TOXIC HABITAT

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

Hunter Community
Environment Centre

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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.

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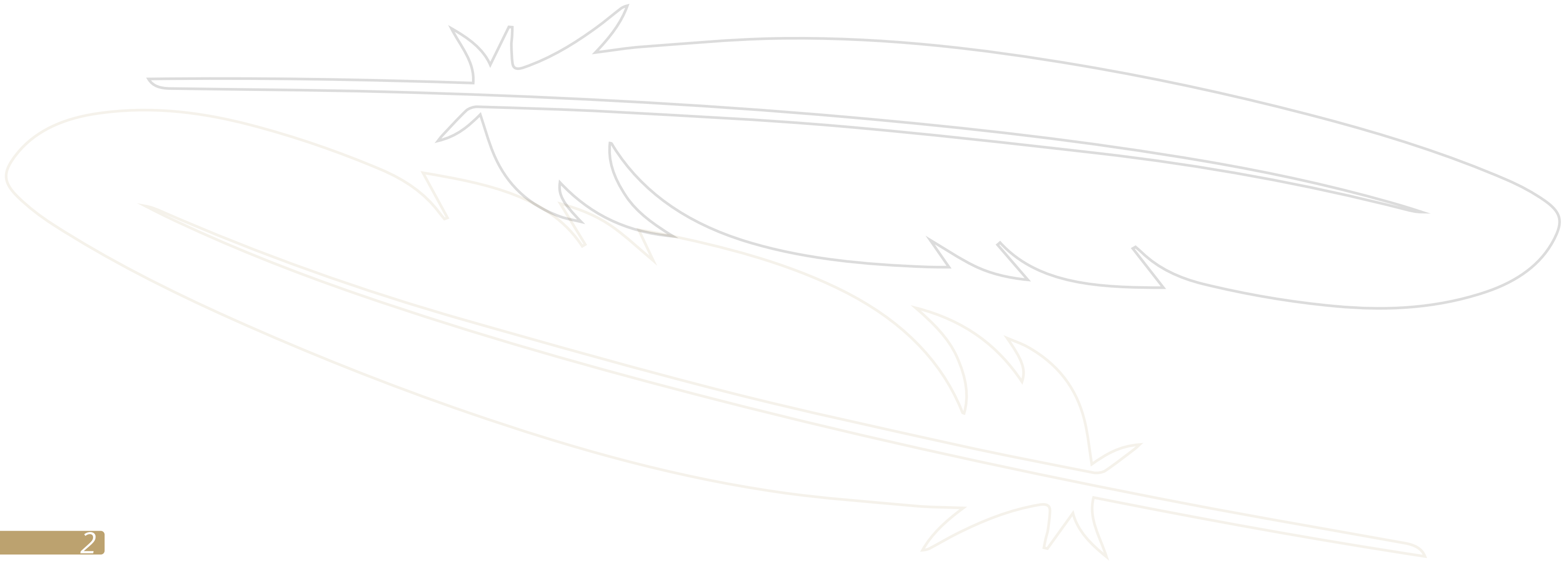
Foreword

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.

Dan Williams

President Hunter Bird Observers Club

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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 and analysed 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.

This report focuses on the metals which pose the greatest concern for bird life: 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;

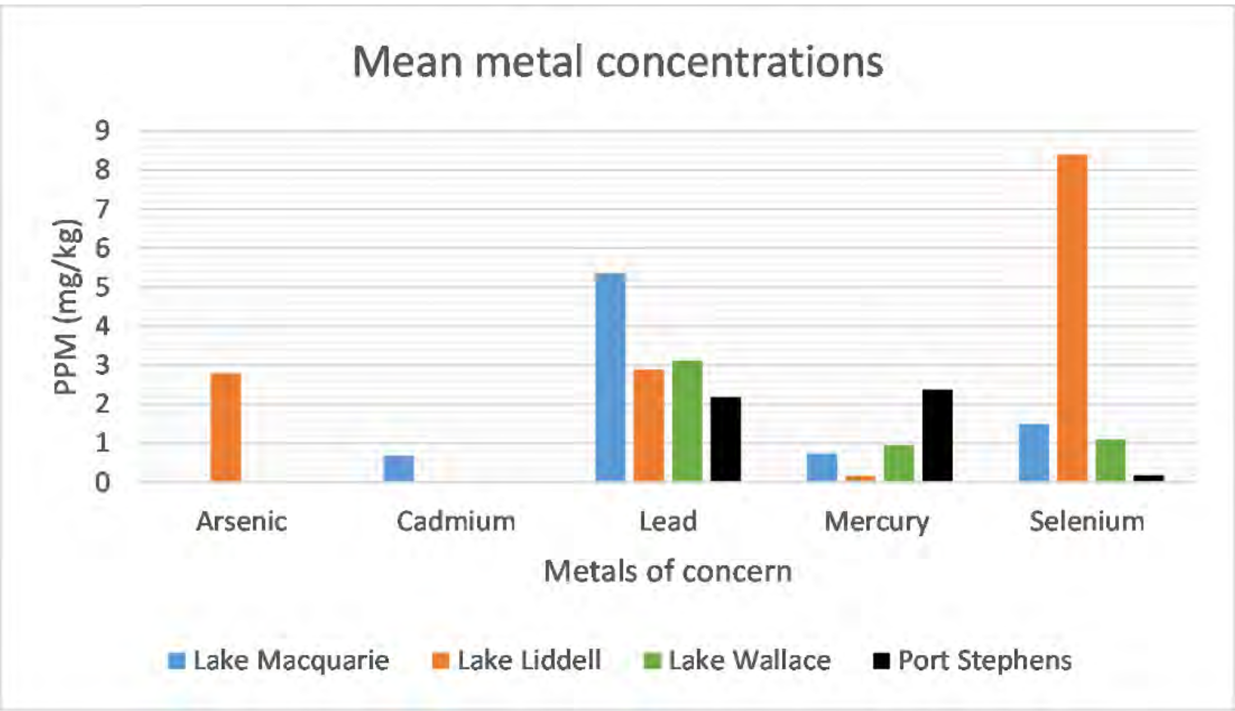
- 85 percent exceeded thresholds for selenium (1.8 mg/kg). The area of greatest concern for selenium was Lake Liddell, where all the feathers collected had concentrations above health and reproduction impacts thresholds.
- 30 percent exceeded published thresholds for lead (4 mg/kg). All but six feathers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

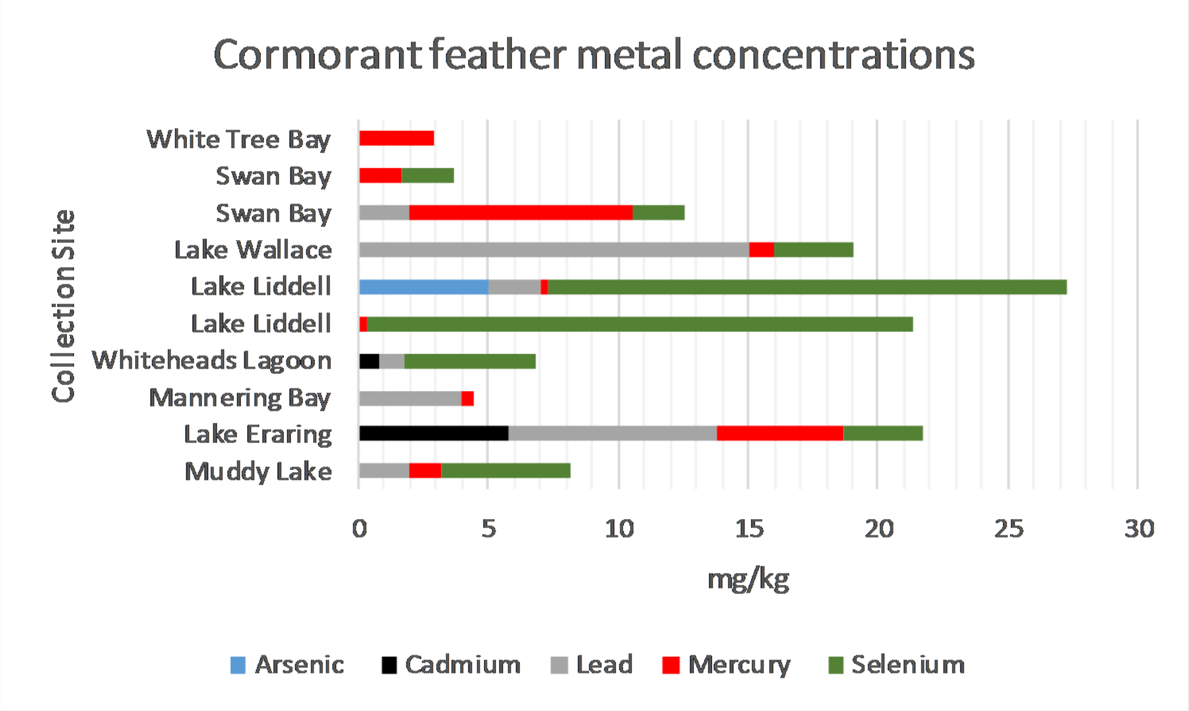
Recent studies have confirmed that the main driver of increased metal concentrations in Lakes close to NSW power stations is the combustion of coal. This mirrors experiences in other parts of the world, where metal contamination has markedly increased in water bodies close to operating coal-fired power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

Coal-fired power stations pollute waterways by emitting heavy metals into the atmosphere, which is 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 sediment[4] 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]

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[1] *Winn et al, 2019. Winn et al, 2020.*

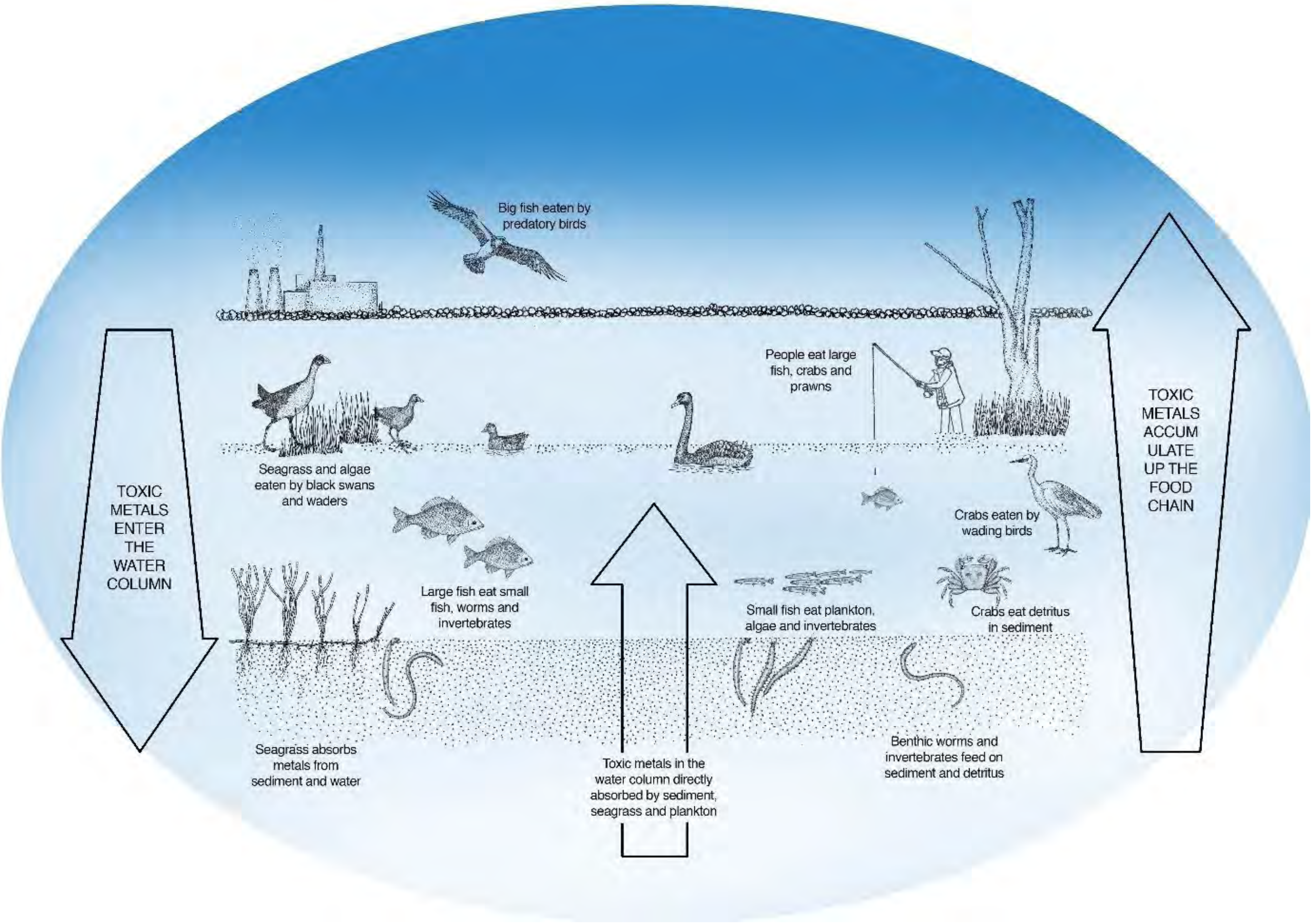
[2] *Tovar-Sánchez, et al, 2018.*

[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 impact early growth and nestling survival.[7] At the population level, heavy metal contamination can lead to dramatic declines in the number of water birds and lead to regional extinctions.[8]

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[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 representi 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 anaylses 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.

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[9] *Naccari, et al, 2009.*

[10] *Naccari, et al, 2009.*

[11] *Kim & Koo, 2007.*

[12] *Markowski, et al 2013.*

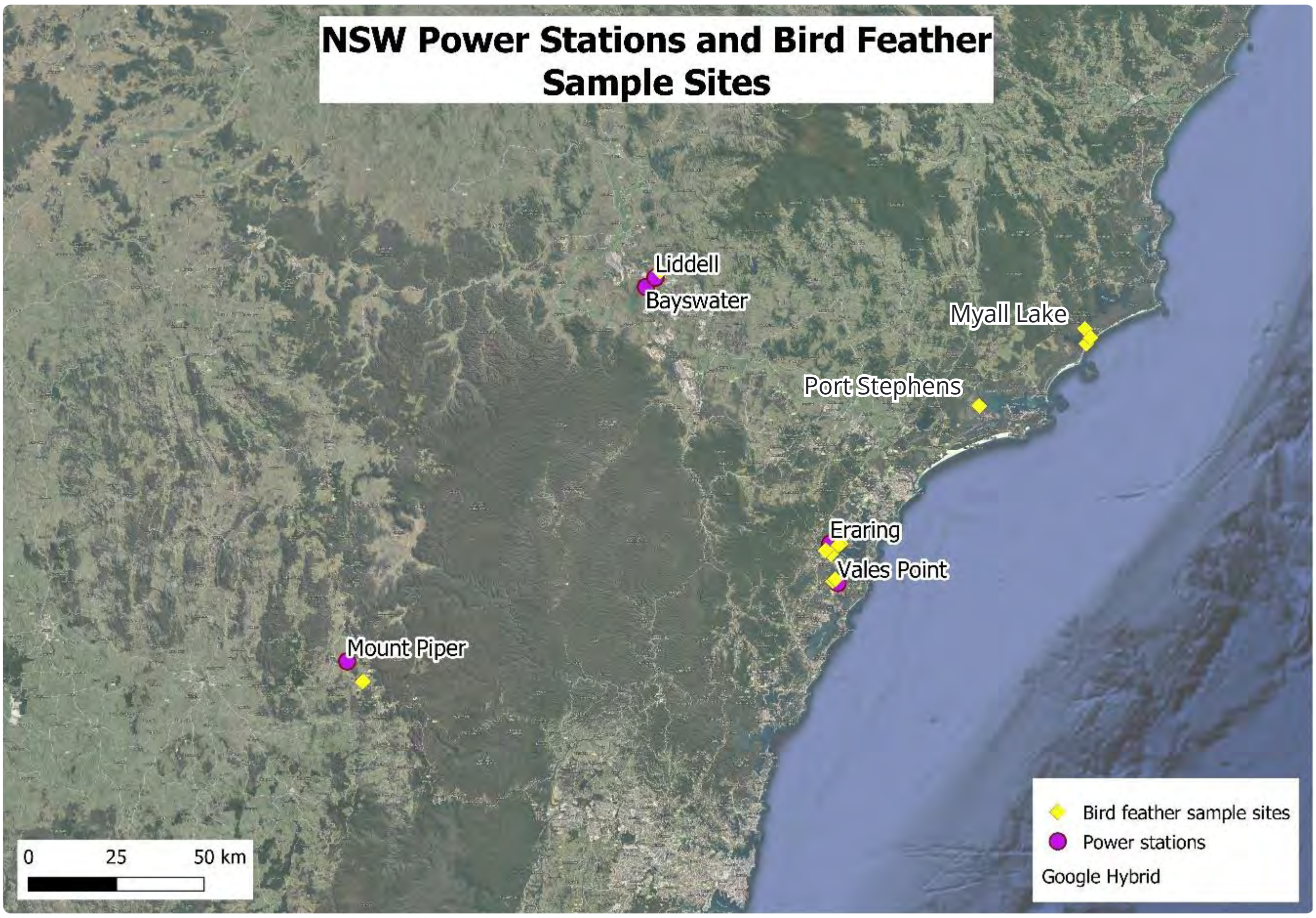
[13] *Burger, 1993.*

Methodology

With a 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 is 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.

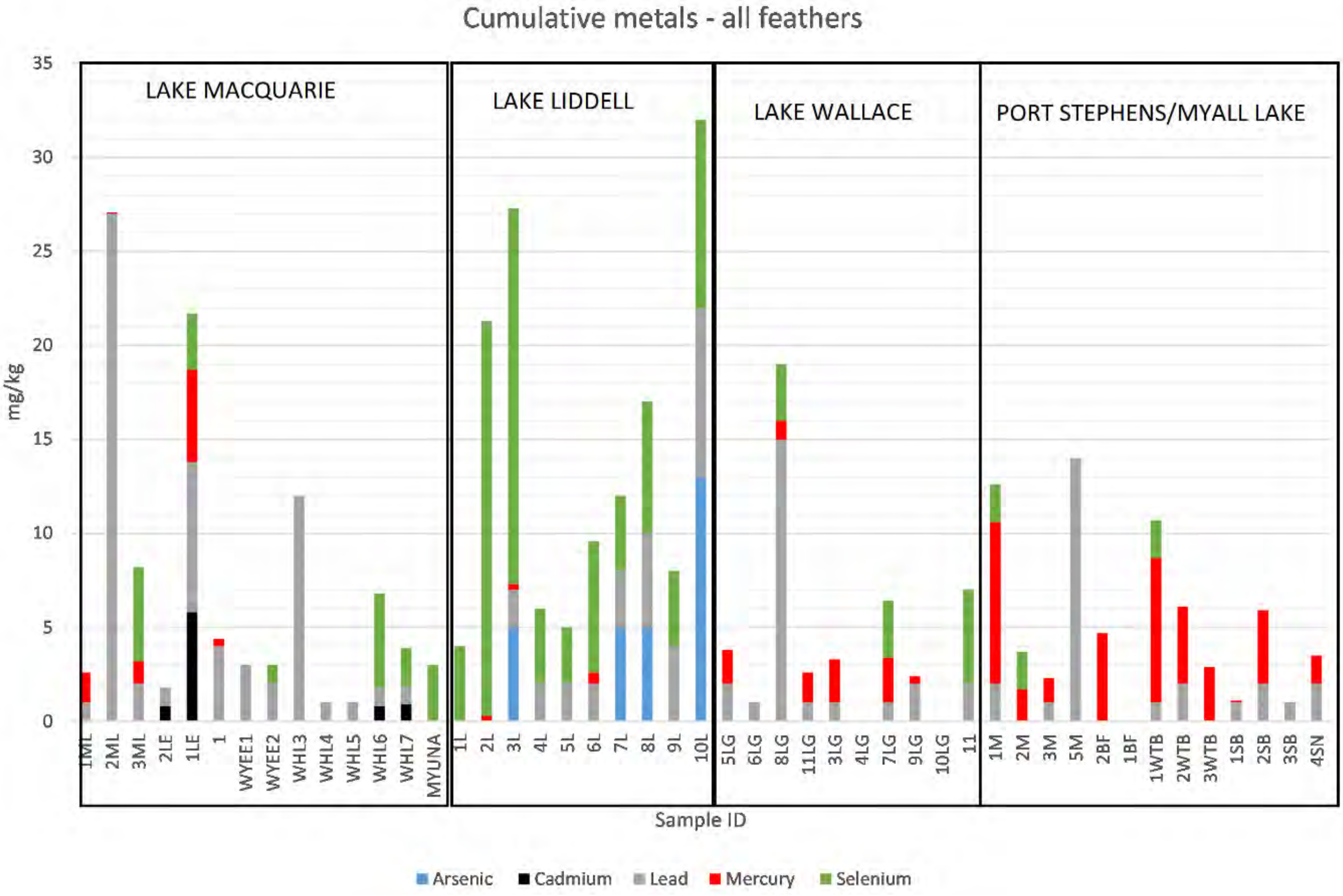


Chart 1: Metal concentrations found in feathers from all four collection areas.

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 toxic[2] 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.

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[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.*

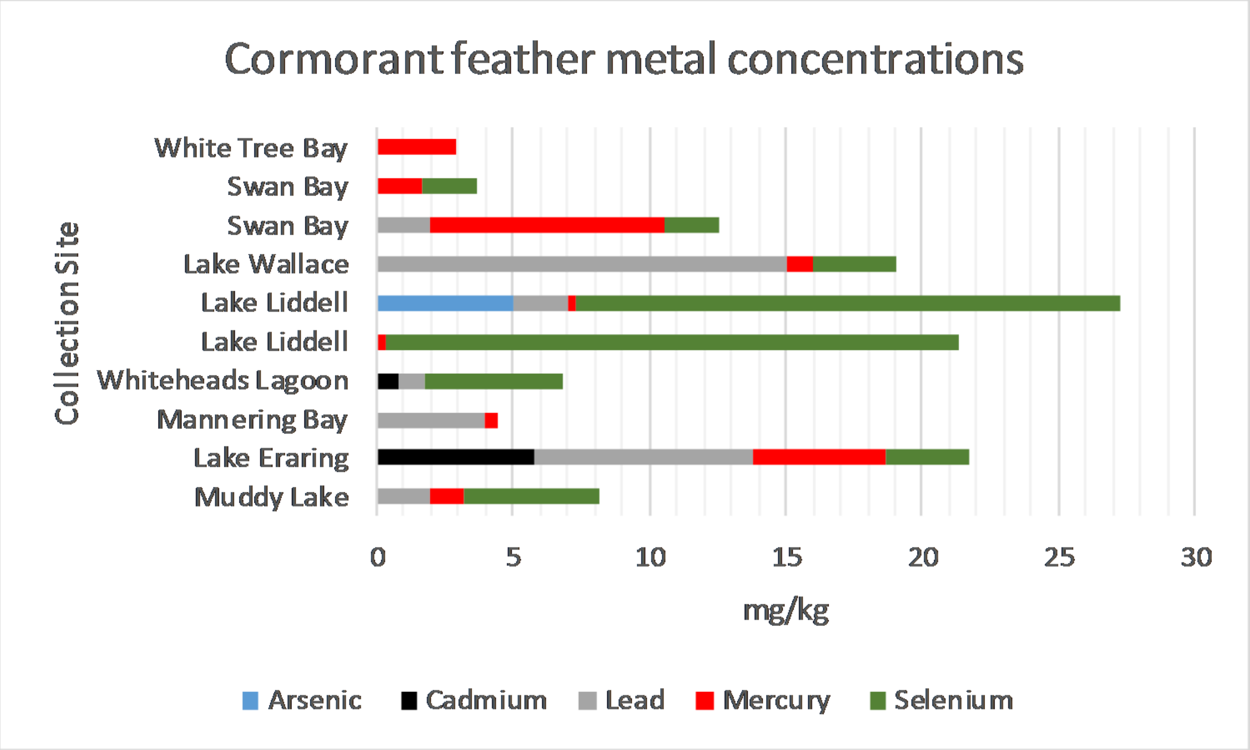

Chart 2: Metal concentrations in Cormorant feathers from all areas

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.

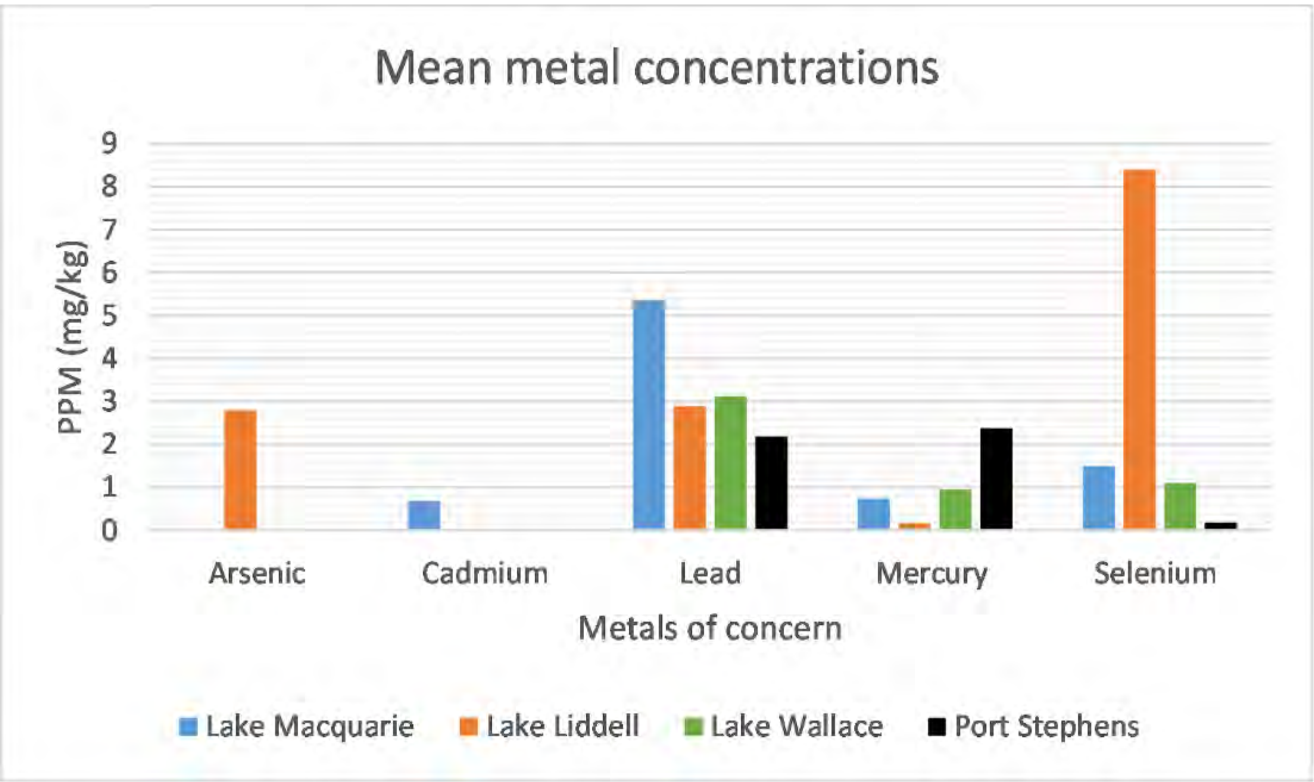

Chart 3: Mean metal concentration in feathers from all collection areas

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 (Wyee 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

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[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 (Wyee Creek, Wyee 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 Wyee 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]

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[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 1993[21] 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.

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[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).

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[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 2mg/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

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[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]

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.
- 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.

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[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]

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[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.

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[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 km^2. 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.

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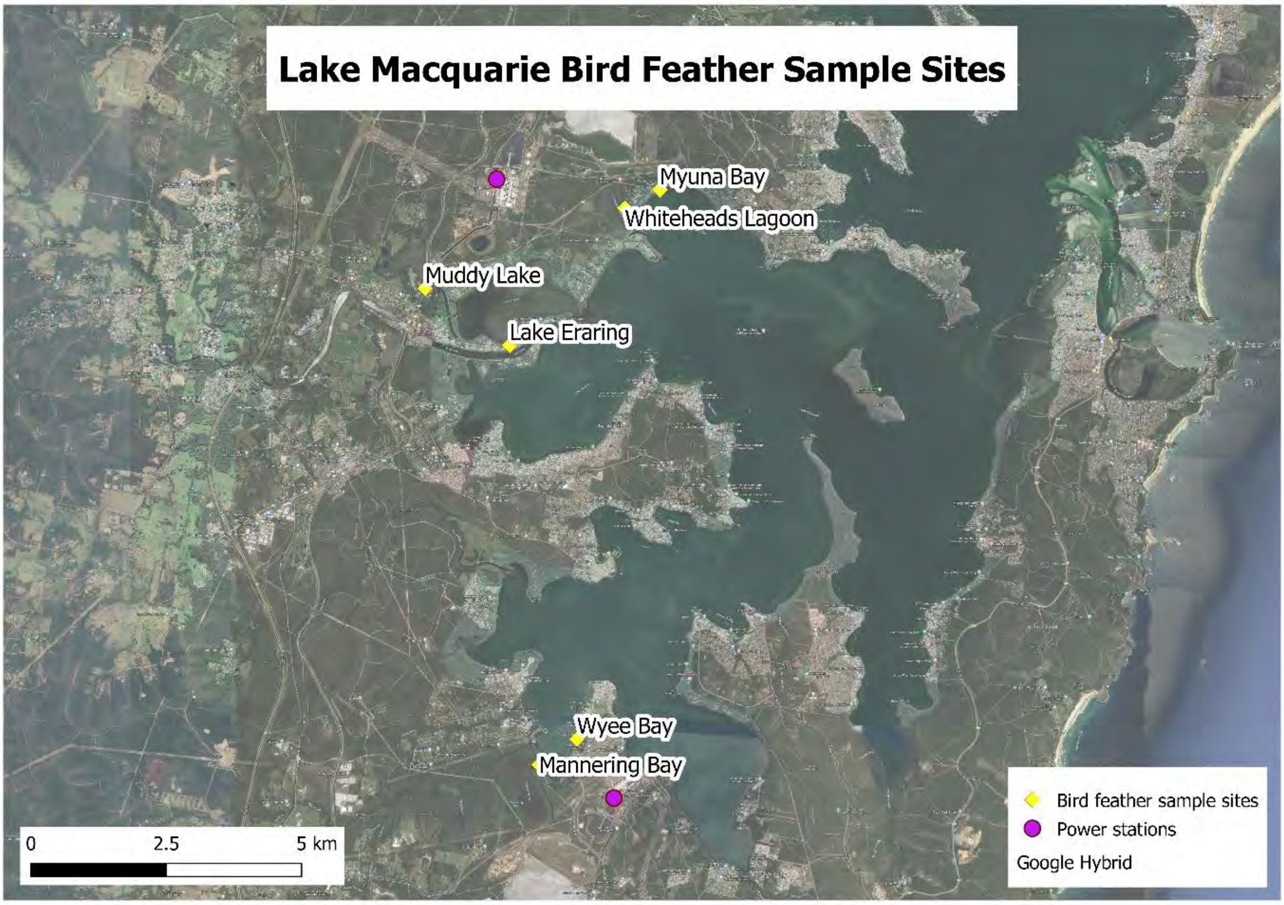
[57] Schneider, 2014.

[58] Schneider, 2014.



Map 2: Southern Lake Macquarie collection sites and power stations

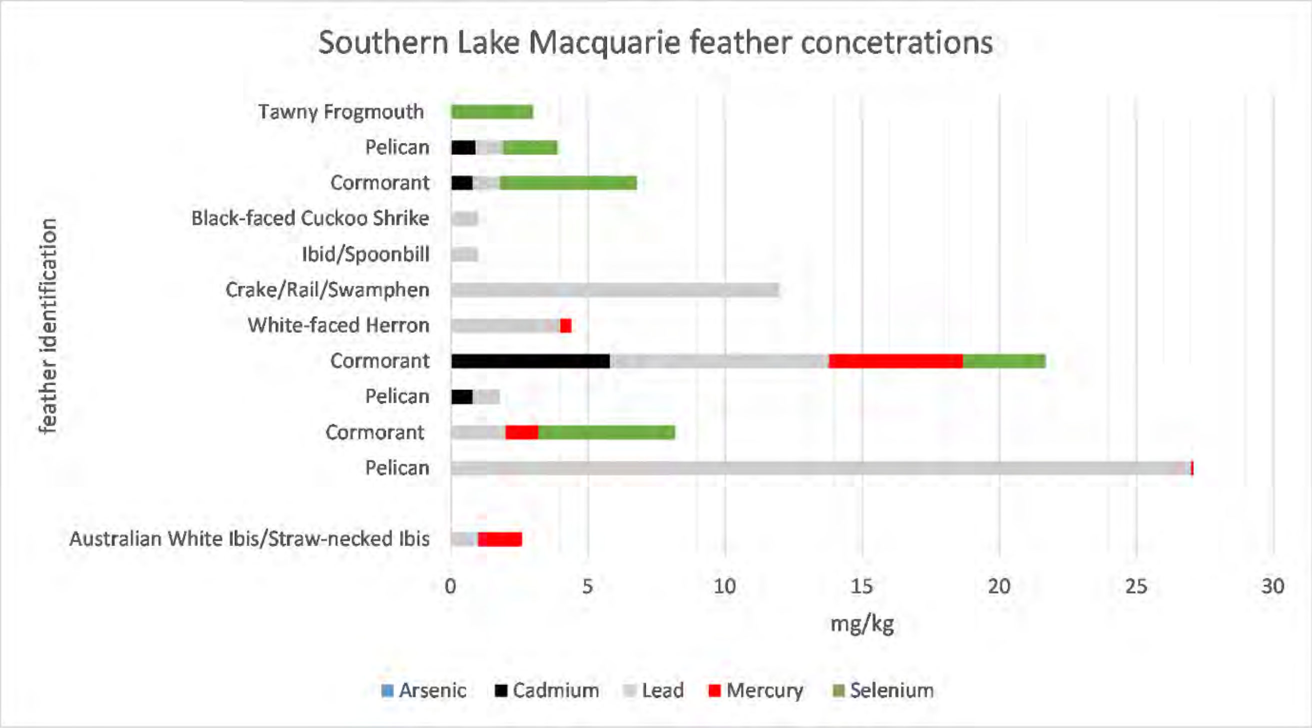


Chart 4: Metal concentrations in feathers collected from Lake Macquarie and Australian Museum identification.

- 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 (Mannering 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**
Lake Macquarie	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	1 WYEE1		530		3			10	810	3	4					7
	Mannering Bay	White-faced Herron			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 Point[60] 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.

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[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.

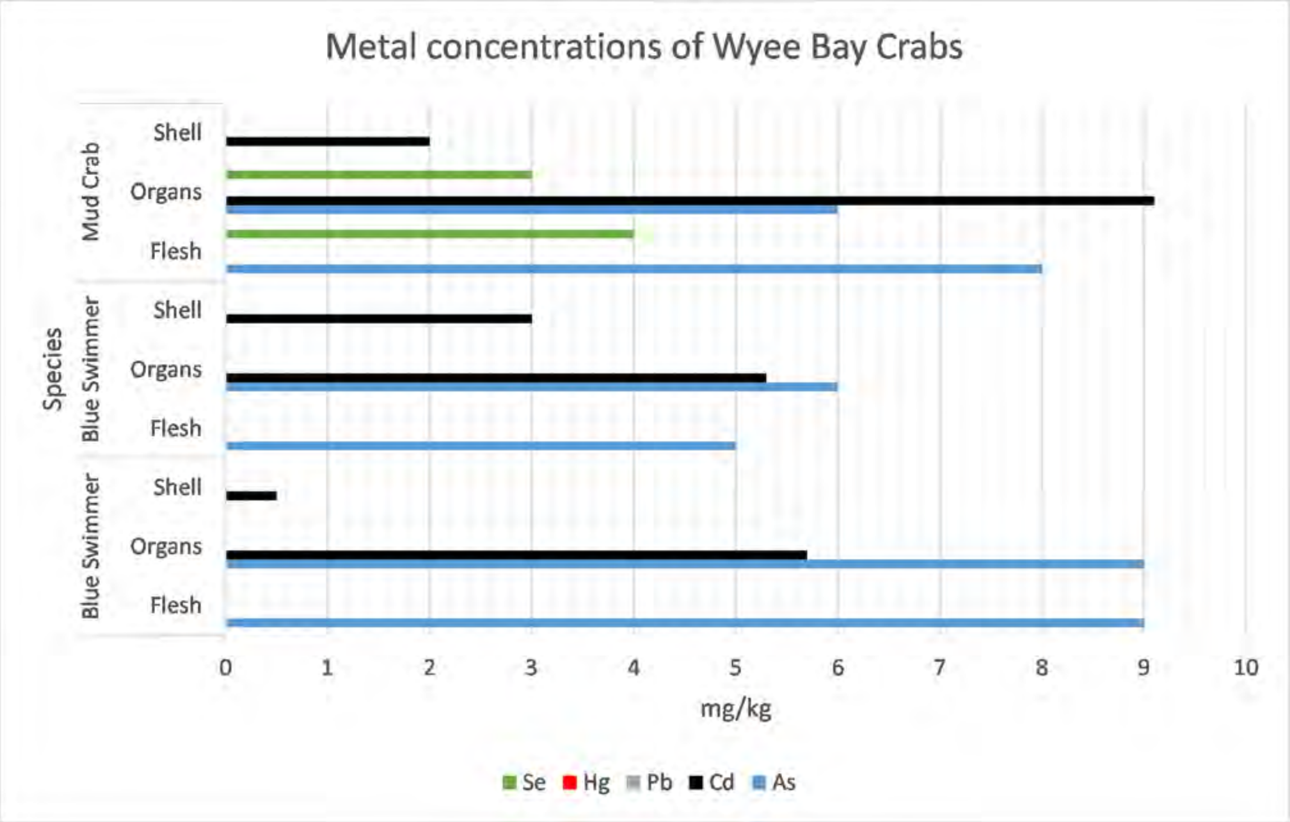


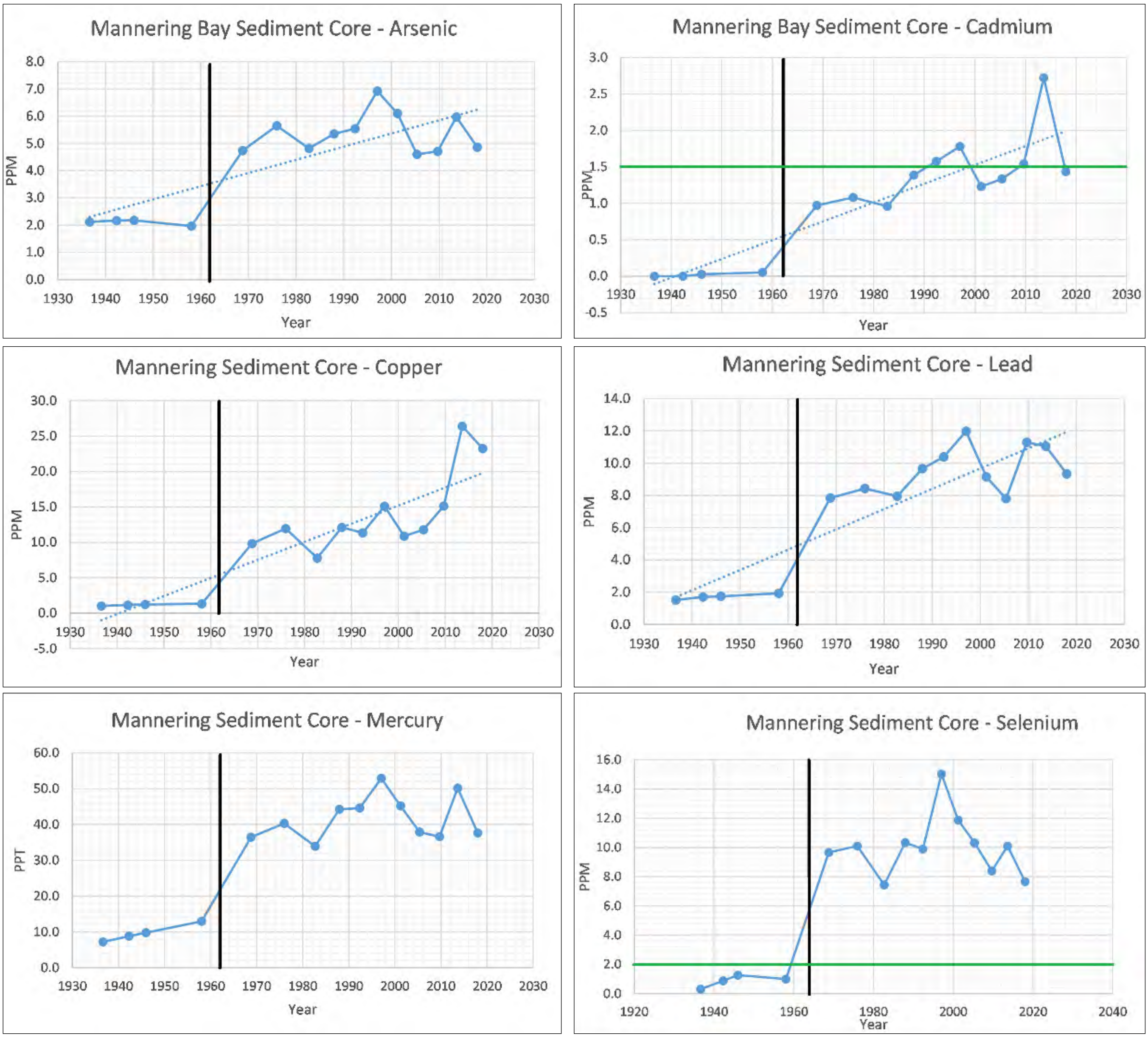
Chart 5: Metal concentrations found in crabs from southern Lake Macquarie – Wyee Bay

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]

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[64] *From Winn et al, 2020.*

Eraring power station Environmental Site Assessment

The Environmental Site Assessment commissioned by NSW Treasury for Eraring power station[65] reveals that:

- **Arsenic** exceeded ANZECC sediment guidelines (20 mg/kg) in nineteen sediment samples with maximum of 33 mg/kg - inked 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

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[65] ERM, 2015.

[66] ERM, 2015.

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

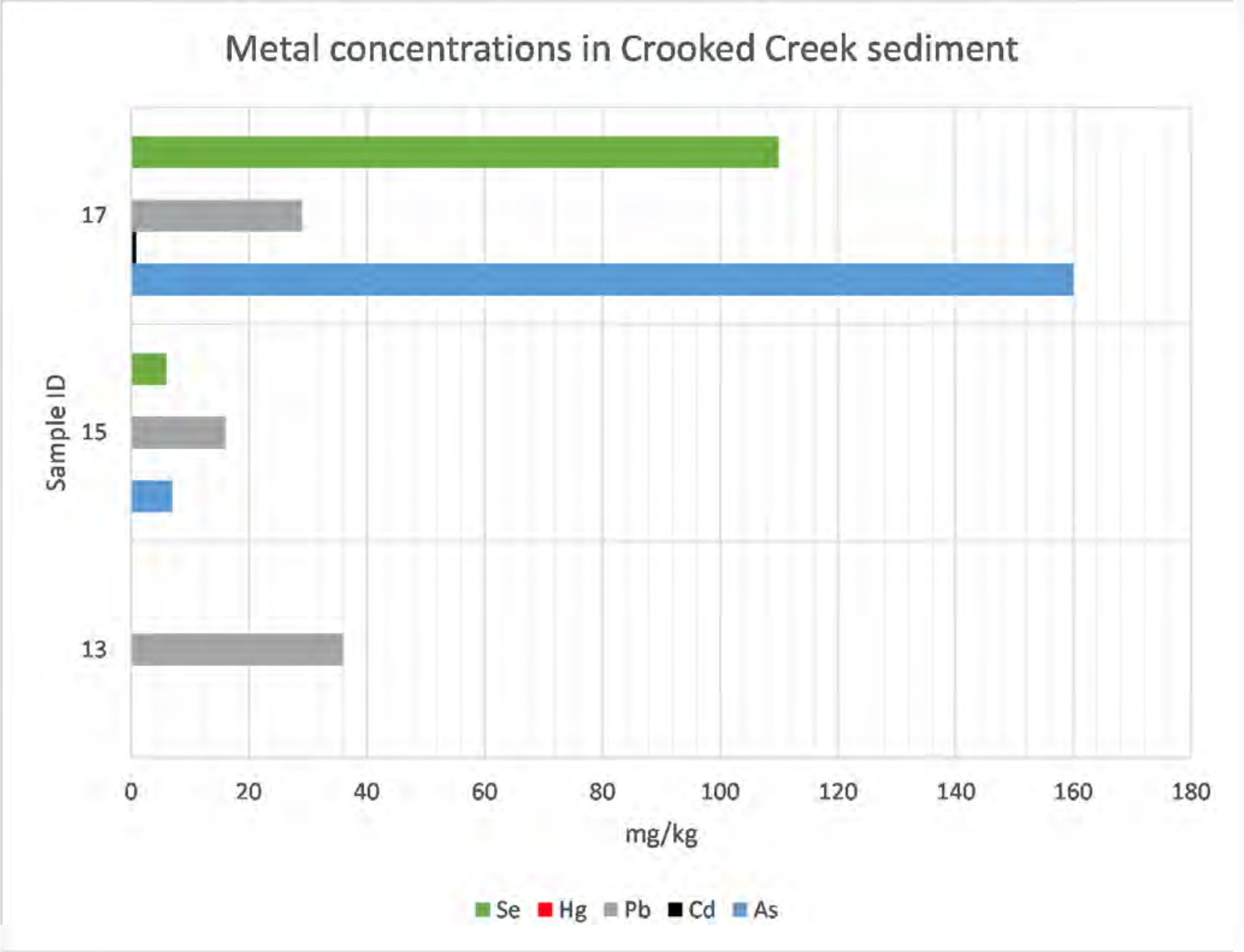
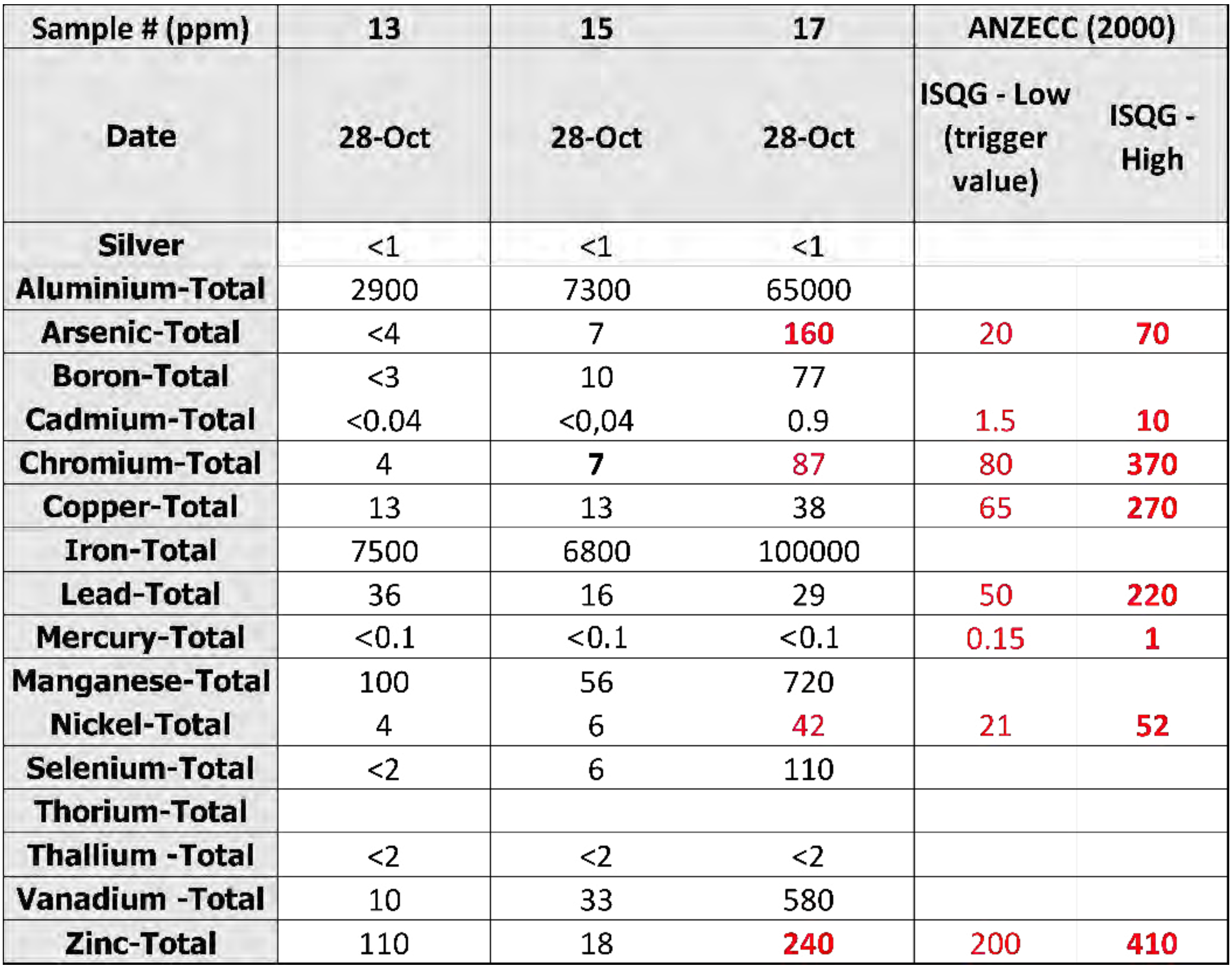


Chart 6: Metal concentrations in HCEC sediment samples from Crooked Creek 2020.



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 Bay[68]

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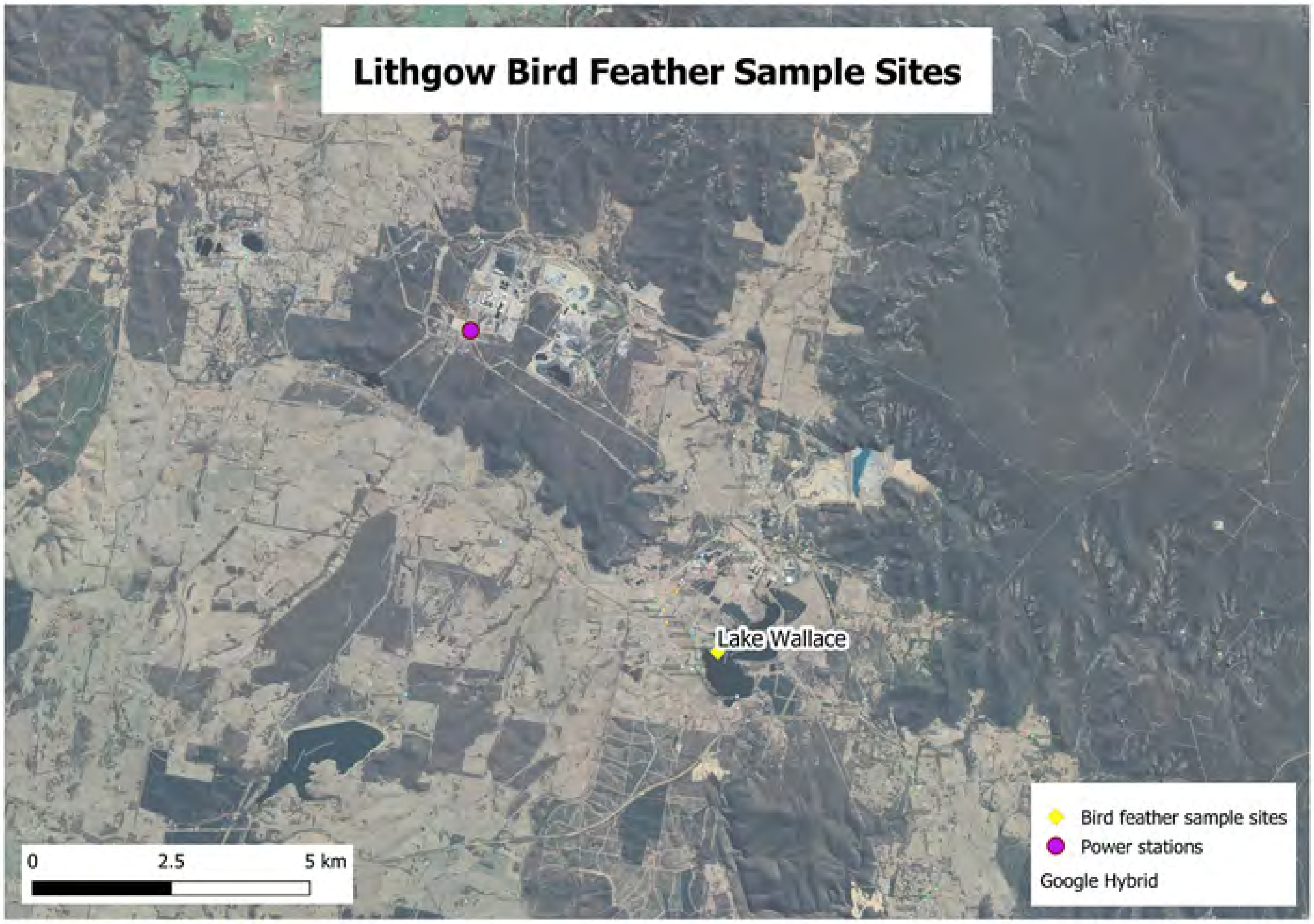
[68] From Winn et al, 2019.

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

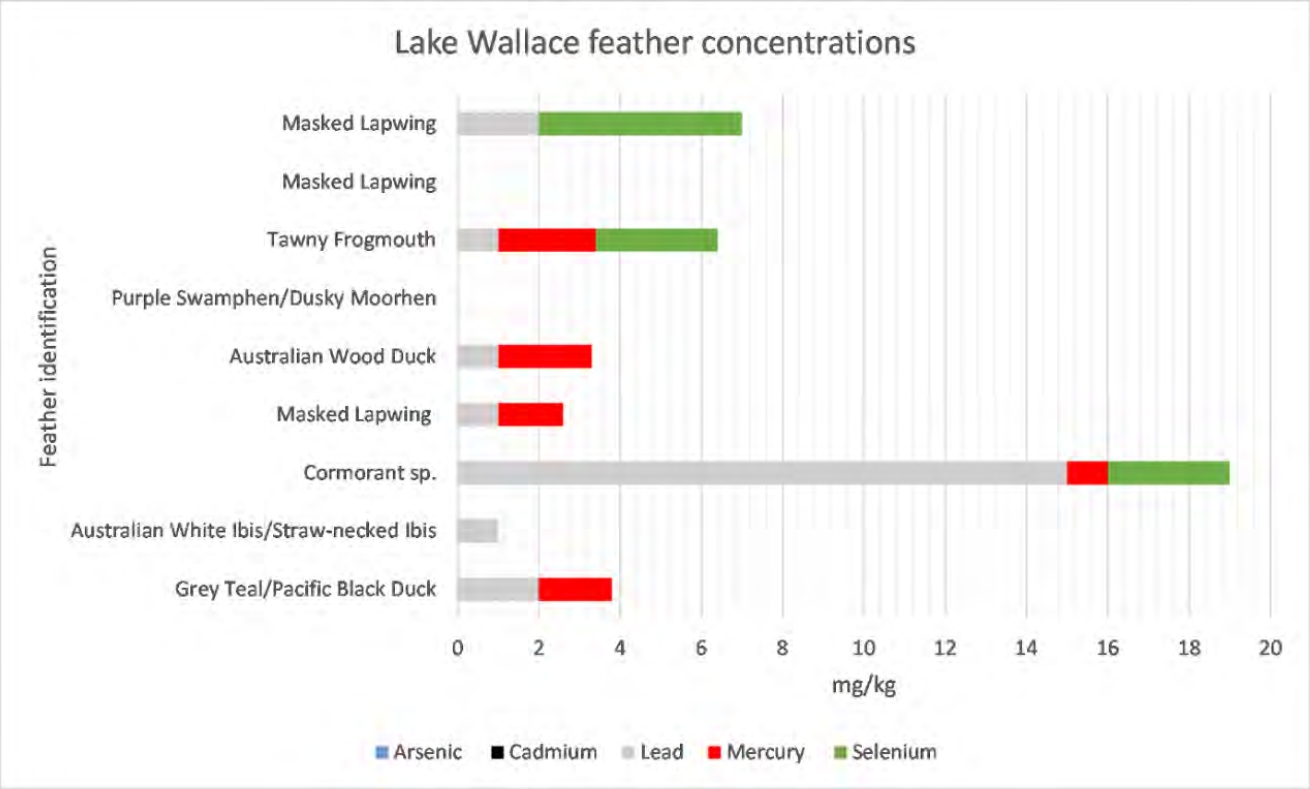


Chart 7: Lake Wallace feather metal concentrations

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 Treasury[69] did not assess Lake Wallace.

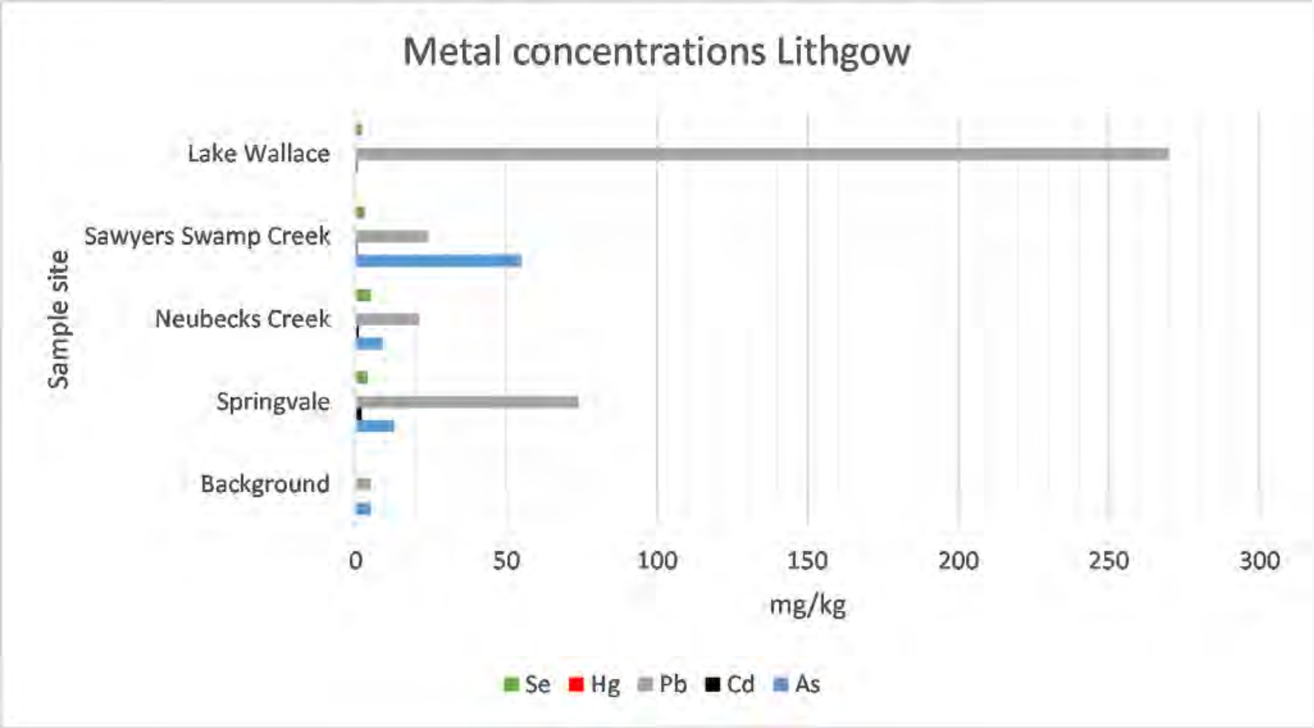


Chart 8: Metal concentrations in HCEC Lithgow sediment samples 2020.

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.

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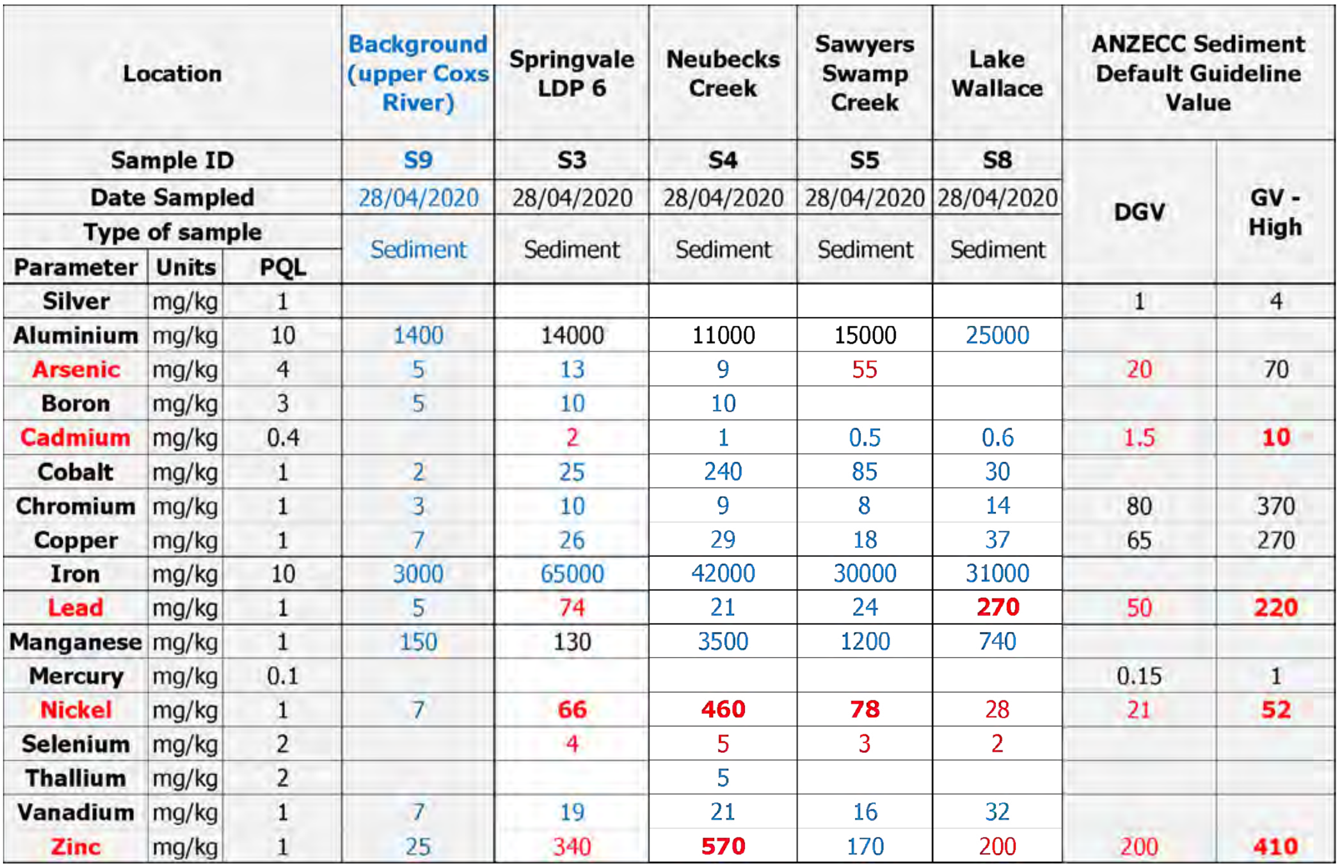
[69] ERM, 2014.



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]

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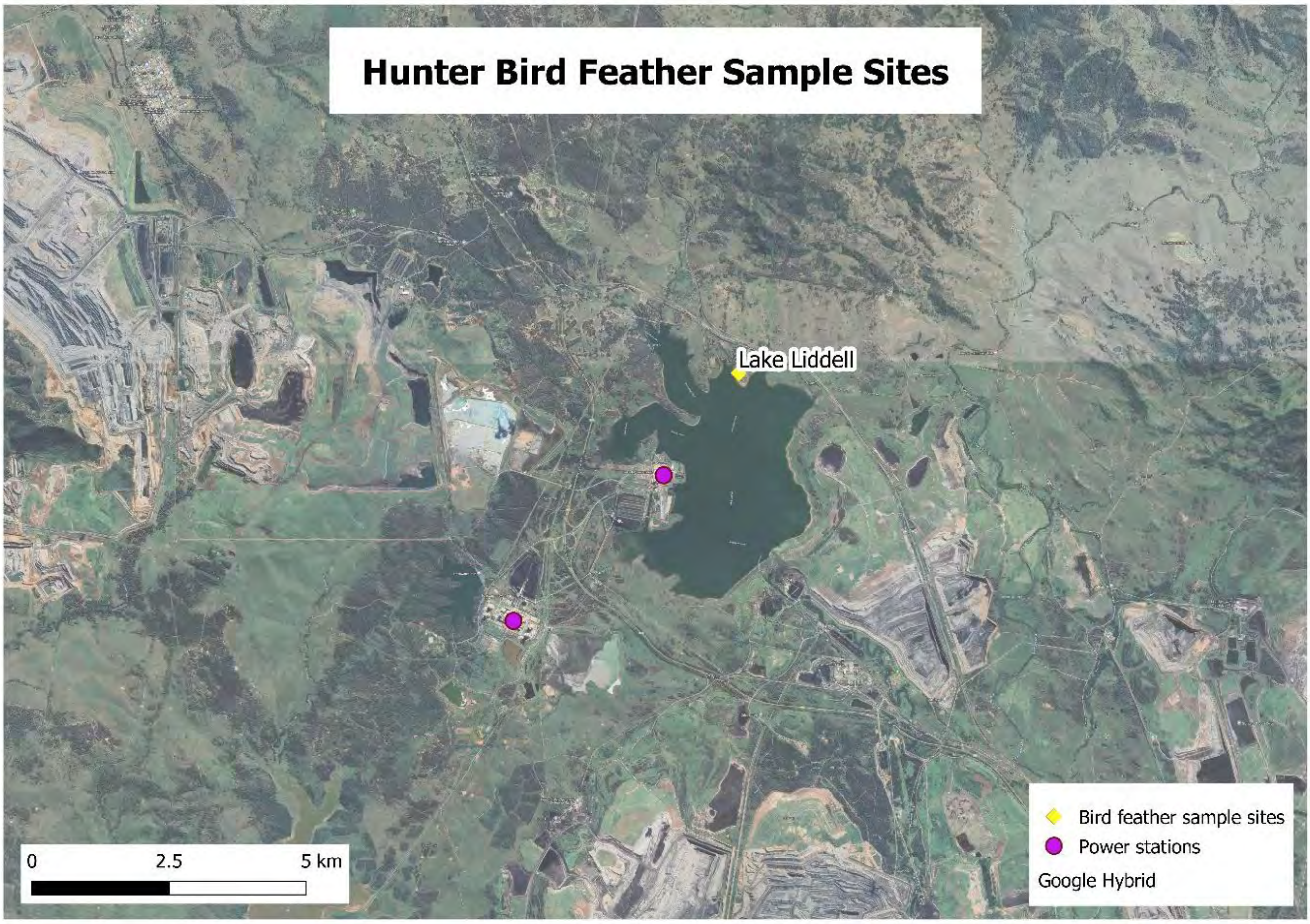
[70] *ERM, 2014a.*

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 (3-21mg/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.

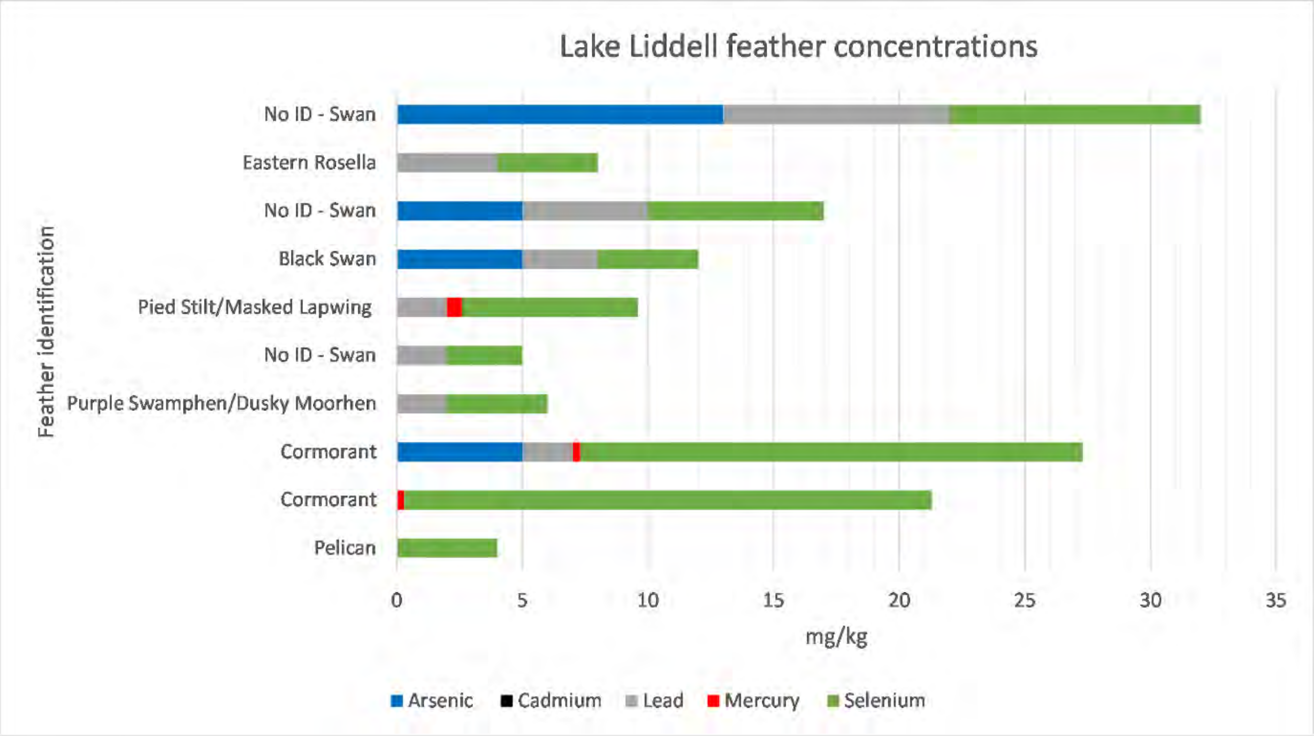


Chart 9: Lake Liddell feather metal concentrations

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

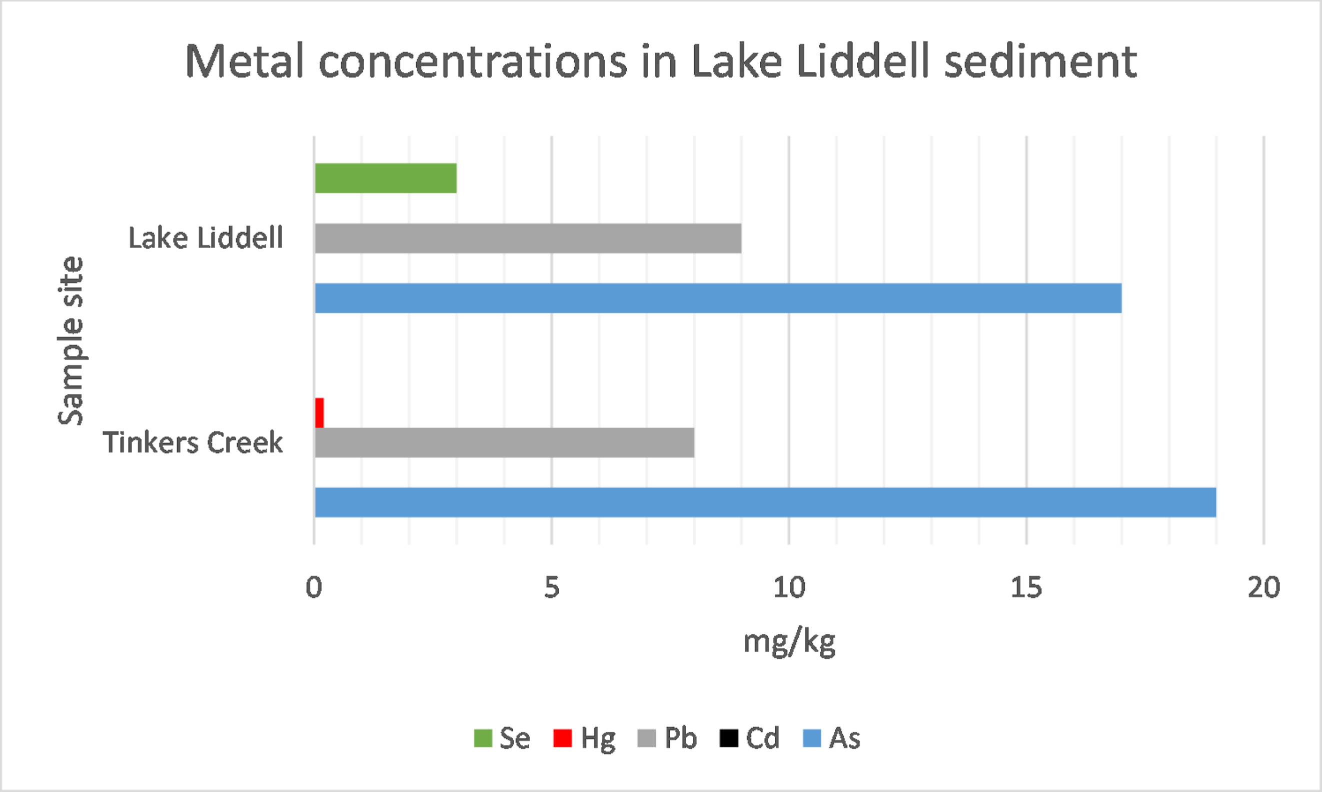


Chart 10: Lake Liddell sediment metal concentration

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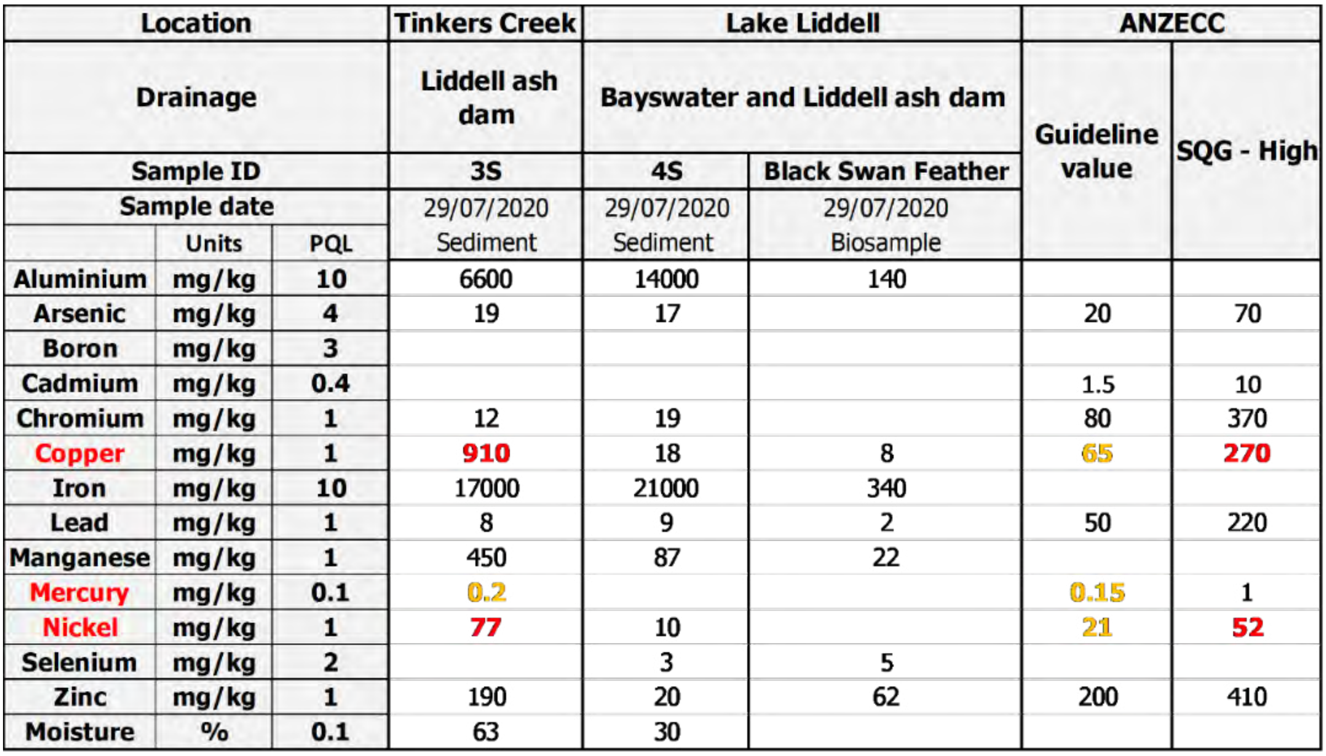
[71] *ERM, 2014a.*

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 Sediment	29/07/2020 Sediment	29/07/2020 Biosample		
	Units	PQL					
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 2020[72]

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 km^2 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.

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[72] *From Winn el al, 2020.*

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

Pelicans on Myall Lake.2020. HCEC.

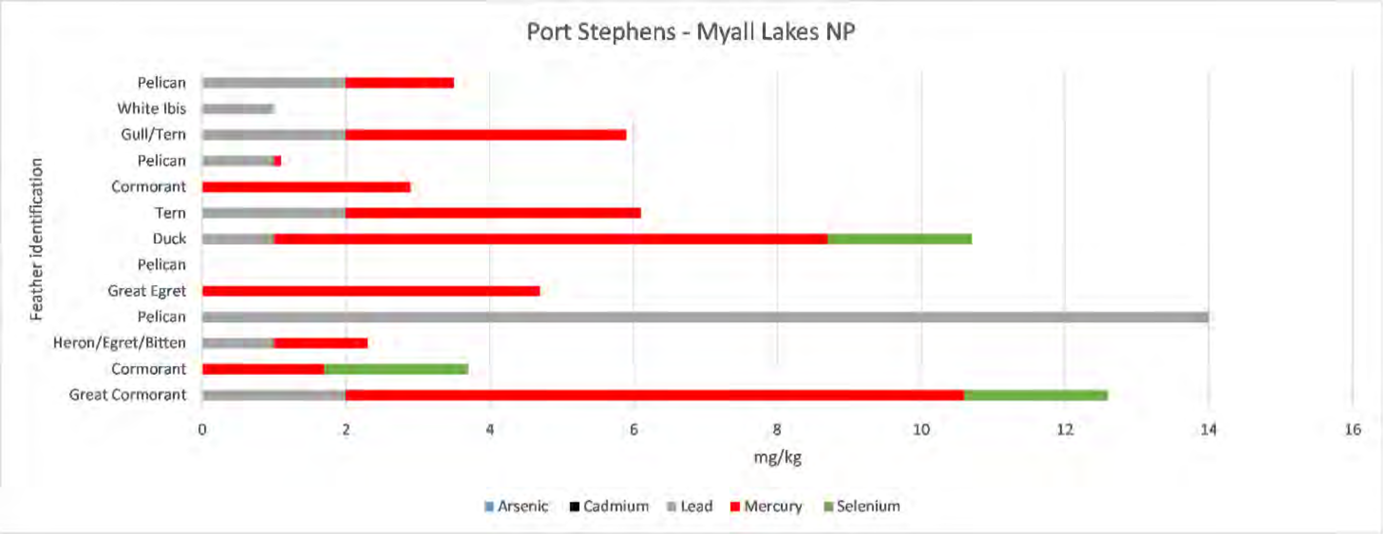

Chart 11: Port Stephens/Myall Lake sediment feather concentrations

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														
Location	Swan Bay				Myall Lakes NP										
	Great Cormorant	Cormorant	Heron/Egret/Bitten	Topnot Pigeon	Pelican	Great Egret	Pelican	Duck	Tern	Cormorant	Pelican	Gull/Tern	White Ibis	Pelican	AVERAGE
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.

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[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]

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[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.

Baywater 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.

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[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.

While we recognise the limitations of the study, we believe our findings warrant a comprehensive investigation by the NSW EPA into the heavy metal pollution impacts facing NSW waterbirds, and the contribution of coal-fired power stations.

Vales Point power station. HCEC.

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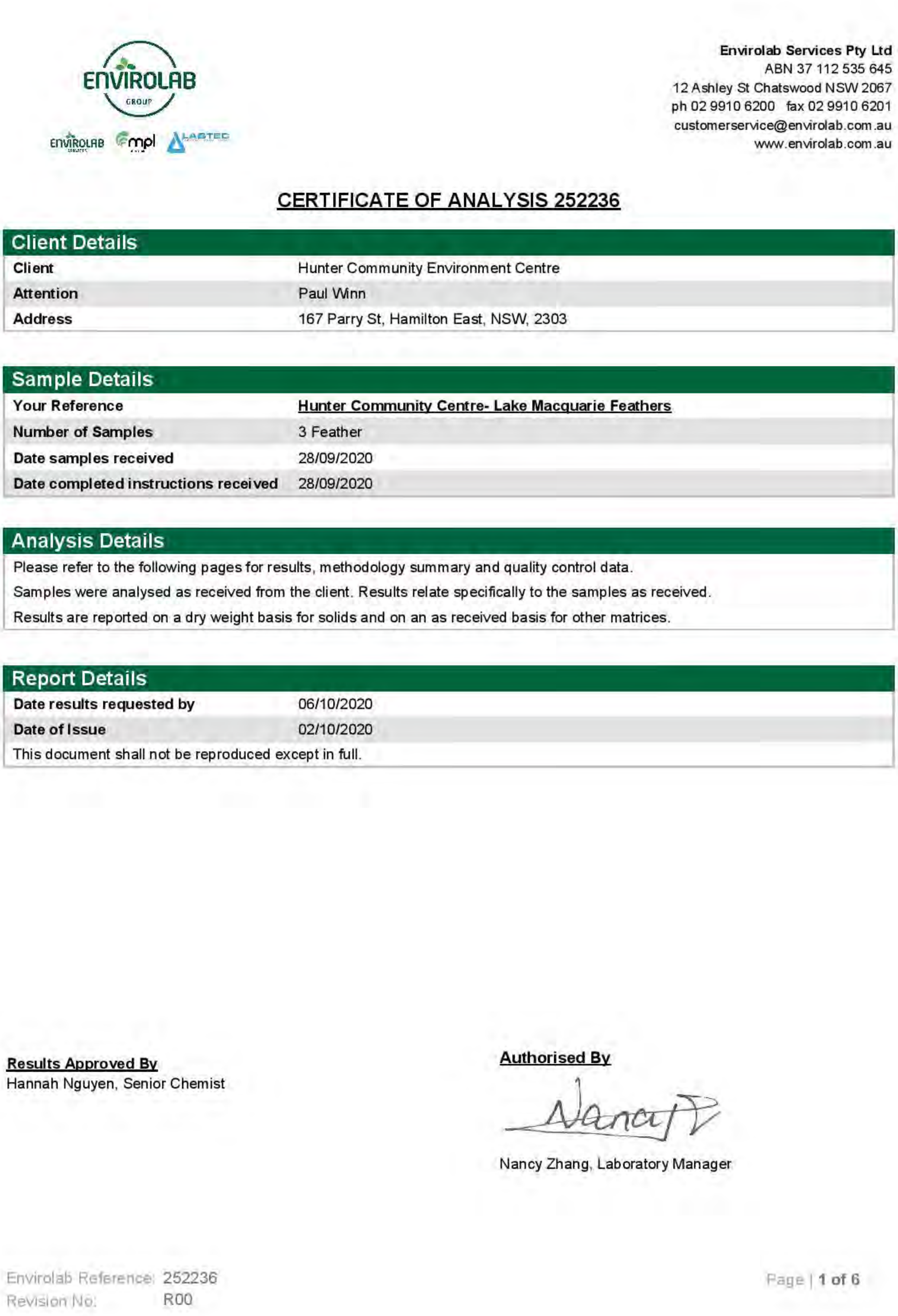
Appendix 1: Laboratory Reports

Lake Macquarie



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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	**Hunter Community Centre- Lake Macquarie Feathers**
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

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Results Approved By
Hannah Nguyen, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

Envirolab Reference: 252236
Revision No: R00

Page | **1 of 6**

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

Acid Extractractable 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					30/09/2020	
Date analysed	-			30/09/2020					30/09/2020	
Aluminium	mg/kg	10	Metals-020	<10					99	
Arsenic	mg/kg	4	Metals-020	<4					93	
Boron	mg/kg	3	Metals-020	<3					88	
Cadmium	mg/kg	0.4	Metals-020	<0.4					87	
Copper	mg/kg	1	Metals-020	<1					100	
Iron	mg/kg	10	Metals-020	<10					104	
Manganese	mg/kg	1	Metals-020	<1					97	
Mercury	mg/kg	0.1	Metals-021	<0.1					102	
Nickel	mg/kg	1	Metals-020	<1					99	
Selenium	mg/kg	2	Metals-020	<2					98	
Zinc	mg/kg	1	Metals-020	<1					102	
Cobalt	mg/kg	1	Metals-020	<1					105	
Lead	mg/kg	1	Metals-020	<1					104	
Molybdenum	mg/kg	1	Metals-020	<1					90	

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.

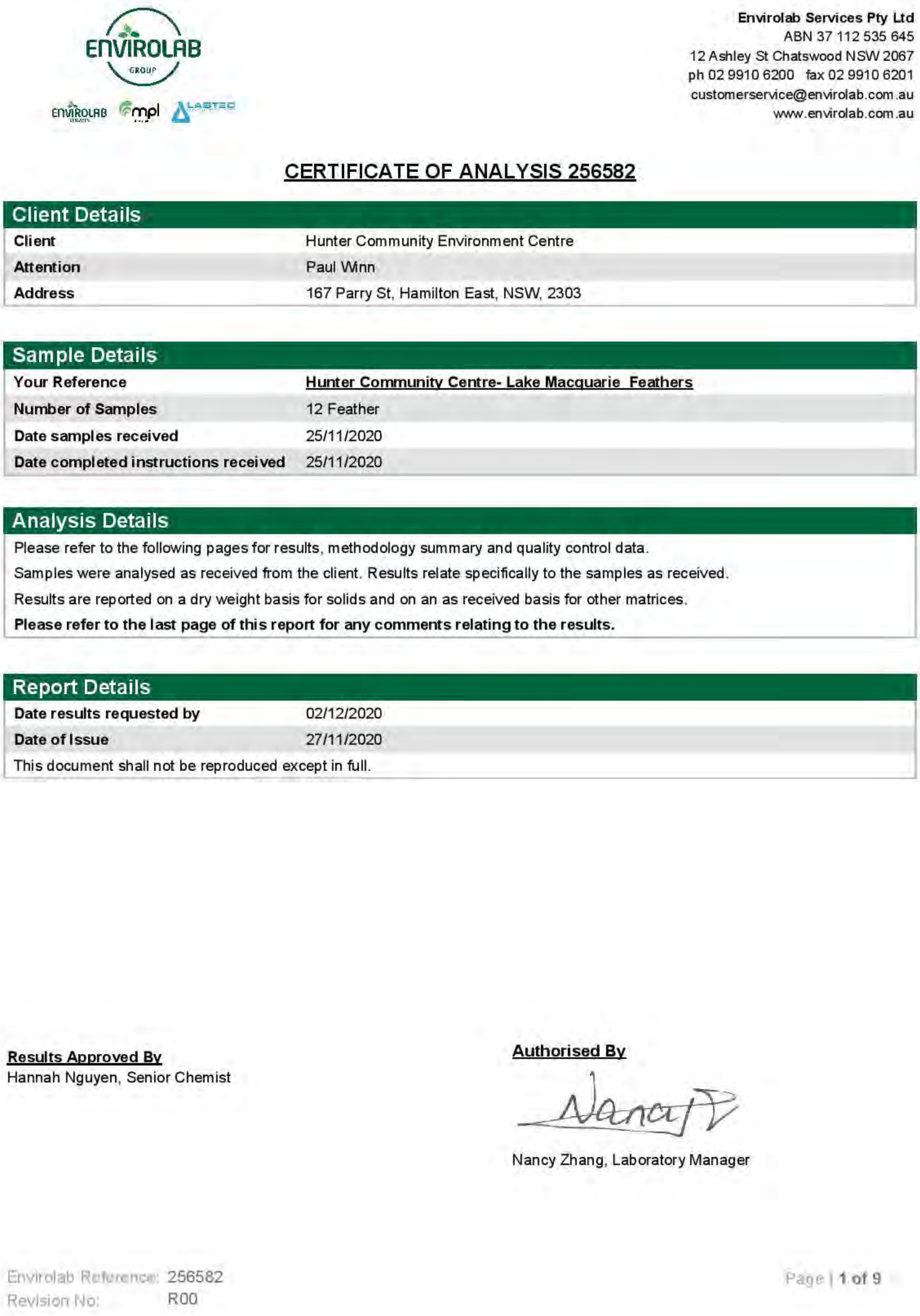
When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

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.



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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	Hunter Community Centre- Lake Macquarie Feathers
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

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Results Approved By
Hannah Nguyen, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

Client Reference: Hunter Community Centre- Lake Macquarie Feathers

Acid Extractractable 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 Extractractable 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 Extractractable 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

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					26/11/2020	
Date analysed	-			26/11/2020					26/11/2020	
Aluminium	mg/kg	10	Metals-020	<10					98	
Arsenic	mg/kg	4	Metals-020	<4					109	
Boron	mg/kg	3	Metals-020	<3					89	
Cadmium	mg/kg	0.4	Metals-020	<0.4					104	
Copper	mg/kg	1	Metals-020	<1					105	
Iron	mg/kg	10	Metals-020	<10					109	
Manganese	mg/kg	1	Metals-020	<1					104	
Mercury	mg/kg	0.1	Metals-021	<0.1					91	
Nickel	mg/kg	1	Metals-020	<1					110	
Selenium	mg/kg	2	Metals-020	<2					97	
Zinc	mg/kg	1	Metals-020	<1					110	
Cobalt	mg/kg	1	Metals-020	<1					110	
Lead	mg/kg	1	Metals-020	<1					103	
Molybdenum	mg/kg	1	Metals-020	<1					98	

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.

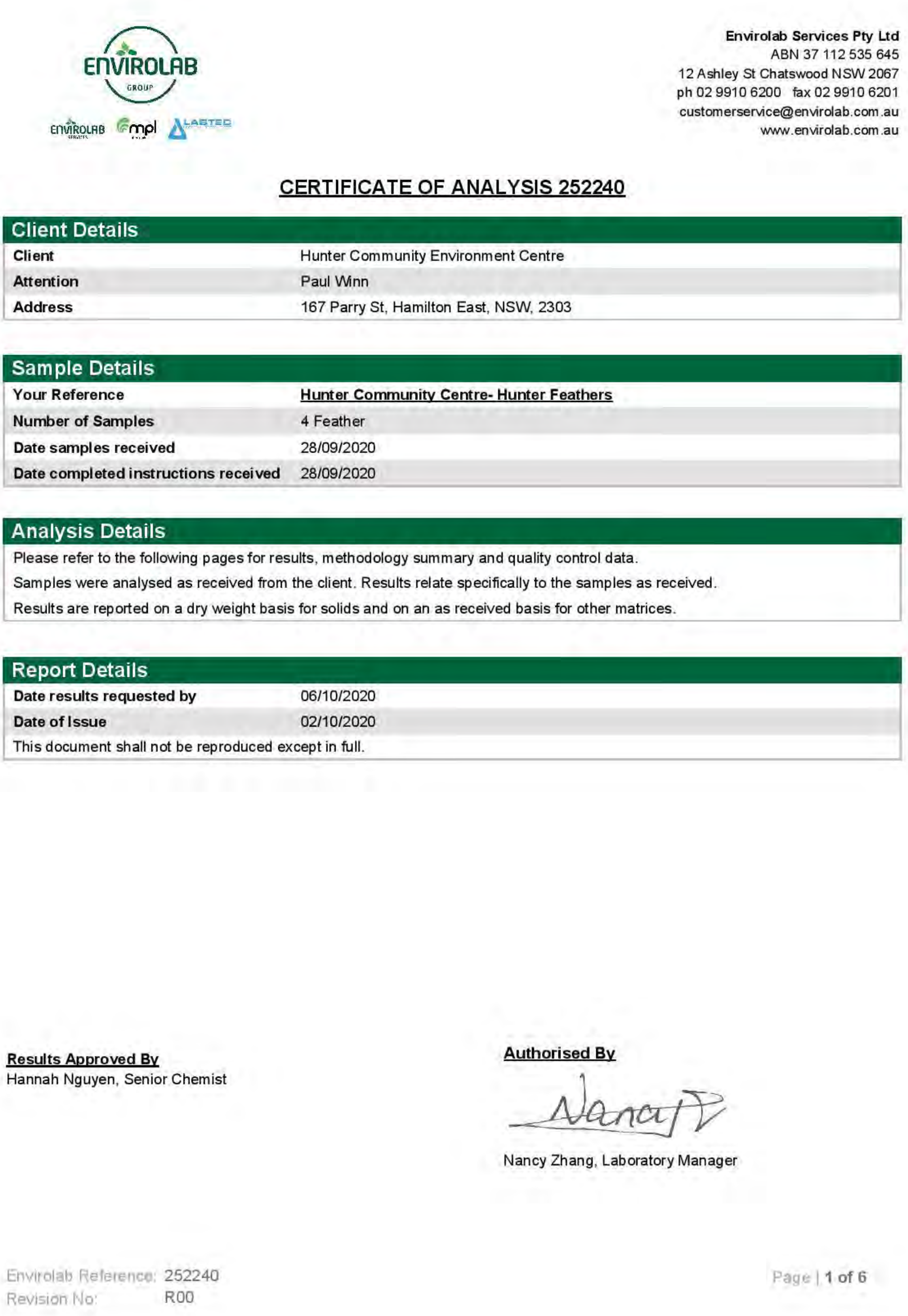
Measurement Uncertainty estimates are available for most tests upon request.

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

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



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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	**Hunter Community Centre- Hunter Feathers**
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

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Results Approved By
Hannah Nguyen, Senior Chemist

Authorised By
Nancy
Nancy Zhang, Laboratory Manager

Envirolab Reference: 252240
Revision No: R00

Page | 1 of 6

Acid Extractractable 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					30/09/2020	
Date analysed	-			30/09/2020					30/09/2020	
Aluminium	mg/kg	10	Metals-020	<10					99	
Arsenic	mg/kg	4	Metals-020	<4					93	
Boron	mg/kg	3	Metals-020	<3					88	
Cadmium	mg/kg	0.4	Metals-020	<0.4					87	
Copper	mg/kg	1	Metals-020	<1					100	
Iron	mg/kg	10	Metals-020	<10					104	
Manganese	mg/kg	1	Metals-020	<1					97	
Mercury	mg/kg	0.1	Metals-021	<0.1					102	
Nickel	mg/kg	1	Metals-020	<1					99	
Selenium	mg/kg	2	Metals-020	<2					98	
Zinc	mg/kg	1	Metals-020	<1					102	
Cobalt	mg/kg	1	Metals-020	<1					105	
Lead	mg/kg	1	Metals-020	<1					104	
Molybdenum	mg/kg	1	Metals-020	<1					90	

Client Reference: Hunter Community Centre- Hunter Feathers

Result Definitions	
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LCS	Laboratory Control Sample
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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.

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Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

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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

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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

Nancy Zhang, Laboratory Manager

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

Acid Extractractable 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	
Date analysed	-			03/08/2020	2	03/08/2020	03/08/2020		03/08/2020	
Aluminium-Dissolved	µg/L	10	Metals-022	<10	2	90	90	0	96	
Arsenic-Dissolved	µg/L	1	Metals-022	<1	2	<1	<1	0	93	
Boron-Dissolved	µg/L	20	Metals-022	<20	2	40	40	0	96	
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	2	<0.1	<0.1	0	94	
Chromium-Dissolved	µg/L	1	Metals-022	<1	2	<1	<1	0	99	
Copper-Dissolved	µg/L	1	Metals-022	<1	2	2	2	0	105	
Iron-Dissolved	µg/L	10	Metals-022	<10	2	110	100	10	105	
Lead-Dissolved	µg/L	1	Metals-022	<1	2	<1	<1	0	105	
Manganese-Dissolved	µg/L	5	Metals-022	<5	2	6	6	0	98	
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	2	<0.05	<0.05	0	100	
Nickel-Dissolved	µg/L	1	Metals-022	<1	2	<1	<1	0	95	
Selenium-Dissolved	µg/L	1	Metals-022	<1	2	<1	<1	0	100	
Zinc-Dissolved	µg/L	1	Metals-022	<1	2	4	2	67	98	

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	
Arsenic-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	92	
Boron-Total	µg/L	20	Metals-022	<20	1	40	40	0	111	
Cadmium-Total	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	95	
Chromium-Total	µg/L	1	Metals-022	<1	1	1	1	0	104	
Copper-Total	µg/L	1	Metals-022	<1	1	3	2	40	106	
Iron-Total	µg/L	10	Metals-022	<10	1	1500	1500	0	102	
Lead-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	107	
Manganese-Total	µg/L	5	Metals-022	<5	1	25	25	0	97	
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	
Selenium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	100	
Zinc-Total	µg/L	1	Metals-022	<1	1	5	4	22	104	

Client Reference: Hunter Community Environment Centre-Hunter Valley

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

Result Definitions

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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.

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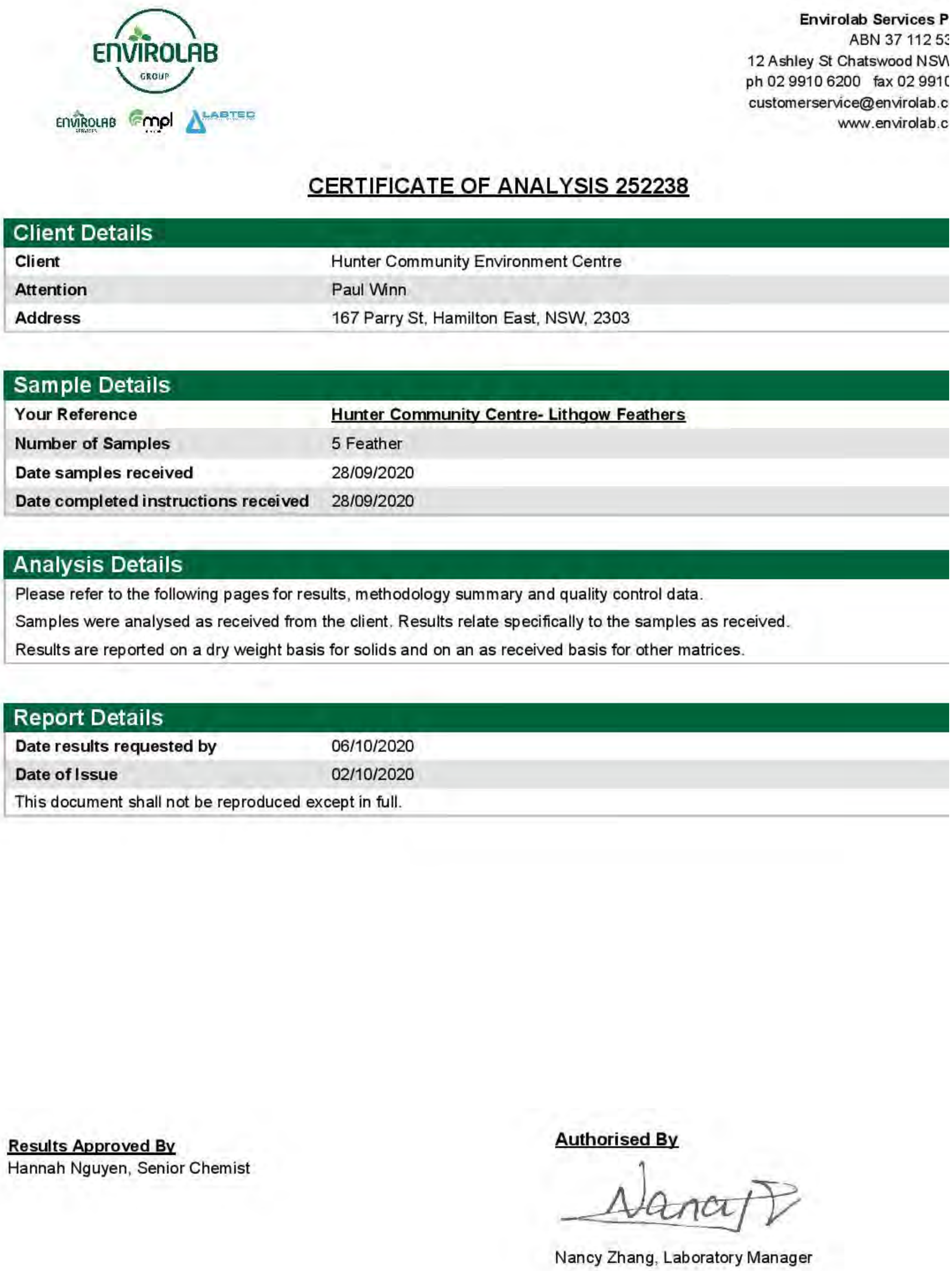
Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

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.



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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	Hunter Community Centre- Lithgow Feathers
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

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Results Approved By
Hannah Nguyen, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Acid Extractractable 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 Extractractable 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					30/09/2020	
Date analysed	-			30/09/2020					30/09/2020	
Aluminium	mg/kg	10	Metals-020	<10					99	
Arsenic	mg/kg	4	Metals-020	<4					93	
Boron	mg/kg	3	Metals-020	<3					88	
Cadmium	mg/kg	0.4	Metals-020	<0.4					87	
Copper	mg/kg	1	Metals-020	<1					100	
Iron	mg/kg	10	Metals-020	<10					104	
Manganese	mg/kg	1	Metals-020	<1					97	
Mercury	mg/kg	0.1	Metals-021	<0.1					102	
Nickel	mg/kg	1	Metals-020	<1					99	
Selenium	mg/kg	2	Metals-020	<2					98	
Zinc	mg/kg	1	Metals-020	<1					102	
Cobalt	mg/kg	1	Metals-020	<1					105	
Lead	mg/kg	1	Metals-020	<1					104	
Molybdenum	mg/kg	1	Metals-020	<1					90	

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.

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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.

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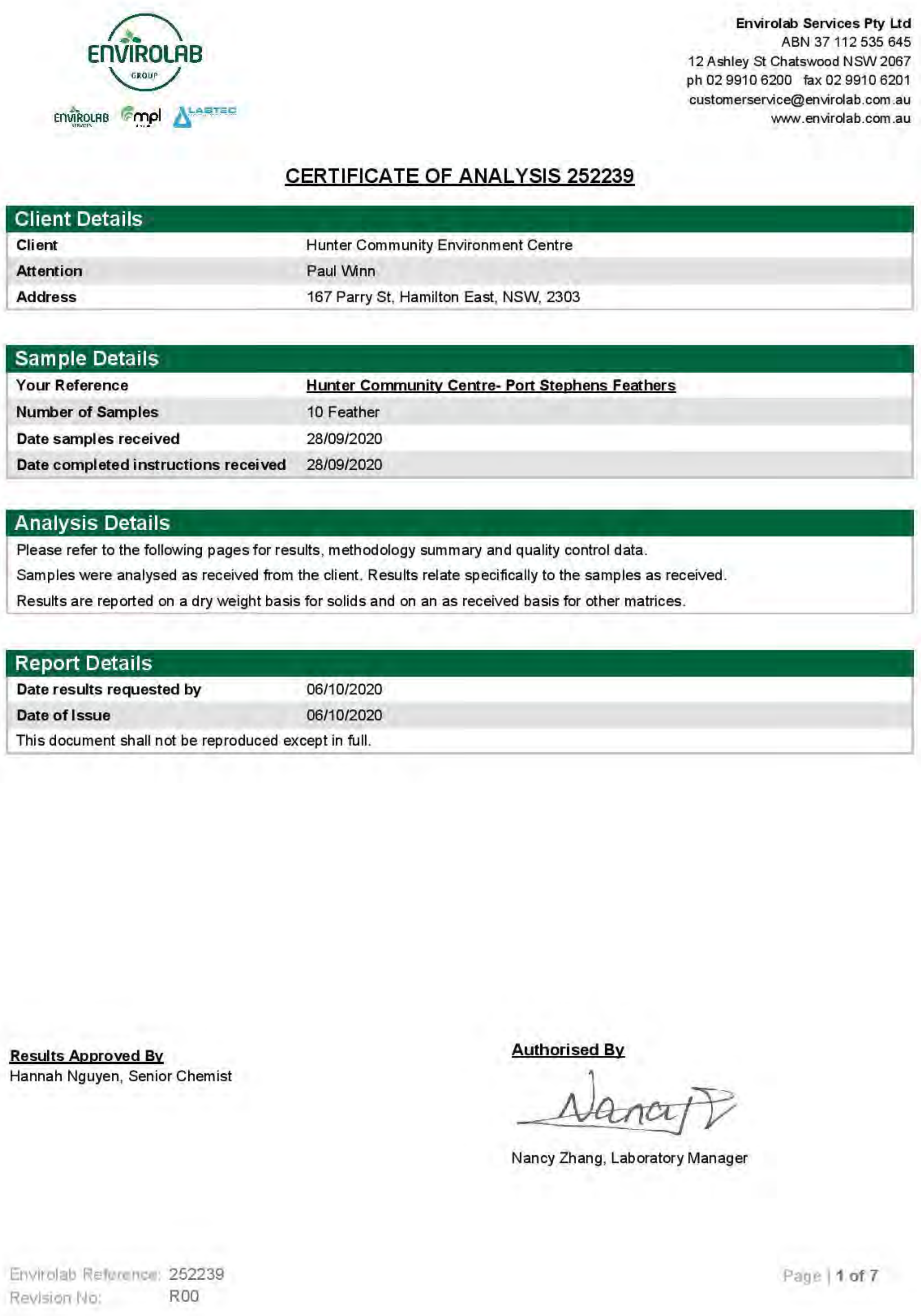
Port Stephens/ Myall Lakes National Park



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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	Hunter Community Centre- Port Stephens Feathers
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

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Results Approved By
Hannah Nguyen, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Envirolab Reference: 252239
Revision No: R00

Page | 1 of 7

Client Reference: Hunter Community Centre- Port Stephens Feathers

Acid Extractractable 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

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

Client Reference: Hunter Community Centre- Port Stephens Feathers

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

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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.
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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

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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.

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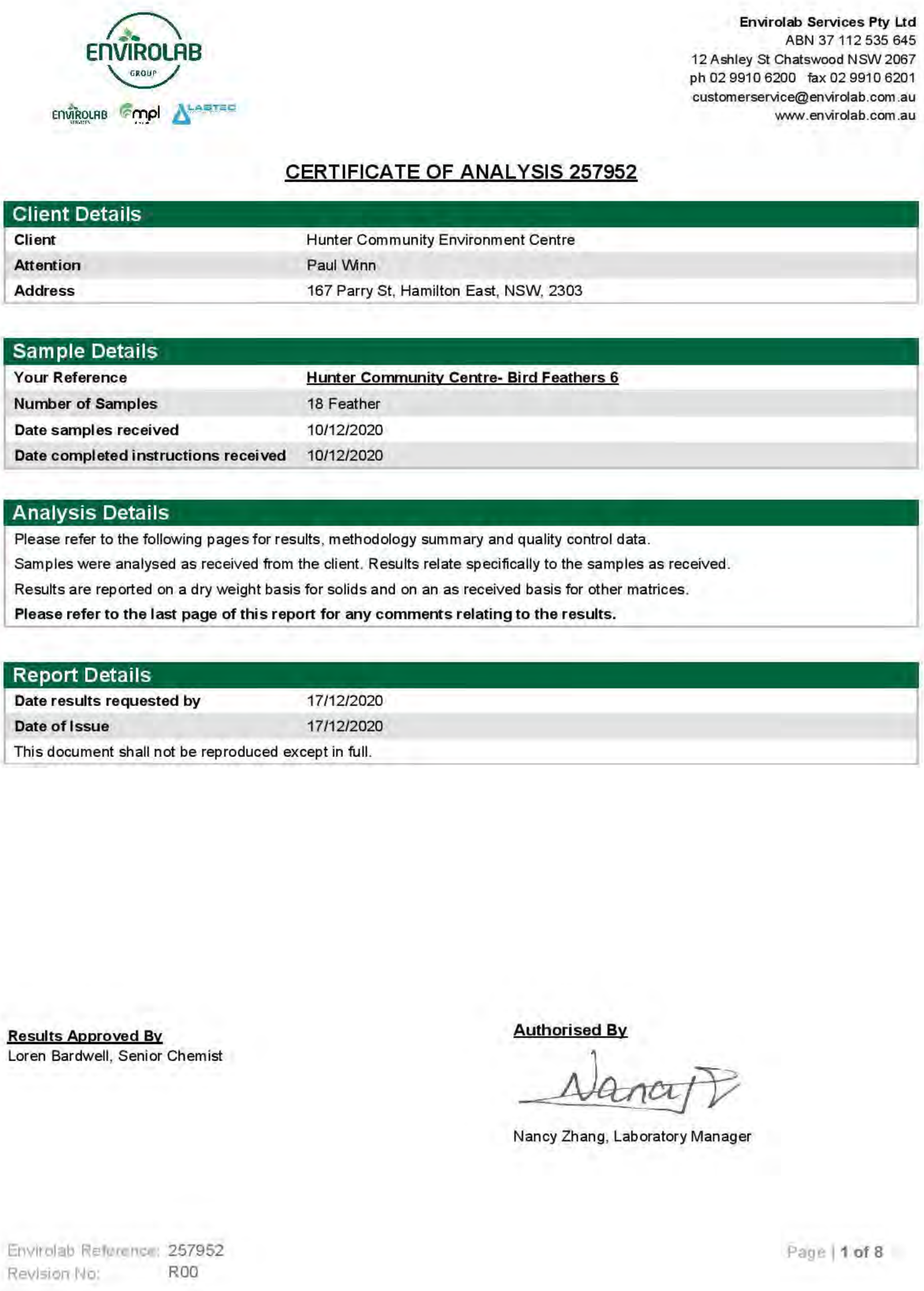
Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.



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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	**Hunter Community Centre- Bird Feathers 6**
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

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Results Approved By
Loren Bardwell, Senior Chemist

Authorised By
Nancy
Nancy Zhang, Laboratory Manager

Envirolab Reference: 257952
Revision No: R00

Page | **1 of 8**

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

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]

Client Reference: Hunter Community Centre- Bird Feathers 6

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
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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.

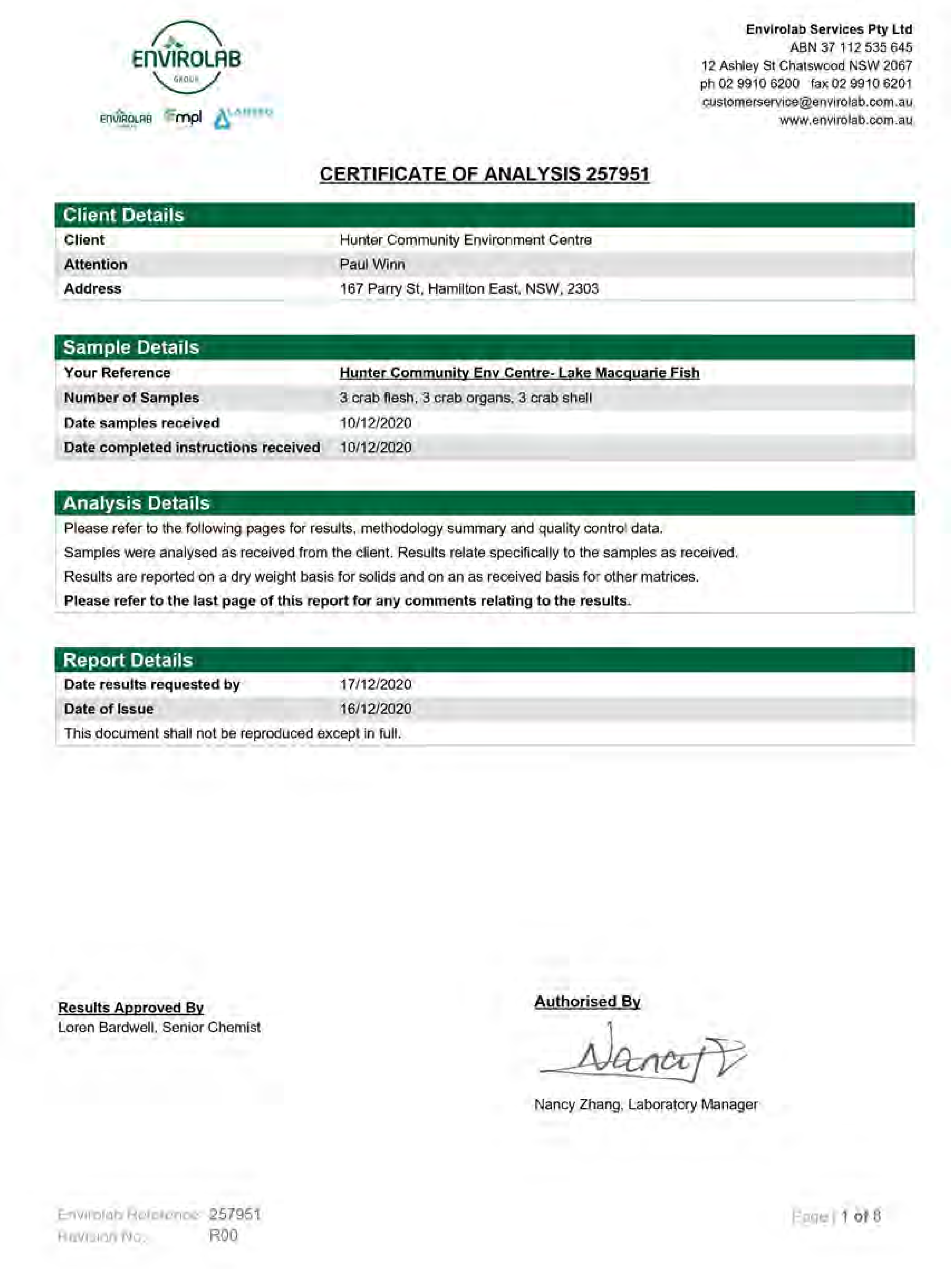
Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical 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
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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	**Hunter Community Env Centre- Lake Macquarie Fish**
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

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

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					11/12/2020	
Date analysed	-			14/12/2020					14/12/2020	
Aluminium	mg/kg	10	Metals-020	<10					112	
Arsenic	mg/kg	4	Metals-020	<4					97	
Boron	mg/kg	3	Metals-020	<3					93	
Cadmium	mg/kg	0.4	Metals-020	<0.4					93	
Chromium	mg/kg	1	Metals-020	<1					98	
Copper	mg/kg	1	Metals-020	<1					104	
Iron	mg/kg	10	Metals-020	<10					108	
Lead	mg/kg	1	Metals-020	<1					110	
Manganese	mg/kg	1	Metals-020	<1					102	
Mercury	mg/kg	0.1	Metals-021	<0.1					108	
Nickel	mg/kg	1	Metals-020	<1					98	
Selenium	mg/kg	2	Metals-020	<2					98	
Thallium	mg/kg	2	Metals-020	<2					105	
Vanadium	mg/kg	1	Metals-020	<1					97	
Zinc	mg/kg	1	Metals-020	<1					107	

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.

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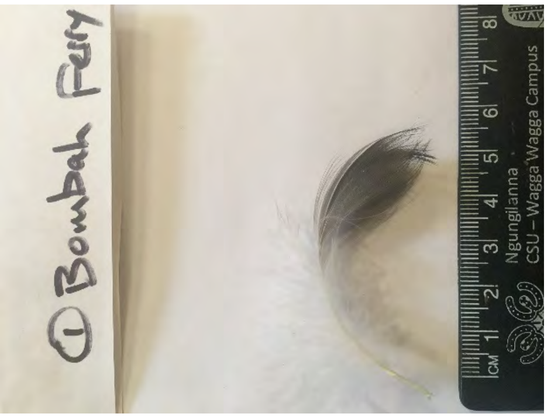
Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

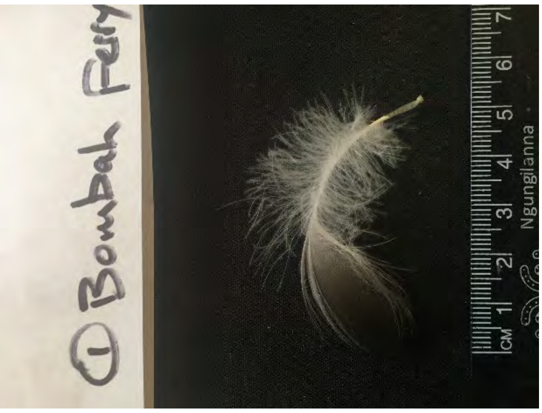
Report Comments

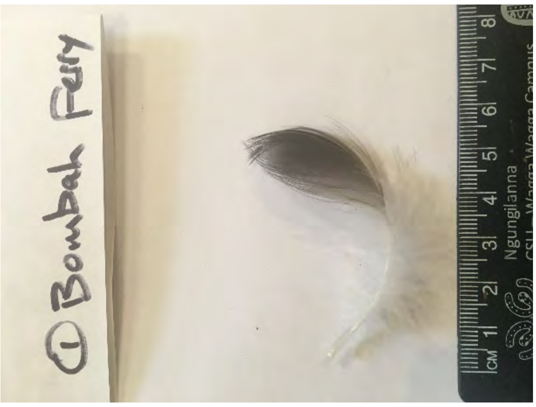
Acid extractable metals in crab - The results are reported on the sample as received i.e. no moisture correction has been applied.

Appendix 2: Photos of collected feathers

Myall Lakes National Park








MUNGO, SEPT 4 2020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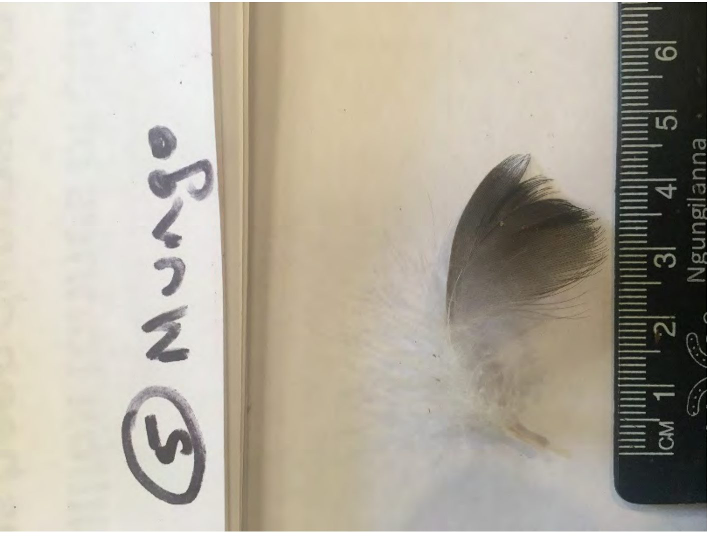
Ngungilanna


5 Mungo
CM 1 2 3 4 5 6
Ngungilanna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⑤ Mungo
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Ngungilanna


⑤ Mungo
CM 1 2 3 4 5 6
Ngungilanna


SWAN BAY, SEPT 4 2020
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③ Swan Bay
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
Barraamielinga
CSU – Dubbo Campus
Ph: 02 6885 7305
Fax: 02 6885 7301


③ Swan Bay
Ngungilanna
CSU – Wagga Wagga Campus
Wammarra
CSU – Bathurst Campus
Barraamielinga


④ Swan Bay
CM 1 2 3 4 5 6 7 8 9
Ngungilanna


④ Swan Bay
CM 1 2 3 4 5 6 7 8 9
Ngungilanna


WHITE TREE BAY, SEPT 4 2020
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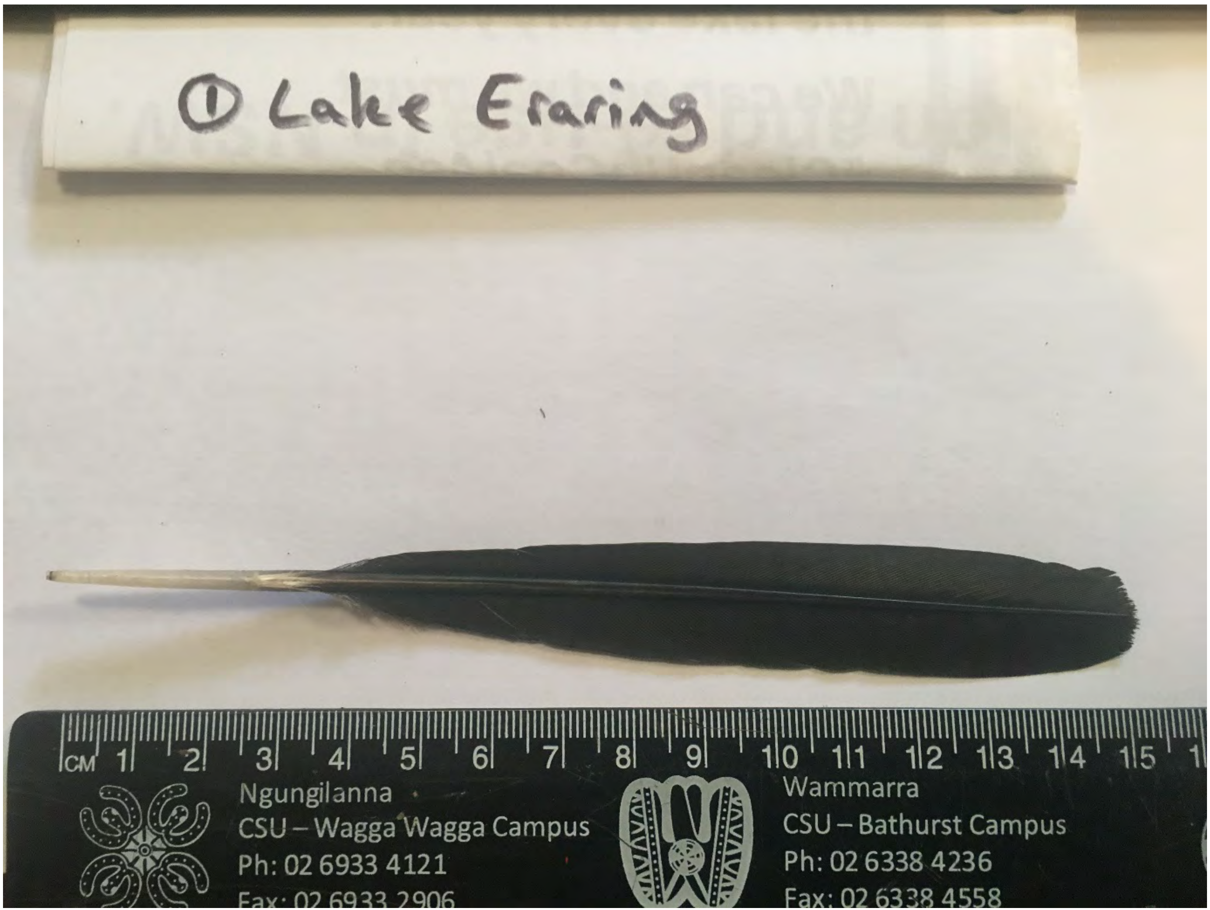
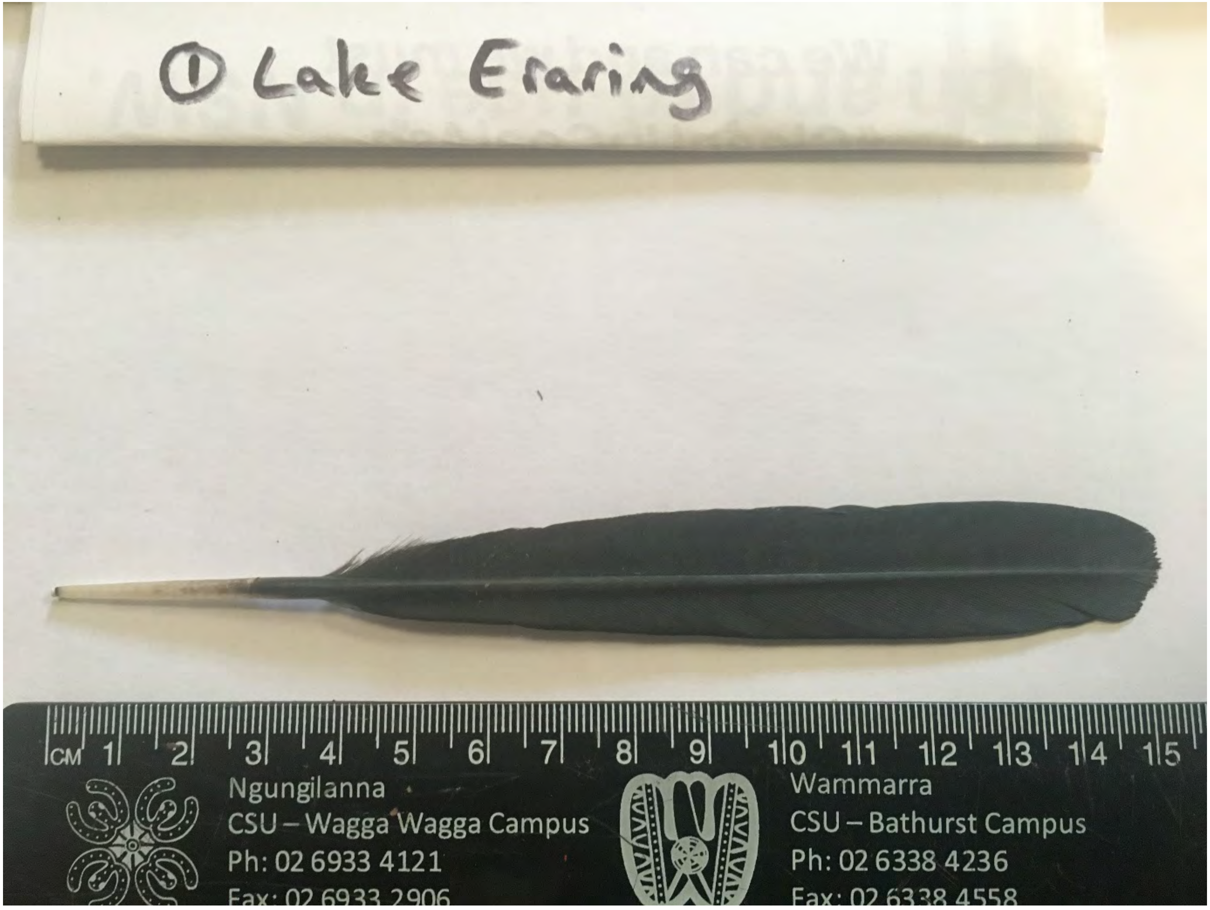
BOMBAH FERRY, SEPT 4 2020
1
2

Lake Macquarie

LAKE MACQUARIE; LAKE ERARING
AUGUST 18 2020


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


① Lake Eraring
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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
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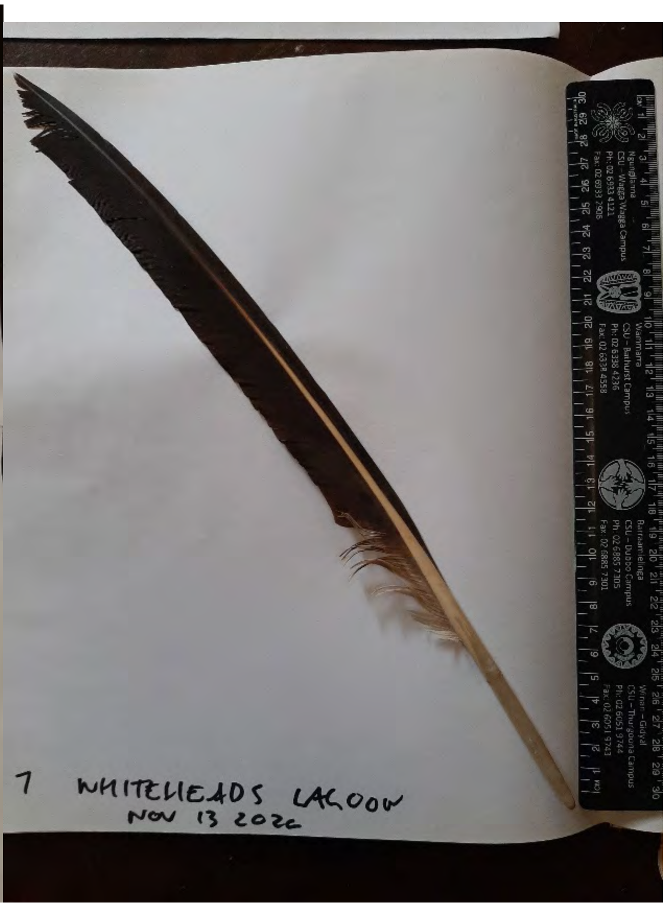
3


① Muddy Lake
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 Muddy Lake
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 MAC: MYUNA BAY
NOV 13 2020
1


7 WHITEHEADS LAGOON
NOV 13 2020


WHITEHEADS LAGOON. NOV 13
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LAKE MAC: WYEE, NOV 13 2020
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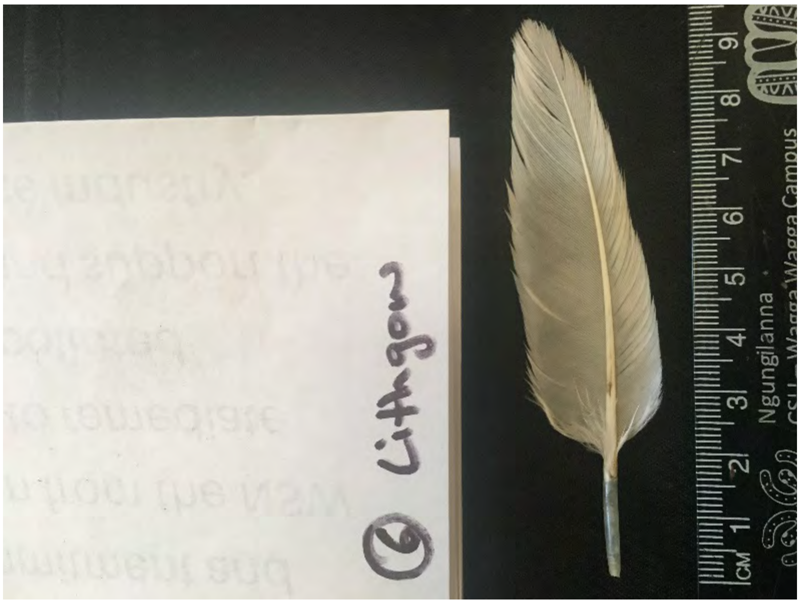
Lake Wallace


5 Lithgow
CM 1 2 3 4 5 6
Ngungilanna
CSU – Wagga Wagga Car


5 Lithgow
CM 1 2 3 4 5 6
Ngungilanna


2 Lithgow
CM 1 2 3 4
Ngungilanna


② Lithgow
CM 1 2 3 4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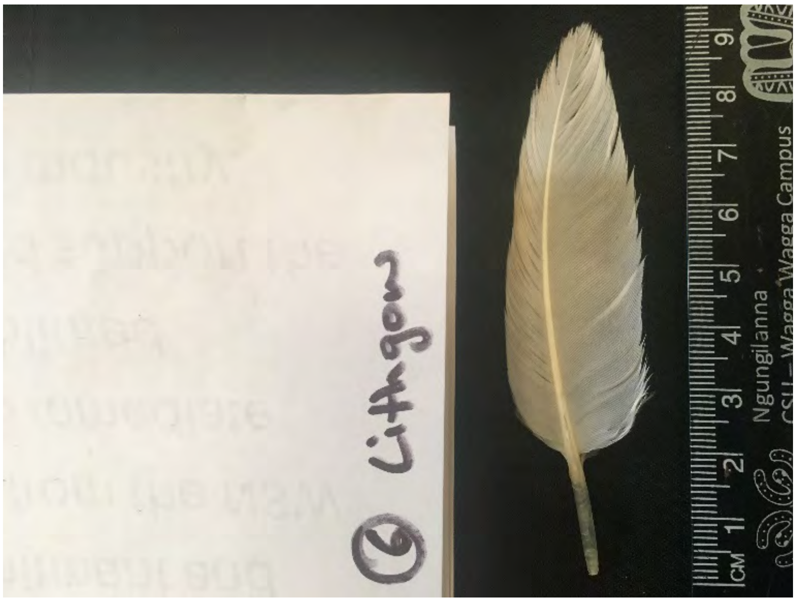
Ngungilanna
CSU – Wagga Wagga Campus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Ngungilanna
CSU – Wagga Wagga Campus


⑥ Lithgow
Ngungilanna


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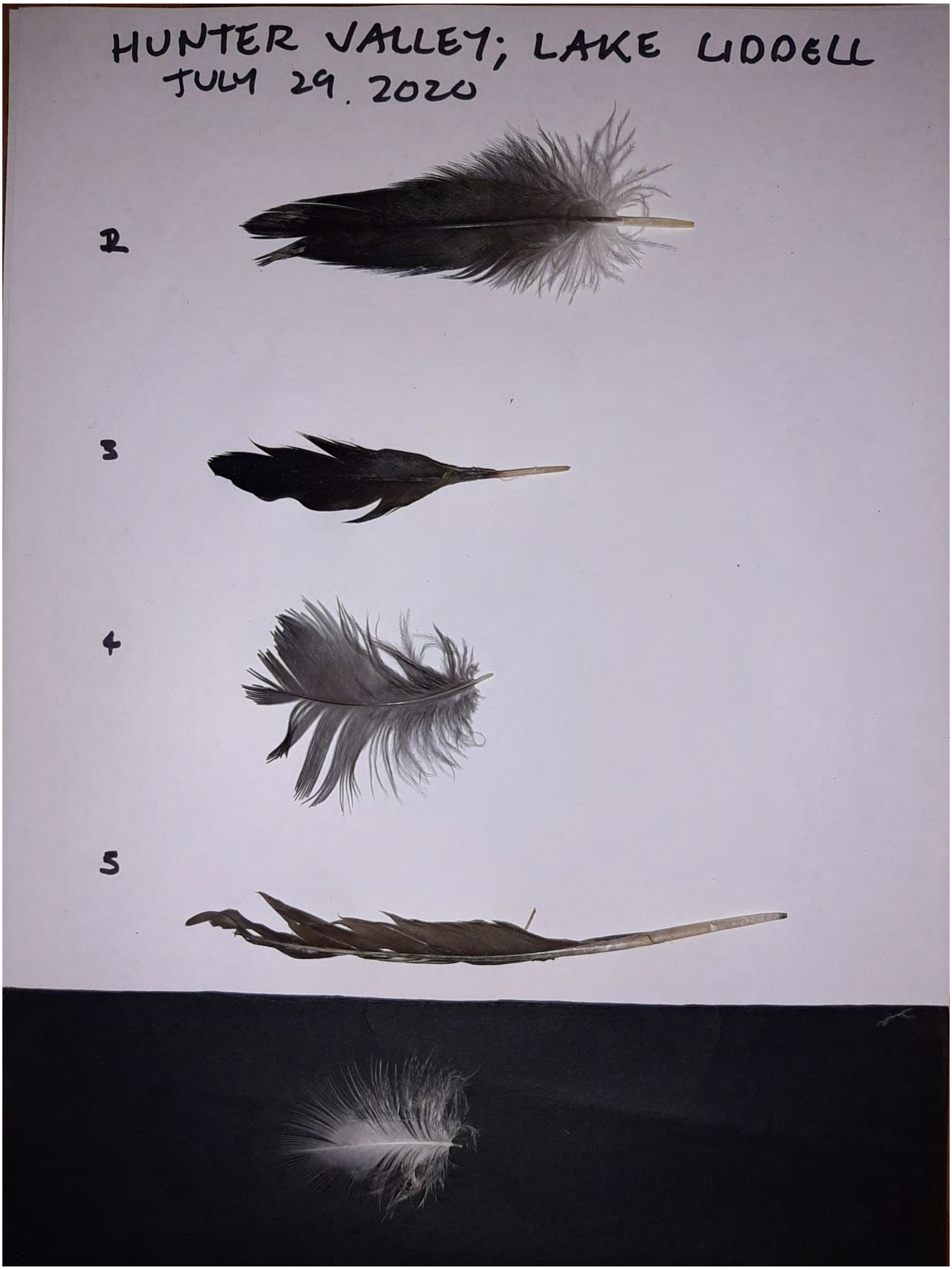
Ngungilanna


⑤ Lithgow
Ngungilanna
CSU – Wagga Wagga Car

Lake Liddell


HUNTER VALLEY; LAKE LIDDELL
JULY 29. 2020
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HUNTER VALLEY; LAKE LIDDELL
JULY 29. 2020
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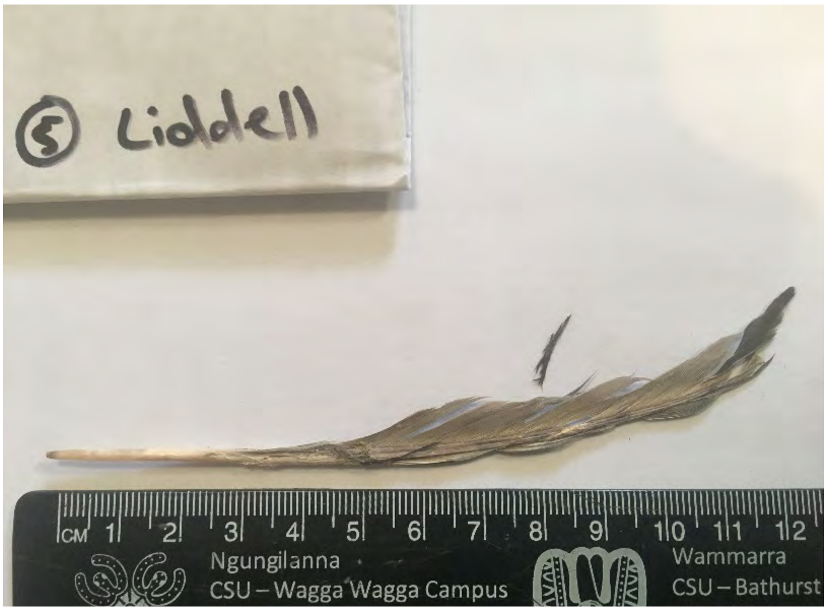
④ Liddell
CM 1 2 3 4 5 6
Ngungilanna


④ Liddell
CM 1 2 3 4 5 6
Ngungilanna


⑤ Liddell
CM 1 2 3 4 5 6 7 8 9 10 11 12
Ngungilanna
CSU – Wagga Wagga Campus
Wammarra
CSU – Bathurst


⑤ Liddell
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Wammarra
Ph: 02 6338 4236


⑦ Liddell
Ngungilanna
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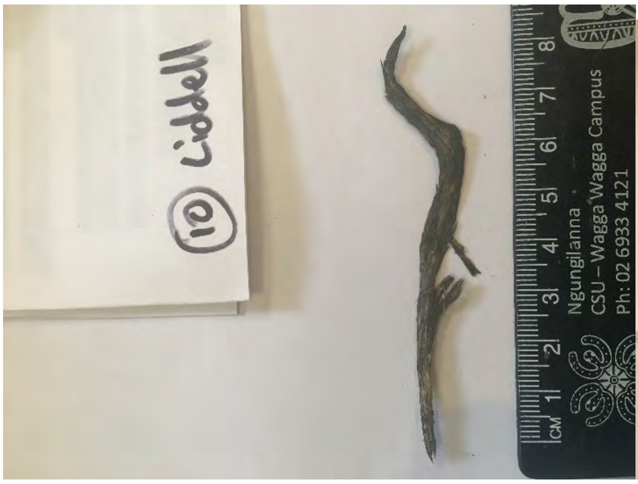
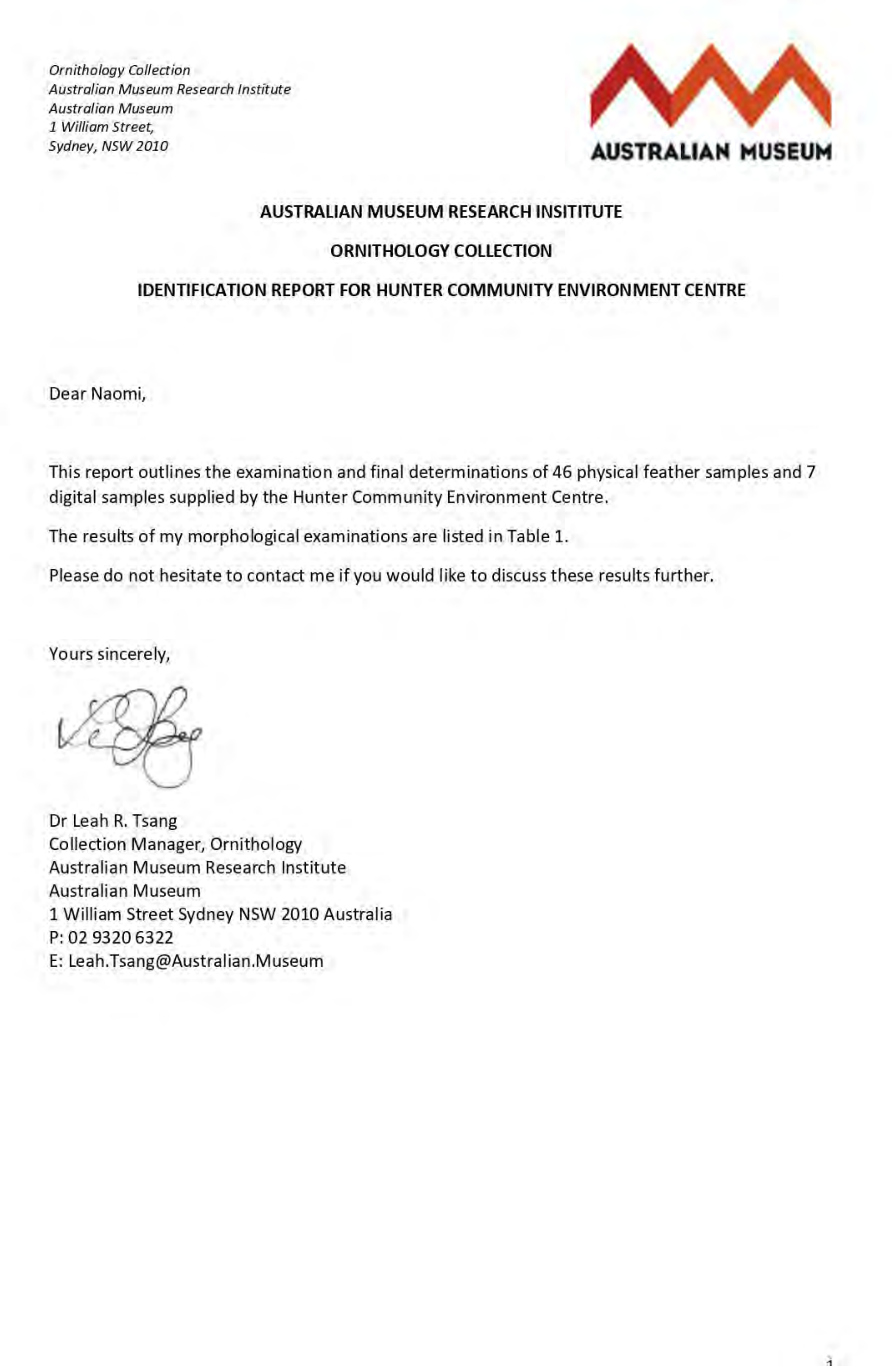
CSU – Wagga Wagga Campus
Wammarra


⑩ Liddell
Ngungilanna
CSU – Wagga Wagga Campus
Ph: 02 6933 4121


⑩ Liddell
Ngungilanna
CSU – Wagga Wagga Campus
Ph: 02 6933 4121

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 INSITITUTE

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

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

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 mis-matched 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 (*Gymnorhina tibicen)*
Lithgow - 2 (digital sample)	Covert feather (wing)	Crested Pigeon (*Ocyphaps lophotes*)
Lithgow - 3	Covert feather (body)	Australian Wood-duck (*Chenonetta jubata*)
Lithgow - 4	Covert feather (body)	Purple Swamphen (*Porphyrio melanotus*) or Dusky Moorhen (*Gallinula tenebrosa*)
Lithgow - 5 (digital sample)	Covert feather (body)	Grey Teal (*Anas gracilis*), Chestnut Teal (*A. castanea*) or Pacific Black Duck (*A. superciliosa*)
Lithgow - 6 (partial sample)	Tail feather	Australian White Ibis (*Threskiornis molucca*) or Straw-necked Ibis (*T. spinicollis*)
Lithgow - 7	Covert feather (body)	Tawny Frogmouth (*Podargus strigoides*)
Lithgow - 8	Covert feather (wing)	Genus *Phalacrocorax* (Cormorants)
Lithgow - 9a	Covert feather (body)	Australian Magpie (*Gymnorhina tibicen)*
Lithgow - 9b	Covert feather (body)	Australian Magpie (*Gymnorhina tibicen)*
Lithgow - 10	Covert feather (body)	Masked Lapwing (*Vanellus miles*)
Lithgow - 11 (digital sample)	Covert feather (body)	Masked Lapwing (*Vanellus miles*)
Muddy Lake - 1 (partial sample)	Tail feather	Australian White Ibis (*Threskiornis molucca*) or Straw-necked Ibis (*T. spinicollis*)
Muddy Lake - 2	Covert feather (wing)	Australian Pelican (*Pelecanus conspicillatus*)
Muddy Lake - 3	Wing feather	Genus *Phalacrocorax* (Cormorants)
Lake Eraring - 1 (partial sample)	Primary Feather (Tail)	Genus *Phalacrocorax* (Cormorants)
Lake Eraring - 2	Wing feather	Australian Pelican (*Pelecanus conspicillatus*)
Muyna - 1 (partial sample)	Wing feather / Primary	Tawny Frogmouth (*Podargus strigoides*)
Mungo - 1	Covert feather (wing)	Great Cormorant (*Phalacrocorax carbo*)
Mungo - 2	Wing feather	Genus *Phalacrocorax* (Cormorants)
Mungo - 3	Covert feather (body)	Family Ardeidae (Herons, Egrets, Bitterns)
Mungo - 4	Covert feather (body)	Topknot Pigeon (*Lopholaimus antarcticus*)
Mungo - 5 (digital sample)	Covert feather (body)	Australian Pelican (*Pelecanus conspicillatus*)
Wyee - 1	Degraded feather	Could not identify
Wyee - 2	Degraded feathers	Could not identify
Wyee - 3 (partial sample)	Tail feather	Genus *Corvus* (Crows & Ravens)
Wyee - 4 (partial sample)	Covert feather (body)	Genus *Corvus* (Crows & Ravens)
Liddell - 1	Degraded feather	Australian Pelican (*Pelecanus conspicillatus*)
Liddell - 2	Covert feather (body)	Genus *Phalacrocorax* (Cormorants)

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

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

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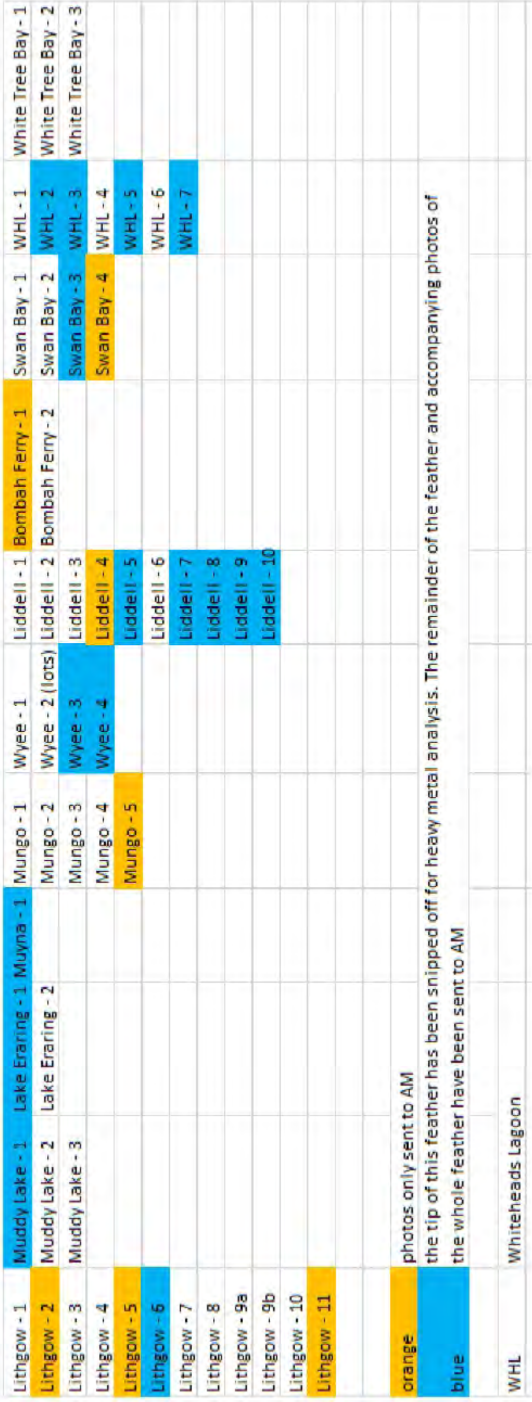
Appendix. Screen snap of original sample list as presented in HCEC electronic spreadsheet, landscape view. (Font size & column widths have been reduced to enable single-page presentation)



Lithgow - 1	Muddy Lake - 1	Lake Eraring - 1	Muyna - 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