰

Most studies of the effect of arsenic in birds have correlated, but have trouble distinguishing the effect of arsenic from other heavy metals.¹¹ However, a recent paper that dosed Great Tits (*Parus major*) in the field (using nest boxes) showed that nestlings with feather concentrations averaging 1.3 mg/kg exhibited some declines in wing growth, whereas nestlings with feather concentrations that averaged 13.6 mg/kg showed increased mortality in the nest.¹²

CADMIUM

- Four feathers from southern Lake Macquarie contained detectable cadmium concentrations – two Pelicans (0.9 and 1 mg/kg) and two Cormorants. One Cormorant feather contained 5.8 mg/kg, well above the 2 mg/kg adverse health threshold described below.
- The mean concentrations of the feathers collected from southern Lake Macquarie was 0.7mg/kg.
- The sediment samples HCEC had analysed from southern Lake Macquarie - Crooked Creek (0.9mg/kg), and Mannering Bay (1.4mg/kg) - and the Vales Point Environmental Site Assessment (Wye Creek, Wye Bay, and Mannering Bay >1.5mg/kg) suggest cadmium contamination of sediment around the power station sites, particularly Vales Point. The sediment

core HCEC took from Mannering Bay suggests sediment concentration has increased 15 fold since Vales Point A was commissioned in 1963.

- Cadmium concentrations found in Lake Macquarie Cormorants (max 5.9 mg/kg) suggest a bioaccumulation factor of about 4 compared to sediment concentrations (1.5 mg/kg), somewhat lower than that for Wye Bay crabs (bioaccumulation factor of 6 - max. 9 mg/kg).
- Cadmium was detectable in all the Lithgow sediment samples taken by HCEC (max 2 mg/kg at Springvale discharge), with 0.6 mg/kg in the Lake Wallace sample. Cadmium was not detected in the background sample.

Thresholds

Cadmium concentrates in the kidneys, which leads to kidney damage.¹³ At low concentrations, its most adverse effect may be on bone structure,¹⁴ and it can also cause reproductive problems, specifically interfering with spermatogenesis.¹⁵ Cadmium bioaccumulates, and, under some conditions may biomagnify.¹⁶ Cadmium concentrates in freshwater and marine animals hundreds to thousands of times higher than in the water. Reported bio concentration factors range from <200 to 18,000 for invertebrates,¹⁷ and from 3 to 4,190 for freshwater aquatic organisms.¹⁸

10 *Sánchez-Virosta et al, 2015.*

11 *Sánchez-Virosta et al, 2015.*

12 *Sánchez-Virosta et al, 2018.*

13 *Järup & Åkesson, 2009.*

14 *Åkesson et al, 2014.*

15 *Marettová et al, 2015.*

16 *Burger, 2008.*

17 *van Hattum et al, 1989.*

18 *US EPA, 1995.*

Cadmium has been shown to adversely affect embryogenesis, hatching success and viability of water birds.¹⁹ Cadmium causes sublethal behavioural effects at lower concentrations than lead and mercury.²⁰ Conversion factors developed from Burger 1993²¹ suggest that feather levels associated with adverse effects would range from 1 mg/kg (shearwaters) to 2 mg/kg (terns). However, a rough estimate of the level of adverse effects in feathers was estimated by Burger and Gochfeld (2000b) at 2 mg/kg.

LEAD

- All the feathers collected from the three contaminated sites, as well as nine of the 13 feathers collected from Port Stephens/Myall Lakes NP, contained detectable lead.
- Feathers of a Pelican, Cormorant, White-faced Herron, and a Crake/Rail/Swamphen, from Lake Macquarie, had significant lead concentrations; above threshold levels for the birds' health (4 mg/kg).
- Lead was detected in all but three Cormorant feathers – White tree Bay, Swan Bay and Lake Liddell. The concentration of lead in the cormorant feather collected from Lake Wallace was 15 mg/kg, significantly higher than Lake Macquarie (max. 8 mg/kg), and Lake Liddell (max. 2 mg/kg), and the control sites (max. 2 mg/kg). Lead is of particular concern in Lake Wallace. Analysis of HCEC sediment sample from the western shore of Lake Wallace shows 270 mg/kg, above the 220 mg/kg ANZECC High Guideline Value.

Lake Macquarie and Lake Wallace Cormorant feathers were 2 and 4 times the concentrations of 4 mg/kg of lead in feathers identified as threshold level for adverse effects of lead that may cause adverse health and reproductive effects.²²

A Pelican feather collected from southern Lake Macquarie (Muddy Lake) contained the highest lead concentration (27 mg/kg); almost seven times the identified threshold may cause adverse health and reproductive effects.

The Mannering Bay sediment core set out in Winn et al (2021), suggests a fourfold enrichment of lead since Vales Point A was commissioned to 8 mg/kg, HCEC's sediment samples taken from Crooked Creek, the result of historic ash dam contamination found concentrations of lead at 16, 29 and 36 mg/kg.

19 *Virág Kertész, 2006.*

20 *Eisler, 1985.*

21 *Burger, 1993.*

22 *Plaza & Lambertucci, 2019.*



Purple Swamphen. Alison Ellis

Thresholds

Lead is a non-degradable metal, and concentrations of 4 mg/kg dry weight in the feather are known to be associated with several behavioural, physiological, and nutritional toxicities in wild birds,²³ such as nervous system alteration, behavioural deficits, and growth slowdown.²⁴

Lead has been shown to adversely affect embryogenesis, hatching success and viability of water birds.²⁵

Older organisms tend to contain the greatest body burdens of lead. In aquatic environments, lead concentrations are usually highest in benthic organisms and algae, and lowest in upper trophic level predators (e.g., carnivorous

fish).²⁶ Bio-concentration factors for aquatic biota are: 42 for fish, 536 for oysters, 500 for insects, 725 for algae, and 2,570 for mussels.²⁷

SELENIUM

- Detectable selenium was found in all but two Cormorant feathers.
- The two Lake Liddell Cormorant feathers were found to have concentrations likely to be acutely toxic (20 mg/kg; 21 mg/kg) - four times that of the other site's maxima (Lake Macquarie and Lake Wallace max. 5 mg/kg), and ten times that of the control sites (Swan Bay and White Tree Bay 2 mg/kg).

23 *Burger and Gochfeld 1994*

24 *Burger and Gochfeld 2000*

25 *Virág Kertész, 2006.*

26 *ATSDR, 2007.*

27 *ibid*

- While HCEC sediment samples, taken from the northern shore (Caravan Park) contained 3 mg/kg selenium, enough to cause bioaccumulation in predators, the Bayswater Environmental Site Assessment revealed maximum 45.2 mg/kg selenium in sediment collected from the bay north of the Liddell Power Station, and an average concentration of 6.2 mg/kg across the Lake.²⁸

Thresholds

About 5 mg selenium per day is considered toxic in the human diet, making it the third most toxic trace element after mercury and lead.²⁹ Significant bioaccumulation can occur in aquatic food chains at water concentrations as low as mg/kg.³⁰

The most sensitive biological indicators of aquatic ecosystem-level impacts of selenium are reproductive effects in fish and aquatic birds.³¹ Despite its status as an essential trace element, waterborne selenium concentrations of 2 mg/kg or greater are considered highly hazardous to the health and long-term survival of sensitive fish and aquatic birds.³²

Dietary exposure due to food-chain bioaccumulation is responsible for the reproductive effects, not direct waterborne toxicity.³³ Some species will be relatively unaffected at the 2 mg/kg level, but sensitive species, many of which are the most important in terms of ecological integrity and

public recreational value, can be seriously affected.³⁴ Under certain environmental conditions, waterborne concentrations of 0.001 mg/kg or less have the potential to bio-accumulate to levels in the food chain that are toxic to predatory species.³⁵

Selenium in water can be concentrated from 100 to more than 30,000 times in the food organisms eaten by fish and wildlife, which exposes them to a highly concentrated dietary source of contamination. Biomagnification may also occur, resulting in a two- to sixfold increase in selenium between primary producers and forage fish.³⁶ If the ecosystem is allowed to reach equilibrium such that recycling of selenium from sediment occurs, the detrital food pathway can deliver toxic doses of selenium for many years even if waterborne sources are eliminated.³⁷ Thus, bioaccumulation in aquatic food chains, and dietary transfer to eggs, cause otherwise innocuous concentrations of waterborne selenium to become toxic.³⁸

Aquatic organisms consumed by fish and birds strongly bioaccumulate selenium—hundreds to thousands of times the waterborne concentration—but are unaffected by tissue residues that are high enough to cause reproductive failure when consumed by fish and aquatic birds.

A significant portion of the selenium consumed by wildlife is passed to their offspring in eggs, where it can kill developing embryos outright or induce a variety of lethal or sublethal

28 ERM, 2014a. ERM, 2014b.

29 Alloway & Ayres, 1993.

30 Peterson & Nebeker, 1992.

31 Lemly, 2002.

32 Lemly, 2002.

33 *ibid*

34 *ibid*

35 *ibid*

36 Lemly, 1999.

37 Lemly, 1982; Lemly, 1985a; Lemly, 1997a.

38 Lemly, 1993b.

teratogenic deformities.³⁹ However, parents that consume a selenium-laden diet can experience partial or complete reproductive failure without exhibiting symptoms of selenium toxicosis themselves.⁴⁰ At high enough doses selenium toxicity can devastate wildlife populations. For example, it was estimated in 1997 that annual avian losses due to selenosis in parts of California were as high as 10,000.⁴¹

Selenium has been reported as an antagonist to mercury, due to it forming an inert and stable compound that then reduces mercury toxicity.⁴² Selenium is also known to reduce the toxicity of cadmium,⁴³ so its presence might be critical to how birds cope with high levels of the most toxic metals/metalloids.

For selenium, feather levels of 3.8 to 26 mg/kg (depending upon species) result in mortality,⁴⁴ and 1.8 mg/kg result in sublethal adverse effects.⁴⁵

- The control sites had an average mercury concentration of 2.4 mg/kg, compared to 0.9 mg/kg in those from Lake Wallace, and 0.75 mg/kg in those from southern Lake Macquarie.
- A Cormorant feather from southern Lake Macquarie (Lake Eraring) was found to contain 4.9 mg/kg, just under the estimated health threshold.

MERCURY

- Mercury was highest in a Cormorant feather from one of the control sites (Swan Bay: 8.6 mg/kg), significantly above the 5 mg/kg feather concentration estimated for adverse effects,⁴⁶ such as reduction in growth or body weight.⁴⁷
- Ten of the fourteen feathers collected from the control sites contained detectable mercury.

39 Lemly, 1993c.

40 Lemly, 1999.

41 O'toole & Raisbeck, 1997.

42 Koeman et al, 1973. Yang et al, 2008.

43 Lin et al, 2012

44 Burger, 1993

45 Heinz, 1996.

46 Burger & Gochfeld, 2000b.

47 Takekawa et al, 2002.



Pied Cormorant. HBOC.

Thresholds

Mercury is a well-known neurotoxin that can be a threat to wildlife health,⁴⁸ as well as human health. Mercury biomagnifies across trophic levels, and thus is highest in carnivores.⁴⁹

Mercury concentrations above 5 mg/kg in feathers are associated with adverse reproductive effects in birds.⁵⁰ However, concentrations of 15 mg/kg mercury are required for adverse effects in some predatory birds.⁵¹

More recently, it has been suggested that adverse effects could be encountered even at 3 mg/kg in tail feathers for small passerines,⁵² although this level may be lower than warranted.⁵³

48 *Scheuhammer et al, 2007.*

49 *Lavoie et al, 2013.*

50 *Eisler, 1987.; Burger & Gochfeld, 2000b;*

51 *Spry & Wiener, 1991; Wiener & Spry, 1996.*

52 *Jackson et al, 2011.*

53 *Fuchsman et al, 2017.*

Major regional heavy metal sources

Coal-fired power stations are a major source of heavy metals, which are emitted into the atmosphere and deposited into catchments and waterways, directly discharged to waterways from ash dams, and leached from unlined coal ash dams into groundwater. Metal contamination has markedly increased in water bodies close to operating coal-fired power stations.⁵⁴ Schneider et al, 2020, suggested that coal mining and coal burning for electricity production were the main drivers of increases in metal concentrations in Lake Glenbawn, 30 km north west of Bayswater power station.

In *Out of the Ashes II*,⁵⁵ we set out National Pollutant Inventory estimates for the proportion of industrial point source air emissions from NSW coal-fired power stations: These include:

- Arsenic 15%
- Cadmium 8%
- Lead 6%
- Mercury 38%
- Selenium 41%,

We also set out mean concentrations of heavy metals found in NSW power station fly ash and estimated the percentage leachate.⁵⁶ These included:

- Arsenic 16 mg/kg; 3% - 0.5 mg/l leached.
- Cadmium 0.5 mg/kg; 13% -0.06 mg/l leached.
- Mercury 0.1 mg/kg; 11% -0.012 mg/l leached.
- Lead 57 mg/kg; 0.05% -0.024 mg/l leached.
- Selenium 4 mg/kg. 23% - 1 mg/l leached.

We estimated heavy metal leachate from power station coal ash waste dumps in NSW. These included annual leachate estimates of:

Arsenic

- Liddell ash dam, which drains into Lake Liddell each year - 360 kg,
- Mt Piper and the former Wallerawang ash dumps, upstream of Lake Wallace - 240 kg,
- Eraring and Vales Point ash dumps (Lake Macquarie) - 1000 kg.

⁵⁴ Meij and teWinkel, 2007; Schneider et al., 2014a

⁵⁵ Winn et al, 2021.

⁵⁶ Winn et al, 2021.

Lead

- Liddell - 17kg.
- Lithgow ash dams - 12 kg.
- Eraring and Vales Point – 50 kg,

Selenium

- Liddell - 670 kg
- Mt Piper and Wallerawang - 677 kg.
- Eraring and Vales Point – 1964 kg,

Mercury

- Liddell – 8 kg,
- Mt Piper and Wallerawang – 9 kg.
- Eraring and Vales Point – 25 kg,

Cadmium

- Liddell – 42 kg.
- Mt Piper and Wallerawang – 43 kg.
- Eraring and Vales Point – 124 kg.

Lake Macquarie

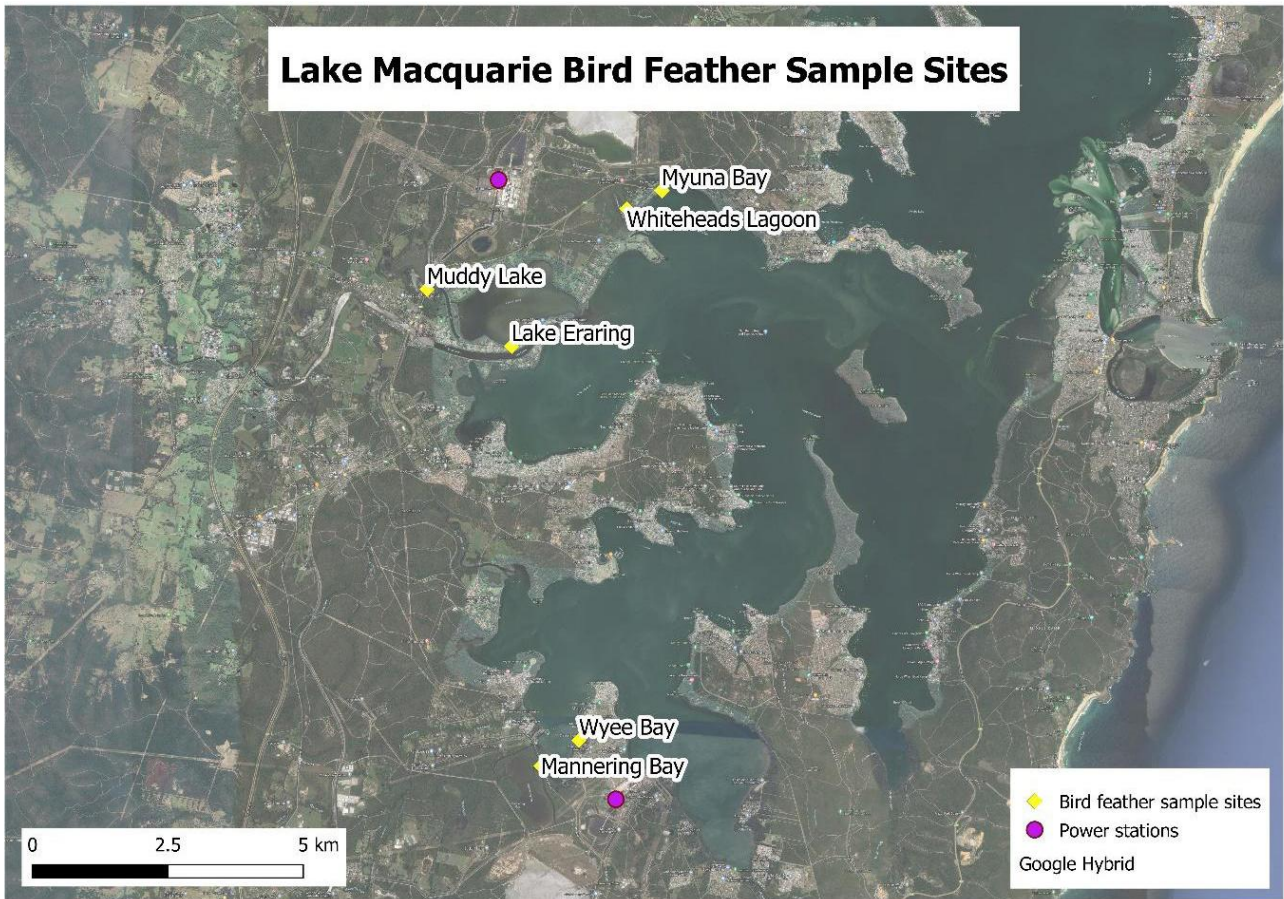
Lake Macquarie, a wave-dominated barrier lagoon between Sydney and Newcastle, is the largest coastal estuary in eastern Australia covering an area of about 110 km². With the exception of the entrance at the Swansea Channel, tidal currents are non-existent in most of the Lake, with winds producing larger changes in water levels than tides.⁵⁷ Despite the poor tidal exchange, the lake has a marine character due to minimal inflows from the two main freshwater creeks of Dora Creek in the south of the Lake and Cockle Creek in the north.⁵⁸

Twelve feathers from five genera of waterbird, one Tawny Frogmouth, and one Black-faced Cuckoo Shrike were collected from southern Lake Macquarie.

- Myuna Bay and Whiteheads Lagoon are downstream from both the Eraring power station ash dam and cooling water discharge.
- Wyee Bay and Mannering Bay receive ash dam overflow, potential leachate, and cooling water discharge from Vales Point power stations.
- Lake Eraring and Muddy Lake are important waterbird foraging, roosting, and nesting sites.

57 Schneider, 2014.

58 Schneider, 2014.



Map 2: Southern Lake Macquarie collection sites and power stations

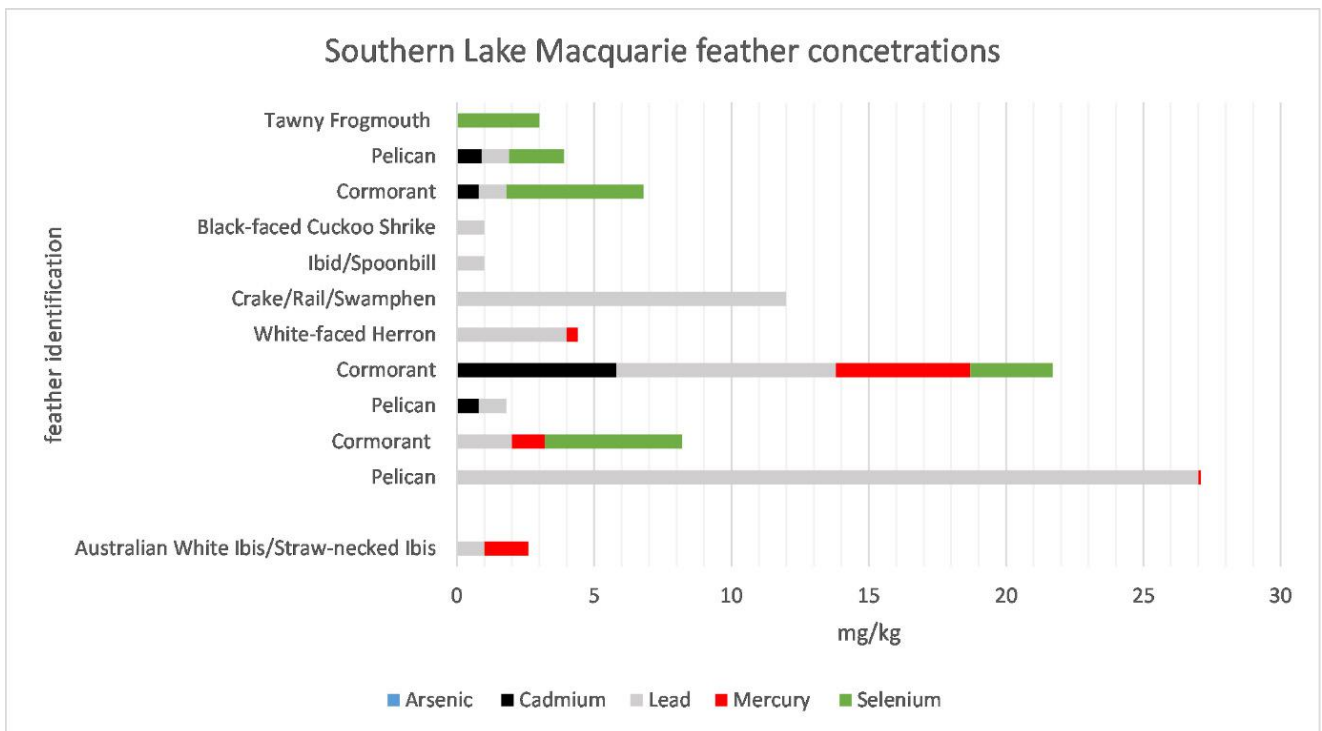


Chart 4: Metal concentrations in feathers collected from Lake Macquarie and Australian Museum identification.

- Significant concentrations of **lead** were found in all the waterbird feathers, and the Shrike.
- Five of the feathers, including the Frogmouth, contained significant concentrations of **selenium** (2 – 5 mg/kg), and above published health threshold levels (1.8 mg/kg).
- Detectable **cadmium** was found in four feathers, including two Pelicans, one from Lake Eraring (0.8 mg/kg) and one from Whiteheads Lagoon (0.9 mg/kg), and two Cormorants, one (5.8 mg/kg) well above estimated health impact thresholds (2 mg/kg) from Lake Eraring, and one from Whiteheads Lagoon (0.8 mg/kg).
- **Mercury** was found in four feathers, two cormorants (Muddy Lake – 1.2 mg/kg; Lake Eraring - 4.9 mg/kg), a White-faced Herron (Manning Bay 0.4 mg/kg), and a White Ibis/Straw-necked Ibis (Muddy Lake 1.6 mg/kg). None above health thresholds (5 mg/kg).

White-necked Heron and Purple Swamphen. HBOC.



Table 1: Laboratory results - all Lake Macquarie feathers

| Region | Location | Sample ID | METAL (mg/kg) | Aluminium | Arsenic | Boron | Cadmium | Cobalt | Copper | Iron | Lead | Manganese | Mercury | Molybdenum | Nickel | Selenium | Zinc |
|--------|-------------------|---|---------------|-----------|---------|-------|---------|--------|--------|------|------|-----------|---------|------------|--------|----------|------|
| | | AVERAGE | | 208 | | 9 | 1 | 5 | 14 | 926 | 17 | 42 | 2 | 0 | 3 | 1 | 245 |
| | Whiteheads Lagoon | Tawny Frogmouth | MYUNA | 20 | | 6 | | | 7 | 30 | | 13 | | | 3 | 3 | 230 |
| | | Pelican | WHL7 | 380 | | 10 | 0.9 | 4 | 15 | 1500 | 1 | 100 | | | 9 | 2 | 120 |
| | | Cormorant | WHL6 | 210 | | 5 | 0.8 | | 17 | 510 | 1 | 26 | | | 5 | 5 | 150 |
| | | Black-faced Cuckoo Shrike | WHL5 | 70 | | 5 | | | 10 | 80 | 1 | 12 | | | 1 | | 130 |
| | | Ibid/Spoonbill | WHL4 | 330 | | 4 | | | 16 | 640 | 1 | 12 | | | 1 | | 50 |
| | | Crake/Rail/Swamphen | WHL3 | 60 | | 10 | | | 33 | 50 | 12 | 18 | | 2 | 5 | | 440 |
| | | Pigeon/Dove | WHL2 | 180 | | 7 | 2 | 4 | 16 | 2300 | 2 | 82 | | 1 | 6 | 4 | 140 |
| | | Crested Pigeon | WHL1 | 60 | | 7 | | | 22 | 180 | | 14 | | | 3 | | 110 |
| | Wyee Bay | Crow/Raven | WYEE4 | 80 | | 20 | | 14 | 270 | 22 | 17 | | 1 | 1 | | 370 | |
| | | Crow/Raven | WYEE3 | 290 | | 8 | | 22 | 580 | 190 | 44 | | | 2 | 2 | 1500 | |
| | | NO ID | WYEE2 | 520 | | | | 5 | 720 | 2 | 11 | | | 1 | 1 | 22 | |
| | | NO ID | WYEE1 | 530 | | 3 | | 10 | 810 | 3 | 4 | | | | | 7 | |
| | Manning Bay | White-faced Herron | 1 WYEE1 | 280 | | 20 | | 15 | 690 | 4 | 14 | 0.4 | | 2 | | 440 | |
| | Lake Eraring | Cormorant | 1LE | 450 | | | 5.8 | 6 | 13 | 7400 | 8 | 340 | 4.9 | | 8 | 3 | 240 |
| | | Pelican | 2LE | 40 | | 20 | 0.8 | | 5 | 280 | 1 | 15 | | | | | 58 |
| | Muddy Lake | Cormorant | 3ML | 20 | | 7 | | 11 | 170 | 2 | 11 | 1.2 | | | | 5 | 130 |
| | | Pelican | 2ML | 150 | | | | 13 | 300 | 27 | 8 | 0.1 | | | | | 130 |
| | | Australian White Ibis/Straw-necked Ibis | 1ML | 80 | | | | | 8 | 160 | 1 | 17 | 1.6 | | 2 | | 140 |

Vales Point Environmental Site Assessment

Selenium and cadmium contamination of southern Lake Macquarie have been identified by numerous studies.⁵⁹ The Environmental Site Assessment commissioned by NSW Treasury for Vales Point⁶⁰ identifies cadmium and selenium in sediments of Wyee Creek and Mannering Bay. These include:

Cadmium:

- Two sediment samples collected from within Wyee Bay were in excess of ANZECC sediment guideline values.
- Sample collected from the control area in excess of the ANZECC sediment guideline values.

Selenium

- Exceedances in numerous sediment samples collected from lower Wyee Creek (max. 26 mg/kg) and Mannering Bay (max. 8 mg/kg).
- Concentrations generally increasing down the Creek towards Mannering Bay.
- Elevated concentrations within sediments in offsite surface water bodies down-gradient of the Ash Dam (Wyee Bay, Mannering Bay, and Wyee Creek) represent a potential risk to the environment (ecological exposure and ingestion of fish).⁶¹

Metals in Wyee Bay crabs

A 1996 NSW health study found mean selenium concentration of the muscle of Lake Macquarie finfish was 1.2 mg/kg (dry weight).⁶² Dalton and Bird (2003) conducted a risk assessment for consumption of fish species from Lake Macquarie based on sampling and analysis conducted and reported that the allowable intake of fish based on selenium concentrations was 1.35 kg/week for an adult.

Documents obtained by the HCEC in 2020 from the then-NSW Office of Environment and Heritage (OEH) under freedom of information law suggest these concentrations have not changed markedly over the intervening 24 years.⁶³ Mud crabs, however, were found to have concentrations above levels that could cause human exposure to cadmium toxicity if consumed more than once a week.

- Mean concentrations of **cadmium** in Mud Crabs was found to be 2.5 mg/kg, and Blue Swimmer Crabs was 0.75 mg/kg. The maximum cadmium concentration of 3.4 mg/kg was from a Mud Crab from the very northern end of Lake Macquarie.
- The maximum **arsenic** concentration was 70 mg/kg from a Blue Swimmer Crab from the very southern end of Lake Macquarie.
- Maximum **selenium** was 3 mg/kg from a bream caught in central Lake Macquarie. The maximum selenium in a crustacean was found in a Mud Crab (2 mg/kg) from the very northern part of the Lake.

59 Peters et al, 1999b; Roach, 2005; Roach et al, 2008; Roberts, 1994; Roach, 2005; Roach et al, 2008; Schneider, 2014.

60 ERM, 2014.

61 ERM, 2014d.

62 Dalton & Bird, 2003.

63 OEH EPS Branch, 2019.

HCEC collected flesh, organs and shell from two male Blue Swimmer Crabs and one male Mud Crab caught in a dilly trap from the southern end of Wyee Bay in late 2020, and sent them for metal analyses. (See (Appendix 1 and 3).

- The flesh and organs of the Mud Crab were found to contain significant concentrations of **Selenium** - 4 mg/kg and 3 mg/kg respectively.
- **Cadmium** was found in the shell and organs, but not the flesh, of all three crabs. The organs contained significantly higher concentrations of cadmium; the Blue Swimmer Crabs 5.3 mg/kg and 5.7 mg/kg, and the Mud Crab 9.1 mg/kg.
- Significant concentrations of **arsenic** was found in the flesh and organs of all three crabs;
 - **Blue Swimmer**
 - 9 mg/kg; 9 mg/kg,
 - 8 mg/kg; 6 mg/kg,
 - **Mud Crab**
 - 8 mg/kg; 6 mg/kg.

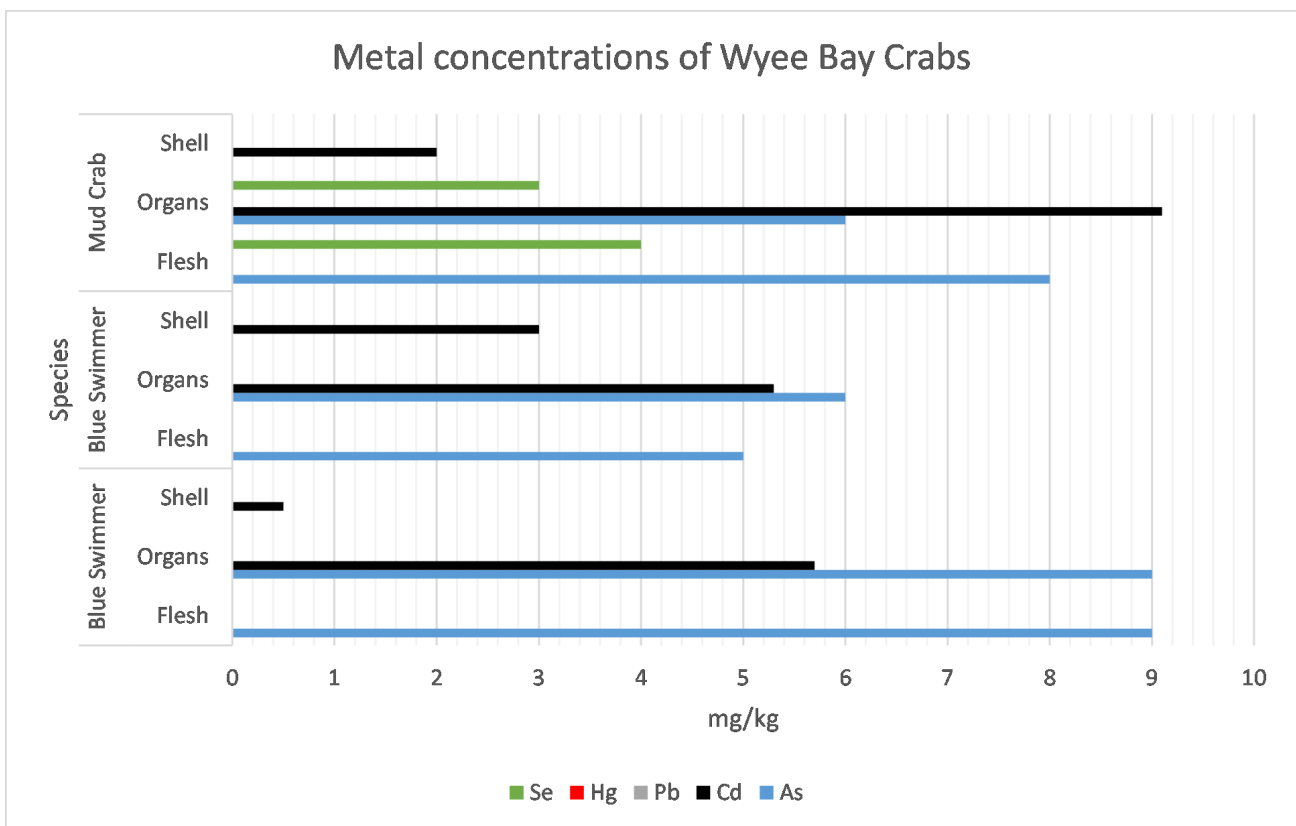


Chart 5: Metal concentrations found in crabs from southern Lake Macquarie – Wyee Bay

Mannering Bay sediment core

As we reported in Out of the Ashes II, HCEC took a 30 cm sediment core from Mannering Bay and asked ANSTO to provide a lead 210 isotopic dating analysis. ANSTO identified 15 dates from 1930 to 2019. Laboratory analysis of the sediment samples taken from these time stamps, shows a substantial increase in metal concentrations between 1960 and 1970.

Vales Point A was commissioned in 1962. The time series shows that from 1930 to 1960 little increase in metal concentrations was apparent. Since 1960;

1. **Cadmium** concentrations increased by a factor of 15,
2. **selenium** by 8 to 10,
3. **lead** by 4, and
4. **arsenic** by 2 to 3.



Charts 6: Metal concentrations found in dated sediment core 64

Eraring power station Environmental Site Assessment

The Environmental Site Assessment commissioned by NSW Treasury for Eraring power station⁶⁵ reveals that:

- **Arsenic** exceeded ANZECC sediment guidelines (20 mg/kg) in nineteen sediment samples with maximum of 33 mg/kg - linked to historical discharges to Crooked Creek or Whiteheads Lagoon.
- **Selenium** concentrations in surface sediments likely related to fly ash from the power station, including the direct release of seepage from the Ash Dam into Crooked Creek prior to 1991.
 - Return Water Dam (max. 42 mg/kg)
 - Crooked Creek (6.3 mg/kg; 18 mg/kg)
 - Southern end of Whiteheads Lagoon (up to 5 mg/kg). The Myuna Bay sediment samples were of the same order of magnitude as those measured in the control locations.⁶⁶

HCEC sediment analysis

HCEC took sediment samples from Crooked Creek in 2020.

The maximum concentrations in our samples were:

- **Selenium** 110 mg/kg, well above ANZECC Default Guideline Value (20 mg/kg) and High GV (70 mg/kg).⁶⁷
- **Arsenic** 160 mg/kg.
- **Lead** 36 mg/kg.
- **Cadmium** 0.9 mg/kg

65 ERM, 2015.

66 ERM, 2015.

67 <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants>

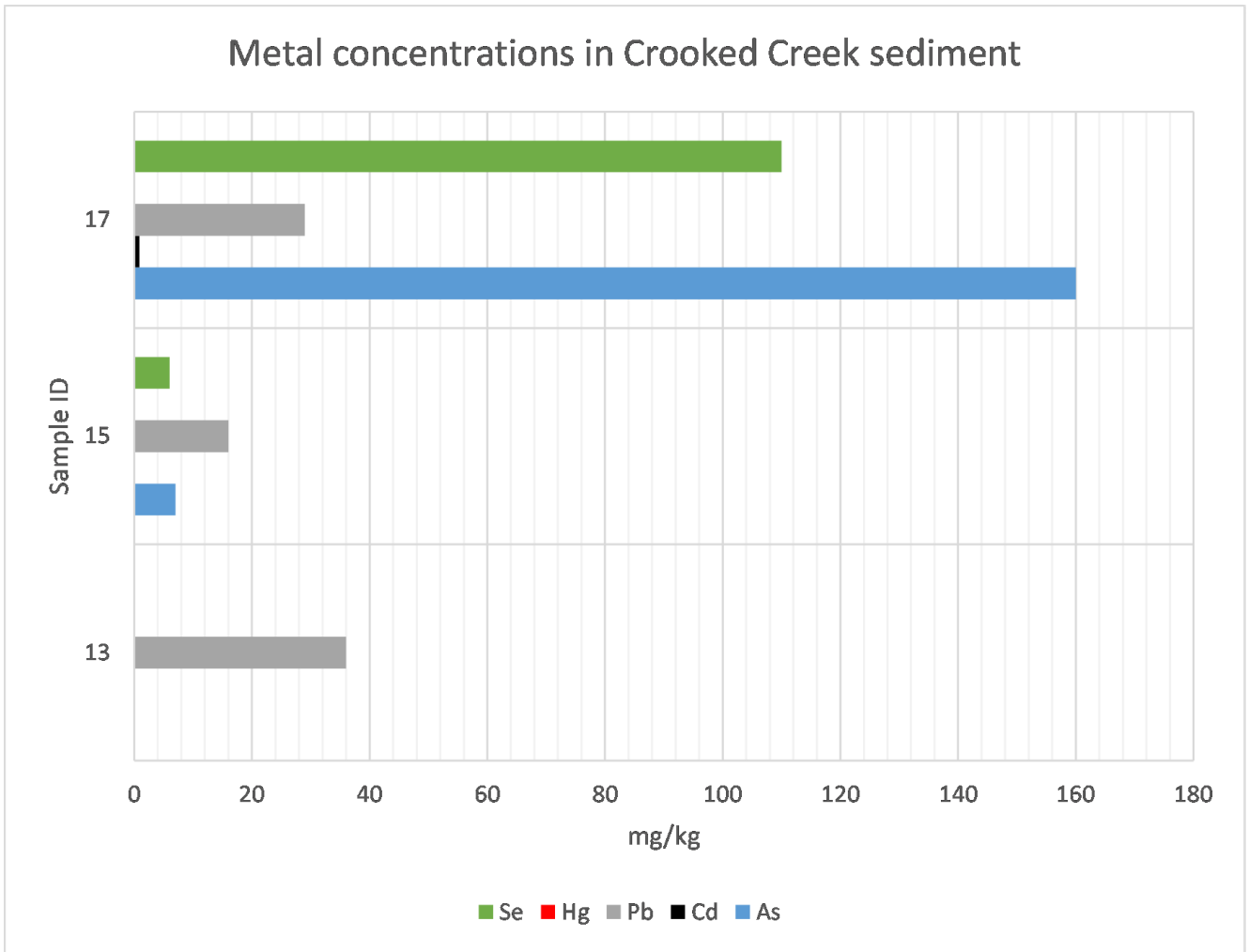


Chart 6: Metal concentrations in HCEC sediment samples from Crooked Creek 2020.

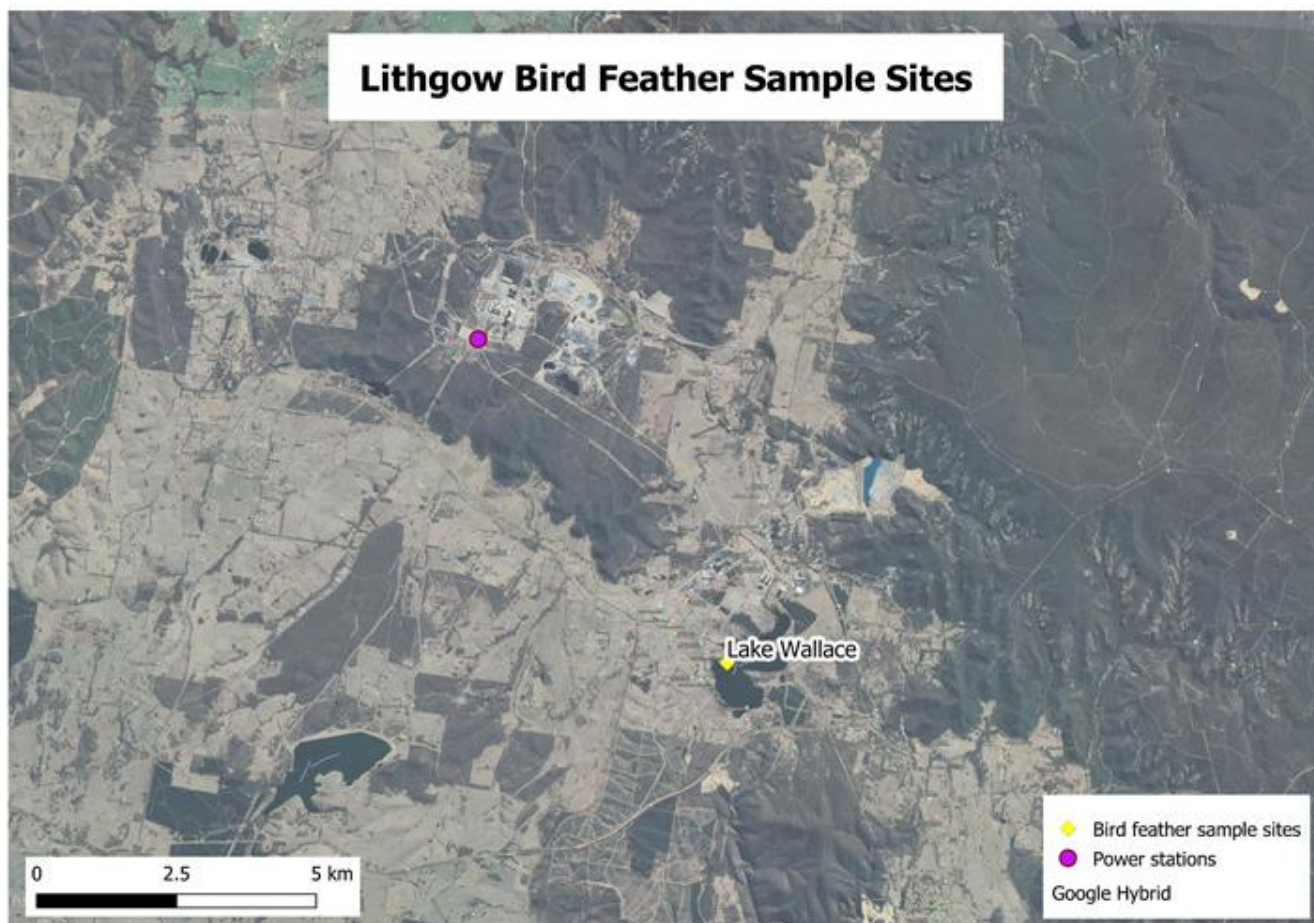
| Sample # (ppm) | 13 | 15 | 17 | ANZECC (2000) | |
|------------------------|--------|----------|------------|----------------------------------|----------------|
| Date | 28-Oct | 28-Oct | 28-Oct | ISQG - Low (trigger value) | ISQG - High |
| Silver | <1 | <1 | <1 | | |
| Aluminium-Total | 2900 | 7300 | 65000 | | |
| Arsenic-Total | <4 | 7 | 160 | 20 | 70 |
| Boron-Total | <3 | 10 | 77 | | |
| Cadmium-Total | <0.04 | <0,04 | 0.9 | 1.5 | 10 |
| Chromium-Total | 4 | 7 | 87 | 80 | 370 |
| Copper-Total | 13 | 13 | 38 | 65 | 270 |
| Iron-Total | 7500 | 6800 | 100000 | | |
| Lead-Total | 36 | 16 | 29 | 50 | 220 |
| Mercury-Total | <0.1 | <0.1 | <0.1 | 0.15 | 1 |
| Manganese-Total | 100 | 56 | 720 | | |
| Nickel-Total | 4 | 6 | 42 | 21 | 52 |
| Selenium-Total | <2 | 6 | 110 | | |
| Thorium-Total | | | | | |
| Thallium -Total | <2 | <2 | <2 | | |
| Vanadium -Total | 10 | 33 | 580 | | |
| Zinc-Total | 110 | 18 | 240 | 200 | 410 |

Table 2: Laboratory results and interim sediment quality guidelines (ISQG) for sediment samples taken from Crooked Creek October 2018 –Eraring power station emergency discharge to Myuna Bay⁶⁸

68 From Winn et al, 2019.

Lake Wallace

Constructed in 1978 by damming the Cox's River, Lake Wallace provided the decommissioned Wallerawang power station with cooling water. The Cox's River ultimately flows to Warragamba Dam, which stores much of Sydney's drinking water supply.



Map 3: Lake Wallace feather collection site and Mt Piper power station

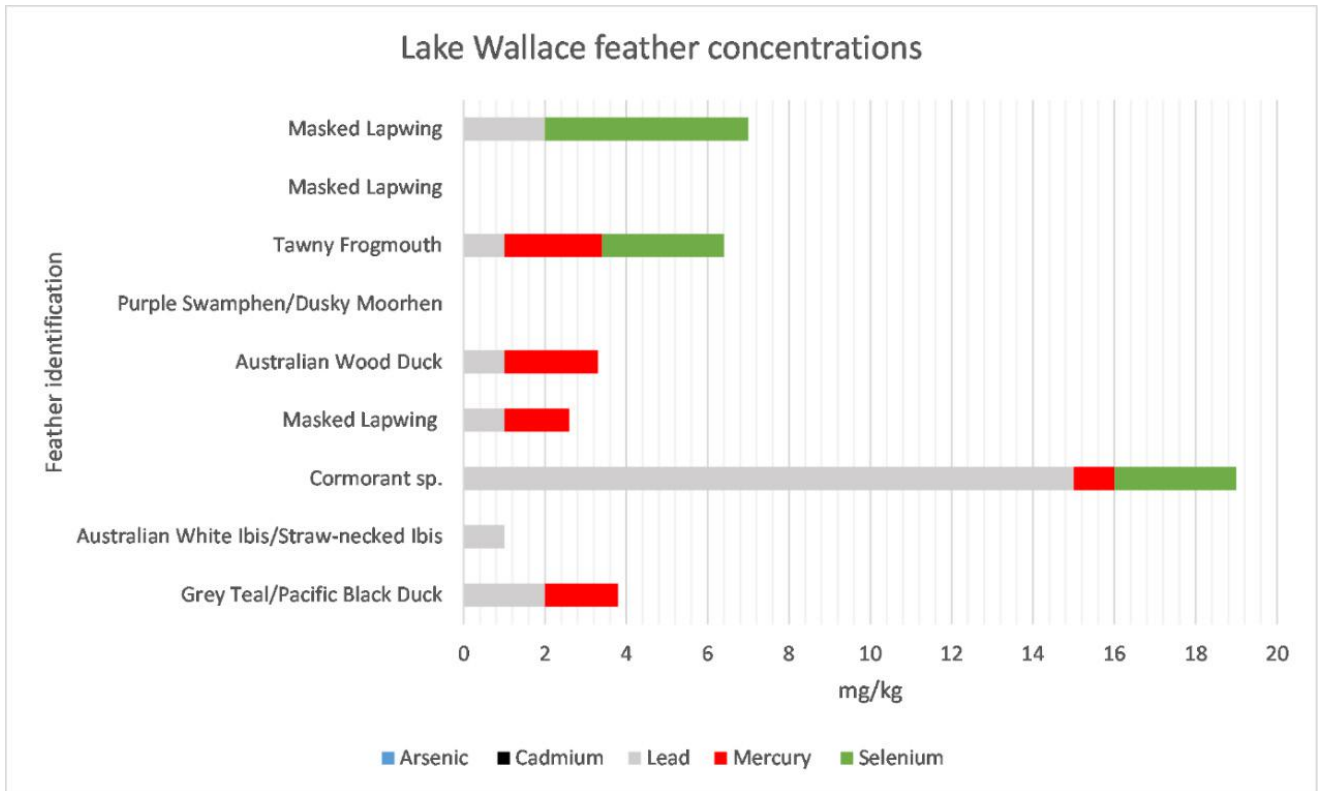


Chart 7: Lake Wallace feather metal concentrations

Seven of the nine feathers collected from Lake Wallace contained detectable concentrations of lead, mercury, and selenium.

- Seven feathers had detectable lead between 1 and 15 mg/kg. One water bird (Cormorant) contained 15 mg/kg lead, almost six times the adverse health impact threshold (4 mg/kg).
- Three of the nine feathers contained detectible selenium (3, 3, 5 mg/kg). All three were above adverse health impact thresholds (1.8 mg/kg).
- Five of the nine feathers contained detectable mercury between. However, a Crested Pigeon (excluded from the chart) contained 9.2 mg/Kg)

| Region | Lithgow | | | | | | | | | | | | |
|---------------|--------------|----------------|------------------------------|---|-----------|----------------|----------------------|-------------------------------|-----------------|--------|----------------|----------------|---------|
| Location | Lake Wallace | | | | | | | | | | | | |
| | Magpie | Crested Pigeon | Grey Teal/Pacific Black Duck | Australian White Ibis/Straw-necked Ibis | Cormorant | Masked Lapwing | Australian Wood Duck | Purple Swamphen/Dusky Moorhen | Tawny Frogmouth | Magpie | Masked Lapwing | Masked Lapwing | AVERAGE |
| Sample ID | 1LG | 2LG | 5LG | 6LG | 8LG | 11LG | 3LG | 4LG | 7LG | 9LG | 10LG | 11 | |
| METAL (mg/kg) | | | | | | | | | | | | | |
| Aluminium | 170 | 270 | 30 | 260 | 70 | 40 | 40 | 10 | 30 | 200 | | 140 | 105.0 |
| Arsenic | | | | | | | | | | | | | |
| Boron | | | | | | | | 5 | | | | | 0.4 |
| Cadmium | | | | | | | | | | | | | |
| Cobalt | | 2 | | | | | | | | | | | 0.2 |
| Copper | 12 | 21 | 20 | 17 | 22 | 8 | 23 | 7 | 18 | 24 | 4 | 8 | 15.3 |
| Iron | 210 | 360 | 80 | 590 | 140 | 160 | 190 | 70 | 250 | 350 | 30 | 340 | 230.8 |
| Lead | 2 | 13 | 2 | 1 | 15 | 1 | 1 | | 1 | 2 | | 2 | 4.0 |
| Manganese | 65 | 24 | 8 | 22 | 42 | 17 | 12 | 15 | 40 | 93 | 3 | 22 | 30.3 |
| Mercury | | 9.2 | 1.8 | | 1 | 1.6 | 2.3 | | 2.4 | 0.4 | | | 1.6 |
| Molybdenum | | | | | | | | | | | | | |
| Nickel | | 13 | 2 | 4 | 2 | 2 | 3 | | 2 | 1 | | | 2.4 |
| Selenium | | | | | 3 | | | | 3 | | | 5 | 0.9 |
| Zinc | 120 | 1500 | 150 | 130 | 180 | 140 | 190 | 120 | 150 | 110 | 73 | 62 | 243.8 |

Table 3: Laboratory results of sediment samples compared to ANZECC DGVs.

Masked Lapwing. HBOC.



HCEC sediment analysis

The Environmental Site Assessment commissioned by NSW Treasury⁶⁹ did not assess Lake Wallace.

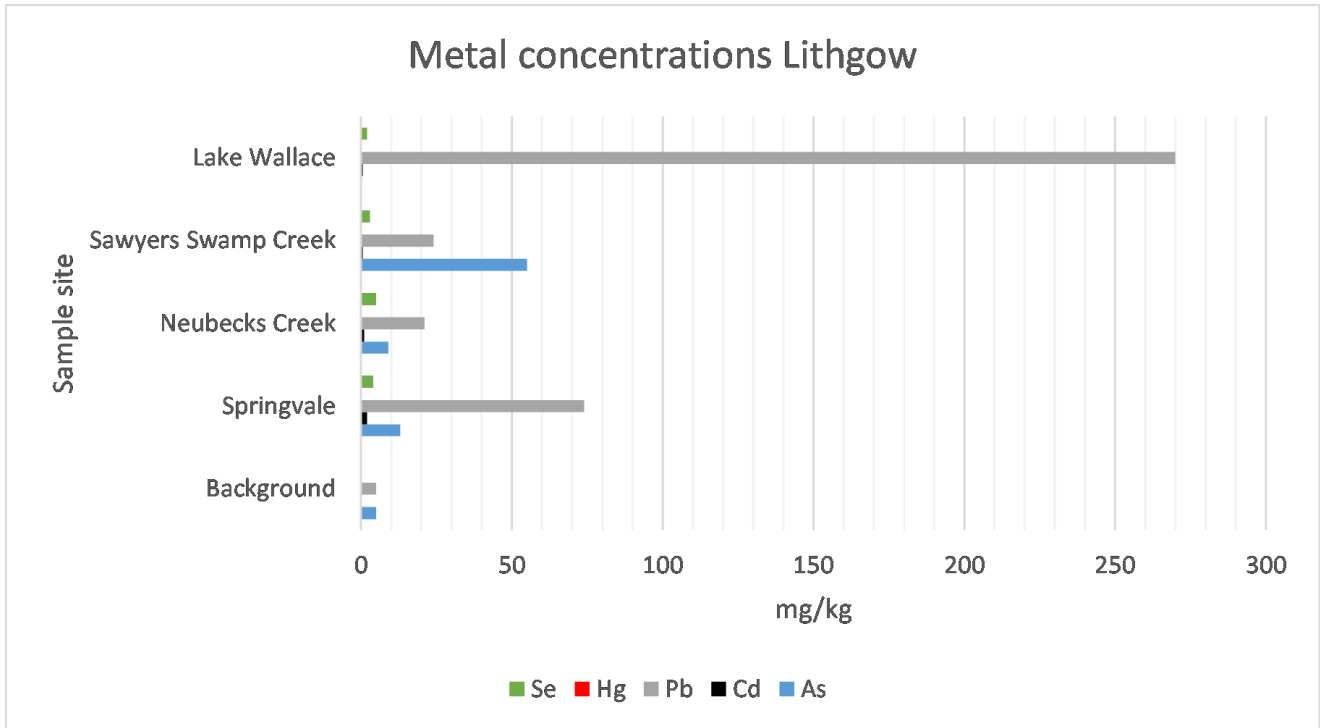


Chart 8: Metal concentrations in HCEC Lithgow sediment samples 2020.

We published the results of analyses of sediment taken from waterways surrounding the two coal ash dams near to Lithgow, and upstream of Lake Wallace.

- Sediment taken from Lake Wallace itself, was found to contain **lead** concentrations of 270 mg/kg (above ANZECC High Guideline Value – 220 mg/kg). Springvale Colliery discharge sediment was 74 mg/kg, above ANZECC DGV (50 mg/kg). Background was 5 mg/kg.
- **Arsenic** was found to be above ANZECC DGV (20 mg/kg) in Sawyers Swamp Creek (55 mg/kg), which drains the Wallerawang power station ash dam. Background was 5 mg/kg.
- **Cadmium** was above ANZECC DGV (1.5 mg/kg) at Springvale Colliery discharge (2 mg/kg) and 0.6 mg/kg in Lake Wallace. Cadmium was not detected in the background sample.
- **Selenium** was 2 mg/kg, increasing towards the ash dumps, with Neubecks Creek at 5 mg/kg. Selenium was not detected in the background sediment sample.
- **Mercury** was not detected in any of the Lithgow sediment samples.

69 ERM, 2014.

| Location | | | Background (upper Coxs River) | Springvale LDP 6 | Neubecks Creek | Sawyers Swamp Creek | Lake Wallace | ANZECC Sediment Default Guideline Value | |
|----------------|-------|-----|----------------------------------|---------------------|-------------------|---------------------------|-----------------|---|--------------|
| Sample ID | | | S9 | S3 | S4 | S5 | S8 | DGV | GV - High |
| Date Sampled | | | 28/04/2020 | 28/04/2020 | 28/04/2020 | 28/04/2020 | 28/04/2020 | | |
| Type of sample | | | Sediment | Sediment | Sediment | Sediment | Sediment | | |
| Parameter | Units | PQL | | | | | | | |
| Silver | mg/kg | 1 | | | | | | 1 | 4 |
| Aluminium | mg/kg | 10 | 1400 | 14000 | 11000 | 15000 | 25000 | | |
| Arsenic | mg/kg | 4 | 5 | 13 | 9 | 55 | | 20 | 70 |
| Boron | mg/kg | 3 | 5 | 10 | 10 | | | | |
| Cadmium | mg/kg | 0.4 | | 2 | 1 | 0.5 | 0.6 | 1.5 | 10 |
| Cobalt | mg/kg | 1 | 2 | 25 | 240 | 85 | 30 | | |
| Chromium | mg/kg | 1 | 3 | 10 | 9 | 8 | 14 | 80 | 370 |
| Copper | mg/kg | 1 | 7 | 26 | 29 | 18 | 37 | 65 | 270 |
| Iron | mg/kg | 10 | 3000 | 65000 | 42000 | 30000 | 31000 | | |
| Lead | mg/kg | 1 | 5 | 74 | 21 | 24 | 270 | 50 | 220 |
| Manganese | mg/kg | 1 | 150 | 130 | 3500 | 1200 | 740 | | |
| Mercury | mg/kg | 0.1 | | | | | | 0.15 | 1 |
| Nickel | mg/kg | 1 | 7 | 66 | 460 | 78 | 28 | 21 | 52 |
| Selenium | mg/kg | 2 | | 4 | 5 | 3 | 2 | | |
| Thallium | mg/kg | 2 | | | 5 | | | | |
| Vanadium | mg/kg | 1 | 7 | 19 | 21 | 16 | 32 | | |
| Zinc | mg/kg | 1 | 25 | 340 | 570 | 170 | 200 | 200 | 410 |

Table 4: HCEC laboratory results Lithgow sediment samples 2020.

Lake Liddell

Lake Liddell, a water storage reservoir for the power station, has a surface area of around 1100 ha and is up to 32m deep and supplies cooling water to Liddell Power Station and make-up water for the Bayswater power station Cooling Water Makeup Dam. It also accepts a range of treated discharges. The lake is constructed in a natural valley at the confluence of Bayswater, Tinkers and Maidswater Creeks and the two power station ash dams.

Water is periodically discharged from Lake Liddell to manage salinity and water level. The discharge point is at the dam wall, and discharges flow via Bayswater Creek to the Hunter River, approximately 13 km downstream. Discharges of salt are managed under the Hunter River Salinity Trading Scheme.⁷⁰

⁷⁰ ERM, 2014a.

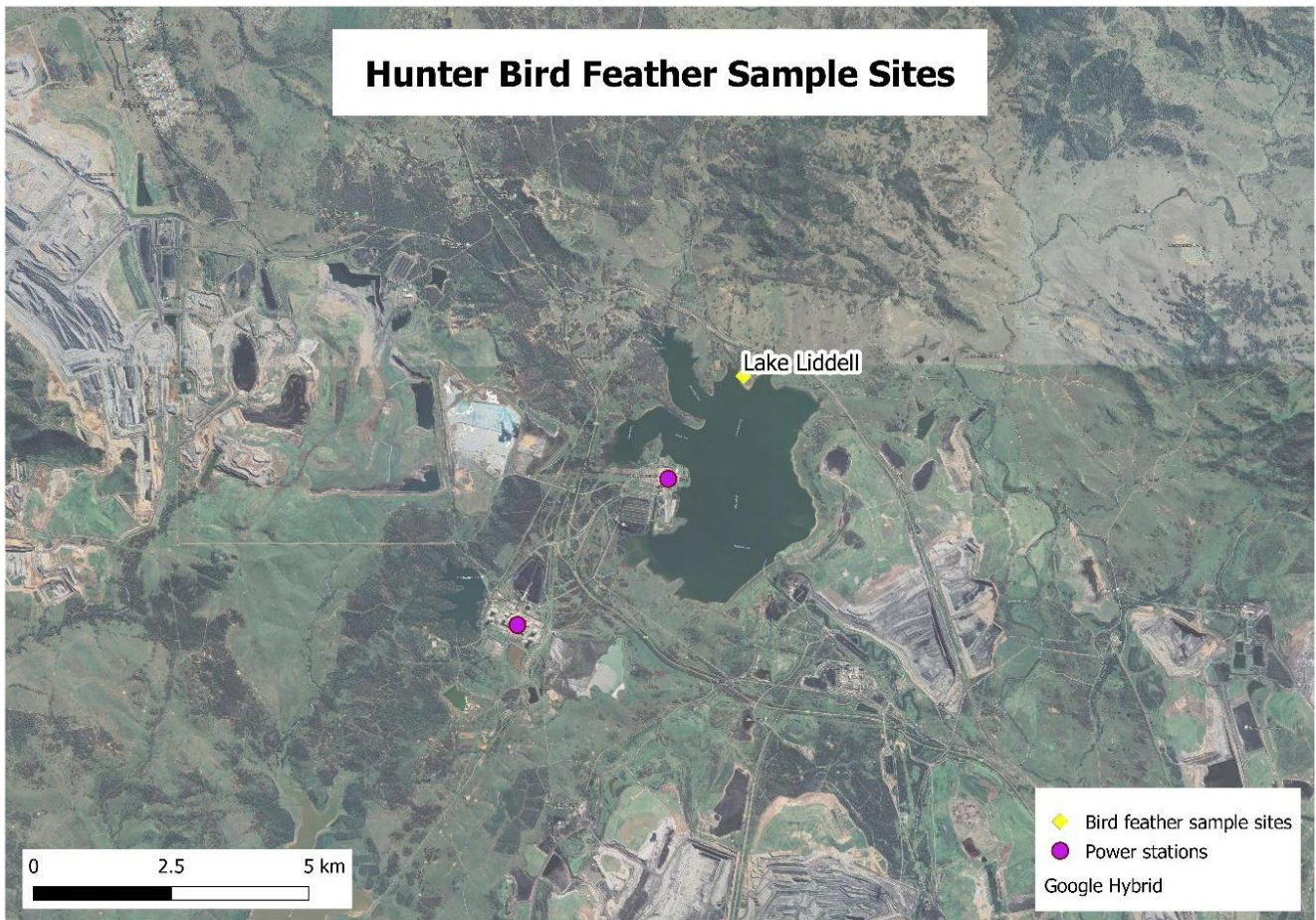
ERM, 2014b.



Black swan and cygnets. HBOC.

Lake Liddell and Liddell power station. HCEC.





Map 4: Lake Liddell feather collection site and power stations.

- **Selenium** was found in all the feathers collected from Lake Liddell (3-21 mg/kg). Many of these are well in excess, some by an order of magnitude, of estimated health impact thresholds.
- **Arsenic** was found in four feathers (three Black Swans (5; 5; 13 mg/kg) and a cormorant (5 mg/kg)).
- **Lead** was found in eight feathers, including all four swan feathers (3; 5; 9 mg/kg).
- **Mercury** was detected in three feathers (two Cormorants and a Pied Stilt/Masked Lapwing).
- The feather with the highest metal burden containing the highest concentrations of **arsenic** (13 mg/kg), lead (9 mg/kg), and selenium (10 mg/kg) was taken from an adult Black Swan carcass.

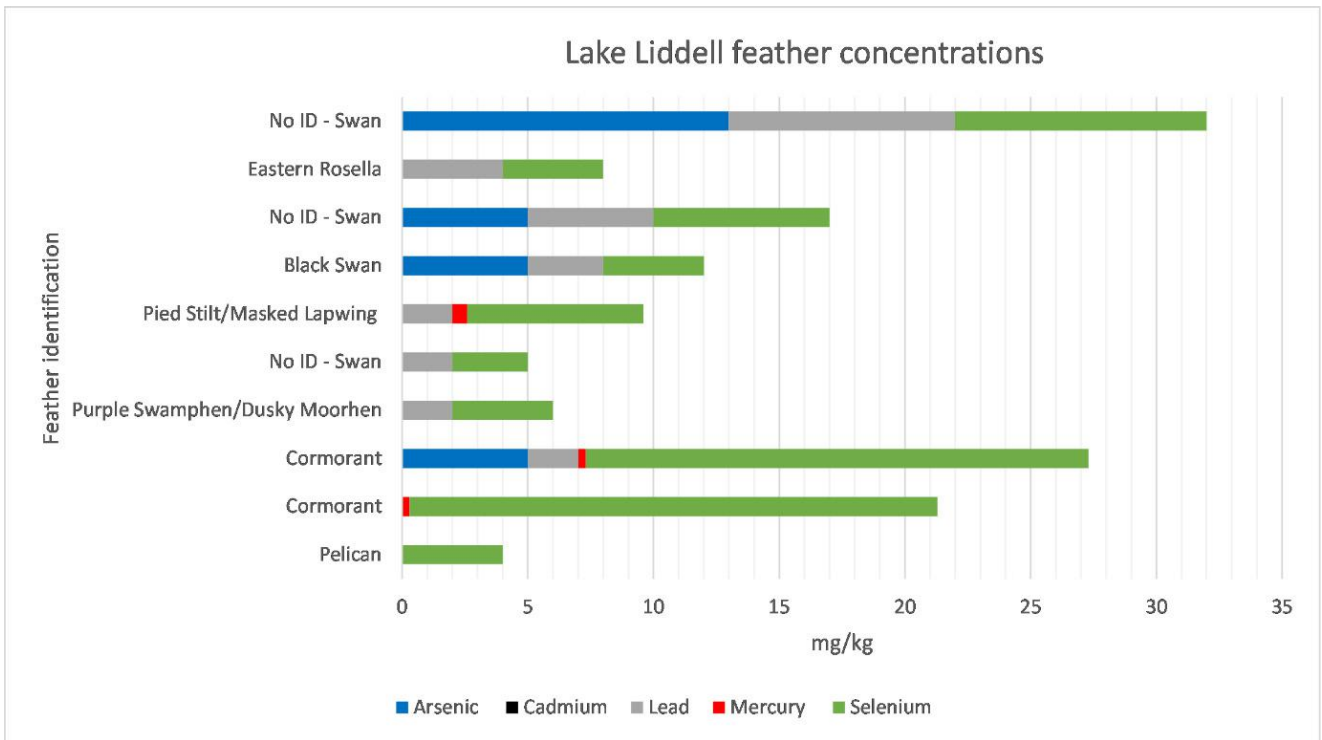


Chart 9: Lake Liddell feather metal concentrations

| Region | Hunter | | | | | | | | | | |
|---------------|--------------|-----------|-----------|-------------------------------|--------------|---------------------------|------------|--------------|-----------------|--------------|---------|
| Location | Lake Liddell | | | | | | | | | | |
| | Pelican | Cormorant | Cormorant | Purple Swamphen/Dusky Moorhen | No ID - Swan | Pied Stilt/Masked Lapwing | Black Swan | No ID - Swan | Eastern Rosella | No ID - Swan | AVERAGE |
| Sample ID | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L | |
| METAL (mg/kg) | | | | | | | | | | | |
| Aluminium | 40 | 150 | 1300 | 30 | 2100 | 170 | 3700 | 4500 | 970 | 7700 | 2066 |
| Arsenic | | | 5 | | | | 5 | 5 | | 13 | 2.8 |
| Boron | | 10 | 5 | | | 6 | | | | | 2.1 |
| Cadmium | | | | | | | | | | | |
| Cobalt | | | 6 | | 4 | | 2 | 4 | 6 | 8 | 3 |
| Copper | 8 | 13 | 19 | 4 | 16 | 19 | 12 | 16 | 10 | 26 | 14.3 |
| Iron | 140 | 360 | 3400 | 90 | 3300 | 320 | 5100 | 8400 | 1700 | 17000 | 3981 |
| Lead | | | 2 | 2 | 2 | 2 | 3 | 5 | 4 | 9 | 2.9 |
| Manganese | 12 | 19 | 140 | 17 | 98 | 11 | 97 | 31 | 160 | 130 | 71.5 |
| Mercury | | 0.3 | 0.3 | | | 0.6 | | | | | 0.4 |
| Molybdenum | | 1 | 1 | | 2 | | 1 | 2 | | 3 | 1 |
| Nickel | | 5 | 21 | | 9 | 1 | 7 | 12 | 5 | 15 | 7.5 |
| Selenium | 4 | 21 | 20 | 4 | 3 | 7 | 4 | 7 | 4 | 10 | 8.4 |
| Zinc | 64 | 160 | 110 | 140 | 100 | 180 | 23 | 58 | 200 | 160 | 119.5 |

Table 5: Laboratory results of feathers collected from Lake Liddell

Bayswater Environmental Site Assessment

The ESA for the Bayswater site found significant metal contamination of Lake Liddell.

Boron and selenium were found to be the primary metals of ecological concern in relation to surface water within Lake Liddell.

Metal contamination of sediments of Lake Liddell include:

- **Arsenic** concentrations exceeded ANZECC Guidelines at all but five sediment sampling locations. Arsenic concentration at the reference location was the highest recorded in the lake. The exceedances are therefore not considered to be a result of site activities.
- One exceedance of the **mercury** ISQG-High, at the sampling location closest to the Power Station. Mercury exceeded the ISQG-High at one location, where coal fines were noted.
- **Selenium** exceeded the ecological screening criteria in surface water samples collected from the unnamed creek to the north of the Pikes Gully Ash Dam spillway and in eight samples from within Lake Liddell. The maximum selenium concentrations in sediment was 45.2 mg/kg, with an average concentration across the Lake of 6.2 mg/kg.⁷¹

HCEC sediment analysis

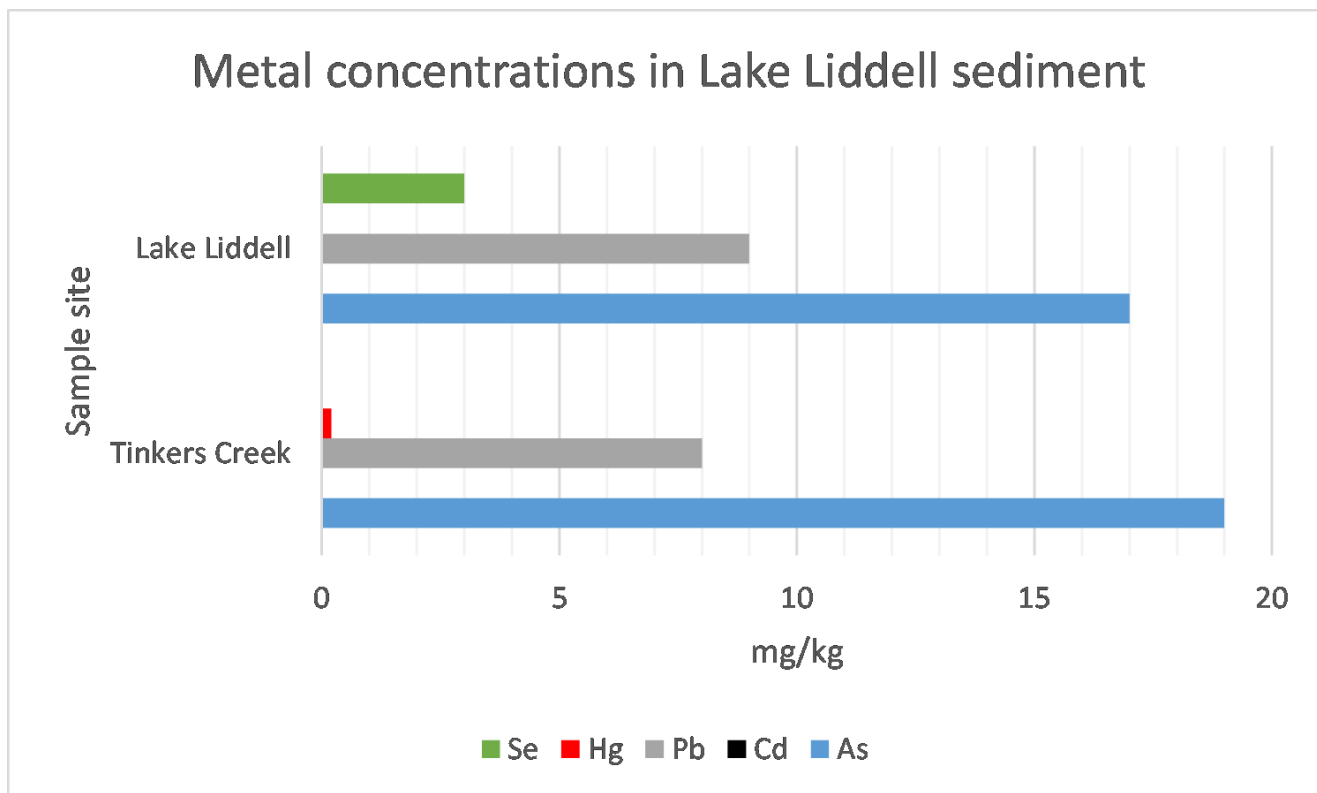


Chart 10: Lake Liddell sediment metal concentration

⁷¹ ERM, 2014a.

ERM, 2014b.

| Location | | | Tinkers Creek | Lake Liddell | | ANZECC | |
|-------------|-------|-----|-----------------|-------------------------------|--------------------|-----------------|------------|
| Drainage | | | Liddell ash dam | Bayswater and Liddell ash dam | | Guideline value | SQG - High |
| Sample ID | | | 3S | 4S | Black Swan Feather | | |
| Sample date | | | 29/07/2020 | 29/07/2020 | 29/07/2020 | | |
| | Units | PQL | Sediment | Sediment | Biosample | | |
| Aluminium | mg/kg | 10 | 6600 | 14000 | 140 | | |
| Arsenic | mg/kg | 4 | 19 | 17 | | 20 | 70 |
| Boron | mg/kg | 3 | | | | | |
| Cadmium | mg/kg | 0.4 | | | | 1.5 | 10 |
| Chromium | mg/kg | 1 | 12 | 19 | | 80 | 370 |
| Copper | mg/kg | 1 | 910 | 18 | 8 | 65 | 270 |
| Iron | mg/kg | 10 | 17000 | 21000 | 340 | | |
| Lead | mg/kg | 1 | 8 | 9 | 2 | 50 | 220 |
| Manganese | mg/kg | 1 | 450 | 87 | 22 | | |
| Mercury | mg/kg | 0.1 | 0.2 | | | 0.15 | 1 |
| Nickel | mg/kg | 1 | 77 | 10 | | 21 | 52 |
| Selenium | mg/kg | 2 | | 3 | 5 | | |
| Zinc | mg/kg | 1 | 190 | 20 | 62 | 200 | 410 |
| Moisture | % | 0.1 | 63 | 30 | | | |

Table 6: Laboratory results of sediment collected by HCEC from Lake Liddell 202072

Port Stephens – Myall Lakes

Port Stephens, a drowned river valley marine estuary and Myall Lake, part of the larger Myall Lakes brackish barrier lake system, are part of the Port Stephen Great Lakes Marine Park.

Port Stephens is a large natural harbour of approximately 134 km² in the Hunter Region, about 160 km north-east of Sydney.

Myall Lakes are a series of fresh water lakes protected under the Ramsar Convention, and mostly surrounded by the Myall Lakes National Park, about 250 km north of Sydney. There are three lakes in the system, Myall Lake, Boolambayte Lake and The Broadwater. When full, Myall Lake covers an area of around 5,800 ha.



Map 5: Control collection sites Myall Lakes NP and western Port Stephens



Pelicans on Myall Lake. 2020. HCEC.

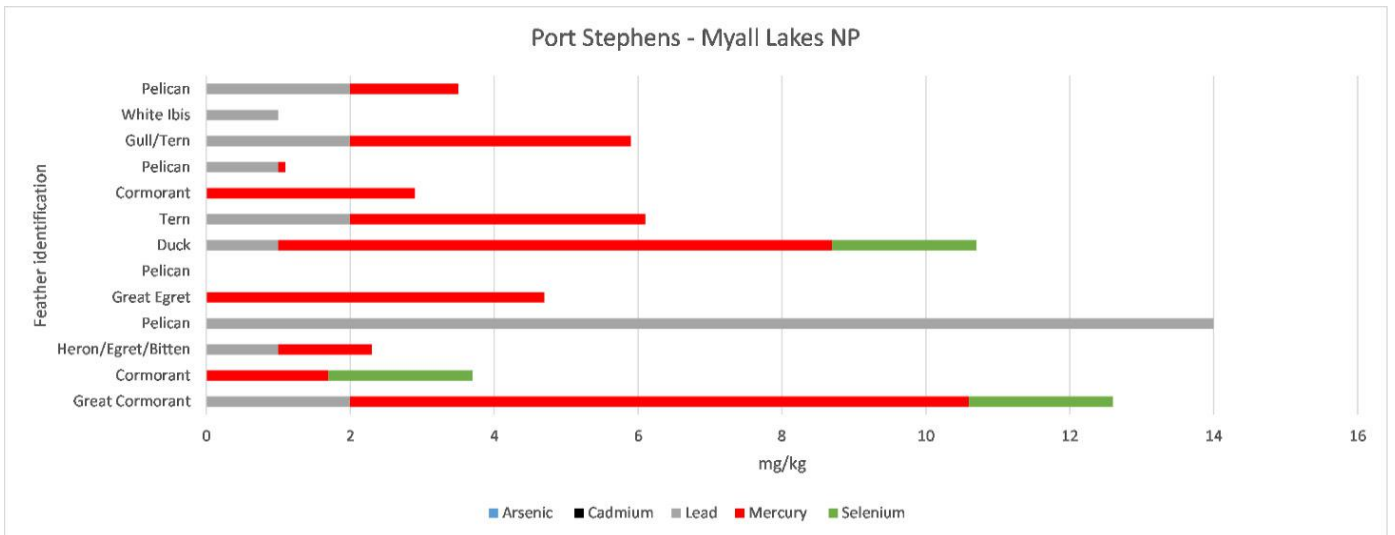


Chart 11: Port Stephens/Myall Lake sediment feather concentrations

Lead, selenium, and/or mercury was detected in the 12 of the 13 feathers collected from Port Stephens and Myall Lake.

- Lead was detected in nine feathers (1 – 14 mg/kg). One Pelican feather contained 14 mg/kg, over three times the threshold for adverse health impacts (4mg/kg).
- Selenium was detected in three feathers (all 2mg/kg), all above health threshold levels (1.8mg/kg).
- Mercury was detected in 10 feathers (0.1 – 8.6 mg/kg). Two of which (a Great Cormorant and a Duck) had mercury concentrations above health impact thresholds (5mg/kg)

| Region | Background | | | | | | | | | | | | | | | AVERAGE |
|---------------|-----------------|-----------|--------------------|---------------|----------------|-------------|---------|------|------|-----------|---------|-----------|------------|---------|-------|---------|
| | Swan Bay | | | | Myall Lakes NP | | | | | | | | | | | |
| Location | Great Cormorant | Cormorant | Heron/Egret/Bitten | Topnot Pigeon | Pelican | Great Egret | Pelican | Duck | Tern | Cormorant | Pelican | Gull/Tern | White Ibis | Pelican | | |
| Sample ID | 1M | 2M | 3M | 4M | 5M | 2BF | 1BF | 1WTB | 2WTB | 3WTB | 1SB | 2SB | 3SB | 4SN | | |
| METAL (mg/kg) | | | | | | | | | | | | | | | | |
| Aluminium | 90 | 70 | 280 | 30 | 70 | 170 | 90 | 280 | 230 | 80 | 630 | 990 | 540 | 590 | 295.7 | |
| Arsenic | | | | | | | | | | | | | | | | |
| Boron | 30 | 7 | 10 | | | 10 | | 10 | 7 | 10 | 32 | 20 | | | 9.7 | |
| Cadmium | | | | | | | | | | | | | | | | |
| Cobalt | | 1 | | | | | | | | | | | | | 0.1 | |
| Copper | 9 | 11 | 10 | 5 | 13 | 8 | 10 | 10 | 9 | 7 | 8 | 10 | 5 | 8 | 8.8 | |
| Iron | 430 | 1200 | 570 | 70 | 280 | 300 | 450 | 10 | 9 | 7 | 8 | 10 | 410 | 640 | 313.9 | |
| Lead | 2 | | 1 | | 14 | | | 1 | 2 | | 1 | 2 | 1 | 2 | 1.9 | |
| Manganese | 31 | 14 | 46 | 4 | 12 | 38 | 16 | 40 | 20 | 8 | 8 | 5 | 3 | 4 | 17.8 | |
| Mercury | 8.6 | 1.7 | 1.3 | | | 4.7 | | 7.7 | 4.1 | 2.9 | 0.1 | 3.9 | | 1.5 | 2.6 | |
| Molybdenum | | | | | | | | | | | | | | | | |
| Nickel | 1 | 0 | | | 1 | | | | | | | | | | 0.1 | |
| Selenium | 2 | 2 | | | | | | 2 | | | | | | | 0.4 | |
| Zinc | 120 | 100 | 40 | 21 | 79 | 34 | 69 | 100 | 64 | 86 | 73 | 49 | 42 | 55 | 66.6 | |

Table 7: Laboratory results of feathers collected from Myall National Park and Port Stephens



Pied Cormorant. HBOC.

Mercury source

Mercury was detected in feathers from all collection areas. However, mercury was found in the greatest number of birds, with the highest maximum mercury concentration and the highest mean mercury concentration in feathers collected from the control area, within the Port Stephens Great Lakes Marine Park, between 90 and 120 km south east from the nearest major mercury emission source (Bayswater power station).

Globally, coal-fired power stations account for approximately 50 percent of anthropogenic emissions of mercury.⁷³ A 2012 study identified the three sectors that contribute most to Australian anthropogenic mercury emissions, gold smelting (49.7%), coal

combustion in power stations (14.8%), and alumina production from bauxite (12.2%).⁷⁴

The authors point out, however, that gold smelting emissions are from a single location at Kalgoorlie in Western Australia. Coal combustion from power stations on the Australian east coast therefore contributes about 30 percent anthropogenic mercury emissions.

Mercury is a natural component of coal and is released into the environment during combustion. Mercury is liberated in several forms that can be categorised into elemental, inorganic and organic mercury. These forms differ in their degree of toxicity, with the organic mercury being the most toxic.

⁷³ Gade, 2015.

⁷⁴ Nelson et al, 2012.

Mercury is most bioavailable and toxic when it is methylated (organic mercury), which is usually facilitated by bacteria in anoxic conditions, such as sediments.⁷⁵ Organic mercury is formed after deposition on the land and surface waters.⁷⁶

Mercury spends about a year in the atmosphere before settling, allowing it to be very widely distributed and eventually deposited on terrestrial or water surfaces.⁷⁷

Schneider et al (2021a) identified that mercury deposition in Lake Glenbawn (30km north west of Bayswater power station) increased by 300 percent in the 1970s after the commissioning of Liddell Power Station and that near-source deposition of mercury is significantly higher in Australia than North America and Europe, where better emission controls (e.g. wet flue gas desulfurization) have been in effect for decades.⁷⁸

In Lake Glenbawn, mercury concentrations and deposition fluxes increased from about 1971, when Liddell was commissioned, reached a peak in around 1989, just before Liddell was retrofitted with bag filters, which occurred in 1990. Although Bayswater, commissioned in 1986, has a higher electricity production capacity (2640 MW) than Liddell (2000 MW), there was minimal increase in mercury deposition to Lake Glenbawn from 1986 to 1990. This is likely a result of Bayswater being commissioned with bag filters in place, a more efficient technology to control metal emissions than the original electrostatic precipitation technology at Liddell.⁷⁹

For Lake Macquarie, Schneider et al (2021b) found mercury deposition increased up to 7-times following coal-fired power plants being commissioned in the catchment and that mercury deposition decreased following

power plant bag-filter retrofits. The authors found the coal ash dams contributed little to the mercury concentrations of Lake Macquarie sediment and that contamination in the lake is a result of atmospheric emissions from the power stations.⁸⁰ Mercury concentrations in the sediment of southern Lake Macquarie peaked in 1978 and following the commissioning of Eraring power station in 1981.

The authors found increases in mercury fluxes in Lake Macquarie and Lake Glenbawn were similar to those of lakes near coal-fired power stations in North America. However, contrasted with Lake Macquarie and Lake Glenbawn, which has shown a small decrease in mercury concentrations since bag filters were introduced, sediment archives collected from lakes in North American and Europe show marked declines in mercury concentrations and fluxes in recent decades associated with the retrofitting of emission control technologies in coal-fired power plants (e.g., wet scrubbers) and stricter regulation of emissions.⁸¹

75 Ullrich et al, 2001.

76 Gade, 2015.

77 Schneider et al, 2021a.

78 Schneider et al, 2021a.

79 Schneider et al, 2021a.

80 Schneider et al, 2021b.

81 Schneider et al, 2021a; Schneider et al, 2021b.



Conclusion

This report identifies trophic level bioaccumulation of metals in birds from three lakes near NSW coal-fired power stations and their associated coal ash dumps.

Concentrations of metals found in 65 percent of the feathers collected from the three contaminated lakes were above identified adverse health and reproduction thresholds. However, half of all the feathers collected from all the sites, including the controls area (Port Stephens/Myall Lake) within the Port Stephens Great Lakes Marine Park, contained metal concentrations at or above health threshold levels.

Nevertheless, clear differences are apparent in the metal concentrations found in feathers from southern Lake Macquarie, Lake Liddell, Lake Wallace, and the Port Stephens Great Lakes Marine Park. The highest maximum and mean feather concentrations for:

- [Mercury in the control area \(Port Stephens/Myall Lake\).](#)
- [Lead and cadmium in southern Lake Macquarie.](#)
- [Selenium and arsenic in Lake Liddell.](#)

The following metals are at concentrations high enough to cause concern for bird populations;

- [Arsenic, lead and selenium in Lake Liddell.](#)
- [Cadmium, lead, mercury and selenium in Lake Macquarie.](#)
- [Lead, mercury, and selenium in Lake Wallace.](#)
- [Lead and mercury in Port Stephens/Myall Lake.](#)

The clearest example of metal contamination is Lake Liddell. All the feathers collected from there contained concentrations of between one and three heavy metals that could potentially cause adverse health and reproductive success. The large Black Swan population of Lake Liddell is likely suffering from the toxic effects of a number of heavy metals. One of the feathers taken from the decaying carcass of an adult Black Swan had concentrations of arsenic at three times, lead three times, and selenium five times adverse health and reproduction impact thresholds.

Indeed, selenium is identified by Government commissioned documents as the primary metal of ecological concern in Lake Liddell, which has been found to have mean selenium concentrations over three times those reported as safe. Selenium concentrations in two of the Cormorant feathers collected were acutely toxic.



While questions remain over the source of arsenic in Lake Liddell, the selenium contamination of Lake Liddell is almost certainly a result of discharge and leachate from the Liddell power station ash dam.¹

Studies have confirmed that burning coal for electricity production is a major driver of increases in metal concentrations in lakes close to NSW power stations. The sources of this contamination includes atmospheric emissions, direct discharge to waterways from ash dams, and coal ash leachate.

This mirrors experiences in other parts of the world, where metal contamination has markedly increased in water bodies close to operating coal-fired power stations.

Studies suggest coal-fired power stations are responsible for 30 percent of anthropogenic mercury emissions in eastern Australia. The concentrations of mercury in feathers collected from the Port Stephens Great Lakes Marine Park, as well as mercury contamination found generally, are therefore, primarily the result of atmospheric deposition of mercury emitted by NSW coal fired power stations, the closest of which are Bayswater and Liddell.



Bayswater power station. HCEC.

Lead concentrations in feathers from Lake Wallace correlate with the very high sediment concentrations in that lake which are directly attributable to the coal mines and power station ash dams up stream.

¹ Burger, 1993

Lake Macquarie contamination is more complex, as the former lead smelter at the northern end of Lake Macquarie was a major contributor to the lead, selenium, and cadmium contamination, and even birds with low dispersal are likely to roam from southern to northern Lake Macquarie. However, the sediment core taken by HCEC from Mannering Bay, at the southern end of Lake Macquarie, strongly suggests Vales Point coal-fired power station is one of the major drivers of metal contamination.

According to the National Pollutant Inventory, coal-fired power stations emit about 40 percent of NSW industrial point source air emissions of mercury and selenium, as well as 15 percent of arsenic and eight percent of cadmium. Much of this pollution could be reduced through the installation of flue gas desulphurisation technology (wet scrubbers) at operating power stations.

Our previous reports on coal ash contamination, as well as Government commissioned Environmental Site Assessments, point to the lingering issue of heavy metal leachate from inadequately contained NSW power station coal ash dumps. The ongoing risks to human health and the environment from the hundreds of millions of tonnes of coal ash waste on waterways can only be removed when these sites are comprehensively decontaminated, and the coal ash waste utilised in environmentally safe road and construction products.

In light of the findings presented in this study, an investigation by the NSW EPA into the full extent of health impacts that may be afflicting water bird and their habitat contaminated by coal-power stations must take place.



Vales Point power station. HCEC.

References

- Åkesson A, Barregard L, Bergdahl IA, Nordberg GF, Nordberg M, and Skerfving S. 2014. Non-renal effects and the risk assessment of environmental cadmium exposure. *Environ Health Persp* 122:431-438.
- Alipour, Hossein & Solgi, Eisa & Majnoni, Farshid., 2016. Concentrations of Heavy Metals in tissues of the Mallard Anas platyrhynchos in Kanibarazan, northwestern Iran. *PODOCES*. 11. 35-42.
- Alloway, B. J. and Ayres, D. C., 1993, *Chemical Principles of Environmental Pollution*, Blackie Academic & Professional, London.
- ATSDR - Agency for Toxic Substances and Disease Registry, 2007a. *Toxicological Profile for Lead*. <https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf>
- Beyer WN. 2000. Hazards to wildlife from soil-bourne cadmium reconsidered. *J Environ Qual* 29:1380-1384.
- Bize, P., A. Roulin and H. Richner. 2002. Covariation between egg size and rearing condition determines of spring quality: an experiment with the alpine swift. *Oecologia*, 132 (2):231-234 (2002) development. *Ecotoxicology and Environmental Safety*, 65: 67-73(2006)
- Burger J. 1993. Metals in avian feathers: bioindicators of environmental pollution. Reviews in *Environmental Toxicology*. 1993; 5:203-311.
- Burger J. 2008. Assessment and management of risk to wildlife from cadmium. *Sci Total Environ* 389:37-45.
- Burger J, and Gochfeld M., 1993. Heavy metal and selenium levels in feathers of young egrets and herons from Hong Kong and Szechuan, China. *Arch Environ Contam Toxicol* 25:322-327:
- Burger, J., & Gochfeld, M., 1994. Behavioral impairments of lead-injected young herring gulls in nature. *Fundamental and Applied Toxicology*, 23, 553-561.
- Burger J, Gochfeld M. 2000a., Metals in albatross feathers from midway atoll: influence of species, age, and nest location. *Environmental Research*. 82:207-221. [PubMed: 10702328]
- Burger J, and Gochfeld M. 2000b. Total metal levels in feathers of twelve species of seabirds from Midway Atoll in the Northern Pacific Ocean. *Sci Total Environ* 257:37-52.
- Burger J, Gochfeld M, Jeitner C, Burke S, Volz CD, Snigaroff R, Snigaroff D, Shukla T, Shukla S., 2009. Mercury and other metals in eggs and feathers of glaucous-winged gulls (*Larus glaucescens*) in the Aleutians. *Environ Monit Assess* 152:179-194
- Cheng, K. & Tian, H.Z. & Dunhua, Zhao & Lu, L. & Wang, Y. & Chen, Jing & Liu, Xingang & Jia, Wenxiao & Huang, Zhe. (2014). Atmospheric emission inventory of cadmium from anthropogenic sources. *International Journal of Environmental Science and Technology*. 11. 10.1007/s13762-013-0206-3.

- Custer, C. M., Custer, T. W., Michael, J. A., Alan, D. A. & David, E. W., 2003. Trace elements in Lesser Scaup (*Aythya affinis*) from the Mississippi flyway. *Ecotoxicology* 12, 47–54.
- Dauwea, T., E. Janssens, B. Kempenaers and M. Eens. 2004. The effect of heavy metal exposure on egg size, eggshell thickness and the number of spermatozoa in blue tit *Parus caeruleus* eggs. *Environ. Pollut.*, 129: 125-129.
- Deng H, Zhang Z, Chang C, Wang Y., 2007. Trace metal concentration in great tit (*Parus major*) and greenfinch (*Carduelis sinica*) at the Western Mountains of Beijing, China. *Environ Pollut* 148:620–626:
- Dmowski K., 1999. Birds as bioindicators of heavy metal pollution: review and examples concerning European species. *Acta Ornithol* 34:1–25
- Eisler, R. 1985. Cadmium hazards to fish, wildlife and invertebrates: a synoptic review. *Biological Report*. Vol. 85. US Fish and Wildlife Service; Washington DC: 1985.
- Eisler, R. 1987. Mercury hazards to fish, wildlife and invertebrates: a synoptic review: Biological Report. Vol. 85. US Fish and Wildlife Service; Washington DC: 1987.
- ERM– Environmental Resource Management P/L, 2014a. Project Symphony – *Bayswater Power Station Stage 2 Environmental Site Assessment*. Final v05.
- ERM– Environmental Resource Management P/L, 2014b. Project Symphony – *Liddell Power Station Stage 2 Environmental Site Assessment*. Final v05.
- ERM – Environmental Resource Management P/L, 2014c. Project Symphony – *Mt Piper. Stage 2 Environmental Site Assessment*. August 2014.
- ERM– Environmental Resource Management P/L, 2014d. Project Symphony – *Vales Point Power Station. Stage 2 Environmental Site Assessment*. Final.
- ERM– Environmental Resource Management P/L, 2015. Project Symphony – *Eraring Power Station Stage 2 Environmental Site Assessment*. Final v05.
- Evers DC, Savoy LJ, DeSorbo CR, Yates DE, Hanson W, Taylor KM, Siegel LS, Cooley Jr JH, Bank MS, Major A, Munney K, Mower BF, Vogel HS, Schoch N, Pokras M, Goodale MW, and Fair J. 2008. Adverse effects from environmental mercury loads on breeding common loons. *Ecotoxicology* 17:69-81.
- Farahani S, Navid E, Abbasi A, Karimi F, Shiri Malekabad E, Rezaei M., 2015. Determination of heavy metals in albumen of hen eggs from the Markazi Province (Iran) using ICP-OES technique. *Toxin Rev* 34(2):96–100:
- Fasola M, Movalli RA, Gandini C (1998) Heavy metals, organochlorine pesticides and PCBs in eggs and feather of heron breeding in northern Italy. *Arch Environ Contam Toxicol* 34:87–93:

Ferns P, Anderson J (1997) Lead in the diet and body tissues of Dunlins, *Calidris alpina*, from the Bristol Channel, UK RID A-5902-2010. *Environmental Pollution*, **96**(1), 35-42. doi:10.1016/S0269-7491(97)00008-0:

Fuchsman PC, Brown LE, Henning MH, Bock MJ, and Magar VS. 2017. Toxicity reference values for methylmercury effects on avian reproduction: Critical review and analysis. *Environ Toxicol Chem* 36:294-319.

Furness RW (1993) Birds as monitors of pollutants. In: Furness RW, Greenwood JJD (eds) Birds as monitors of environmental change. Chapman and Hall, London, pp 86–143

Gade, Divya, 2015. Mercury Emissions from Coal-Fired Powerplants. *Environmental Management & Risk Assessment (PH 560)*. Paper 4.http://digitalcommons.wku.edu/pubh_560/4

Gilbertson, M.; Eliot, JE.; 1987. Peakall, DB. Seabirds as indicators of marine pollution. In: Diamond, AW. Fillion, F., editors. *The value of birds*. International Council for Bird Preservation; Cambridge: 1987. p. 231-248. ICBP Tech. Publ. 6

Heinz, GH. Selenium in birds. In: Beyer, WM.; Heinz, WM., editors. *Environmental contaminants in wildlife: interpreting tissue concentrations*. Lewis; Boca Raton, FL: 1996. p. 447-458.

Jackson AK, Evers DC, Etterson MA, Condon AM, Folsom SB, Detweiler J, Schmerfeld J, and Cristol DA. 2011. Mercury exposure affects the reproductive success of a free-living terrestrial songbird, the Carolina wren (*Thryothorus ludovicianus*). *Auk* 128:759-769.

Janssens, E., T.Dauwe , R.Pinxten, L.Bervoets, R.Blust and M. Eens. 2003. Effects of heavy metal exposure on the condition and health of nestlings of the great tit (*Parus major*), a small songbird species. *Environ. Pollut.*, 126:267-274 (2003):

Janssens,E., T.Dauwe , R.Pinxten, L.Bervoets, R.Blust and M. Eens. 2003. Effects of heavy metal exposure on the condition and health of nestlings of the great tit (*Parus major*), a small songbird species. *Environ. Pollut.*, 126:267-274 (2003):

Jayakumar R, Muralidharana S (2011) Metal contamination in select species of birds in Nilgiris District, Tamil Nadu, India. *Bull Environ Contam Toxicol* 87:166–170

Järup L, and Åkesson A. 2009. Current status of cadmium as an environmental health problem. *Toxicology and Applied Pharmacology* 238:201-208.

Jayakumar R, Muralidharana S (2011) Metal contamination in select species of birds in Nilgiris District, Tamil Nadu, India. *Bull Environ Contam Toxicol* 87:166–170

Jayakumar R, Muralidharan S (2011) Metal contamination in select species of birds in Nilgiris District, Tamil Nadu, India. *Bull Environ Contam Toxicol* 87:166–170.

Johansen, P., Asmund, G. & Riget, F., 2004. High human exposure to lead through consumption of birds hunted with lead shot. *Environ. Pollut.* 127, 125–129.

Kim J, Koo TH (2007) Heavy metal concentrations in diet and livers of black-crowned night heron *Nycticorax nycticorax* and grey heron *Ardea cinerea* chicks from Pyeongtaek, Korea. *Ecotoxicology* 16:411–416

- Kim J and T.-H. Koo, Arch. Environ. Contam. Toxicol., 2008, 55, 122: A. Pilastro, L. Congju, L. Tallandini and M. Turchetto, Arch. Environ. Contam. Toxicol., 1993, 24, 355.
- Kim J, Shin J-R, Koo T-H (2009) Heavy metal distribution in some wild birds from Korea. Arch Environ Contam Toxicol 56:317–324
- Kitowski I, Sujak A, Wiącek D, Strobel W, Komosa A, Stobiński M (2016) Heavy metals in livers of raptors from eastern Poland - the importance of diet composition. Belg J Zool 146(1):3–13:
- Koeman JH, Peeters WH, Koudstaal-Hol CH, Tjioe PS, and de Goeij JJ. 1973. Mercury-selenium correlations in marine mammals. *Nature* 245:385-386:
- Koivula MJ, and Eeva T. 2010. Metal-related oxidative stress in birds. *Environ Pollut* 158:2359-2370.
- Lavoie RA, Jardine TD, Chumchal MM, Kidd KA, and Campbell LM. 2013. Biomagnification of mercury in aquatic food webs: A worldwide meta-analysis. *Environ Sci Technol* 47:13385-13394.
- Lemly, A. D. (1982). Response of juvenile centrarchids to sublethal concentrations of waterborne selenium. Uptake, tissue distribution, and retention. *Aquat. Toxicol.* 2, 235-252:
- Lemly. A. D. (1985a). Toxicology of selenium in a freshwater reservoir: Implications for environmental hazard evaluation and safety. *Ecotoxicol. Environ. Saf.* 10, 314-338:
- Lemly, A. D. (1993c). Teratogenic effects of selenium in natural populations of freshwater fish. *Ecotoxicol. Environ. Saf.* **26**, 181-204.
- Lemly, A. D. (1993b). Guidelines for evaluating selenium data from aquatic monitoring and assessment studies. *Environ. Monitor. Assess.* 28, 83–100.
- Lemly, A. D. (1997a). Ecosystem recovery following selenium contamination in a freshwater reservoir. *Ecotoxicol. Environ. Saf.* 36, 275-281.
- Lemly, DA, 1999. Selenium Transport and Bioaccumulation in Aquatic Ecosystems: A Proposal for Water Quality Criteria Based on Hydrological Units. *Ecotoxicology and Environmental Safety* **42**, 150-156.
- Lemly, D, 2002. *Selenium Assessment in Aquatic Ecosystems, A Guide for Hazard Evaluation and Water Quality Criteria*. Springer Series on Environmental Management. Springer Science & Business Media, 2002. 0387953469, 9780387953465. 162 pages. Pp 34-36.
- Lin L, Zhou WH, Dai HX, Cao FB, Zhang GP, and Wu FB. 2012. Selenium reduces cadmium uptake and mitigates cadmium toxicity in rice. *J Hazard Mater* 235:343-351.
- Lucia M, Andre J, Gontier K, Diot N, Veiga J, Davail S (2010) Trace element concentrations (mercury, cadmium, copper, zinc, lead, aluminium, nickel, arsenic, and selenium) in some aquatic birds of the southwest Atlantic Coast of France. *Archives of Environmental Contamination and Toxicology*, **58**(3), 844-853.
- Larison JR, Likens GE, Fitzpatrick JW, and Crock JG. 2000. Cadmium toxicity among wildlife in the Colorado Rocky Mountains. *Nature* 406:181-183.
- Mansouri, N. E. et al., 2012. Research on the suitability of organosolv semi-chemical triticale fibres as reinforcement for recycled HDPE composites. *Bio. Resources.* 7(4), 5032–5047.

Marettová E, Marett M, and Legáth J. 2015. Toxic effects of cadmium on testis of birds and mammals: A review. *Anim Reprod Sci* 155:1-10.

Mailman, RB. Heavy metals. In: Perry, JJ., editor. Introduction to environmental toxicology. Elsevier; New York: 1980. p. 34-43. Mandal BK, and Suzuki KT. 2002. Arsenic round the world: A review. *Talanta* 58:201-235.

Mateo R, Guitart R (2003) Heavy metals in livers of water birds from Spain. *Arch Environ Contam Toxicol* 44:398-404:

Meij, R., teWinkel, H., 2007. The emissions of heavy metals and persistent organic pollutants from modern coal-fired power stations. *Atmos. Environ.* 41, 9262-9272. <https://doi.org/10.1016/j.atmosenv.2007.04.042>.

Millener, P. R. (1972). The biology of the New Zealand pied cormorant *Phalacrocorax varius varius* Gmelin (1789). Unpublished. MSc Thesis, University of Auckland, Auckland, New Zealand

Mirosława & Markowski, Janusz & Zielinski, Piotr & Banbura, Jerzy. (2013). Avian Feathers as Bioindicators of the Exposure to Heavy Metal Contamination of Food. *Bulletin of environmental contamination and toxicology*. 91.

Monteiro LR, Furness RW. Seabirds as monitors of mercury in the marine environment. *Water, Air, and Soil Pollution*. 1995; 80:831-870. Naccari C., Cristani M., Cimino F., Arcoraci T. & Trombetta D. (2009). Common buzzards (*Buteo*

buteo) bio-indicators of heavy metals pollution in Sicily (Italy). *Environment International*, 35(3):594-598. Nelson, P., Anthony L. Morrison, Hugh J. Malfroy, Martin Cope, Sunhee Lee, Mark L. Hibberd, C.P. (Mick)

Meyer, John McGregor, 2012. Atmospheric mercury emissions in Australia from anthropogenic, natural and recycled sources, *Atmospheric Environment*, 62, 291-302. <https://doi.org/10.1016/j.atmosenv.2012.07.067>.

OEH – NSW Office of Environment and Heritage, EPS Branch, 2019. *Contaminates and risk assessment and advice for metal concentrations in seafood from Lake Macquarie*, NSW June 2018. DOC18/421445

O'toole, D., and Raisbeck, M. F., 1997. Experimentally Induced Selenosis of Adult Mallard Ducks: Clinical Signs, Lesions, and Toxicology, *Vet Pathol* 34:330-340 (1997)

Peters, G. M.; H. K. Jeswani; J. P. Barford; V. G. Gomes; W. A. Maher; F. Krikowa; A. C. Roach; D. D. Reible, 1999b. Selenium in sediments, pore waters and benthic infauna of Lake Macquarie, New South Wales, Australia. *Marine Environmental Research*, ISSN: 0141-1136, Vol: 47, Issue: 5, Page: 491-508

Peterson, A, Nebeker, A V., 1992. Estimation of waterborne selenium concentrations that are toxicity thresholds for wildlife. *Arch. Envir. Contam. Toxicol* 23, (2), 154-162.

Pilastro, Andrea & Congiu, Leonardo & Tallandini, Laura & Turchetto, M.. (1993). The use of bird feathers for the monitoring of cadmium pollution. *Archives of Environmental Contamination and Toxicology*. 24. 355-358. 10.1007/BF01128733.

Plaza PI, Lambertucci SA (2019) What do we know about lead contamination in wild vultures and condors? A review of decades of research. *Sci Total Environ* 654:409-417

Roach, A.C., 2005. Assessment of metals in sediments from Lake Macquarie, New South Wales, Australia, using normalisation models and sediment quality guidelines. *Marine Environmental Research*, Volume 59, Issue 5, June 2005, Pages 453-472

Roach, A.C., Maher, W. & Krikowa, F. 2008. Assessment of Metals in Fish from Lake Macquarie, New South Wales, Australia. *Arch Environ Contam Toxicol* (2008) 54: 292. <https://doi.org/10.1007/s00244-007-9027-z>

Roberts, B., 1994, *The accumulation and distribution of selenium in fish from Lake Macquarie, NSW*, Honours thesis, Faculty of Applied Sciences, University of Canberra.

Roach, A.C., 2005. Assessment of metals in sediments from Lake Macquarie, New South Wales, Australia, using normalisation models and sediment quality guidelines. *Marine Environmental Research*, Volume 59, Issue 5, June 2005, Pages 453-472

Roach, A.C., Maher, W. & Krikowa, F. 2008. Assessment of Metals in Fish from Lake Macquarie, New South Wales, Australia. *Arch Environ Contam Toxicol*. 54: 292. <https://doi.org/10.1007/s00244-007-9027-z>

Renedo M, Bustamante P, Tessier E, Pedrero Z, Cherel Y, Amouroux D (2017) Assessment of mercury speciation in feathers using species-specific isotope dilution analysis. *Talanta* 174:100–110

Sánchez-Virosta P, Espín S, García-Fernández AJ, and Eeva T. 2015. A review on exposure and effects of arsenic in passerine birds. *Sci Total Environ* 512-513:506-525.

Sánchez-Virosta P, Espín S, Ruiz S, Salminen J-P, García-Fernández AJ, and Eeva T. 2018. Experimental manipulation of dietary arsenic levels in great tit nestlings: Accumulation pattern and effects on growth, survival and plasma biochemistry. *Environ Pollut* 233:764-773.

Salzano, R. & Angelone, M. 2013 Reactivity of urban environments towards legislative actions. The case of Roma (Italy). In E3S Web of Conferences.1, 22003 EDP Sciences (2013);

Scheuhammer A. M., 1987. The chronic toxicity of aluminium, cadmium, mercury and lead in birds: a review. *Environ. Pollut.*, 46:263-295 (1987)

Scheuhammer AM, Meyer MW, Sandheinrich MB, and Murray MW. 2007. Effects of environmental methylmercury on the health of wild birds, mammals, and fish. *AMBIO* 36:12-18.

Scheuhammer., am., 1987. The chronic toxicity of aluminium, cadmium, mercury and lead in birds: a review. *Environ. Pollut.*, 46:263-295 (1987)

Schneider, I., Rose, N., Lauri Myllyvirta, Simon Haberle, Anna Lintern, Jingjing Yuan, Darren Sinclair, Cameron

Holley, Atun Zawadzki, Ruoyu Sun, 2021. Mercury atmospheric emission, deposition and isotopic fingerprinting from major coal-fired power plants in Australia: Insights from palaeo-environmental analysis from sediment cores, *Environmental Pollution*, 287,117596. <https://doi.org/10.1016/j.envpol.2021.117596>.

Schneider, L., 2014a. *Fates of selenium and other metals in estuarine lakes receiving inputs from coal-fired power stations, NSW, Australia*. A thesis submitted in fulfilment of the requirements of the Degree of Doctor of Philosophy at the University of Canberra.

- Schneider, L., Maher, W.A., Potts, J., Taylor, A.M., Batley, G.E., Krikowa, F., Chariton, A.A., Gruber, B., 2014b. Modeling food web structure and selenium biomagnification in Lake Macquarie, New South Wales, Australia, using stable carbon and nitrogen isotopes. *Environ. Toxicol. Chem.* <https://doi.org/10.1002/etc.2847>.
- Solgi, Eisa & Mirzaei-Rajeouni, Elham & Zamani, Abbas. (2020). Feathers of Three Waterfowl Bird Species from Northern Iran for Heavy Metals Biomonitoring. *Bulletin of Environmental Contamination and Toxicology*. 104. 1-6. [10.1007/s00128-020-02852-7](https://doi.org/10.1007/s00128-020-02852-7).
- Spry DJ, Wiener JG. 1991. Metal bioavailability and toxicity to fish in low-alkalinity lakes: a critical review. *Environmental Pollution*. 1991; 71:243–304. [PubMed: 15092121]:
- Takekawa, J., S. E. Wainwright-De La Cruz, and R. L. Hothem. 2002. Relating body condition to inorganic contaminant concentrations of diving ducks wintering in coastal California. *Archives of Environmental Contamination and Toxicology*, 42: 60-70 (2002)
- Tessier A, Campbell P (1987) Partitioning of trace-metals in sediments – relationships with bioavailability. *Hydrobiologia*, 149, 43-52. doi:10.1007/BF00048645:
- Thompson DR, Furness RW. Seabirds as biomonitors of mercury inputs to epipelagic and mesopelagic marine food chains. *Science of the Total Environment*. 1998; 213:299–305.
- Thomas CA, Bendell-Young LI (1998) Linking the sediment geochemistry of an intertidal region to metal bioavailability in the deposit feeder *Macoma balthica*. *Marine Ecology-Progress Series*, 173, 197-213.
- Tovar-Sánchez, Efraín & Hernández-Plata, Isela & Martínez, Miguel & Valencia-Cuevas, Leticia & Mussali, Patricia. (2018). Heavy Metal Pollution as a Biodiversity Threat. [10.5772/intechopen.74052](https://doi.org/10.5772/intechopen.74052).
- Ullrich SM, Tanton TW, and Abdrashitova SA. 2001. Mercury in the aquatic environment: A review of factors affecting methylation. *Crit Rev Environ Sci Technol* 31:241-293.
- Ullah, K., Hashmi, M. Z. & Malik, R. N. Heavy-metal levels in feathers of cattle egret and their surrounding environment: a case of the Punjab province, Pakistan. *Arch. Environ. Contam. Toxicol.* 66, 139–153 (2014).
- US EPA - United States Environmental Protection Agency, 1995. ASTER. 1995. *ASTER (Assessment Tools for the Evaluation of Risk) ecotoxicity profile*. Duluth, MN: U.S. Environmental Protection Agency, Environmental Research Laboratory.
- van Hattum B, de Voogt P, van den Bosch L, et al. 1989. Bioaccumulation of cadmium by the freshwater isopod *Asellus aquaticus* (L.) from aqueous and dietary sources. *Environ Pollut* 62:129-152.
- Virág Kertész, Gábor Bakonyi and Beáta Farkas. 2006. Water pollution by Cu and Pb can adversely affect mallard embryonic development. *Ecotoxicology and Environmental Safety*, 65: 67–73(2006)
- Wayland AM, Scheuhammer M (2011) Cadmium in Birds, in *Environmental Contaminants in Biota* (W.N. Beyer, J.P Meador Eds.) CRC Press, Boca Raton, FL.
- Wei Zhang, Jian Zhang MA, 2011 Waterbirds as bioindicators of wetland heavy metal pollution. *Procedia Environmental Sciences* 10 (2011) 2769 – 2774. www.elsevier.com/locate/procedia

Wiener, JG.; Spry, DJ. 1996. Toxicological significance of mercury in freshwater fish. In: Beyer, WN.; Heinz, GH.; Redmon-Norwood, AW., editors. *Environmental contaminants in wildlife: interpreting tissue concentrations*. SETAC Special Publications, Lewis; Boca Raton, FL: 1996. p. 297-339.

Winn, P., Lynch, J., and Woods. 2019. Out of the ashes: Water pollution and Lake Macquarie's aging coal-fired power stations. Hunter Community Environment Centre, Newcastle, Australia. <https://www.hcec.org.au/research-and-reports>

Winn, P., Lynch, J., and Woods, 2020. *Out of the Ashes II: NSW water pollution and our aging coal-fired power stations*. Hunter Community Environment Centre, Newcastle, Australia. <https://www.hcec.org.au/out-of-the-ashes-ii>;

Yang D, Chen Y, Gunn JM, and Belzile N. 2008. Selenium and mercury in organisms: Interactions and mechanisms. *Environ Rev* 16:71-92.

Zarrintab M, Mirzaei R, Mostafaei G, Dehghani R, Akbari H (2016) Concentrations of metals in feathers of magpie (*Pica Pica*) from Aran-O-Bidgol city in Central Iran. *Bull Environ Contam Toxicol* 96:465–471



Appendix 1: Laboratory Reports

Lake Macquarie



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 252236

Client Details

| | |
|-----------|--|
| Client | Hunter Community Environment Centre |
| Attention | Paul Winn |
| Address | 167 Parry St, Hamilton East, NSW, 2303 |

Sample Details

| | |
|--------------------------------------|---|
| Your Reference | <u>Hunter Community Centre- Lake Macquarie Feathers</u> |
| Number of Samples | 3 Feather |
| Date samples received | 28/09/2020 |
| Date completed instructions received | 28/09/2020 |

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 | 06/10/2020 |
| Date of Issue | 02/10/2020 |

This document shall not be reproduced except in full.

Results Approved By
Hannah Nguyen, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| Acid Extractable metals in material | | | | |
|-------------------------------------|-------|------------|------------|------------|
| Our Reference | | 252236-1 | 252236-2 | 252236-3 |
| Your Reference | UNITS | 2ML | 3ML | 2LE |
| Date Sampled | | 18/08/2020 | 18/08/2020 | 21/07/2020 |
| Type of sample | | Feather | Feather | Feather |
| Date prepared | - | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Date analysed | - | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Aluminium | mg/kg | 150 | 20 | 40 |
| Arsenic | mg/kg | <4 | <4 | <4 |
| Boron | mg/kg | <3 | 7 | 20 |
| Cadmium | mg/kg | <0.4 | <0.4 | 0.8 |
| Copper | mg/kg | 13 | 11 | 5 |
| Iron | mg/kg | 300 | 170 | 280 |
| Manganese | mg/kg | 8 | 11 | 15 |
| Mercury | mg/kg | 0.1 | 1.2 | <0.1 |
| Nickel | mg/kg | <1 | <1 | <1 |
| Selenium | mg/kg | <2 | 5 | <2 |
| Zinc | mg/kg | 130 | 130 | 58 |
| Cobalt | mg/kg | <1 | <1 | <1 |
| Lead | mg/kg | 27 | 2 | 1 |
| Molybdenum | mg/kg | <1 | <1 | <1 |

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| Method ID | Methodology Summary |
|-------------------|--|
| Metals-020 | Determination of various metals by ICP-AES. |
| Metals-021 | Determination of Mercury by Cold Vapour AAS. |

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| QUALITY CONTROL: Acid Extractable metals in material | | | | | Duplicate | | | Spike Recovery % | | |
|--|-------|-----|------------|------------|-----------|------|------|------------------|------------|------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-2 | [NT] |
| Date prepared | - | | | 30/09/2020 | [NT] | [NT] | [NT] | [NT] | 30/09/2020 | [NT] |
| Date analysed | - | | | 30/09/2020 | [NT] | [NT] | [NT] | [NT] | 30/09/2020 | [NT] |
| Aluminium | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 99 | [NT] |
| Arsenic | mg/kg | 4 | Metals-020 | <4 | [NT] | [NT] | [NT] | [NT] | 93 | [NT] |
| Boron | mg/kg | 3 | Metals-020 | <3 | [NT] | [NT] | [NT] | [NT] | 88 | [NT] |
| Cadmium | mg/kg | 0.4 | Metals-020 | <0.4 | [NT] | [NT] | [NT] | [NT] | 87 | [NT] |
| Copper | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 100 | [NT] |
| Iron | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Manganese | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 97 | [NT] |
| Mercury | mg/kg | 0.1 | Metals-021 | <0.1 | [NT] | [NT] | [NT] | [NT] | 102 | [NT] |
| Nickel | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 99 | [NT] |
| Selenium | mg/kg | 2 | Metals-020 | <2 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Zinc | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 102 | [NT] |
| Cobalt | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 105 | [NT] |
| Lead | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Molybdenum | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 90 | [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 |

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| 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 |
|--|
| <p>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.</p> <p>Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.</p> <p>Spikes for Physical and Aggregate Tests are not applicable.</p> <p>For VOCs in water samples, three vials are required for duplicate or spike analysis.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>Measurement Uncertainty estimates are available for most tests upon request.</p> <p>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.</p> <p>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.</p> |



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 256582

| Client Details | |
|-----------------------|--|
| Client | Hunter Community Environment Centre |
| Attention | Paul Winn |
| Address | 167 Parry St, Hamilton East, NSW, 2303 |

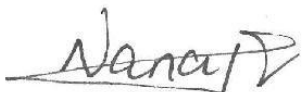
| Sample Details | |
|---|--|
| Your Reference | <u>Hunter Community Centre- Lake Macquarie Feathers</u> |
| Number of Samples | 12 Feather |
| Date samples received | 25/11/2020 |
| Date completed instructions received | 25/11/2020 |

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 | 02/12/2020 |
| Date of Issue | 27/11/2020 |
| This document shall not be reproduced except in full. | |

Results Approved By
 Hannah Nguyen, Senior Chemist

Authorised By

 Nancy Zhang, Laboratory Manager

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| Acid Extractable metals in material | | | | | | |
|-------------------------------------|-------|------------|------------|------------|------------|------------|
| Our Reference | | 256582-1 | 256582-2 | 256582-3 | 256582-4 | 256582-5 |
| Your Reference | UNITS | WHL1 | WHL2 | WHL3 | WHL4 | WHL5 |
| Date Sampled | | 13/11/2020 | 13/11/2020 | 13/11/2020 | 13/11/2020 | 13/11/2020 |
| Type of sample | | Feather | Feather | Feather | Feather | Feather |
| Date prepared | - | 26/11/2020 | 26/11/2020 | 26/11/2020 | 26/11/2020 | 26/11/2020 |
| Date analysed | - | 26/11/2020 | 26/11/2020 | 26/11/2020 | 26/11/2020 | 26/11/2020 |
| Aluminium | mg/kg | 60 | 180 | 60 | 330 | 70 |
| Arsenic | mg/kg | <4 | <4 | <4 | <4 | <4 |
| Boron | mg/kg | 7 | 7 | 10 | 4 | 5 |
| Cadmium | mg/kg | <0.4 | 2 | <0.4 | <0.4 | <0.4 |
| Copper | mg/kg | 22 | 16 | 33 | 16 | 10 |
| Iron | mg/kg | 180 | 2,300 | 50 | 640 | 80 |
| Manganese | mg/kg | 14 | 82 | 18 | 12 | 12 |
| Mercury | mg/kg | <0.3 | <0.3 | <2 | <0.1 | <0.3 |
| Nickel | mg/kg | 3 | 6 | 5 | 1 | 1 |
| Selenium | mg/kg | <2 | 4 | <2 | <2 | <2 |
| Zinc | mg/kg | 110 | 140 | 440 | 50 | 130 |
| Cobalt | mg/kg | <1 | 4 | <1 | <1 | <1 |
| Lead | mg/kg | <1 | 2 | 12 | 1 | 1 |
| Molybdenum | mg/kg | <1 | 1 | 2 | <1 | <1 |

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| Acid Extractable metals in material | | | | | | |
|-------------------------------------|-------|------------|------------|------------|------------|------------|
| Our Reference | | 256582-6 | 256582-7 | 256582-8 | 256582-9 | 256582-10 |
| Your Reference | UNITS | WHL6 | WHL 7 | MYUNA | WYEE 1 | WYEE2 |
| Date Sampled | | 13/11/2020 | 13/11/2020 | 13/11/2020 | 13/11/2020 | 13/11/2020 |
| Type of sample | | Feather | Feather | Feather | Feather | Feather |
| Date prepared | - | 26/11/2020 | 26/11/2020 | 26/11/2020 | 26/11/2020 | 26/11/2020 |
| Date analysed | - | 26/11/2020 | 26/11/2020 | 26/11/2020 | 26/11/2020 | 26/11/2020 |
| Aluminium | mg/kg | 210 | 380 | 20 | 530 | 520 |
| Arsenic | mg/kg | <4 | <4 | <4 | <4 | <4 |
| Boron | mg/kg | 5 | 10 | 6 | 3 | <3 |
| Cadmium | mg/kg | 0.8 | 0.9 | <0.4 | <0.4 | <0.4 |
| Copper | mg/kg | 17 | 15 | 7 | 10 | 6 |
| Iron | mg/kg | 510 | 1,500 | 30 | 810 | 720 |
| Manganese | mg/kg | 26 | 100 | 13 | 4 | 11 |
| Mercury | mg/kg | <0.1 | <0.1 | <0.2 | <0.1 | <0.1 |
| Nickel | mg/kg | 5 | 9 | 3 | <1 | 1 |
| Selenium | mg/kg | 5 | 2 | <2 | <2 | <2 |
| Zinc | mg/kg | 150 | 120 | 230 | 7 | 22 |
| Cobalt | mg/kg | <1 | 4 | <1 | <1 | <1 |
| Lead | mg/kg | 1 | 1 | <1 | 3 | 2 |
| Molybdenum | mg/kg | <1 | <1 | <1 | <1 | <1 |

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| Acid Extractable metals in material | | | |
|-------------------------------------|-------|------------|------------|
| Our Reference | | 256582-11 | 256582-12 |
| Your Reference | UNITS | WYEE3 | WYEE4 |
| Date Sampled | | 13/11/2020 | 13/11/2020 |
| Type of sample | | Feather | Feather |
| Date prepared | - | 26/11/2020 | 26/11/2020 |
| Date analysed | - | 26/11/2020 | 26/11/2020 |
| Aluminium | mg/kg | 290 | 80 |
| Arsenic | mg/kg | <4 | <4 |
| Boron | mg/kg | 8 | 20 |
| Cadmium | mg/kg | <0.4 | <0.4 |
| Copper | mg/kg | 22 | 14 |
| Iron | mg/kg | 580 | 270 |
| Manganese | mg/kg | 44 | 17 |
| Mercury | mg/kg | <0.3 | <0.2 |
| Nickel | mg/kg | 2 | 1 |
| Selenium | mg/kg | 2 | <2 |
| Zinc | mg/kg | 1,500 | 370 |
| Cobalt | mg/kg | <1 | <1 |
| Lead | mg/kg | 190 | 22 |
| Molybdenum | mg/kg | <1 | 1 |

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| Method ID | Methodology Summary |
|-------------------|--|
| Metals-020 | Determination of various metals by ICP-AES. |
| Metals-021 | Determination of Mercury by Cold Vapour AAS. |

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| QUALITY CONTROL: Acid Extractable metals in material | | | | | Duplicate | | | Spike Recovery % | | |
|--|-------|-----|------------|------------|-----------|------|------|------------------|------------|------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-1 | [NT] |
| Date prepared | - | | | 26/11/2020 | [NT] | [NT] | [NT] | [NT] | 26/11/2020 | [NT] |
| Date analysed | - | | | 26/11/2020 | [NT] | [NT] | [NT] | [NT] | 26/11/2020 | [NT] |
| Aluminium | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Arsenic | mg/kg | 4 | Metals-020 | <4 | [NT] | [NT] | [NT] | [NT] | 109 | [NT] |
| Boron | mg/kg | 3 | Metals-020 | <3 | [NT] | [NT] | [NT] | [NT] | 89 | [NT] |
| Cadmium | mg/kg | 0.4 | Metals-020 | <0.4 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Copper | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 105 | [NT] |
| Iron | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 109 | [NT] |
| Manganese | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Mercury | mg/kg | 0.1 | Metals-021 | <0.1 | [NT] | [NT] | [NT] | [NT] | 91 | [NT] |
| Nickel | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 110 | [NT] |
| Selenium | mg/kg | 2 | Metals-020 | <2 | [NT] | [NT] | [NT] | [NT] | 97 | [NT] |
| Zinc | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 110 | [NT] |
| Cobalt | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 110 | [NT] |
| Lead | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 103 | [NT] |
| Molybdenum | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 98 | [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 |

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

| 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

The PQL has been raised due to the light weight nature of samples, which results in a higher than routine dilution factor.



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 252240

Client Details

| | |
|------------------|--|
| Client | Hunter Community Environment Centre |
| Attention | Paul Winn |
| Address | 167 Parry St, Hamilton East, NSW, 2303 |

Sample Details

| | |
|---|---|
| Your Reference | <u>Hunter Community Centre- Hunter Feathers</u> |
| Number of Samples | 4 Feather |
| Date samples received | 28/09/2020 |
| Date completed instructions received | 28/09/2020 |

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 | 06/10/2020 |
| Date of Issue | 02/10/2020 |

This document shall not be reproduced except in full.

Results Approved By
Hannah Nguyen, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Client Reference: Hunter Community Centre- Hunter Feathers

| Acid Extractable metals in material | | | | | |
|-------------------------------------|-------|------------|------------|------------|------------|
| Our Reference | | 252240-1 | 252240-2 | 252240-3 | 252240-4 |
| Your Reference | UNITS | 1L | 2L | 3L | 6L |
| Date Sampled | | 29/07/2020 | 29/07/2020 | 29/07/2020 | 29/07/2020 |
| Type of sample | | Feather | Feather | Feather | Feather |
| Date prepared | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Date analysed | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Aluminium | mg/kg | 40 | 150 | 1,300 | 170 |
| Arsenic | mg/kg | <4 | <4 | 5 | <4 |
| Boron | mg/kg | <3 | 10 | 20 | 6 |
| Cadmium | mg/kg | <0.4 | <0.4 | <0.4 | <0.4 |
| Copper | mg/kg | 8 | 13 | 19 | 19 |
| Iron | mg/kg | 140 | 360 | 3,400 | 320 |
| Manganese | mg/kg | 12 | 19 | 140 | 11 |
| Mercury | mg/kg | <0.1 | 0.3 | 0.3 | 0.6 |
| Nickel | mg/kg | <1 | 5 | 21 | 1 |
| Selenium | mg/kg | 4 | 21 | 20 | 7 |
| Zinc | mg/kg | 64 | 160 | 110 | 160 |
| Cobalt | mg/kg | <1 | <1 | 6 | <1 |
| Lead | mg/kg | <1 | <1 | 2 | 2 |
| Molybdenum | mg/kg | <1 | 1 | 1 | <1 |

Client Reference: Hunter Community Centre- Hunter Feathers

| Method ID | Methodology Summary |
|-------------------|--|
| Metals-020 | Determination of various metals by ICP-AES. |
| Metals-021 | Determination of Mercury by Cold Vapour AAS. |

Client Reference: Hunter Community Centre- Hunter Feathers

| QUALITY CONTROL: Acid Extractable metals in material | | | | | Duplicate | | | Spike Recovery % | | |
|--|-------|-----|------------|------------|-----------|------|------|------------------|------------|------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-2 | [NT] |
| Date prepared | - | | | 30/09/2020 | [NT] | [NT] | [NT] | [NT] | 30/09/2020 | [NT] |
| Date analysed | - | | | 30/09/2020 | [NT] | [NT] | [NT] | [NT] | 30/09/2020 | [NT] |
| Aluminium | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 99 | [NT] |
| Arsenic | mg/kg | 4 | Metals-020 | <4 | [NT] | [NT] | [NT] | [NT] | 93 | [NT] |
| Boron | mg/kg | 3 | Metals-020 | <3 | [NT] | [NT] | [NT] | [NT] | 88 | [NT] |
| Cadmium | mg/kg | 0.4 | Metals-020 | <0.4 | [NT] | [NT] | [NT] | [NT] | 87 | [NT] |
| Copper | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 100 | [NT] |
| Iron | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Manganese | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 97 | [NT] |
| Mercury | mg/kg | 0.1 | Metals-021 | <0.1 | [NT] | [NT] | [NT] | [NT] | 102 | [NT] |
| Nickel | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 99 | [NT] |
| Selenium | mg/kg | 2 | Metals-020 | <2 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Zinc | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 102 | [NT] |
| Cobalt | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 105 | [NT] |
| Lead | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Molybdenum | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 90 | [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 |

Client Reference: Hunter Community Centre- Hunter Feathers

| 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 |
|--|
| <p>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.</p> <p>Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.</p> <p>Spikes for Physical and Aggregate Tests are not applicable.</p> <p>For VOCs in water samples, three vials are required for duplicate or spike analysis.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>Measurement Uncertainty estimates are available for most tests upon request.</p> <p>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.</p> <p>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.</p> |



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 248119

| Client Details | |
|------------------|--|
| Client | Hunter Community Environment Centre |
| Attention | Paul Winn |
| Address | 167 Parry St, Hamilton East, NSW, 2303 |

| Sample Details | |
|---|--|
| Your Reference | Hunter Community Environment Centre-Hunter Valley |
| Number of Samples | 11 Water, 2 Sediment, 1 Feather |
| Date samples received | 31/07/2020 |
| Date completed instructions received | 31/07/2020 |

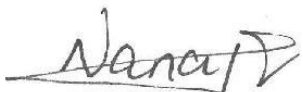
Analysis Details

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 | 07/08/2020 |
| Date of Issue | 07/08/2020 |
| NATA Accreditation Number 2901. This document shall not be reproduced except in full. | |
| Accredited for compliance with ISO/IEC 17025 - Testing. Tests not covered by NATA are denoted with * | |

Results Approved By
 Jaimie Loa-Kum-Cheung, Metals Supervisor
 Ken Nguyen, Reporting Supervisor
 Steven Luong, Organics Supervisor

Authorised By



Nancy Zhang, Laboratory Manager

Envirolab Reference: 248119
 Revision No: R00



Client Reference: Hunter Community Environment Centre-Hunter Valley

| All metals in water-dissolved | | | | | | |
|--------------------------------------|--------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Our Reference | | 248119-2 | 248119-5 | 248119-7 | 248119-9 | 248119-11 |
| Your Reference | UNITS | 1F | 2F | 3F | 4F | 6F |
| Date Sampled | | 29/07/2020 | 29/07/2020 | 29/07/2020 | 29/07/2020 | 29/07/2020 |
| Type of sample | | Water | Water | Water | Water | Water |
| Date prepared | - | 03/08/2020 | 03/08/2020 | 03/08/2020 | 03/08/2020 | 03/08/2020 |
| Date analysed | - | 03/08/2020 | 03/08/2020 | 03/08/2020 | 03/08/2020 | 03/08/2020 |
| Aluminium-Dissolved | µg/L | 90 | 70 | 10 | 20 | 90 |
| Arsenic-Dissolved | µg/L | <1 | <1 | 1 | 4 | <1 |
| Boron-Dissolved | µg/L | 40 | 40 | 910 | 1,200 | 200 |
| 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 | 2 | 2 | 50 | 3 | 3 |
| Iron-Dissolved | µg/L | 110 | 98 | <10 | 14 | 110 |
| Lead-Dissolved | µg/L | <1 | <1 | <1 | <1 | <1 |
| Manganese-Dissolved | µg/L | 6 | 6 | 26 | <5 | 14 |
| Mercury-Dissolved | µg/L | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Nickel-Dissolved | µg/L | <1 | <1 | 24 | 4 | 1 |
| Selenium-Dissolved | µg/L | <1 | <1 | 4 | 5 | <1 |
| Zinc-Dissolved | µg/L | 4 | 22 | 12 | 2 | 9 |

Client Reference: Hunter Community Environment Centre-Hunter Valley

| All metals in water - total | | | | | | |
|------------------------------------|-------|------------|------------|------------|------------|------------|
| Our Reference | | 248119-1 | 248119-4 | 248119-6 | 248119-8 | 248119-10 |
| Your Reference | UNITS | 1T | 2T | 3T | 4T | 6T |
| Date Sampled | | 29/07/2020 | 29/07/2020 | 29/07/2020 | 29/07/2020 | 29/07/2020 |
| Type of sample | | Water | Water | Water | Water | Water |
| Date prepared | - | 03/08/2020 | 03/08/2020 | 03/08/2020 | 03/08/2020 | 03/08/2020 |
| Date analysed | - | 03/08/2020 | 03/08/2020 | 03/08/2020 | 03/08/2020 | 03/08/2020 |
| Aluminium-Total | µg/L | 2,700 | 2,800 | 420 | 330 | 2,200 |
| Arsenic-Total | µg/L | <1 | 1 | 2 | 5 | <1 |
| Boron-Total | µg/L | 40 | 40 | 1,000 | 1,200 | 210 |
| Cadmium-Total | µg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Chromium-Total | µg/L | 1 | 1 | 1 | <1 | 1 |
| Copper-Total | µg/L | 3 | 2 | 120 | 4 | 3 |
| Iron-Total | µg/L | 1,500 | 1,800 | 1,500 | 310 | 1,100 |
| Lead-Total | µg/L | <1 | <1 | <1 | <1 | <1 |
| Manganese-Total | µg/L | 25 | 120 | 46 | 11 | 13 |
| Mercury-Total | µg/L | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Nickel-Total | µg/L | 1 | 2 | 28 | 4 | 2 |
| Selenium-Total | µg/L | <1 | <1 | 4 | 5 | <1 |
| Zinc-Total | µg/L | 5 | 10 | 44 | 2 | 8 |

Client Reference: Hunter Community Environment Centre-Hunter Valley

| Acid Extractable metals in soil | | | | |
|--|--------------|-------------------|-------------------|---------------------|
| Our Reference | | 248119-12 | 248119-13 | 248119-14 |
| Your Reference | UNITS | 3S | 4S | Bird Feather |
| Date Sampled | | 29/07/2020 | 29/07/2020 | 29/07/2020 |
| Type of sample | | Sediment | Sediment | Feather |
| Date prepared | - | 03/08/2020 | 03/08/2020 | 03/08/2020 |
| Date analysed | - | 03/08/2020 | 03/08/2020 | 03/08/2020 |
| Aluminium | mg/kg | 6,600 | 14,000 | 140 |
| Arsenic | mg/kg | 19 | 17 | <4 |
| Boron | mg/kg | <3 | <3 | <3 |
| Cadmium | mg/kg | <0.4 | <0.4 | <0.4 |
| Chromium | mg/kg | 12 | 19 | <1 |
| Copper | mg/kg | 910 | 18 | 8 |
| Iron | mg/kg | 17,000 | 21,000 | 340 |
| Lead | mg/kg | 8 | 9 | 2 |
| Manganese | mg/kg | 450 | 87 | 22 |
| Mercury | mg/kg | 0.2 | <0.1 | <0.1 |
| Nickel | mg/kg | 77 | 10 | <1 |
| Selenium | mg/kg | <2 | 3 | 5 |
| Zinc | mg/kg | 190 | 20 | 62 |

Client Reference: Hunter Community Environment Centre-Hunter Valley

| Moisture | | | |
|----------------|-------|------------|------------|
| Our Reference | | 248119-12 | 248119-13 |
| Your Reference | UNITS | 3S | 4S |
| Date Sampled | | 29/07/2020 | 29/07/2020 |
| Type of sample | | Sediment | Sediment |
| Date prepared | - | 03/08/2020 | 03/08/2020 |
| Date analysed | - | 04/08/2020 | 04/08/2020 |
| Moisture | % | 63 | 30 |

Client Reference: Hunter Community Environment Centre-Hunter Valley

| Method ID | Methodology Summary |
|-------------------|---|
| Inorg-008 | Moisture content determined by heating at 105+/-5 °C for a minimum of 12 hours. |
| Metals-020 | Determination of various metals by ICP-AES. |
| Metals-021 | Determination of Mercury by Cold Vapour AAS. |
| Metals-022 | Determination of various metals by ICP-MS. |

Client Reference: Hunter Community Environment Centre-Hunter Valley

| QUALITY CONTROL: All metals in water-dissolved | | | | Duplicate | | | | Spike Recovery % | | |
|--|-------|------|------------|------------|---|------------|------------|------------------|------------|------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-W2 | [NT] |
| Date prepared | - | | | 03/08/2020 | 2 | 03/08/2020 | 03/08/2020 | | 03/08/2020 | [NT] |
| Date analysed | - | | | 03/08/2020 | 2 | 03/08/2020 | 03/08/2020 | | 03/08/2020 | [NT] |
| Aluminium-Dissolved | µg/L | 10 | Metals-022 | <10 | 2 | 90 | 90 | 0 | 96 | [NT] |
| Arsenic-Dissolved | µg/L | 1 | Metals-022 | <1 | 2 | <1 | <1 | 0 | 93 | [NT] |
| Boron-Dissolved | µg/L | 20 | Metals-022 | <20 | 2 | 40 | 40 | 0 | 96 | [NT] |
| Cadmium-Dissolved | µg/L | 0.1 | Metals-022 | <0.1 | 2 | <0.1 | <0.1 | 0 | 94 | [NT] |
| Chromium-Dissolved | µg/L | 1 | Metals-022 | <1 | 2 | <1 | <1 | 0 | 99 | [NT] |
| Copper-Dissolved | µg/L | 1 | Metals-022 | <1 | 2 | 2 | 2 | 0 | 105 | [NT] |
| Iron-Dissolved | µg/L | 10 | Metals-022 | <10 | 2 | 110 | 100 | 10 | 105 | [NT] |
| Lead-Dissolved | µg/L | 1 | Metals-022 | <1 | 2 | <1 | <1 | 0 | 105 | [NT] |
| Manganese-Dissolved | µg/L | 5 | Metals-022 | <5 | 2 | 6 | 6 | 0 | 98 | [NT] |
| Mercury-Dissolved | µg/L | 0.05 | Metals-021 | <0.05 | 2 | <0.05 | <0.05 | 0 | 100 | [NT] |
| Nickel-Dissolved | µg/L | 1 | Metals-022 | <1 | 2 | <1 | <1 | 0 | 95 | [NT] |
| Selenium-Dissolved | µg/L | 1 | Metals-022 | <1 | 2 | <1 | <1 | 0 | 100 | [NT] |
| Zinc-Dissolved | µg/L | 1 | Metals-022 | <1 | 2 | 4 | 2 | 67 | 98 | [NT] |

Client Reference: Hunter Community Environment Centre-Hunter Valley

| QUALITY CONTROL: All metals in water - total | | | | Duplicate | | | | Spike Recovery % | | |
|--|-------|------|------------|------------|---|------------|------------|------------------|------------|------------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-W2 | 248119-4 |
| Date prepared | - | | | 03/08/2020 | 1 | 03/08/2020 | 03/08/2020 | | 03/08/2020 | 03/08/2020 |
| Date analysed | - | | | 03/08/2020 | 1 | 03/08/2020 | 03/08/2020 | | 03/08/2020 | 03/08/2020 |
| Aluminium-Total | µg/L | 10 | Metals-022 | <10 | 1 | 2700 | 2600 | 4 | 108 | [NT] |
| Arsenic-Total | µg/L | 1 | Metals-022 | <1 | 1 | <1 | <1 | 0 | 92 | [NT] |
| Boron-Total | µg/L | 20 | Metals-022 | <20 | 1 | 40 | 40 | 0 | 111 | [NT] |
| Cadmium-Total | µg/L | 0.1 | Metals-022 | <0.1 | 1 | <0.1 | <0.1 | 0 | 95 | [NT] |
| Chromium-Total | µg/L | 1 | Metals-022 | <1 | 1 | 1 | 1 | 0 | 104 | [NT] |
| Copper-Total | µg/L | 1 | Metals-022 | <1 | 1 | 3 | 2 | 40 | 106 | [NT] |
| Iron-Total | µg/L | 10 | Metals-022 | <10 | 1 | 1500 | 1500 | 0 | 102 | [NT] |
| Lead-Total | µg/L | 1 | Metals-022 | <1 | 1 | <1 | <1 | 0 | 107 | [NT] |
| Manganese-Total | µg/L | 5 | Metals-022 | <5 | 1 | 25 | 25 | 0 | 97 | [NT] |
| Mercury-Total | µg/L | 0.05 | Metals-021 | <0.05 | 1 | <0.05 | <0.05 | 0 | 101 | 100 |
| Nickel-Total | µg/L | 1 | Metals-022 | <1 | 1 | 1 | 1 | 0 | 94 | [NT] |
| Selenium-Total | µg/L | 1 | Metals-022 | <1 | 1 | <1 | <1 | 0 | 100 | [NT] |
| Zinc-Total | µg/L | 1 | Metals-022 | <1 | 1 | 5 | 4 | 22 | 104 | [NT] |

Client Reference: Hunter Community Environment Centre-Hunter Valley

| QUALITY CONTROL: Acid Extractable metals in soil | | | | | Duplicate | | | Spike Recovery % | | |
|--|-------|-----|------------|------------|-----------|------|------|------------------|------------|------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-6 | [NT] |
| Date prepared | - | | | 03/08/2020 | [NT] | [NT] | [NT] | [NT] | 03/08/2020 | [NT] |
| Date analysed | - | | | 03/08/2020 | [NT] | [NT] | [NT] | [NT] | 03/08/2020 | [NT] |
| Aluminium | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 125 | [NT] |
| Arsenic | mg/kg | 4 | Metals-020 | <4 | [NT] | [NT] | [NT] | [NT] | 103 | [NT] |
| Boron | mg/kg | 3 | Metals-020 | <3 | [NT] | [NT] | [NT] | [NT] | 96 | [NT] |
| Cadmium | mg/kg | 0.4 | Metals-020 | <0.4 | [NT] | [NT] | [NT] | [NT] | 99 | [NT] |
| Chromium | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 99 | [NT] |
| Copper | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 105 | [NT] |
| Iron | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 128 | [NT] |
| Lead | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 102 | [NT] |
| Manganese | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Mercury | mg/kg | 0.1 | Metals-021 | <0.1 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Nickel | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 99 | [NT] |
| Selenium | mg/kg | 2 | Metals-020 | <2 | [NT] | [NT] | [NT] | [NT] | 96 | [NT] |
| Zinc | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 97 | [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 |

Client Reference: Hunter Community Environment Centre-Hunter Valley

| 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.

Client Reference: Hunter Community Environment Centre-Hunter Valley

Report Comments

In theory the total metal content should be higher than the dissolved metal content. However, in some samples this is not the case. The sample has been re-analysed for both Total and Dissolved and results have been confirmed.

Lake Wallace



Envirolab Services P
ABN 37 112 53
12 Ashley St Chatswood NSW
ph 02 9910 6200 fax 02 9910
customerservice@envirolab.c
www.envirolab.c

CERTIFICATE OF ANALYSIS 252238

Client Details

| | |
|------------------|--|
| Client | Hunter Community Environment Centre |
| Attention | Paul Winn |
| Address | 167 Parry St, Hamilton East, NSW, 2303 |

Sample Details

| | |
|---|--|
| Your Reference | <u>Hunter Community Centre- Lithgow Feathers</u> |
| Number of Samples | 5 Feather |
| Date samples received | 28/09/2020 |
| Date completed instructions received | 28/09/2020 |

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 | 06/10/2020 |
| Date of Issue | 02/10/2020 |

This document shall not be reproduced except in full.

Results Approved By
Hannah Nguyen, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Client Reference: Hunter Community Centre- Lithgow Feathers

| Acid Extractable metals in material | | | | | | |
|-------------------------------------|-------|------------|------------|------------|------------|------------|
| Our Reference | | 252238-1 | 252238-2 | 252238-3 | 252238-4 | 252238-5 |
| Your Reference | UNITS | 3LG | 4LG | 7LG | 9LG | 10LG |
| Date Sampled | | 28/08/2020 | 28/08/2020 | 28/08/2020 | 28/08/2020 | 28/08/2020 |
| Type of sample | | Feather | Feather | Feather | Feather | Feather |
| Date prepared | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Date analysed | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Aluminium | mg/kg | 40 | 10 | 30 | 200 | <10 |
| Arsenic | mg/kg | <4 | <4 | <4 | <4 | <4 |
| Boron | mg/kg | <3 | 5 | <3 | <3 | <3 |
| Cadmium | mg/kg | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 |
| Copper | mg/kg | 23 | 7 | 18 | 24 | 4 |
| Iron | mg/kg | 190 | 70 | 250 | 350 | 30 |
| Manganese | mg/kg | 12 | 15 | 40 | 93 | 3 |
| Mercury | mg/kg | 2.3 | <0.1 | 2.4 | 0.4 | <0.1 |
| Nickel | mg/kg | 3 | <1 | 2 | 1 | <1 |
| Selenium | mg/kg | <2 | <2 | 3 | <2 | <2 |
| Zinc | mg/kg | 190 | 120 | 150 | 110 | 73 |
| Cobalt | mg/kg | <1 | <1 | <1 | <1 | <1 |
| Lead | mg/kg | 1 | <1 | 1 | 2 | <1 |
| Molybdenum | mg/kg | <1 | <1 | <1 | <1 | <1 |

Client Reference: Hunter Community Centre- Lithgow Feathers

| Acid Extractable metals in material | | | | | | |
|-------------------------------------|-------|------------|------------|------------|------------|------------|
| Our Reference | | 252238-1 | 252238-2 | 252238-3 | 252238-4 | 252238-5 |
| Your Reference | UNITS | 3LG | 4LG | 7LG | 9LG | 10LG |
| Date Sampled | | 28/08/2020 | 28/08/2020 | 28/08/2020 | 28/08/2020 | 28/08/2020 |
| Type of sample | | Feather | Feather | Feather | Feather | Feather |
| Date prepared | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Date analysed | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Aluminium | mg/kg | 40 | 10 | 30 | 200 | <10 |
| Arsenic | mg/kg | <4 | <4 | <4 | <4 | <4 |
| Boron | mg/kg | <3 | 5 | <3 | <3 | <3 |
| Cadmium | mg/kg | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 |
| Copper | mg/kg | 23 | 7 | 18 | 24 | 4 |
| Iron | mg/kg | 190 | 70 | 250 | 350 | 30 |
| Manganese | mg/kg | 12 | 15 | 40 | 93 | 3 |
| Mercury | mg/kg | 2.3 | <0.1 | 2.4 | 0.4 | <0.1 |
| Nickel | mg/kg | 3 | <1 | 2 | 1 | <1 |
| Selenium | mg/kg | <2 | <2 | 3 | <2 | <2 |
| Zinc | mg/kg | 190 | 120 | 150 | 110 | 73 |
| Cobalt | mg/kg | <1 | <1 | <1 | <1 | <1 |
| Lead | mg/kg | 1 | <1 | 1 | 2 | <1 |
| Molybdenum | mg/kg | <1 | <1 | <1 | <1 | <1 |

Client Reference: Hunter Community Centre- Lithgow Feathers

| Method ID | Methodology Summary |
|-------------------|--|
| Metals-020 | Determination of various metals by ICP-AES. |
| Metals-021 | Determination of Mercury by Cold Vapour AAS. |

Client Reference: Hunter Community Centre- Lithgow Feathers

| QUALITY CONTROL: Acid Extractable metals in material | | | | | Duplicate | | | Spike Recovery % | | |
|--|-------|-----|------------|------------|-----------|------|------|------------------|------------|------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-2 | [NT] |
| Date prepared | - | | | 30/09/2020 | [NT] | [NT] | [NT] | [NT] | 30/09/2020 | [NT] |
| Date analysed | - | | | 30/09/2020 | [NT] | [NT] | [NT] | [NT] | 30/09/2020 | [NT] |
| Aluminium | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 99 | [NT] |
| Arsenic | mg/kg | 4 | Metals-020 | <4 | [NT] | [NT] | [NT] | [NT] | 93 | [NT] |
| Boron | mg/kg | 3 | Metals-020 | <3 | [NT] | [NT] | [NT] | [NT] | 88 | [NT] |
| Cadmium | mg/kg | 0.4 | Metals-020 | <0.4 | [NT] | [NT] | [NT] | [NT] | 87 | [NT] |
| Copper | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 100 | [NT] |
| Iron | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Manganese | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 97 | [NT] |
| Mercury | mg/kg | 0.1 | Metals-021 | <0.1 | [NT] | [NT] | [NT] | [NT] | 102 | [NT] |
| Nickel | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 99 | [NT] |
| Selenium | mg/kg | 2 | Metals-020 | <2 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Zinc | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 102 | [NT] |
| Cobalt | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 105 | [NT] |
| Lead | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Molybdenum | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 90 | [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 |

Client Reference: Hunter Community Centre- Lithgow Feathers

| 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.

Port Stephens/ Myall Lakes National Park



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 252239

Client Details

| | |
|-----------|--|
| Client | Hunter Community Environment Centre |
| Attention | Paul Winn |
| Address | 167 Parry St, Hamilton East, NSW, 2303 |

Sample Details

| | |
|--------------------------------------|--|
| Your Reference | <u>Hunter Community Centre- Port Stephens Feathers</u> |
| Number of Samples | 10 Feather |
| Date samples received | 28/09/2020 |
| Date completed instructions received | 28/09/2020 |

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 | 06/10/2020 |
| Date of Issue | 06/10/2020 |

This document shall not be reproduced except in full.

Results Approved By
Hannah Nguyen, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Client Reference: Hunter Community Centre- Port Stephens Feathers

| Acid Extractable metals in material | | | | | | |
|-------------------------------------|-------|------------|------------|------------|------------|------------|
| Our Reference | | 252239-1 | 252239-2 | 252239-3 | 252239-4 | 252239-5 |
| Your Reference | UNITS | 1M | 2M | 3M | 4M | 2BF |
| Date Sampled | | 02/09/2020 | 02/09/2020 | 02/09/2020 | 02/09/2020 | 02/09/2020 |
| Type of sample | | Feather | Feather | Feather | Feather | Feather |
| Date prepared | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Date analysed | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Aluminium | mg/kg | 90 | 70 | 260 | 30 | 170 |
| Arsenic | mg/kg | <4 | <4 | <4 | <4 | <4 |
| Boron | mg/kg | 30 | 7 | 10 | <3 | 10 |
| Cadmium | mg/kg | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 |
| Copper | mg/kg | 9 | 11 | 10 | 5 | 8 |
| Iron | mg/kg | 430 | 1,200 | 570 | 70 | 390 |
| Manganese | mg/kg | 31 | 14 | 46 | 4 | 38 |
| Mercury | mg/kg | 8.6 | 1.7 | 1.3 | <0.1 | 4.7 |
| Nickel | mg/kg | 1 | <1 | <1 | <1 | <1 |
| Selenium | mg/kg | 2 | 2 | <2 | <2 | <2 |
| Zinc | mg/kg | 120 | 100 | 40 | 21 | 34 |
| Cobalt | mg/kg | <1 | 1 | <1 | <1 | <1 |
| Lead | mg/kg | 2 | <1 | 1 | 2 | 4 |
| Molybdenum | mg/kg | <1 | <1 | <1 | <1 | <1 |

Client Reference: Hunter Community Centre- Port Stephens Feathers

| Acid Extractable metals in material | | | | | | |
|-------------------------------------|-------|------------|------------|------------|------------|------------|
| Our Reference | | 252239-6 | 252239-7 | 252239-8 | 252239-9 | 252239-10 |
| Your Reference | UNITS | 1WTB | 2WTB | 3WTB | 1SB | 2SB |
| Date Sampled | | 02/09/2020 | 02/09/2020 | 02/09/2020 | 02/09/2020 | 02/09/2020 |
| Type of sample | | Feather | Feather | Feather | Feather | Feather |
| Date prepared | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Date analysed | - | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 | 30/09/2020 |
| Aluminium | mg/kg | 280 | 230 | 80 | 630 | 990 |
| Arsenic | mg/kg | <4 | <4 | <4 | <4 | <4 |
| Boron | mg/kg | 10 | 7 | 10 | 32 | 20 |
| Cadmium | mg/kg | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 |
| Copper | mg/kg | 10 | 9 | 7 | 8 | 10 |
| Iron | mg/kg | 830 | 490 | 140 | 710 | 900 |
| Manganese | mg/kg | 40 | 20 | 8 | 8 | 5 |
| Mercury | mg/kg | 7.7 | 4.1 | 2.9 | 0.1 | 3.9 |
| Nickel | mg/kg | <1 | <1 | <1 | <1 | <1 |
| Selenium | mg/kg | 2 | <2 | <2 | <2 | <2 |
| Zinc | mg/kg | 100 | 64 | 86 | 73 | 49 |
| Cobalt | mg/kg | <1 | <1 | <1 | <1 | <1 |
| Lead | mg/kg | 1 | 2 | <1 | 1 | 2 |
| Molybdenum | mg/kg | <1 | <1 | <1 | <1 | <1 |

Client Reference: Hunter Community Centre- Port Stephens Feathers

| Method ID | Methodology Summary |
|-------------------|--|
| Metals-020 | Determination of various metals by ICP-AES. |
| Metals-021 | Determination of Mercury by Cold Vapour AAS. |

Client Reference: Hunter Community Centre- Port Stephens Feathers

| QUALITY CONTROL: Acid Extractable metals in material | | | | | Duplicate | | | Spike Recovery % | | |
|--|-------|-----|------------|------------|-----------|------|------|------------------|------------|------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-1 | [NT] |
| Date prepared | - | | | 30/09/2020 | [NT] | [NT] | [NT] | [NT] | 30/09/2020 | [NT] |
| Date analysed | - | | | 30/09/2020 | [NT] | [NT] | [NT] | [NT] | 30/09/2020 | [NT] |
| Aluminium | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 107 | [NT] |
| Arsenic | mg/kg | 4 | Metals-020 | <4 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Boron | mg/kg | 3 | Metals-020 | <3 | [NT] | [NT] | [NT] | [NT] | 92 | [NT] |
| Cadmium | mg/kg | 0.4 | Metals-020 | <0.4 | [NT] | [NT] | [NT] | [NT] | 94 | [NT] |
| Copper | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 105 | [NT] |
| Iron | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 114 | [NT] |
| Manganese | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 103 | [NT] |
| Mercury | mg/kg | 0.1 | Metals-021 | <0.1 | [NT] | [NT] | [NT] | [NT] | 103 | [NT] |
| Nickel | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Selenium | mg/kg | 2 | Metals-020 | <2 | [NT] | [NT] | [NT] | [NT] | 105 | [NT] |
| Zinc | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 109 | [NT] |
| Cobalt | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 110 | [NT] |
| Lead | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 110 | [NT] |
| Molybdenum | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 96 | [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 |

Client Reference: Hunter Community Centre- Port Stephens Feathers

| 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 |
|--|
| <p>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.</p> <p>Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.</p> <p>Spikes for Physical and Aggregate Tests are not applicable.</p> <p>For VOCs in water samples, three vials are required for duplicate or spike analysis.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>Measurement Uncertainty estimates are available for most tests upon request.</p> <p>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.</p> <p>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.</p> |

Lake Wallace and Lake Macquarie



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 257952

Client Details

| | |
|-----------|--|
| Client | Hunter Community Environment Centre |
| Attention | Paul Winn |
| Address | 167 Parry St, Hamilton East, NSW, 2303 |

Sample Details

| | |
|--------------------------------------|---|
| Your Reference | <u>Hunter Community Centre- Bird Feathers 6</u> |
| Number of Samples | 18 Feather |
| Date samples received | 10/12/2020 |
| Date completed instructions received | 10/12/2020 |

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 | 17/12/2020 |
| Date of Issue | 17/12/2020 |

This document shall not be reproduced except in full.

Results Approved By
Loren Bardwell, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Envirolab Reference: 257952
Revision No: R00

Page | 1 of 8

Client Reference: Hunter Community Centre- Bird Feathers 6

| Method ID | Methodology Summary |
|-------------------|--|
| Metals-020 | Determination of various metals by ICP-AES. |
| Metals-021 | Determination of Mercury by Cold Vapour AAS. |

Client Reference: Hunter Community Centre- Bird Feathers 6

| QUALITY CONTROL: Acid Extractable metals in Feathers | | | | | Duplicate | | | Spike Recovery % | | |
|--|-------|-----|------------|------------|-----------|------|------|------------------|------------|------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-1 | [NT] |
| Date prepared | - | | | 15/12/2020 | [NT] | [NT] | [NT] | [NT] | 15/12/2020 | [NT] |
| Date analysed | - | | | 16/12/2020 | [NT] | [NT] | [NT] | [NT] | 16/12/2020 | [NT] |
| Aluminium | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 113 | [NT] |
| Arsenic | mg/kg | 4 | Metals-020 | <4 | [NT] | [NT] | [NT] | [NT] | 106 | [NT] |
| Boron | mg/kg | 3 | Metals-020 | <3 | [NT] | [NT] | [NT] | [NT] | 94 | [NT] |
| Cadmium | mg/kg | 0.4 | Metals-020 | <0.4 | [NT] | [NT] | [NT] | [NT] | 103 | [NT] |
| Copper | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 113 | [NT] |
| Iron | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 119 | [NT] |
| Manganese | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 102 | [NT] |
| Mercury | mg/kg | 0.1 | Metals-021 | <0.1 | [NT] | [NT] | [NT] | [NT] | 112 | [NT] |
| Nickel | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 106 | [NT] |
| Selenium | mg/kg | 2 | Metals-020 | <2 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Zinc | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 110 | [NT] |
| Cobalt | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 111 | [NT] |
| Lead | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 110 | [NT] |
| Molybdenum | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 100 | [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

Acid Extractable Metals in Feathers:

- The results are reported on the sample as received i.e. no moisture correction has been applied.
- The PQL has been raised due to the light weight nature of all samples, which results in a higher than routine dilution factor.

Lake Macquarie Crabs



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 257951

Client Details

| | |
|------------------|--|
| Client | Hunter Community Environment Centre |
| Attention | Paul Winn |
| Address | 167 Parry St, Hamilton East, NSW, 2303 |

Sample Details

| | |
|---|---|
| Your Reference | <u>Hunter Community Env Centre- Lake Macquarie Fish</u> |
| Number of Samples | 3 crab flesh, 3 crab organs, 3 crab shell |
| Date samples received | 10/12/2020 |
| Date completed instructions received | 10/12/2020 |

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 | 17/12/2020 |
| Date of Issue | 16/12/2020 |

This document shall not be reproduced except in full.

Results Approved By
Loren Bardwell, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Envirolab Reference: 257951
Revision No: R00

Page | 1 of 8

Client Reference: Hunter Community Env Centre- Lake Macquarie Fish

| Acid Extractable metals in crab | | | | | | |
|---------------------------------|-------|------------|-------------|------------|------------|-------------|
| Our Reference | | 257951-1 | 257951-2 | 257951-3 | 257951-4 | 257951-5 |
| Your Reference | UNITS | 1a | 1b | 1c | 2a | 2b |
| Date Sampled | | 24/11/2020 | 24/11/2020 | 24/11/2020 | 24/11/2020 | 24/11/2020 |
| Type of sample | | crab flesh | crab organs | crab shell | crab flesh | crab organs |
| Date prepared | - | 11/12/2020 | 11/12/2020 | 11/12/2020 | 11/12/2020 | 11/12/2020 |
| Date analysed | - | 14/12/2020 | 14/12/2020 | 14/12/2020 | 14/12/2020 | 14/12/2020 |
| Aluminium | mg/kg | <10 | <10 | 20 | <10 | <10 |
| Arsenic | mg/kg | 9 | 9 | <4 | 5 | 6 |
| Boron | mg/kg | <3 | <3 | 4 | <3 | <3 |
| Cadmium | mg/kg | <0.4 | 5.7 | 0.5 | <0.4 | 5.3 |
| Chromium | mg/kg | <1 | <1 | <1 | <1 | <1 |
| Copper | mg/kg | 16 | 140 | 15 | 15 | 69 |
| Iron | mg/kg | <10 | 20 | 20 | <10 | 30 |
| Lead | mg/kg | <1 | <1 | <1 | <1 | <1 |
| Manganese | mg/kg | <1 | 2 | 36 | <1 | 2 |
| Mercury | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Nickel | mg/kg | <1 | <1 | <1 | <1 | <1 |
| Selenium | mg/kg | <2 | <2 | <2 | <2 | <2 |
| Thallium | mg/kg | <2 | <2 | <2 | <2 | <2 |
| Vanadium | mg/kg | <1 | <1 | <1 | <1 | <1 |
| Zinc | mg/kg | 43 | 19 | 10 | 35 | 24 |

Client Reference: Hunter Community Env Centre- Lake Macquarie Fish

| Acid Extractable metals in crab | | | | | |
|---------------------------------|-------|------------|------------|-------------|------------|
| Our Reference | | 257951-6 | 257951-7 | 257951-8 | 257951-9 |
| Your Reference | UNITS | 2c | 3a | 3b | 3c |
| Date Sampled | | 24/11/2020 | 24/11/2020 | 24/11/2020 | 24/11/2020 |
| Type of sample | | crab shell | crab flesh | crab organs | crab shell |
| Date prepared | - | 11/12/2020 | 11/12/2020 | 11/12/2020 | 11/12/2020 |
| Date analysed | - | 14/12/2020 | 14/12/2020 | 14/12/2020 | 14/12/2020 |
| Aluminium | mg/kg | 30 | <10 | <10 | 20 |
| Arsenic | mg/kg | <4 | 8 | 6 | <4 |
| Boron | mg/kg | 3 | <3 | <3 | <3 |
| Cadmium | mg/kg | 3 | <0.4 | 9.1 | 2 |
| Chromium | mg/kg | <1 | <1 | <1 | <1 |
| Copper | mg/kg | 22 | 21 | 140 | 35 |
| Iron | mg/kg | 30 | <10 | 50 | 20 |
| Lead | mg/kg | <1 | <1 | <1 | <1 |
| Manganese | mg/kg | 30 | 1 | 4 | 60 |
| Mercury | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 |
| Nickel | mg/kg | <1 | <1 | <1 | <1 |
| Selenium | mg/kg | <2 | 4 | 3 | <2 |
| Thallium | mg/kg | <2 | <2 | <2 | <2 |
| Vanadium | mg/kg | <1 | <1 | <1 | <1 |
| Zinc | mg/kg | 11 | 79 | 52 | 30 |

Client Reference: Hunter Community Env Centre- Lake Macquarie Fish

| Method ID | Methodology Summary |
|-------------------|--|
| Metals-020 | Determination of various metals by ICP-AES. |
| Metals-021 | Determination of Mercury by Cold Vapour AAS. |

Client Reference: Hunter Community Env Centre- Lake Macquarie Fish

| QUALITY CONTROL: Acid Extractable metals in crab | | | | | Duplicate | | | | Spike Recovery % | |
|--|-------|-----|------------|------------|-----------|------|------|------|------------------|------|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-1 | [NT] |
| Date prepared | - | | | 11/12/2020 | [NT] | [NT] | [NT] | [NT] | 11/12/2020 | [NT] |
| Date analysed | - | | | 14/12/2020 | [NT] | [NT] | [NT] | [NT] | 14/12/2020 | [NT] |
| Aluminium | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 112 | [NT] |
| Arsenic | mg/kg | 4 | Metals-020 | <4 | [NT] | [NT] | [NT] | [NT] | 97 | [NT] |
| Boron | mg/kg | 3 | Metals-020 | <3 | [NT] | [NT] | [NT] | [NT] | 93 | [NT] |
| Cadmium | mg/kg | 0.4 | Metals-020 | <0.4 | [NT] | [NT] | [NT] | [NT] | 93 | [NT] |
| Chromium | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Copper | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 104 | [NT] |
| Iron | mg/kg | 10 | Metals-020 | <10 | [NT] | [NT] | [NT] | [NT] | 108 | [NT] |
| Lead | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 110 | [NT] |
| Manganese | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 102 | [NT] |
| Mercury | mg/kg | 0.1 | Metals-021 | <0.1 | [NT] | [NT] | [NT] | [NT] | 108 | [NT] |
| Nickel | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Selenium | mg/kg | 2 | Metals-020 | <2 | [NT] | [NT] | [NT] | [NT] | 98 | [NT] |
| Thallium | mg/kg | 2 | Metals-020 | <2 | [NT] | [NT] | [NT] | [NT] | 105 | [NT] |
| Vanadium | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 97 | [NT] |
| Zinc | mg/kg | 1 | Metals-020 | <1 | [NT] | [NT] | [NT] | [NT] | 107 | [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 |

Client Reference: Hunter Community Env Centre- Lake Macquarie Fish

| 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 |
|--|
| <p>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.</p> <p>Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.</p> <p>Spikes for Physical and Aggregate Tests are not applicable.</p> <p>For VOCs in water samples, three vials are required for duplicate or spike analysis.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>Measurement Uncertainty estimates are available for most tests upon request.</p> <p>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.</p> <p>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.</p> |

Report Comments

Acid extractable metals in crab - The results are reported on the sample as received i.e. no moisture correction has been applied.

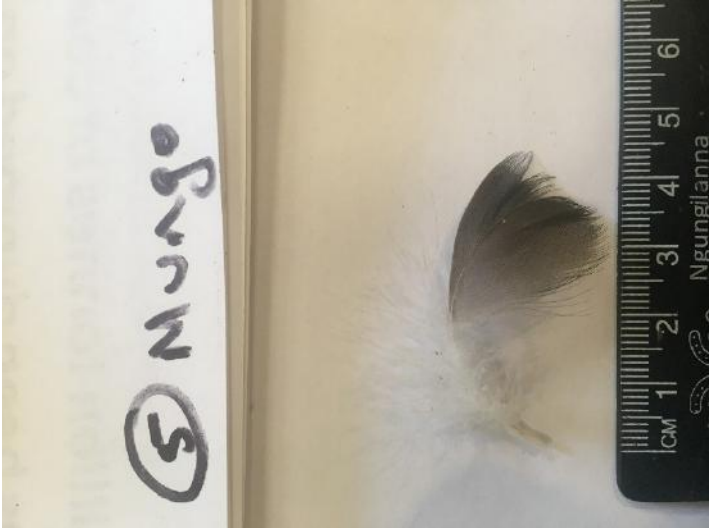
Appendix 2: Photos of collected feathers

Myall Lakes National Park



MUNGO, SEPT 4 2020







SWAN BAY, SEPT 4 2020

1



2



3







WHITE TREE BAY, SEPT 4 2020

1



2



3



BOMBAH FERRY, SEPT 4 2020

1



2



Lake Macquarie

LAKE MACQUARIE; LAKE ERANG
AUGUST 18 2020



① Lake Eraring



CM 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 1

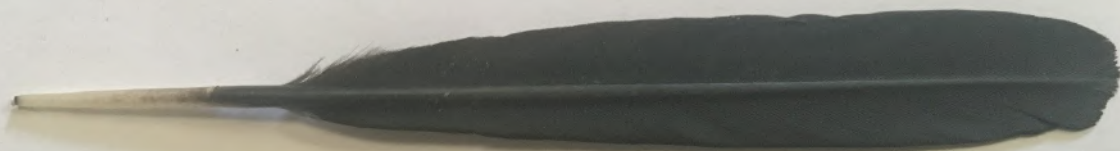


Ngungilanna
CSU - Wagga Wagga Campus
Ph: 02 6933 4121
Fax: 02 6933 2906



Wammarra
CSU - Bathurst Campus
Ph: 02 6338 4236
Fax: 02 6338 4558

① Lake Eraring



CM 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15



Ngungilanna
CSU - Wagga Wagga Campus
Ph: 02 6933 4121
Fax: 02 6933 2906



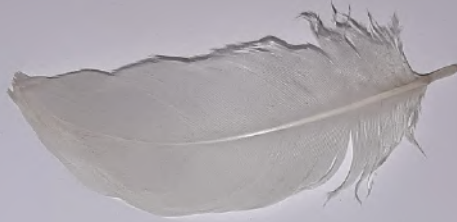
Wammarra
CSU - Bathurst Campus
Ph: 02 6338 4236
Fax: 02 6338 4558

LAKE MACQUARIE; MUDDY LAKE, JULY 21
2020

1

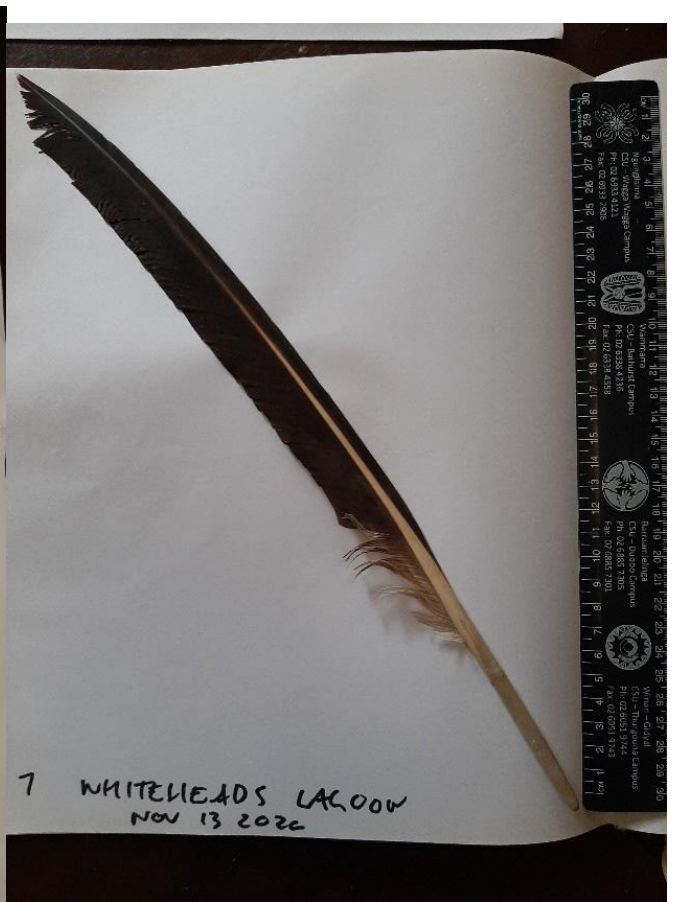


2



3





WHITEHEADS LAGOON, NOV 13
2020



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

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

Ngungwana
CSU - Wagga Wagga Campus
Ph: 02 6933 4121
Fax: 02 6933 2906

Warramarr
CSU - Bathurst Campus
Ph: 02 6338 4236
Fax: 02 6338 4558

Barramieelnga
CSU - Dubbo Campus
Ph: 02 6885 7305
Fax: 02 6885 7301

Wiran - Gidyal
CSU - Thurgoonna Campus
Ph: 02 6051 9744
Fax: 02 6051 9743

LAKE MAC: WYEE, NOV 13 2020



2



3

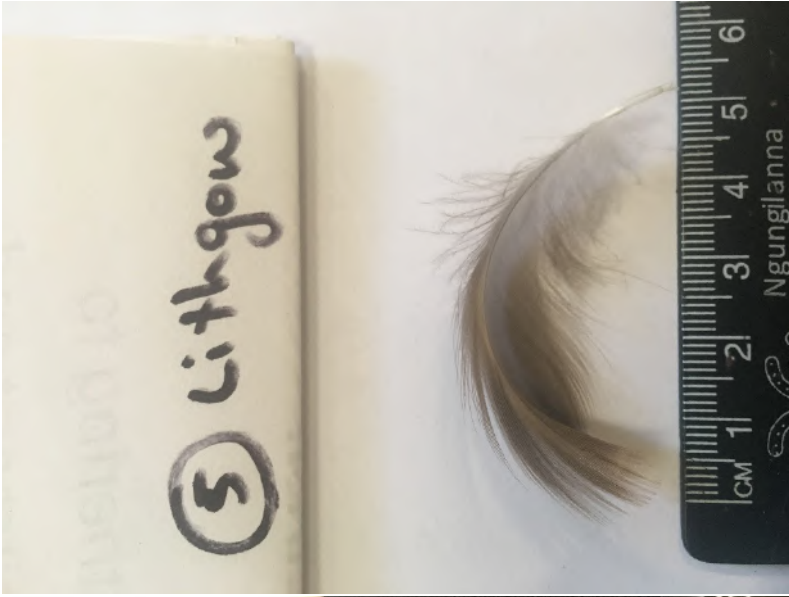


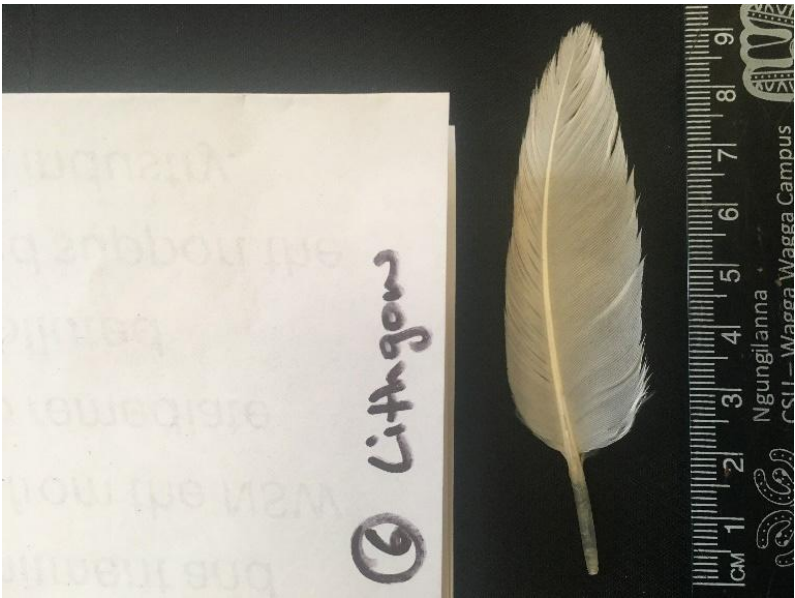
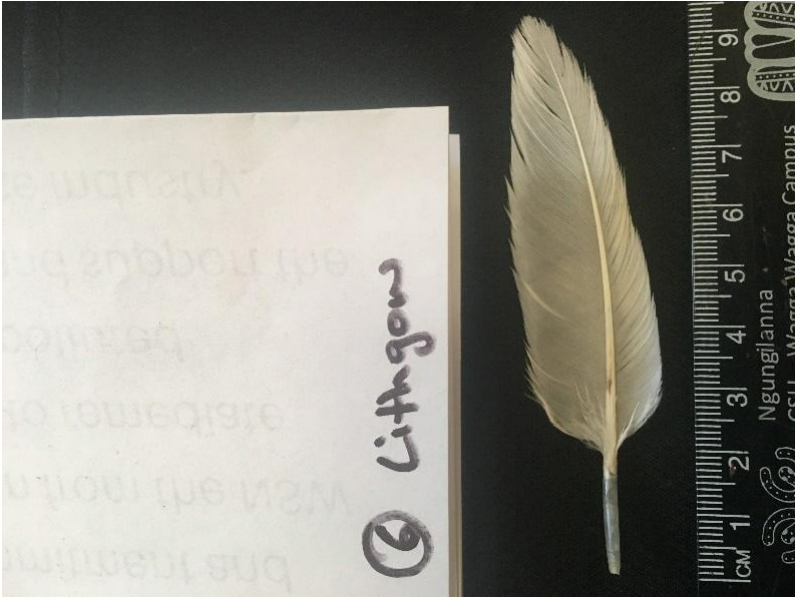
4

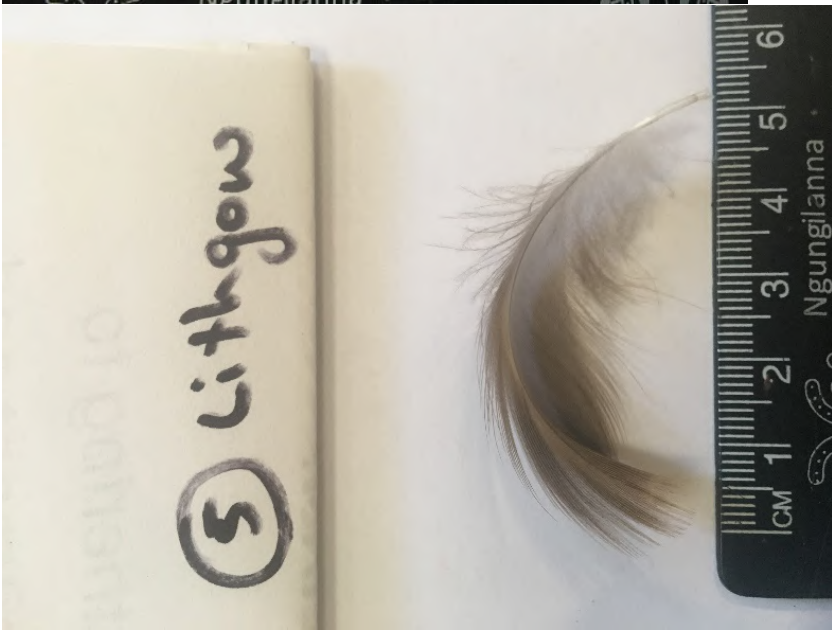


Lake Wallace









Lake Liddell



HUNTER VALLEY; LAKE LIDDELL
JULY 29, 2020

2



3



4



5



HUNTER VALLEY; LAKE LIDDELL
JULY 29, 2020

7

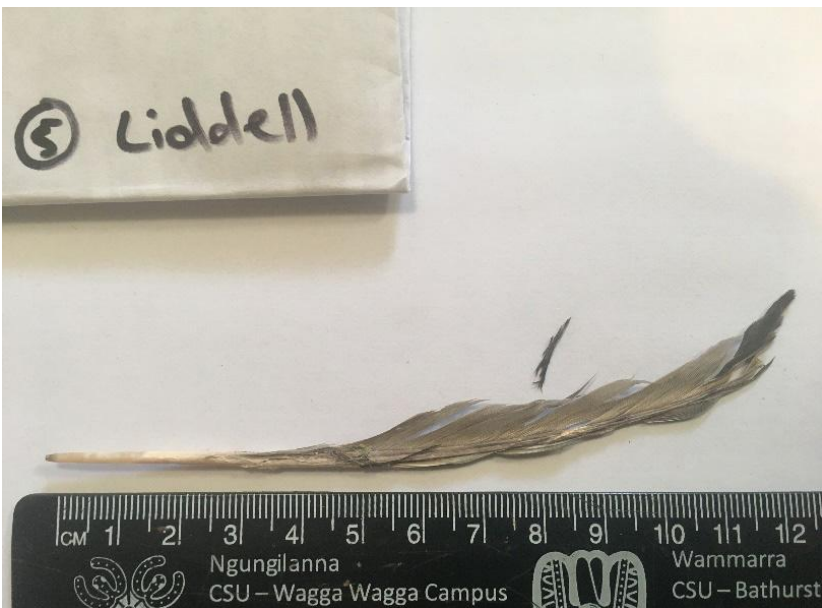


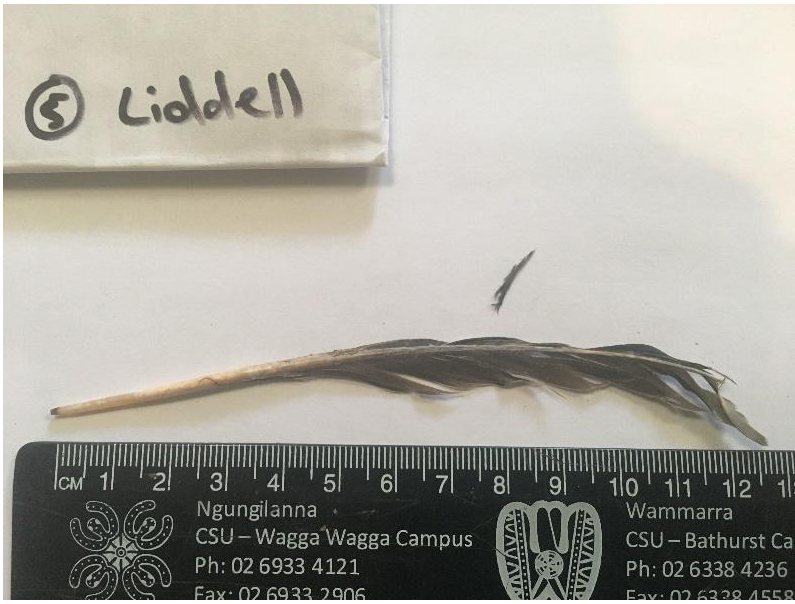
8



9









Appendix 3: Photos of Lake Macquarie crab



Appendix 4: Australia Museum feather identification

*Ornithology Collection
Australian Museum Research Institute
Australian Museum
1 William Street,
Sydney, NSW 2010*



**AUSTRALIAN MUSEUM RESEARCH INSTITUTE
ORNITHOLOGY COLLECTION
IDENTIFICATION REPORT FOR HUNTER COMMUNITY ENVIRONMENT CENTRE**

Dear Naomi,

This report outlines the examination and final determinations of 46 physical feather samples and 7 digital samples supplied by the Hunter Community Environment Centre.

The results of my morphological examinations are listed in Table 1.

Please do not hesitate to contact me if you would like to discuss these results further.

Yours sincerely,



Dr Leah R. Tsang
Collection Manager, Ornithology
Australian Museum Research Institute
Australian Museum
1 William Street Sydney NSW 2010 Australia
P: 02 9320 6322
E: Leah.Tsang@Australian.Museum

Reporting Date: Monday, 07th June 2021

Re: Species identification report of feather specimens (physical & digital samples) supplied by the Hunter Community Environment Centre (HCEC)

To: Naomi Jones (NJ), Campaign Assistant, HCEC

CC: Paul Winn (HCEC), Mark Eldridge (AM)

Prepared by: Leah Tsang (LT) (AM)

Background:

On Tuesday, 08th December 2020, NJ sent documentation via email pertaining to the feathers collected by HCEC for identification (AM Deed of Gift, NPWS Licence for feather collection, HCEC request on letterhead, electronic spreadsheet of feather samples sent through, listing samples by location).

A formal Services Agreement to conduct the identifications was prepared by LT in consultation AM Legal Services, and formally signed off by all parties (AM & HCEC) on Wednesday, 24th March 2021.

Results

The final determinations are listed in Table 1 (page 3-4). There were 46 physical samples, and 16 of these physical samples were partial feather samples (section of feather removed for chemical analyses prior to being sent to the AM).

There were 7 digital samples that had a photographic image instead of a physical sample that were made available online via Google Drive. Images of the partial feather samples (prior to feather tip removal) were also made available online.

HCEC specimen sample names as provided in the HCEC electronic sample list have been retained and used in the results list here for both physical and digital samples. A copy of this electronic list has been attached as an appendix (page 5). It should be noted that there are 2 samples that have mismatched sample numbers between that which is inscribed on sample bags and the sample number indicated in the online sample reference image. These are indicated with an asterix.

For some samples, a subset of species-level identifications are provided where higher-level classifications were too broad. For example, the Family *Rallidae* is a group containing the rails, crakes and swamphens – however if a sample was determined to be not from a crake species, but determined to be potentially from several species of rail, these species of rail have been listed against that sample.

There were 6 samples that were unable to be identified owing to sample degradation.

Total hours spent on this project: 16 hours.

Table 1. Results of morphological species identification

| HCEC Sample No. | Sample Description | Determination |
|--------------------------------------|------------------------|---|
| Lithgow - 1 | Tail feather | Australian Magpie (<i>Gymnorhina tibicen</i>) |
| Lithgow - 2 (digital sample) | Covert feather (wing) | Crested Pigeon (<i>Ocyphaps lophotes</i>) |
| Lithgow - 3 | Covert feather (body) | Australian Wood-duck (<i>Chenonetta jubata</i>) |
| Lithgow - 4 | Covert feather (body) | Purple Swamphen (<i>Porphyrio melanotus</i>) or Dusky Moorhen (<i>Gallinula tenebrosa</i>) |
| Lithgow - 5 (digital sample) | Covert feather (body) | Grey Teal (<i>Anas gracilis</i>), Chestnut Teal (<i>A. castanea</i>) or Pacific Black Duck (<i>A. superciliosa</i>) |
| Lithgow - 6 (partial sample) | Tail feather | Australian White Ibis (<i>Threskiornis molucca</i>) or Straw-necked Ibis (<i>T. spinicollis</i>) |
| Lithgow - 7 | Covert feather (body) | Tawny Frogmouth (<i>Podargus strigoides</i>) |
| Lithgow - 8 | Covert feather (wing) | Genus <i>Phalacrocorax</i> (Cormorants) |
| Lithgow - 9a | Covert feather (body) | Australian Magpie (<i>Gymnorhina tibicen</i>) |
| Lithgow - 9b | Covert feather (body) | Australian Magpie (<i>Gymnorhina tibicen</i>) |
| Lithgow - 10 | Covert feather (body) | Masked Lapwing (<i>Vanellus miles</i>) |
| Lithgow - 11 (digital sample) | Covert feather (body) | Masked Lapwing (<i>Vanellus miles</i>) |
| Muddy Lake - 1 (partial sample) | Tail feather | Australian White Ibis (<i>Threskiornis molucca</i>) or Straw-necked Ibis (<i>T. spinicollis</i>) |
| Muddy Lake - 2 | Covert feather (wing) | Australian Pelican (<i>Pelecanus conspicillatus</i>) |
| Muddy Lake - 3 | Wing feather | Genus <i>Phalacrocorax</i> (Cormorants) |
| Lake Eraring - 1 (partial sample) | Primary Feather (Tail) | Genus <i>Phalacrocorax</i> (Cormorants) |
| Lake Eraring - 2 | Wing feather | Australian Pelican (<i>Pelecanus conspicillatus</i>) |
| Muyna - 1 (partial sample) | Wing feather / Primary | Tawny Frogmouth (<i>Podargus strigoides</i>) |
| Mungo - 1 | Covert feather (wing) | Great Cormorant (<i>Phalacrocorax carbo</i>) |
| Mungo - 2 | Wing feather | Genus <i>Phalacrocorax</i> (Cormorants) |
| Mungo - 3 | Covert feather (body) | Family Ardeidae (Herons, Egrets, Bitterns) |
| Mungo - 4 | Covert feather (body) | Topknot Pigeon (<i>Lopholaimus antarcticus</i>) |
| Mungo - 5 (digital sample) | Covert feather (body) | Australian Pelican (<i>Pelecanus conspicillatus</i>) |
| Wyee - 1 | Degraded feather | Could not identify |
| Wyee - 2 | Degraded feathers | Could not identify |
| Wyee - 3 (partial sample) | Tail feather | Genus <i>Corvus</i> (Crows & Ravens) |
| Wyee - 4 (partial sample) | Covert feather (body) | Genus <i>Corvus</i> (Crows & Ravens) |
| Liddell - 1 | Degraded feather | Australian Pelican (<i>Pelecanus conspicillatus</i>) |
| Liddell - 2 | Covert feather (body) | Genus <i>Phalacrocorax</i> (Cormorants) |

| | | |
|--|-----------------------|---|
| Liddell - 3 | Wing feather | Genus <i>Phalacrocorax</i> (Cormorants) |
| Liddell - 4 (digital sample) | Covert feather (body) | Purple Swamphen (<i>Porphyrio melanotus</i>) or Dusky Moorhen (<i>Gallinula tenebrosa</i>) |
| Liddell - 5 (partial sample) | Degraded feather | Could not identify |
| Liddell - 6 | Covert feather (body) | Pied Stilt (<i>Himantopus leucocephalus</i>) or Masked Lapwing (<i>Vanellus miles</i>) |
| Liddell - 7 (partial sample) | Degraded feather | Black Swan (<i>Cygnus atratus</i>) |
| Liddell - 8 (partial sample) | Degraded feather | Could not identify |
| Liddell - 9 (partial sample) | Tail Feather | Eastern Rosella (<i>Platycercus eximius</i>) |
| Liddell - 10 (partial sample) | Degraded feather | Could not identify |
| Bombah Ferry - 1 (digital sample) | Covert feather (body) | Australian Pelican (<i>Pelecanus conspicillatus</i>) |
| Bombah Ferry - 2 | Covert feather (body) | Great Egret (<i>Ardea alba</i>) |
| Swan Bay - 1 | Covert feather (body) | Australian Pelican (<i>Pelecanus conspicillatus</i>) |
| Swan Bay - 2 | Degraded feather | Could not identify (possibly Family <i>Laridae</i>) |
| Swan Bay - 3* (partial sample) | Wing feather | Australian White Ibis (<i>Threskiornis molucca</i>) |
| Swan Bay - 4* (digital sample) | Covert feather | Australian Pelican (<i>Pelecanus conspicillatus</i>) |
| WHL - 1 | Covert feather (wing) | Crested Pigeon (<i>Ocyphaps lophotes</i>) |
| WHL - 2 (partial sample) | Tail Feather | Family <i>Columbidae</i> (Pigeons & Doves) |
| WHL - 3 (partial sample) | Body feather | Family <i>Rallidae</i> (Crakes, Rails and Swampheas) |
| WHL - 4 | Tail Feather | Family <i>Threskionithidae</i> (Ibis & Spoonbills) |
| WHL - 5 (partial sample) | Wing feather | Black-faced Cuckoo-shrike (<i>Coracina novaehollandiae</i>) |
| WHL - 6 | Wing feather | Genus <i>Phalacrocorax</i> (Cormorants) |
| WHL - 7 (partial sample) | Wing feather | Australian Pelican (<i>Pelecanus conspicillatus</i>) |
| White Tree Bay - 1 | Covert feather (body) | Genus <i>Anas</i> (Ducks) |
| White Tree Bay - 2 | Covert feather (wing) | Genus <i>Sterna</i> (Terns) |
| White Tree Bay - 3 | Wing feather | Genus <i>Phalacrocorax</i> (Cormorants) |

Appendix. Screen snap of original sample list as presented in HCEC electronic spreadsheet, landscape view. (Font size & column widths have been reduced to enable single-page presentation)

| | | | | | | | | | | |
|--------------|---|------------------|------------|-----------|-----------------|--------------|------------------|--------------|---------|--------------------|
| Lithgow - 1 | Muddy Lake - 1 | Lake Eraring - 1 | Muyina - 1 | Mungo - 1 | Wyee - 1 | Liddell - 1 | Bombah Ferry - 1 | Swan Bay - 1 | WHL - 1 | White Tree Bay - 1 |
| Lithgow - 2 | Muddy Lake - 2 | Lake Eraring - 2 | | Mungo - 2 | Wyee - 2 (lots) | Liddell - 2 | Bombah Ferry - 2 | Swan Bay - 2 | WHL - 2 | White Tree Bay - 2 |
| Lithgow - 3 | Muddy Lake - 3 | | | Mungo - 3 | Wyee - 3 | Liddell - 3 | | Swan Bay - 3 | WHL - 3 | White Tree Bay - 3 |
| Lithgow - 4 | | | | Mungo - 4 | Wyee - 4 | Liddell - 4 | | Swan Bay - 4 | WHL - 4 | |
| Lithgow - 5 | | | | Mungo - 5 | | Liddell - 5 | | | WHL - 5 | |
| Lithgow - 6 | | | | | | Liddell - 6 | | | WHL - 6 | |
| Lithgow - 7 | | | | | | Liddell - 7 | | | WHL - 7 | |
| Lithgow - 8 | | | | | | Liddell - 8 | | | | |
| Lithgow - 9a | | | | | | Liddell - 9 | | | | |
| Lithgow - 9b | | | | | | Liddell - 10 | | | | |
| Lithgow - 10 | | | | | | | | | | |
| Lithgow - 11 | | | | | | | | | | |
| orange | photos only sent to AM | | | | | | | | | |
| blue | the tip of this feather has been snipped off for heavy metal analysis. The remainder of the feather and accompanying photos of the whole feather have been sent to AM | | | | | | | | | |
| WHL | Whiteheads Lagoon | | | | | | | | | |

