APPENDIX E
COMPARATIVE ECOLOGICAL RISK ASSESSMENT

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RAMBOLL ENVIRON

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1. INTRODUCTION

This Comparative Ecological Risk Assessment (CERA) has been prepared by Ramboll Environ Australia Pty Ltd (Ramboll Environ) on behalf of Hydro Aluminium Kurri Kurri Pty Ltd (Hydro) to inform a Capped Waste Stockpile Waste Management Options Analysis (the Management Options Analysis) for submission to the Environmental Protection Authority (EPA). This CERA was prepared to assess the ecological risk from the identified Management Options for the Capped Waste Stockpile (CWS) at the former Hydro Aluminium Kurri Kurri aluminium smelter at Hart Road Loxford (the Smelter).

1.1 Background

The objective of the Management Options Analysis report relevant to this CERA is to prepare a report for submission to the EPA that provides a detailed assessment of the options considered for the management of the wastes within the CWS (the Management Options).

The rational for, and background to, the identified Management Options is detailed in **Section 2** and **Section 3** of the Management Options Analysis. Six options (Management Options 2 to 7) have been identified for the management of the wastes within the CWS and for comparison against a do nothing scenario. These Management Options are the subject of the Management Options Analysis and this CERA. A brief description of each of the CWS Management Options is provided in **Table E1.1**.

Table E1.1: Capped Waste Stockpile Waste Management Options

Option	Description	Outline
Do Nothing	CWS remains *in situ*	The CWS would remain in its current location, with no improvement works. Ongoing groundwater, leachate and gas monitoring would occur at the CWS. Visual inspections would also be required to identify any faults in the capping layer. Long-term management and maintenance would comprise vegetation cover maintenance such as mowing, weed and tree/deep rooted plant removal and cap repairs as required.
2	Containment Cell	Removal of the CWS and onsite transport of materials for placement in an onsite Containment Cell. This would involve ongoing long term monitoring and maintenance of the Containment Cell for leachate, gas and any visual changes.
3	Sorting of Recyclables from the CWS and Treatment of Non-Recyclables Placed in Containment Cell	Removal of the CWS and onsite transport of materials for placement in an onsite Containment Cell. Potentially recyclable materials from the CWS (steel and carbon) would be sorted, cleaned, validated and make available for recycling. Non-recyclable materials from the CWS would be crushed prior to being treated to comply with the Chemical Control Order (CCO) and placement in the onsite Containment Cell. The ongoing maintenance and monitoring of the onsite Containment Cell would be as per Management Option 2.
4	Treatment of All Material within Containment Cell	Removal of the CWS and placement of all materials in the onsite Containment Cell with layers of lime interlayered with the placed CWS material. This option does not include any recycling or sorting of material. The ongoing maintenance and monitoring of the onsite Containment Cell would be as per Management Option 2.
5	Offsite Disposal of CWS to Licensed Waste Facility in NSW	Removal of the CWS, separation of the steel for cleaning and recycling and transport of the remaining waste offsite to a licensed waste management facility/facilities in NSW. Treatment to comply with the COO would occur at the receiving facility. There would be ongoing maintenance and monitoring at the receiving waste management facility/facilities.
6	Offsite Disposal of CWS to Salt Mine	Removal of the CWS material, separation of the steel for cleaning and recycling and heat treatment of the remaining material to 600 °C (in an onsite purpose built facility) prior to transportation offsite via road and rail to a salt mine in the Northern Territory. The receiving facility would dispose of the CWS material without further treatment. There would be ongoing maintenance and monitoring at the receiving waste management facility.
7	Onsite Destruction (Plasma Gasification) of CWS Material	Removal of the CWS material, separation of the steel for cleaning and recycling with the remaining waste material being subject to an onsite plasma gasification process to remove fluorides and cyanides. By-products of the plasma gasification process would include vitrified rock (slag) and elemental metal which would theoretically be suitable for a beneficial re-use.

1.2 Comparative Ecological Risk Assessment Objectives

The purpose of this CERA is to provide Hydro with robust and relevant ecological risk information to assist in the selection of the best remediation option for the CWS. The risk assessment will be used to identify, and where possible, quantify, the risks, if any, posed to offsite ecological receptors as a result of the different Management Options being considered for the CWS material.

1.3 Comparative Ecological Risk Assessment Methodology

The 2013 revision of the National Environment Protection (Assessment of Site Contamination) Measure (the NEPM) includes a Guideline on Ecological Risk Assessment (Volume 6, Schedule B5a; NEPC 2013). The Guideline describes the process of ERA for the assessment of "risk posed to terrestrial ecosystems (including soil processes, soil flora and fauna, and terrestrial invertebrates and vertebrates) from adverse effects of chemical contaminants in soil" (p.2). The derivation of ecological investigation levels (EILs) for offsite aquatic effects are specifically discussed in Schedule B5c, and in ANZECC (2000).

NEPC (2013) states that an "*ERA requires an integrated approach, using multiple lines of evidence gathered from physical, chemical and biological data combined with site-specific data about exposure, toxicological and chemical parameters and the consideration of properties of soil, sediments and water relevant to the site, in order to estimate the level of effects. The movement of contaminants from soil to other environmental media (that is, air, water or sediment) and subsequent exposure to biota should be included in the ERA"* (p.2)

Furthermore, the "*risk-based process is inextricably linked to the principles of ecologically sustainable development (ESD). ESD aims to protect biodiversity and maintain ecological processes and functions and it is a central paradigm to both Australian and international environmental regulations and policies. However, it is also acknowledged that all human activity impacts on the environment and hence it is not possible to protect all species, processes and functions. Rather, it is necessary to manage the risks associated with various human activities in order to achieve the goals of ESD"* (p.2).

The framework for conducting ERAs was simplified in 2013 and now consists of two levels: a Preliminary ERA and a Definitive ERA (NEPC 2013). Preliminary and Definitive ERAs both consist of the same five basic components (NEPC 2013):

1. **Issues identification** is a scoping phase that establishes the objectives of the ERA and identifies the data required to achieve those objectives. It is essential that engagement with various stakeholders is undertaken early in this phase to provide opportunities for their input.
2. **Receptor identification** focuses on 'what species may be at risk?' and 'what do we want to protect?' Of importance in this phase is the need to introduce the concept of what is acceptable risk in the context of the ecological values that need to be protected. This requires the identification of local species, communities and ecological processes that are of ecological value based on the relevance and significance of societal, cultural, ecological, and economic factors.
3. **Exposure assessment** characterises the site, identifies potential exposure pathways and estimates exposure duration, concentrations and intakes.
4. **Toxicity assessment** involves estimating the concentration of contaminants at which species and ecological functions experience no harmful effects and those at which toxic effects are caused. This data is in turn used to determine the concentration of contaminants that an ecosystem can be exposed to without adverse effect or with adverse effects of a certain magnitude (i.e. EILs).
5. **Risk characterisation** involves combining data and information from the exposure and toxicity assessments to determine the risk that ecosystems at the site face from the contaminants. This is usually done by comparing the measured contaminant concentrations with the EILs.

On completion of the five ERA steps a decision on risk management is developed based on the calculated risk characterisation within the context of external risk management factors, such as social, economic, cultural and engineering aspects.

Ideally, site-specific EILs are derived to focus the ERA on the specific characteristics of the investigation area and to account for receptors of most interest. However, sufficient high quality environmental and toxicology data required to underpin the EIL derivation process are not always available for each investigation site. For this reason, the first stage in ERA typically involves screening the available environmental data against generic guideline values (GVs). Parameters (e.g. contaminants) that fail the initial screening process are further investigated to assess whether their concentrations represent an unacceptable risk to the receptors, and if so, to undertake the more detailed 'comprehensive' ERA.

The scope of work undertaken to achieve the project objectives follows that recommended in guidance for assessing risk to the environment in Australia as provided in:

- Schedule B5 Guideline on Ecological Risk Assessment, National Environmental Protection (Assessment of Site Contamination) Measure (NEPM). National Environment Protection Council, Australia (NEPC 2013).

In addition, the following guidelines for the assessment of contamination and environmental quality were also considered within the ERA approach, where relevant:

- Guidelines for Consultants Reporting on Contaminated Sites. Office of Environment & Heritage, NSW Government (OEH 2011)
- Guidelines for the Assessment and Management of Groundwater Contamination. Department of Environment and Conservation NSW (DEC 2007)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC 2000)

1.4 Report Structure

The remainder of this report is structured as follows:

Section 2: Existing Environment

Section 3: Issues Identification

Section 4: Receptor Identification and Exposure Pathways

Section 5: Exposure Assessment

Section 6: Risk Characterisation

Section 7: Loss of Ecological Habitat

Section 8: Conclusions

Section 9: References

Section 10: Limitations

Appendices

2. EXISTING ENVIRONMENT

Site description information presented below is considered relevant for the CERA when identifying the exposure scenarios likely to result from the different CWS Management Options.

2.1 Site Layout and Description

The Smelter is located approximately 30 km west of Newcastle and 150 km north of Sydney, in New South Wales, Australia. The smelter is located off Hart Road in Loxford and includes a 60 ha plant area and a 2,500 ha buffer zone. The buffer zone consists of areas of remnant native vegetation including wetlands, the Wangara farming property (used for cattle grazing), the Loxford Park Junior Raceway (sealed motorcycle track) and residential areas (leased by Hydro to local residents). The township of Kurri Kurri lies just over 2 km south of the Smelter and a mix of cleared and partially cleared agricultural land lies west, east and north of the Smelter.

The CWS is located near the eastern boundary of the Smelter and occupies an area of approximately 22,100 m^2. The CWS is a stockpile of mixed waste derived from early smelter operations between 1969 and 1992. An estimated 100,000 m^3 of mixed wastes, including Spent Pot Liner (SPL), anodes, scrubber bags, concrete, brick, bulk waste, fines and other smelter wastes were stored in this area; the stockpile was subsequently capped with clay in 1995. Investigations commencing in the mid-1980s identified that the original uncapped method of waste storage had resulted in leachate impacts to groundwater down-gradient of the CWS and that a plume of leachate-impacted groundwater extended approximately 250 m into the buffer zone to the north-east of the CWS. The capping of the Alcan Mound in 1995 was designed to address the leachate issue by reducing the infiltration of rainwater through the CWS.

The CWS and associated leachate-impacted groundwater were subsequently identified as 'Area of Environmental Concern 1' (AEC1) in the Phase 2 Environmental Site Assessment completed by Ramboll Environ in 2012. **Figure E1, Appendix E1** shows the location of the CWS and main features mentioned in the text.

2.2 Environmental Setting

The Smelter includes the smelter facility (60 ha) and a buffer zone of approximately 2,500 ha. The buffer zone consists of areas of remnant native vegetation, farmland and wetlands. Information pertaining to the local ecology is based on EIA reports prepared for the various development stages of the Smelter, supplemented with additional information obtained from online biodiversity databases managed by State and Commonwealth government agencies. Hydro also conducts routine sampling and survey of terrestrial species, from which additional information has been sourced.

2.2.1 Topography

The local topography ranges from 8 m AHD on the eastern margin adjacent to Swamp Creek to 20 m AHD on the western boundary of the Smelter, with typically gentle to moderate slopes across the intervening area (Croft & Associates 1980). The CWS and AEC1 are located on low lying, relatively flat land that straddles the central eastern portion of the Smelter site and the eastern buffer zone. The natural gradient slopes down in a north-easterly direction.

The CWS consists of a clay-capped hill approximately 130 m by 160 m, with steep sides and a maximum elevation of 25 m AHD.

2.2.2 Hydrology

Surface water runoff from the Smelter site is directed to a number of 'surge ponds'. The East Surge Pond is located to the north of the CWS on the eastern boundary of the Smelter (**Figure E1, Appendix E1**), and receives surface water runoff from the Smelter site via an open channel. Excess water from the East Surge Pond is pumped to the North Surge Pond and/or the North Boundary Dam where water is discharged under licence to an irrigation area within the buffer zone. All of the surface water ponds and dams were constructed by excavation into the residual clay underlying weathered bedrock.

Swamp Creek lies approximately 500 m east of the Smelter and flows in a northerly direction into Wentworth Swamps. Black Waterholes Creek and several smaller unnamed creeks run in a predominantly northerly direction along the western and northern side of the Smelter, eventually entering Wentworth Swamp from the southwest.

Within the buffer zone, surface water is distributed via infiltration into sandy soils, with some overland flow occurring. In the east, excess surface water flows through natural depressions to Swamp Creek, which is the closest 'natural' surface water receptor to the CWS. Swamp Creek flows north and discharges into Wentworth Swamp approximately 2 km north of the Smelter. Water from the Wentworth Swamp eventually discharges to the Hunter River near Maitland, approximately 15 km northeast of the Smelter.

Swamp Creek and the Wentworth Swamp are within the Fishery Creek Catchment, where declining stream water quality and a reduction in diversity of native plants and animals has occurred due to human population growth and development pressures within the catchment over the last ten years (Worley Parsons 2013).

2.2.3 Geology

According to the Geological Series Sheet 9312 (DMR 1993), the regional geology at the site comprises alluvial sediments of Quaternary age associated with the erosional and depositional environments of the Hunter River. The sediments include point bar, levee, overbank and alluvial terrace deposits, which are highly variable both horizontally and vertically and show extensive inter-fingering and inter-lensing. The alluvial sediments are underlain by siltstone, marl and minor sandstone from the Permian aged Rutherford Formation (Dalwood Group) in the Sydney Basin.

The Smelter is located within the Hexham and Hunter land systems, which are characterised by freshwater swamps and underlain by dark sandy and sandy-clay soils that can be high in organic matter. Soils vary greatly in texture and consistency from sands to clayey soils of medium to high plasticity. Profiles are generally indicative of high water tables and water-logged ground conditions and the variable and complex nature of the sedimentary layers is a result of the deposition of the sediments in an alluvial environment with a meandering river system migrating across the historical flood plain (Croft & Associates 1980).

2.2.4 Hydrogeology

Regional groundwater follows topography flowing northeast towards Swamp Creek although the complexity of the system likely results in discontinuities occurring within the flow pathways. Groundwater aquifers are present within both bedrock and unconsolidated sediments. The topography and the presence of surface water bodies such as Swamp Creek, Black Waterholes Creek and Wentworth Swamp are expected to influence the regional groundwater flow regime.

Seventeen licensed groundwater abstractions (bores) are located within the Smelter's buffer zone (Office of Industry and Investment, NSW), although the bores were installed for monitoring purposes, not for stock watering or domestic water use.

Groundwater aquifers in the immediate vicinity of the CWS comprise near-surface aquifers within a complex system of relict braided alluvial channels. One such channel is present beneath the CWS and trends northeast extending to depths of between 0.6 and 3.2 m below ground surface (bgs). The presence of local topographical changes and lenses of lower permeability strata within the geological sequence results in the discharge of shallow groundwater from this aquifer to surface water in areas along the channel path. These seep zones form localised areas of overland surface water flow.

The presence of a semi-continuous clay aquitard has been identified in most locations where investigation drilling has continued to depth. Sand lenses are identified beneath the clay aquitard extending to at least 15 m bgs and it is likely that these sand lenses also form part of a relict braided alluvial system and that the clay aquitard is remnant of a period of floodplain or swamp environment. The clay aquitard acts to mitigate the vertical and horizontal movement of groundwater from the shallow relict channel systems.

2.2.5 Aquatic Environment

Surface water features within and adjacent to the Smelter include artificial surge ponds within the Smelter grounds, small creeks, ephemeral soaks and overland drainage lines within the buffer zone. With the exception of the surge ponds and Swamp Creek, the majority of surface water features within the Smelter's buffer zone are ephemeral and do not support permanent aquatic communities.

East of the CWS there is a small ephemeral dam near the motorcycle track, a semi-permanent dam immediately up-gradient of Swamp Creek and Swamp Creek itself. West of the Smelter there are a number of small ephemeral drainage lines, including Black Waterholes Creek and the 'unnamed watercourse' that runs along the western boundary of the Smelter.

The surge ponds are not included in this assessment as their main purpose is for the onsite management of storm water. The surface water features of interest in this risk assessment include:

- A semi-permanent dam forms an elongated feature that runs roughly north-south along the western bank of Swamp Creek and is perched several metres above the level of the creek. The semi-permanent dam is fed from an ephemeral dam along a meandering gully that runs along the northern boundary of the motorcycle track property. The dam is likely to contain water for most of the year although may dry during extended periods without rainfall. The approximate dimensions of the dam are 150 m x 30 m.
- Swamp Creek runs roughly north-south along the boundary between the outer margin of the vegetated buffer zone to the east of the CWS and the predominantly cleared agricultural land further east. In its natural state the creek would be considered ephemeral; however, treated effluent is discharged directly into Swamp Creek from the Kurri Kurri Wastewater Treatment Works located 2.5 km upstream and diffuse runoff occurs from surrounding agricultural and urban areas. Swamp Creek varies in width but is up to 10 m wide. Water depth is unknown and variable depending upon the in-stream topography and time of year.
- The 'unnamed watercourse' that runs northwards along the western boundary of the Smelter originates in agricultural land on the northern outskirts of Weston (southwest of the Smelter). The drainage lines associated with the watercourse upstream of the Smelter would be mainly ephemeral considering the number of agricultural dams that have been built along its length. Downstream of the Smelter, the watercourse would only flow after significant rainfall although there are a number of small waterholes which may be semi-permanent. The watercourse flows into the southwestern 'arm' of Wentworth Swamp.
- Black Waterholes Creek originates west-southwest of the Smelter and runs north-easterly via a series of ephemeral drainage channels into the southwestern arm of Wentworth Swamp. The nearest this creek system approaches the Smelter is approximately 350 m, at a point west of the proposed containment cell footprint.

Due to the highly ephemeral nature of the soaks, overland drainage lines and most of the small dams/waterholes, these features will not continuously support aquatic invertebrates or fish species, and are unlikely to provide a reliable source of water for other wildlife species. In contrast, the semi-permanent dam perched above Swamp Creek is known to support a range of aquatic invertebrate species, fish and water plants, and wildlife species such as birds and mammals are likely to utilise the dam water for drinking, and waterfowl are known to occur on the dam.

Due to their perennial nature, Swamp Creek and Wentworth Swamp are expected to provide a reliable source of water for a range of terrestrial species (including livestock) and are known to support aquatic plant species, invertebrates, fish and water birds.

2.2.6 Terrestrial Environment

Flora

Various vegetation assemblages have been described for the Smelter's buffer zone (Croft & Associates 1980, Hydro 2007, ELA 2016). There is no evidence of old growth vegetation within the buffer zone and most areas have been highly disturbed in the past through clearing, easements for overhead power lines, vehicle access tracks, and regular fires. Blocks of native vegetation, mainly north and west of the Smelter, are reported to be in good condition with relatively few introduced species, and retaining a large proportion of their natural biodiversity (Hydro 2007).

ELA (2016) indicated two types of remnant vegetation found in the buffer zone that are listed as Endangered Ecological Community (EEC) in Schedule 3 of the *Threatened Species Conservation Act, 1995* (TSC Act):

- *Kurri Sand Swamp Woodland in the Sydney Basin Bioregion.* This community consists of a highly variable vegetation type mostly occurring on sandy soils and comprising a number of combinations of canopy and understorey species (Bell 2004 referenced in ELA 2016). Canopy species include *Angophora bakeri*, *Corymbia gummifera*, *Eucalyptus agglomerata*, *Eucalyptus resinifera*, *Eucalyptus parramattensis* subsp. *decadens*, *Eucalyptus fibrosa*, *Eucalyptus punctata*, *Eucalyptus racemosa*, and *Eucalyptus capitellata*. Scrub and heath variants are also present, where a stunted and widely spaced canopy of trees occurs (Bell 2004 referenced in ELA 2016).
- *Lower Hunter Spotted Gum - Ironbark Forest in the Sydney Basin Bioregion.* The canopy is dominated by *Eucalyptus fibrosa* (red ironbark) with Corymbia maculata (spotted gum) being absent from this area. The mid-storey of this community is dominated by *Melaleuca nodosa* (prickly-leaved paperbark) and *Bursaria spinosa* (blackthorn), with a diverse native ground layer also present. This community appears to have a history of timber harvesting, with few large or hollow-bearing trees now present in the area (ELA 2016, p.21).

Four threatened flora species were detected within the broader study area (ELA 2016). *Eucalyptus parramattensis* subsp. *decadens* is a dominant or co-dominant canopy species throughout much of the Kurri Sand Swamp Woodland within the study area. *Grevillea parviflora* subsp. *parviflora* was also found in scattered patches throughout much of the Kurri Sand Swamp Woodland within the study area and was particularly abundant within and directly adjacent to the large power easements to the north and south of the Project site (ELA 2016).

The area east of Swamp Creek and east of the Wentworth Swamp consists of cleared farmland for cattle grazing (Wangara Property). Woodland/forest vegetation and areas of Wentworth Swamp on Hydro-owned land have been fenced to prevent livestock from accessing these areas. This fencing aims to promote natural regeneration of native plant species.

Fauna

In total 167 fauna species were recorded within the study area by ELA (2016), consisting of 15 microbat species, a further 15 non-bat mammal species, 110 bird species, 15 reptile and 12 amphibian species.

ELA (2016) reported ten threatened and six listed migratory fauna species detected within the Hydro land (the study area), with two threatened fauna species - squirrel glider (*Petaurus norfolcensis*) and little lorikeet (*Glossopsitta pusilla*) - recorded within and surrounding the proposed footprint for the containment cell.

The Hydro property is located within the Hunter River drainage basin. Fish species which have been recorded from the Hunter River Drainage Basin (Harris & Gerhke 1997) include: long-finned eel (*Anguilla reinhardtii*), striped mullet (*Mugil cephalus*), freshwater mullet (*Myxus petardi*), bullrout (*Notesthes robusta*), mountain galaxias (*Galaxias olidus*), flathead gudgeon (*Philypnodon grandiceps*), dwarf flathead gudgeon (*Philypnodon* sp. 1), striped gudgeon (*Gobiomorphus australis*), freshwater herring (*Potamalosa richmondia*), Cox's gudgeon (*Gobiomorphus coxii*), Australian smelt (*Retropinna semoni*), sprat (*Herklotsichthys castelnaui*), freshwater catfish (*Tandanus tandanus*) and Australian bass (*Macquaria novemaculeata*). Three introduced fish species - goldfish (*Carassius auratus*), mosquito fish (*Gambusia holbrooki*) and common carp (*Cyprinus carpio*) - are also known to occur within the Hunter River drainage basin.

There is no current information regarding the presence of specific fish species within the Hydro lands or adjacent areas.

Fourteen amphibians species have previously been recorded during surveys (Hydro 2004), namely the common eastern froglet (*Crinia signifera*), eastern banjo frog (*Limnodynastes dumerilii*), brown-striped frog (*Limnodynastes peronii*), spotted grass frog (*Limnodynastes tasmaniensis*), ornate burrowing frog (*Limnodynastes ornatus*), bleating tree frog (*Litoria dentata*), green reed frog (*Litoria fallax*), brown toadlet (*Pseudophryne bibronii*), smooth toadlet (*Uperoleia laevigata*), eastern dwarf tree frog (*Litoria caerulea*), green thighed frog (*Litoria brevipalmata*), broad-palmed frog (*Litoria latopalmata*), Peron's tree frog (*Litoria peronii*) and the leaf-green tree frog (*Litoria phyllochroa*). Many of the amphibian species were recorded in a variety of habitat types. Some of these species are expected to occur in permanent or semi-permanent surface water features.

Ten reptile species were recorded during surveys in 2004 (Hydro 2004), namely the eastern snake-necked turtle (*Chelodina longicollis*), lace monitor (*Varanus varius*), jacky lizard (*Amphibolurus muricatus*), eastern water dragon (*Physignathus lesueurii* subsp. *lesueurii*), southern rainbow skink (*Carlia tetradactyla*), heath monitor (*Varanus rosenbergi*), copper-tailed skink (*Ctenotus taeniolatus*), blackish blind snake (*Ramphotylphlops nigrescens*), red-bellied black snake (*Pseudechis porphyriacus*) and yellow-faced whip snake (*Demansia psammophis*). All reptiles recorded were either uncommon or recorded on one occasion only.

Twenty-six native mammal species were recorded during fauna surveys (Hydro 2004). Many of the mammals recorded were bats, comprising 11 of the 26 mammal species recorded. A number of the bat species roost in caves (e.g. little bentwing bat [*Miniopterus australis*] and southern myotis [*Myotis macropus*]), while others roost in tree hollows (e.g. Gould's wattled bat [*Chalinolobus gouldii*], chocolate wattled bat [*Chalinolobus morio*] and little forest bat [*Vespadelus vulturnus*]).

Other native mammal species recorded include the common brushtail possum (*Trichosurus vulpecular*), eastern grey kangaroo (*Macropus giganteus*), red necked wallaby (*Macropus rufogriseus*), swamp wallaby (*Wallabia bicolour*), short-beaked echidna (*Tachyglossus aculeatus*), common ringtail possum (*Pseudocheirus peregrinus*), brown antechinus (*Antechinus stuartii*), common dunnart (*Sminthopsis murina*), common wombat (*Vombatus ursinus*), sugar glider (*Petaurus breviceps*) and feathertail glider (*Acrobates pygmaeus*) (Hydro 2004).

A total of 68 to 95 bird species have been reported for the buffer zone during annual avifauna surveys conducted between 2006 and 2009. During November 2009, 92 native bird species – 25 water birds, three raptors and 64 woodland or forest birds – and three introduced species were recorded. None of the observed species were listed as threatened under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*, and only one species – the Grey-crowned Babbler (*Pomatostomus temporalis temporalis*) – is listed under the NSW *Threatened Species Conservation Act 1995*.

2.2.7 Introduced Pests

Hydro's property management activities includes management of introduced pests on Hydro lands. Survey records for introduced pests include eleven terrestrial weed species (e.g. lantana, blackberry, pampas grass), two aquatic weed species (e.g. *Salvinia* and water hyacinth) and feral animals (e.g. wild dogs, foxes, cats, pigs, rabbits). European carp (*Cyprinus carpio*) are known to occur in the permanent waterways such as Wentworth Swamp, Swamp Creek and associated waterholes. Some of these introduced species have the potential to cause degradation of habitats through intensive grazing and foraging, and by predation of and competition with native species.

2.3 Capped Waste Stockpile

A full discussion of the CWS is provided in **Appendix 2** of the *Capped Waste Stockpile Waste Management Options Evaluation Study* (Ramboll Environ 2017). The information provided below is included here due to its relevance to the assessment of risk to the ecological receptors, primarily from leachates derived from the waste material.

2.3.1 Groundwater Quality

Groundwater is monitored across the site by Hydro. Four of the CWS remediation options under consideration involve keeping the waste material onsite, either retained in its current form within the undisturbed CWS or relocated to a purpose-built containment cell at the northwest corner of the Smelter. Each of these four options has the potential to generate leachates from the waste, with leachates considered to be the primary source of risk to the local ecology, and therefore leachates are the primary focus for this ecological risk assessment.

The assessment of ecological risk from leachates is based on our current understanding of leachate characteristics derived from groundwater monitoring beneath the CWS and in down-gradient areas to the east of the CWS where investigations of ecological risk associated with an existing leachate-impacted groundwater plume have previously been undertaken (Environ 2013a,b). Considering that leachate-impacted groundwater could potentially only surface in areas down-gradient from the waste stockpile (CWS or containment cell), where the shallow aquifer intersects with surface topography, the previously reported concentrations of priority contaminants of potential concern (CoPC) in shallow groundwater and/or surface water features in down-gradient areas have been used as an indication of potential exposure risk to the ecology.

A leachate-impacted groundwater plume originating from the CWS has been monitored via a network of 25 monitoring wells installed down-gradient of the CWS, and data from 14 monitoring events between July 2013 and March 2017 have been reviewed. In the offsite well network, 17 wells target shallow groundwater (≤2 m bgs) and 11 wells target deeper groundwater (≥5 m bgs). Shallow groundwater intersects with the ground surface more frequently than deep groundwater, and therefore the concentrations reported in shallow groundwater are most applicable for the assessment of potential risk to the ecology.

The leachate plume is characterised by alkalinity (pH>9), elevated electrical conductivity, elevated soluble fluoride and free cyanide; and has migrated approximately 250 m northeast into the buffer area. In 2016, two additional shallow wells (G5, G6) were installed adjacent to Swamp Creek.

Offsite groundwater samples were analysed for soluble fluoride, free cyanide, total aluminium and pH; other parameters such as BTEX, TPH and PAH were either not detected or were below the adopted assessment criteria and therefore were not routinely analysed. The analytical results obtained between July 2013 and March 2017 are presented in **Appendix E2**.

A review of these data indicates that soluble fluoride and aluminium in the shallow aquifer have migrated down-gradient to the furthest well located approximately 250 m northeast from the CWS; and concentrations have fluctuated over time with no clear increasing or decreasing trends.

The maximum, average and 95% upper confidence limit (UCL) groundwater concentrations reported in the shallow wells located down-gradient from the CWS are summarised in **Table E2-1**.

Table E2-1: Chemical Concentrations in Shallow Groundwater Down-gradient of the CWS (mg/L)

Chemical [a]	Maximum Concentration (mg/L)	Mean Concentration (mg/L)	95% Upper Confidence Limit (mg/L) [b]	Ecological Assessment Criteria (mg/L)
Soluble Fluoride (n=148)	1100	277	357.1	1.0 [c]
Free Cyanide (n=83)	11	0.19	0.77	0.007 [d]
Total Aluminium (n=146)	1200	50	93.9	0.055 [d]
pH	10.71 [e]/8.1 [f]	8.55 [e]/7.6 [f]	8.7	6.5-9.0 [g]

Notes:

a) Concentrations down-gradient from the CWS between July 2013 and March 2017
b) 95% Upper Confidence Limit (UCL) calculated using the USEPA ProUCL v5.1
c) Site-specific assessment criteria (Environ 2013a)
d) Protection level for 95% of freshwater species (ANZECC 2000)
e) Maximum and mean pH value from down-gradient wells excluding Swamp Creek (*n* = 150)
f) Maximum and mean pH value for Swamp Creek only (*n* = 8)
g) Generic pH range for NSW Lowland Rivers (Table 8.2.8, ANZECC 2000)

The main scenario associated with leachate exposure is expected to occur for Do Nothing where the CWS remains in-place and leachate-impacted groundwater occurring down-gradient would be an ongoing issue. Management Options 2 - 4 involve a purpose-built, engineered Containment Cell with an integrated leachate management system for the capture of leachate and subsequent 'pump and treat' methods of leachate disposal. Under normal circumstances, leachate from the Containment Cell would be unable enter the local aquatic environment.

In conducting the CERA, we have assumed that the integrated leachate management system is fully functional and working to the design specifications as the basis for risk assessment. We have, however, also considered a 'worst-case' scenario where high volume rain events occurring during placement of CWS waste material into the Containment Cell cause loss of containment of rain-generated leachate. In this unlikely event, the assessment of risk to down-gradient receptors has been assessed using the surface water data collected from water features down-gradient of the existing CWS. We have assumed that these data are representative of leachate-impacted surface water within 300 – 500 m of the leachate source, which is directly relevant to surface hydrology adjacent to the proposed Containment Cell location.

2.3.2 Surface Water Quality

Potential risk to aquatic species is directly associated with CoPC concentrations in surface water (as opposed to groundwater) down-gradient from potential sources of contamination. Consequently, the physico-chemical data for surface water samples adjacent to the CWS were reviewed. In August and September 2012, surface water samples were collected at one semi-permanent dam and at three Swamp Creek locations down-gradient from the CWS; these data were used during the assessment of ecological risk associated with the groundwater plume from the CWS (Environ 2013a). Additional surface water samples were collected from a single location in Swamp Creek in September 2014 and another Swamp Creek location in June 2016, with analysis for soluble fluoride and pH. These later data were within the range reported in 2012 data and have been added to the data set for consideration in the CERA calculations. Summary statistics for soluble fluoride, total aluminium and pH are presented in **Table E2-2**.

Table E2-2: Surface Water Quality in the Semi-permanent Dam and Swamp Creek Locations Down-gradient of the CWS (mg/L)

Chemical	Maximum Concentration (mg/L)	Average Concentration (mg/L)	95% Upper Confidence Limit (mg/L)[a]	Ecological Assessment Criteria (mg/L)
Soluble fluoride (*n*=10)	21	5.68	15.49	1.0 [b]
Total aluminium (*n*=8)	2.0	0.88	1.40	0.055 [c]
pH (*n=10*)	8.1	7.63	7.80	6.5-9.0 [d]

Notes:

a) 95% Upper Confidence Limit (UCL) calculated using USEPA's ProUCL v5.1

b) Site-specific assessment criteria (Environ 2013a)

c) Protection level for 95% of freshwater species (ANZECC 2000)

d) Generic pH range for NSW Lowland Rivers (Table 8.2.8, ANZECC 2000)

Free cyanide was not detected in any surface water samples and is therefore not included as a CoPC in the CERA. The summary statistics for pH of surface waters are all within the recommended range for Lowland Rivers in NSW (ANZECC 2000) and therefore pH is not of concern with respect to ecological risk associated with surface waters. The 95% UCL concentrations for soluble fluoride and total aluminium exceed the adopted GVs and are therefore designated as priority CoPCs in this risk assessment.

2.3.3 Solid Waste Material

Do Nothing and Options 2 – 4 involve the retention of waste material onsite, either undisturbed within the existing CWS (Do Nothing) or transferred to a new engineered Containment Cell on the western side of the Smelter. The offsite ecological risk from solid material for these options is therefore categorised as negligible since no solid waste would be moved offsite. In contrast, Management Options 5 and 6 involve the transport of CWS solid material to offsite waste management facilities either intrastate or interstate, and there is an inherent risk of spillage of solid waste if a transport accident (truck or train) occurs along the transport route.

Spillage of solid waste alongside the transport route could involve either terrestrial or aquatic environments. In a terrestrial environment, the solid waste is likely to be completely removed within a short time period and the risk to ecology is considered negligible. Spillage of solid waste directly into an aquatic environment, while highly unlikely to occur, presents greater risk and this scenario has been included within the CERA as a conservative approach.

Potential risk from solid waste in aquatic environments is directly associated with the leachability of contaminants within the waste material. Hydro commissioned leachability testing of CWS waste material for the purposes of waste classification (Ramboll Environ 2017b). Total cyanide was assessed in accordance with the Australian Standard Leaching Potential (ASLP) using a pH neutral leaching solution, whereas fluoride was assessed in accordance with the toxicity characteristic leaching procedure (TCLP, Method 1311) using an acidic leaching solution (pH 2.88).

Table E2-3 includes a comparison of the total and leachable cyanide and fluoride concentrations to the site criteria and the allowable concentrations in the Chemical Control Order (CCO), with an indication of how many data points exceed the criteria. This comparison shows that leachable cyanide concentrations do not exceed the allowable concentration in the CCO. The maximum soluble fluoride concentration of 21,100 mg/kg does exceed the site criteria of 17,000 mg/kg, and the maximum leachable fluoride concentration of 909 mg/L was approximately six times the allowable concentration of 150 mg/L in the CCO; however, the 95% Upper Confidence Limit (UCL) of leachable fluoride in bulk CWS samples is 158.7 mg/L, which is only marginally above the CCO limit.

Following recommended guidance (e.g. ANZECC 2000, NEPC 2013), the 95% UCL concentration has been adopted as the basis for the assessment of potential risk to aquatic ecological receptors under a scenario where solid waste directly enters the aquatic environment as a result of vehicle accident during offsite transfer of CWS waste.

Table E2-3: Physico-chemical Characteristics of Capped Waste Stockpile Materials (Ramboll Environ 2017b)

Analyte	Units	Number of Samples Analysed	Min	Max	No. above GL
Waste Materials					
pH Value	pH Unit	18	6.3	11.4	N/A
Aluminium	mg/kg	0	0	0	N/A
Mercury	mg/kg	0	0	0	0
Total Cyanide	mg/kg	18	14	158	0
Total Cyanide (ASLP Leachate)	mg/L	18	0.198	8.54	0
Fluoride (total)	mg/kg	0	0	0	N/A
Fluoride (soluble)	mg/kg	18	184	21,100	3
Fluoride (TCLP Leachate)	**mg/L**	**18**	**68.9**	**909**	**15**
Total Polychlorinated biphenyls	mg/kg	0	0	0	0
Naphthalene	mg/kg	6	<0.5	8.1	0
Benzo(a)pyrene	mg/kg	6	<0.5	832	3
Sum of polycyclic aromatic hydrocarbons	mg/kg	6	0.5	6320	2
C6-C10 Fraction minus BTEX (F1)	mg/kg	0	0	0	0
>C16-C34 Fraction	mg/kg	0	0	0	0
>C34-C40 Fraction	mg/kg	0	0	0	0
>C10-C16 Fraction minus Naphthalene (F2)	mg/kg	0	0	0	0
Sum of BTEX	mg/kg	0	0	0	N/A
Naphthalene	mg/kg	0	0	0	0
Volatile Organic Compounds	mg/kg	7	various	various	N/A
Dibenzofuran	mg/kg	6	<0.5	44.4	N/A
Carbazole	mg/kg	6	<0.5	50.5	N/A

3. ISSUES IDENTIFICATION

As previously stated, six options are being considered for the remediation of the CWS and for comparison against Do Nothing.

1. **Do Nothing** – monitor and manage existing CWS in perpetuity.
2. **Onsite Containment Cell** – CWS removed without treatment and all material placed in a purpose-built Containment Cell.
3. **Recycling + Containment Cell** - CWS removed, recyclable materials extracted before non-recyclables are treated prior to placement in Containment Cell.
4. **Containment Cell with Treatment** – CWS removed, all material placed in Containment Cell by interlayering with lime or gypsum.
5. **Offsite Disposal, NSW** – CWS removed and transported to a licensed waste management facility (LWMF) in NSW.
6. **Offsite Disposal, NT** – CWS removed, heat treated and transported by road and rail to a Salt Mine in the Northern Territory.
7. **Plasma Gasification** – CWS removed and all material processed onsite by plasma gasification.

Do Nothing and Options 2 – 4 involve the retention of waste material onsite, Options 5 and 6 involve the transport of waste material to an offsite waste management facility, and Option 7 involves onsite processing of waste material, followed by deposition of inert waste product into existing (local) landfills.

The potential ecological risks vary with each Management Option. Leachates from waste material are considered to be the primary ecological risk driver for options where waste material is retained onsite (Do Nothing and Options 2 - 4). Note that the risk from leachates in offsite waste management facilities is presumed to be incorporated into the management plan and permit conditions for each facility and therefore has not been considered in this current assessment. However, risks associated with the transport of waste material offsite have been included with respect to the potential for vehicle accidents and the loss of solid waste material into the environment enroute to each waste management facility.

Risks to ecology from onsite Plasma Gasification (Option 7) are deemed to be negligible considering the end-product is an inert general waste, and the process includes the scrubbing and/or collection of the various gas and metallic products.

4. RECEPTOR IDENTIFICATION AND EXPOSURE PATHWAY

Leachates from waste stockpiles represent the primary concern for ecological risk.

Solid waste material would either be retained within the existing CWS (Do Nothing), extracted under controlled conditions (Options 2 – 7) and transported, with or without separation of recyclable materials, to the purpose-built containment cell (Options 2 - 4), transported offsite using covered trucks and/or trains (Options 5 and 6), or transferred to the onsite Plasma Gasification plant (Option 7).

In each case other than Do Nothing, the solid waste material would be extracted from the existing CWS using excavators and/or other plant, loaded onto trucks and moved via roadways to the deposition location. For Options 2 – 4, the onsite roads would be regularly maintained via grader to remove any spilt waste material so there would be little opportunity for solid waste to be released into the natural environment under those options. Offsite transport of waste material would be undertaken using appropriately covered trucks and/or trains, with no opportunity for loss of solid waste material to the environment, except in the case of vehicle accidents.

Consequently, the ecological receptors focused on in this risk assessment are those that could be exposed to leachate in areas where impacted groundwater may intersect with the ground surface and become surface water, or stormwater runoff from the stockpiled waste interacts with nearby surface water features. The main areas of potential exposure are in the local creeks and the receptors of interest are therefore aquatic species residing in any semi-permanent or permanent surface water features, since aquatic communities (invertebrates, water plants and fish) cannot develop and be maintained within ephemeral water features.

Contaminants of potential concern (CoPCs) in surface waters may become an issue for ecological receptors that are dependent on water for survival, such as aquatic species or terrestrial species that utilise water sources for drinking and/or species that consume aquatic plants and animals. Once CoPCs are present in environmental media, such as surface waters and sediments, a variety of organisms may be exposed to them via different exposure pathways. Exposed organisms are referred to as 'receptors'. An exposure pathway has five parts:

- Source of contaminants (e.g. the CWS)
- Environmental medium and transport mechanism (e.g. leachate contaminated surface water moving down-gradient)
- Point of exposure (e.g. Swamp Creek)
- Route of exposure (e.g. dermal absorption)
- Population of receptors (e.g. fish)

The exposure pathway is viable and potentially capable of causing unacceptable risks only when all five parts are present. Identification of receptors initially relies on the identification of functional groups or feeding 'guilds' that are representative of, or essential to, habitat function. Based on the environmental setting, the feeding guilds potentially exposed to CoPCs via complete exposure pathways and their dominant exposure routes from surface waters are those considered in the earlier ERA (Environ 2013a), specifically:

- Terrestrial fauna (via ingestion of drinking water)
- Aquatic plants (via direct contact with surface water and/or sediment)
- Aquatic invertebrates (via direct contact with surface water)
- Fish (via gill exchange with surface water)
- Aquatic birds (via ingestion of drinking water and aquatic species)
- Cattle (via ingestion of drinking water)

Although populations of herpetofauna (reptiles and amphibians) are valued ecological entities, the current state-of-the-art techniques for risk assessment are insufficient to adequately incorporate herpetofauna in risk analysis with acceptable levels of uncertainty. Generalisations from fish (and aquatic invertebrates) are somewhat applicable to the herpetofauna receptor group, so that the risks to herpetofauna are estimated by using these other receptor groups as surrogates.

Most healthy ecosystems support a large number of individual species representing a variety of feeding guilds, and it is not feasible to complete risk calculations for all potentially exposed species. Moreover, such an effort would be duplicative because of the similarity of exposure patterns among closely related species and among those with similar feeding habits. For these reasons, a range of receptors of interest (ROIs) are selected to represent the different feeding guilds and their selection is primarily based on ecological relevance, potential for high exposure, toxicological sensitivity and expected presence in the area of interest.

Using the list of available flora and fauna species for the area of interest, either confirmed or expected, the main groups identified as potential ecological ROIs are:

- Aquatic plants
- Aquatic invertebrates
- Fish
- Birds, including waterbirds
- Native mammals
- Cattle

These ROIs are considered to be among the most highly exposed and ecotoxicologically sensitive (i.e. susceptible) of the species likely to contact surface waters within the area of interest, so extrapolation of conclusions regarding these ROIs is assumed to be protective of other, less susceptible species. The focus for this CERA is on risks from contaminated surface water and therefore the main exposure pathway investigated for birds is via consumption of drinking water.

4.1 Conceptual Site Model

A conceptual site model (CSM) is a written description and visual representation of predicted relationships between ecological receptors and the stressors to which they may be exposed. This subsection provides a narrative description of the ecological CSM for the study area, and **Figure E2, Appendix E1** provides a tabulated depiction of the ecological CSM.

The detailed ecological risk assessment undertaken for leachate impacts from the CWS (Environ, 2013a) comprised an assessment of risk to terrestrial and aquatic species in areas down-gradient from the CWS (previously known as the 'Alcan Mound'). The results of that risk assessment are directly relevant for any of the Management Options that involve retention of the waste material onsite (Do Nothing and Options 2 – 4).

For those options involving offsite transport of waste material (Management Options 5 and 6), the assessment of risk includes consideration of vehicular accident where solid waste material could inadvertently enter the natural aquatic environment adjacent to the transport route. This aspect has different concentrations of CoPC to those assessed for waste leachates, using instead the toxicity characteristic leaching procedure (TCLP) results from testing of the bulk CWS waste material, although for consistency the same aquatic receptors have been assessed.

5. EXPOSURE ASSESSMENT

Exposure assessment is the process of measuring or estimating the magnitude, frequency, and duration of ROI exposures to CoPCs (USEPA 2017). The exposure assessment builds upon qualitative descriptions presented in the CSM in order to quantitatively estimate COPC exposures for each ROI. The exposure assessment reflects the exposures likely to occur in the ROIs evaluated, exposure routes specific to the area of interest and the selected measurement endpoints.

Exposure is based on the CoPC concentration in an environmental medium (water, sediment, soil) with respect to exposure routes such as direct contact with contaminated media, or ingestion of CoPCs in food or drinking water.

Quantitative assessment is undertaken when sufficient environmental data and toxicological data exist for a COPC and the data are relevant to the environmental setting under assessment. For quantitative assessments, the exposures are based on calculation of hazard quotients (HQs) which are defined as the ratio of the estimated exposure of a receptor at the site to a "benchmark" exposure that is believed to be without significant risk of unacceptable adverse effect:

HQ = Exposure / Benchmark

If the HQ value is less than or equal to 1, the risk of adverse effects in the exposed ROI is deemed to be low and acceptable. If the HQ is greater than 1, the risk of adverse effects in the ROI is of potential concern. The probability and/or severity of effect increases with increasing HQ values.

The detailed ecological risk assessment undertaken for leachate impacts from the CWS (Environ, 2013a) included quantitative assessment of risk from fluoride and aluminium to a variety of receptor groups associated with surface water features within the buffer zone east of the CWS. Those risk profiles are directly relevant to the current CWS Management Options where leachate impacted groundwater could interact with surface waters (Do Nothing and Options 2 – 4), and the data and risk profiles (i.e. HQs) from those earlier studies have been used to support the assessment of Management Otions in this report.

In addition, the underlying toxicity data have been used to assess the risk of spilt solid waste in aquatic environments adjacent to the transport routes, and to develop HQ for risks from vehicle accidents when CWS material is being transported to offsite facilities (Options 5 and 6). For consistency, the same receptors, dietary requirements, uptake factors and exposure scenarios used in the ERA at the Smelter (Environ 2013a) have been used to calculate risk to aquatic receptors within two theoretical roadside aquatic habitats – a small dam (0.45 ha) and a small creek. It is acknowledged that the actual receptors of importance to a particular location along the transport route would vary but it has been assumed that the range of feeding guilds and species types used in the initial assessment are representative of the likely receptors along the transport routes.

5.1 Exposure Assessment for Aquatic Plants

Exposures for the aquatic plants are evaluated based on concentrations of CoPCs in surface water. Aquatic plants are likely to occur only in semi-permanent dams and waterholes and in Swamp Creek, although they are also known to occur within areas of the ‘unnamed watercourse’ that runs along the western side of the Smelter, and possibly in a number of isolated waterholes in the lower reaches of Black Waterholes Creek. The COPC concentrations within these surface water features were used for individual exposure assessments for aquatic plants at each location.

5.2 Exposure Assessment for Aquatic Invertebrates

Exposures for the aquatic invertebrates are evaluated based on concentrations of CoPCs in surface water. Within the investigation area, aquatic invertebrates are likely to occur only in the semi-permanent dam and Swamp Creek, and possibly in a number of isolated waterholes in the lower reaches of Black Waterholes Creek. The COPC concentrations within these surface water features were used for individual exposure assessments for aquatic invertebrates at each location.

5.3 Exposure Assessment for Fish

Exposures for the fish populations are evaluated based on concentrations of CoPCs in surface water. Within the investigation area, fish are likely to occur only in the semi-permanent dam and Swamp Creek, and possibly in a number of isolated waterholes in the lower reaches of Black Waterholes Creek. The COPC concentrations within surface waters were used for exposure assessments for fish at these locations.

5.4 Exposure Assessment for Birds and Mammal Populations

Exposures for birds and mammals are estimated from concentrations of CoPCs in surface water. For most wildlife ROIs, measurement endpoints focus on the comparison of estimates of dose (in units of mg/kg/day) to published dose-based toxicity reference values (TRVs).

TRVs for Australian ROIs are lacking and therefore the exposure assessment for birds and mammals is based on published wildlife toxicity benchmarks from the US, using data for species that, as far as possible, are from similar taxonomic groups, trophic levels and body size.

5.5 Exposure Assessment for Cattle

The exposure assessment for cattle was based on a similar approach to that used for mammals and birds, whereby the TDI of CoPCs was calculated for ingestion via drinking water. Cattle water ingestion rates and body weights were obtained from published literature. The only water body within the investigation area that is accessible to cattle is Swamp Creek.

6. RISK CHARACTERISATION

Risk characterisation involves the integration of the exposure assessment and toxicity assessment to evaluate the likelihood, severity, and spatial distribution of predicted or observed effects. Risk characterisation involves mathematical comparison of exposure and effects estimates for each measurement endpoint. Exposure estimates that are below the relevant effects metric (i.e. surface water quality benchmark or TRV) indicate that adverse effects to a given ROI are unlikely. Exposure estimates that exceed the relevant effects metric indicate that further investigation is warranted to define the potential for adverse effects at the population level, as well as the spatial extent and severity of any such adverse effects (Barnthouse *et al*. 2008).

Evaluation of key uncertainties is an important element of the risk characterisation. Therefore, risk characterisation includes a discussion of the sources of uncertainty in the CERA and the effects of that uncertainty on the risk conclusions (i.e. whether each source of uncertainty is likely to lead to an overestimation or underestimation of the HQ). In many cases, unavoidable uncertainty in an ERA is balanced by purposefully conservative assumptions. Therefore, sources of conservatism in the CERA are also discussed.

HQ values previously derived for toxicity to birds and mammals from fluoride in surface waters within the semi-permanent dam and perennial Swamp Creek were all less than 1, indicating no unacceptable risks (Environ 2013a). HQ values previously derived for aquatic invertebrates and fish from fluoride in surface waters of the semi-permanent dam, and for aquatic invertebrates in Swamp Creek, marginally exceeded 1, indicating a potential risk (Environ 2013a). However, subsequent aquatic sampling in 2013 indicated no discernible difference in aquatic ecology within the semi-permanent dam and nearby reference dams as a result of elevated concentrations of fluoride in surface water and sediments (Environ 2013b). On this basis it was concluded in 2013 that the leachate-impacted groundwater from CWS does not pose an unacceptable risk to ecological receptors down-gradient from the CWS.

Similarly, the HQ values derived for toxicity from a roadside spill of solid CWS waste into two types of aquatic habitats – a small dam and a small creek – were less than 1 for most bird and mammal receptors (***Table E6-1***), the exceptions being Eastern yellow robin (HQ=4.78, HQ=13.3), little forest bat (HQ=2.62, HQ=2.92) and brown antechinus (HQ=1.73, HQ=4.80). HQ values for aquatic species (***Table E6-1***) were greater than 1 for invertebrates (HQ=90.9) and fish (HQ=63.2).

Table E6-1: Calculated Hazard Quotients for Receptors Exposed to Fluoride in Surface Water Impacted by Leachate and Solid Waste

Scenario	**Offsite Migration of Leachate from CWS [a] or Containment Cell**		**Solid Waste Spill during Offsite Transport**	
Location	**Semi-permanent Dam**	**Swamp Creek**	**Roadside Small Dam**	**Roadside Small Creek**
Exposure Point Concentration (mg/L)	**13.4 [b]**	**1.6 [b]**	**337 [c]**	**337 [c]**
Receptor of Interest				
Eastern yellow robin	0.30	0.06	**4.78**	**13.3**
Nankeen kestrel	3.77E-04	7.98E-05	6.05E-03	0.017
Pacific black duck	5.94E-06	5.03E-07	9.54E-05	1.06E-04
White-faced heron	2.01E-05	1.70E-06	3.23E-04	3.58E-04
Little forest bat	0.16	0.01	**2.62**	**2.92**
Brown antechinus	0.11	0.02	**1.73**	**4.80**
Brushtail possum	1.28E-03	2.71E-04	0.021	0.057
Eastern grey kangaroo	2.92E-03	6.17E-04	0.047	0.130
Aquatic invertebrates	**3.62**	**2.96**	**90.9**	**90.9**
Fish	**2.51**	0.30	**63.2**	**63.2**
Aquatic plants	*Fluoride criterion not available for aquatic plants*			
Livestock – dairy cattle	n/a	1.02E-05	7.73E-04	2.15E-03

Notes: *a Environ (2013a)*
b Environ (2013b)
c 95% UCL of Toxicity Leaching Procedure testing results for bulk CWS waste
values in bold indicate a possible inherent risk to receptor of interest (i.e. HQ above 1)

Note that these values are based on undiluted 95% UCL concentrations from TCLP testing of bulk waste and are likely to represent worst-case exposure scenarios since the receptors would have to be exposed at the direct point of entry of solid waste into an aquatic habitat to be at these risk levels. Realistically, exposures are more likely to occur at some point distant (e.g. metres or tens of metres) from the spill location and after some degree of dilution within each water body. Nevertheless, the risk assessment does indicate some level of risk for species that utilise aquatic habitats for drinking (birds and mammals) and for aquatic species under the scenarios assessed.

Risk characterisation is discussed independently for each of the CWS Management Options under consideration since each option has specific aspects that drive the assessment of risk. For comparative purposes the derived HQ values presented in ***Table E6-1*** are used as an indication of ecological risk, with a value of '1' conservatively representing the lowest risk. Note that since HQ values have been derived for multiple receptor groups for each scenario, the highest HQ value (potential worst case) has been used to designate the overall risk rating for each option. Note also that the HQ values previously derived for the CWS leachate issues (Environ 2013a,b) are used on the basis of the actual HQ values presented in ***Table E6-1*** despite additional lines-of-evidence indicating no unacceptable risk to ecological receptors down-gradient from the CWS (Environ 2013b).

For completeness, a number of additional exposure events have been considered for some of the Management Options, even though these events have a low likelihood of occurring. When estimating the potential ecological risk associated with these additional exposure events, it was assumed that they occur as a single isolated event rather than as cumulative risk associated with the Base Case scenario for each Management Option.

6.1 Do Nothing

Leaving the CWS *in-situ* with monitoring and management in perpetuity would essentially maintain the current situation where CWS leachate is being generated and not captured. This situation is associated with elevated fluoride and aluminium in down-gradient groundwater and surface water features east of the CWS, including Swamp Creek.

However, the CWS leachate-impacted groundwater plumes have been the subject of previous ecological risk assessments (Environ 2013a,b) in which no unacceptable risk to ecological receptors was identified for receptors that either utilise surface water for drinking or are resident in the aquatic habitats. On the basis of these conclusions, and the proposed *status quo* for the CWS associated with this option, the ecological risk characterisation for Do Nothing is designated as 'low' (4). The likelihood of leachate generation and release to the environment is high (i.e. certain) since there is no leachate collection/treatment option associated with the CWS in its current form.

The uncertainties pertain to the unknown level of leachate generated over time and whether the current impacts to groundwater (and downstream surface waters) would increase or decrease over time as the CWS waste continues to age.

Do Nothing			
Scenario:	**Risk Rating:**	**Likelihood:**	**Uncertainties:**
Base Case CWS *status quo* - leachate interaction with local groundwater and down-gradient surface water	**4** Based on previous ERA conclusions (Environ 2013a,b)	**Certain** No integrated leachate collection, CWS unlined, leachate migration	Unknown level of leachate impact to groundwater and surface water into the future
Additional Exposure Events			
Major Failure of CWS Loss of leachate to buffer zone	**4** Based on previous ERA conclusions (Environ 2013a,b)	**Highly Unlikely** Ongoing maintenance and monitoring of CWS	Unknown volume and quality of leachate reaching aquatic habitats if suddenly released into the buffer zone

6.2 Option 2 – Onsite Containment Cell

The Management Option involving construction of a purpose-built Containment Cell includes an integrated leachate containment system whereby any leachate from the waste material is captured, collected and treated offsite. This engineered solution to leachate generation is designed to prevent the release of leachates to the environment, and is an improved management approach compared to Do Nothing.

The integration of a leachate management system and the engineered design of the Containment Cell, including an impermeable geofabric lining and impermeable cap to prevent infiltration of rainwater into the waste, would reduce the generation of leachate and prevent any leachate entering the environment. This 'Base Case' has a Risk rating of '1' (Negligible).

A worst-case scenario, where leachate is inadvertently released under extreme rainfall conditions during placement of the waste into the Containment Cell, is included in this assessment. Leachate generated in the Containment Cell which is caused to overflow under an extreme rainfall event is assumed to have similar characteristics to the leachate derived from the existing CWS, and the effects on the quality of surface water down-gradient from the Containment Cell would be similar to the surface water assessed during the earlier ERAs (Environ 2013a,b). Hence, the conclusions of the earlier ERAs are directly applicable to any loss of leachate from the Containment Cell, if it were to occur, and the risk to ecological receptors from exposure to surface water features down-gradient from the cell is therefore expected to be low (Risk Rating of 4). The likelihood of leachate generation from the Containment Cell and subsequent release to the environment is also low, especially compared to the certainty of CWS leachate impacting shallow groundwater associated with Do Nothing. Additional scenarios of leachate tanker spills or overtopping, and major failure of the CWS are also assumed to have a similar Risk Rating of 4.

The key uncertainties associated with this assessment relate to the actual quality and volume of leachate that could inadvertently be released from the containment cell. The quality of leachate is unlikely to differ significantly from the existing leachate generated from the CWS since the waste material is the same. The volume of leachate is unknown and would depend upon the circumstance of leachate generation, i.e. the amount of rainfall and spatial extent of waste material affected by the rainfall.

Option 2 – Onsite Containment Cell			
Scenario:	**Risk Rating:**	**Likelihood:**	**Uncertainties:**
Base Case CWS waste transferred into a purpose-built Containment Cell with integrated leachate management system	**1** No release of leachate to the environment	**Certain** Due to engineered design and integrated leachate management system	Volume and quality of leachates is unknown but assumed to be similar to leachate currently being generated from the CWS
Additional Exposure Events			
Rainfall-induced Loss of Leachate Leachate generated from extreme rainfall event while waste material within the CWS and/or Containment Cell is exposed	**4** Leachate volume and quality assumed to be similar to leachate currently being generated from the CWS	**Unlikely** Due to engineered design and integrated leachate management system	Unknown volume and quality of leachate
Leachate Tanker Spills or Overtops Loss of leachate at filling point	**4** Small volume of leachate involved	**Unlikely** Due to leachate and vehicle management practices	Unknown volume and quality of leachate
Major Failure of CWS Loss of leachate to buffer zone	**4** Based on previous ERA conclusions (Environ 2013a,b)	**Highly Unlikely** Ongoing maintenance and monitoring of Containment Cell	Unknown volume and quality of leachate reaching aquatic habitats if suddenly released into the buffer zone

6.3 Option 3 – Onsite Containment Cell with Recycling

The removal of recyclable material from the CWS waste prior to the deposit of non-recyclable material into the containment cell is an intermediate step in the remedial process that would not affect the ecological risk profile compared to Option 2. Therefore, the risk profile for Option 3 is assumed to be exactly the same as for Option 2, and the worst-case scenario of leachate generation and loss from the containment cell has been assessed in a similar fashion for both options. That is, the conclusions of the earlier ERAs (Environ 2013a,b) are directly applicable to any loss of leachate from the containment cell, if it were to occur during an extreme rainfall event, and the risk to ecological receptors from exposure to surface water features down-gradient from the cell is expected to be negligible.

The risk rating for Option 3 is identical to Option 2. The likelihood and key uncertainties are also the same as for Option 3, and relate to the quality and volume of leachate. Additional scenarios of leachate tanker spills or overtopping, and major failure of the CWS are also assumed to have a similar Risk Rating of 4.

Due to the additional time required to sort and process recyclable materials from the CWS waste, Option 3 is expected to take longer to complete than the other options. Although the duration does not affect the ecological risk, the extended timeframe does increase the chance for extreme rainfall events impacting the waste material while it is being extracted from the CWS and deposited into the Containment Cell.

Option 3 – Onsite Containment Cell with Recycling			
Scenario:	**Risk Rating:**	**Likelihood:**	**Uncertainties:**
Base Case CWS waste transferred into a purpose-built Containment Cell with integrated leachate management system	**1** No release of leachate to the environment	**Certain** Due to engineered design and integrated leachate management system	Volume and quality of leachates is unknown but assumed to be similar to leachate currently being generated from the CWS
Additional Exposure Events			
Rainfall-induced Loss of Leachate Leachate generated from extreme rainfall event while waste material within the CWS and/or Containment Cell is exposed	**4** Leachate volume and quality assumed to be similar to leachate currently being generated from the CWS	**Unlikely** Due to engineered design and integrated leachate management system	Unknown volume and quality of leachate
Leachate Tanker Spills or Overtops Loss of leachate at filling point	**4** Small volume of leachate involved	**Unlikely** Due to leachate and vehicle management practices	Unknown volume and quality of leachate
Major Failure of CWS Loss of leachate to buffer zone	**4** Based on previous ERA conclusions (Environ 2013a,b)	**Highly Unlikely** Ongoing maintenance and monitoring of Containment Cell	Unknown volume and quality of leachate reaching aquatic habitats if suddenly released into the buffer zone

6.4 Option 4 – Onsite Containment Cell with Waste Treatment

The treatment of waste using lime (or a similar material) during deposition into the containment cell does not affect the assessment of risk associated with the use of a purpose-built containment cell as it merely reflects a minor variation to the process of waste deposition. Therefore, the risk profile for Option 4 is exactly the same as for Options 2 and 3, and the worst-case scenario of leachate generation and loss from the Containment Cell has been assessed in a similar fashion for all three options. That is, the conclusions of the earlier ERAs are directly applicable to any loss of leachate from the containment cell, if it were to occur during an extreme rainfall event, and the risk to ecological receptors from exposure to surface water features down-gradient from the cell is expected to be negligible.

The risk rating for Option 4 is identical to Options 2 and 3, as are the likelihood and key uncertainties. Additional scenarios of leachate tanker spills or overtopping, and major failure of the CWS are also assumed to have a similar Risk Rating of 4.

Option 4 – Onsite Containment Cell with Waste Treatment			
Scenario:	**Risk Rating:**	**Likelihood:**	**Uncertainties:**
Base Case CWS waste transferred into a purpose-built Containment Cell with integrated leachate management system	**1** No release of leachate to the environment	**Certain** Due to engineered design and integrated leachate management system	Volume and quality of leachates is unknown but assumed to be similar to leachate currently being generated from the CWS
Additional Exposure Events			
Rainfall-induced Loss of Leachate Leachate generated from extreme rainfall event while waste material within the CWS and/or Containment Cell is exposed	**4** Volume and quality of leachate assumed to be similar to leachate currently being generated from the CWS	**Unlikely** Due to engineered design and integrated leachate management system	Unknown volume and quality of leachate
Leachate Tanker Spills or Overtops Loss of leachate at filling point	**4** Small volume of leachate involved	**Unlikely** Due to leachate and vehicle management practices	Unknown volume and quality of leachate
Major Failure of CWS Loss of leachate to buffer zone	**4** Based on previous ERA conclusions (Environ 2013a,b)	**Highly Unlikely** Ongoing maintenance and monitoring of Containment Cell	Unknown volume and quality of leachate reaching aquatic habitats if suddenly released into the buffer zone

6.5 Option 5 – Transfer of Waste to an Offsite Waste Management Facility in NSW

Transferring CWS waste material offsite removes the opportunity for future impacts from leachate on down-gradient receptors in the local environment. As such the risk to the local ecology is negligible. However, the movement of waste in covered trucks to a licensed waste management facility elsewhere in NSW does include a risk of ecological harm if a vehicle accident occurs and solid waste material is spilled directly into the environment alongside the transport route.

Solid waste spilled onto the ground would be completely removed within a short period of time and therefore is not expected to provide ongoing risk to terrestrial ecology. In contrast, if the solid waste material was inadvertently spilled directly into an aquatic environment there is the opportunity for some localised effects on the aquatic ecology or down-gradient from the spill site.

The inherent leachability of fluoride from bulk CWS waste material represents a risk to aquatic species (invertebrates and fish) and to some birds and mammals that could be exposed to impacted water via drinking, if solid waste was spilled directly into an aquatic environment as a result of a truck accident. The highest HQ of 90.9 (for aquatic invertebrates) was used to derive the risk rating of 91.

Additional scenarios of loss of leachate due to failure of the licensed waste facility's leachate management system or loss of leachate from the CWS under extreme rainfall events during excavation of the waste material are also assumed to have a similar Risk Rating of 4.

The main uncertainties are associated with the actual rate of truck accidents where there is loss of containment of solid material. It is expected that most truck accidents would not involve roll-over and therefore would not result in loss of solid waste to the environment, and an even smaller percentage of accidents would involve truck roll-over into an aquatic environment. The likelihood of risk to the aquatic environment is therefore expected to be low.

Option 5 – Transfer of Waste to an Offsite Waste Management Facility in NSW			
Scenario:	**Risk Rating:**	**Likelihood:**	**Uncertainties:**
Base Case CWS waste transferred to a licensed waste management facility, or facilities, in NSW	**1** No release of leachate to the environment	**Certain** Dependent on the rate of vehicle accidents for trucks carrying solid waste Leachate is managed under facility licence conditions	Nature of Licensed Waste Facility's leachate management systems
Additional Exposure Events			
Solid Waste Spill Vehicle accident resulting in a spill of waste material into aquatic habitat alongside the transportation route	**91** Leachability of CoPCs from solid material in aquatic environments	**Highly Unlikely** Dependent on the rate of vehicle accidents for trucks carrying solid waste	Actual rate of accidents occurring, and possibility of accident occurring where solid material is spilled directly into an aquatic environment
Loss of Leachate from Licensed Waste Facility Failure of the facility's leachate management system	**4** Volume and quality of leachate assumed to be similar to leachate currently being generated from the CWS	**Unlikely** Leachate is managed under facility licence conditions	Unknown volume and quality of leachate Facility management systems not under management of Hydro
Extreme Weather Event High rainfall results in uncontrolled release of rainfall-generated leachate at staging areas	**4** Leachability of CoPCs from solid material in aquatic environments	**Highly Unlikely** Dependent on leachate management system at staging areas	Unknown volume and quality of leachate – dependent on rainfall and magnitude of loss of containment

6.6 Option 6 – Transfer of Waste to an Offsite Waste Management Facility in NT

Similar to Option 5, the transfer of CWS waste to a licensed waste management facility in the Northern Territory (NT) removes the risk of leachates to the local ecology adjacent to the Smelter but provides a potential opportunity for environmental harm along the transport route if an accidental spill occurs.

The longer transport route from the Smelter to the NT deposition location increases the chance of an accidental spill, although the proposed use of a train to haul the waste from a rail siding in NSW to a rail siding adjacent to the waste management facility in the NT is likely to reduce the chance of an accidental spill since the likelihood of a train derailment is expected to be less than the likelihood of a truck accident. The volume of spilled waste (spill magnitude) would however, be greater for a train derailment compared to a single truck accident. As a consequence, the overall risk likelihood is deemed to be the same as for Option 5.

As with Option 5, the inherent leachability of fluoride from bulk CWS waste material represents a risk to aquatic species (invertebrates and fish) and to some birds and mammals that could be exposed to impacted water via drinking, if solid waste was spilled directly into an aquatic environment as a result of a truck/train accident. The highest HQ of 90.9 (for aquatic invertebrates) was used to derive the risk rating of 91 (the same as Option 5).

Additional scenarios of loss of leachate due to failure of the licensed waste facility's leachate management system or loss of leachate from the CWS under extreme rainfall events during excavation of the waste material are also assumed to have a similar Risk Rating of 4.

The main uncertainties are associated with the actual rate of truck/train accidents where there is loss of containment of solid material. It is expected that most accidents would not involve roll-over and therefore would not result in loss of solid waste to the environment, and an even smaller percentage of accidents would involve roll-over into an aquatic environment. The likelihood of risk to the aquatic environment is therefore expected to be low.

Option 6 – Transfer of Waste to an Offsite Waste Management Facility in NT			
Scenario:	**Risk Rating:**	**Likelihood:**	**Uncertainties:**
Base Case CWS waste transferred to a licensed waste management facility, or facilities, in NT	**1** No release of leachate to the environment	**Certain** Dependent on the rate of vehicle accidents for trucks carrying solid waste Leachate is managed under facility licence conditions	Actual rate of accidents occurring, and possibility of accident occurring where solid material is spilled directly into an aquatic environment
Additional Exposure Events			
Solid Waste Spill Vehicle accident resulting in a spill of waste material into aquatic habitat alongside the transportation route	**91** Leachability of CoPCs from solid material in aquatic environments	**Highly Unlikely** Dependent on the rate of vehicle accidents for trucks carrying solid waste	Actual rate of accidents occurring, and possibility of accident occurring where solid material is spilled directly into an aquatic environment
Loss of Leachate from Licensed Waste Facility Failure of the facility's leachate management system	**4** Volume and quality of leachate assumed to be similar to leachate currently being generated from the CWS	**Unlikely** Leachate is managed under facility licence conditions	Unknown volume and quality of leachate Facility management systems not under management of Hydro
Extreme Weather Event High rainfall results in uncontrolled release of rainfall-generated leachate at staging areas	**4** Leachability of CoPCs from solid material in aquatic environments	**Highly Unlikely** Dependent on leachate management system at staging areas	Unknown volume and quality of leachate – dependent on rainfall and magnitude of loss of containment

6.7 Option 7 – Plasma Gasification

The processing of CWS waste in an onsite, purpose-built plasma gasification plant removes the risk of leachates to the local ecology since the waste would be removed from the CWS and temporarily stored prior to being fed into the plasma gasification plant. The storage of waste would be within weather-proof buildings, with an integrated leachate collection system. Rain-induced leachate is therefore unlikely. Any leachates would be collected and treated offsite by a licensed waste management contractor.

Additional scenario of loss of leachate from the CWS under extreme rainfall events during excavation of the waste material is assumed to have a similar Risk Rating of 4.

The uncertainties associated with the Plasma Gasification option are associated with the products of the process – gases and solid waste – and the collection, re-use and/or disposal of those products. It has been assumed that the solid waste product would be inert and either distributed for beneficial reuse (e.g. as road base) or designated as 'General Waste' for disposal at licensed waste management facilities in NSW.

Option 7 – Plasma Gasification			
Scenario:	**Risk Rating:**	**Likelihood:**	**Uncertainties:**
Base Case CWS waste stockpiled inside and any leachate collected and treated offsite by licensed contractor No hazardous wastes from plasma gasification process	**1** No release of leachate to the environment	**Certain** Leachate collected and treated	Nature and volume of end products, re-use and disposal options for end products
Additional Exposure Events			
Extreme Weather Event High rainfall results in uncontrolled release of rainfall-generated leachate from the CWS	**4** Leachability of CoPCs from solid material in aquatic environments	**Highly Unlikely** Dependent on leachate management system during CWS removal	Unknown volume and quality of leachate – dependent on rainfall and magnitude of loss of containment

7. LOSS OF ECOLOGICAL HABITAT

The potential loss of important natural habitat associated with each of the CWS Management Options has also been considered within the overall process of selecting the most appropriate option. The assessment of loss of habitat is based purely on the areal extent of existing terrestrial habitat that occurs within the proposed footprint of each Management Option. The estimated area of habitat lost (in hectares) for each Management Option is indicated in the **Table E7-1**.

Table E7-1: Comparison of Estimated Loss of Ecological Habitat for each Management Option

Management Option	Estimated Area of Habitat Lost (hectares)	Reason / Reference
Do Nothing	0	No change in footprint
2 – Deposit Waste in Onsite Containment Cell	2.5	Estimate as per ELA (2015)
3 – Recycle and Deposit in Onsite Containment Cell	2.5	Estimate as per ELA (2015)
4 – Treat and Deposit in Onsite Containment Cell	2.5	Estimate as per ELA (2015)
5 – Offsite Disposal in NSW	0	No change in footprint – waste exported from site
6 – Offsite Disposal in NT	0	No change in footprint – waste exported from site
7 – Plasma Gasification	0	No change in footprint – the plasma gasification plant would be built on existing industrial land at the Smelter

The only expected loss of habitat is associated with the construction of an onsite containment cell within an existing borrow ground west of the Smelter. The borrow ground currently consists of an area of highly disturbed and unvegetated land which would need to be enlarged slightly to accommodate the proposed Containment Cell. A narrow band of natural habitat around the periphery of the borrow ground would be consumed in the enlargement process. ELA (2016) stated:

> *the removal of approximately 2.5 ha of native (intact) vegetation is required for demolition activities and construction of a containment cell in the north-western section of the Project site and dust suppression activities (vehicular access to dams and facilities for the filling of water carts) in the north east section of the Project site.*

However, ELA (2016) concluded that construction of the Containment Cell in the nominated location is:

> *unlikely to have a significant impact on the species assessed primarily due to the relatively small area of native vegetation proposed to be impacted and it's [sic] relatively disturbed state, given it's [sic] near proximity to an aluminium smelter.*

Those options not involving the construction of a Containment Cell have no associated loss of habitat since the remedial actions would not disturb the waste material (Do Nothing), or waste material would be transported to a designated offsite disposal facility (Options 5 and 6), or remedial activities would occur on existing industrial land at the Smelter (Option 7).

Despite the loss of habitat associated with Options 2 – 4, there is not expected to be a significant impact to the ecological value of the Hydro land from any of the proposed CWS Management Options.

8. CONCLUSIONS

The assessment of potential ecological risk associated with the Management Options being considered for the management of waste material in the CWS was undertaken using both historical and recently collected environmental data. The assessment of ecological risk was primarily focused on the potential impact of waste leachates on surface water quality downstream of the existing CWS and downstream of a proposed purpose-built Containment Cell on the western side of the Smelter. Most surface water features within close proximity to the waste materials (either in the CWS or the containment cell) are ephemeral in nature and therefore unlikely to support aquatic species throughout the year. For this reason, the risk assessment focused on semi-permanent and permanent water features only, such as a small dam and Swamp Creek east of the CWS, and possible semi-permanent waterholes on the lower reaches of Black Waterholes Creek north of the Smelter.

In the absence of specific surface water data for Black Waterholes Creek, Ramboll Environ assumed that water quality downstream of the existing CWS would be representative of surface water quality downstream of the Containment Cell if the leachate management system inherent within the Containment Cell ever fails, or if excessive rainfall during placement of the waste material into the Containment Cell causes a loss of leachate from the cell. Under those circumstances, leachate is expected to readily mix with groundwater or rainwater and CoPC concentrations would be consistent with diluted leachate.

The results of an earlier comprehensive ecological risk assessment for leachate-impacted groundwater and surface waters down-gradient from the CWS (Environ 2013a,b) are directly relevant to the assessment of risk to aquatic species down-gradient from the proposed Containment Cell. The underlying assumptions and receptors of interest used in the earlier assessment are equally relevant to the assessment of ecological risk associated with leachates generated during placement of CWS waste in the Containment Cell. For this reason, the results of the earlier ERA were used to support the assessment of risk to ecological receptors potentially exposed to leachate-impacted surface waters associated with Do Nothing and Options 2 – 4.

Management Options 5 and 6 require export of CWS material offsite to either a NSW facility or interstate. These options involve complete removal of the waste offsite, and hence there would be negligible risk to local ecology into perpetuity; however, these options do provide an opportunity for ecological receptors along the offsite transport corridor to be exposed to impacts from solid waste if a vehicle accident occurs and solid waste is spilled into an aquatic environment (we assume that solid waste spilled into non-aquatic environments would be completely removed within a short period).

Management Option 7 involves processing of CWS material using an onsite plasma gasification plant, which would produce an inert waste for general disposal in local waste landfills. As such, there is negligible risk to ecological receptors associated with waste handling and treatment during Option 7.

The risk assessment provided a comparative assessment of risks to offsite ecological receptors, either locally for species in areas down-gradient from the proposed waste areas or along the transport corridors to be used during intra- and interstate transport to licensed waste management facilities elsewhere. **Table E8.1** provides a summary of the risk assessment results.

Table E8-1: Comparison of Ecological Risk for the Base Case in each Management Option

Management Option	Risk Rating	Justification
Do Nothing	4	Down-gradient aquatic habitats impacted by CoPCs (Environ 2013a)
2 – Deposit Waste in Onsite Containment Cell	1	No release of leachates to environment
3 – Recycle then Deposit Waste in Onsite Containment Cell	1	No release of leachates to environment
4 –Deposit Waste in Onsite Containment Cell with Treatment	1	No release of leachates to environment
5 – Offsite Disposal of Waste - NSW	1	No release of leachates to environment
6 – Offsite Disposal of Waste - NT	1	No release of leachates to environment
7 – Onsite Plasma Gasification	1	No release of leachates to environment

From the above information, it is concluded that the ecological risk rating is the same for the base case in each Management Option except Do Nothing. This is due to the inclusion of an inherent leachate management system for Management Options 2 – 7, with a focus on preventing leachate generation wherever possible, and establishing a backup system to collect and treat leachate if it does occur.

The risk assessment conclusions are based on the assumption that the CWS waste material will be carefully removed and placed into a purpose-built Containment Cell (Options 2 – 4), transported to a licensed waste management facility (Options 5 and 6) or treated onsite using a purpose-built plasma gasification plant (Option 7). There is no discernible difference in ecological risk profile associated with placement of the entire waste amount without sorting or treatment (Option 2), removing recyclables (Option 3) or interlayering the waste material with lime or an equivalent neutralising agent (Option 4), since in each case the CWS material would be placed into the same type of Containment Cell containing an integrated leachate management system.

The highest risk is associated with Do Nothing where the existing CWS is left in-place and ongoing leachate impacts to groundwater and surface waters would occur. Note however, that the results from the 2013 detailed ERA (Environ 2013a) and the additional lines-of-evidence (Environ 2013b) indicated that the leachate-impacted groundwater is having a negligible impact on down-gradient surface waters and aquatic ecology. Notwithstanding these conclusions, Do Nothing retains the CWS in its current form without an integrated leachate management system and ongoing impacts to down-gradient aquatic habitats are likely.

9. REFERENCES

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10. LIMITATIONS

Ramboll Environ Australia Pty Ltd prepared this report in accordance with the scope of work as outlined in our proposal to Hydro Aluminium Kurri Kurri Pty Ltd and in accordance with our understanding and interpretation of current regulatory standards.

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

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

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

10.1 User Reliance

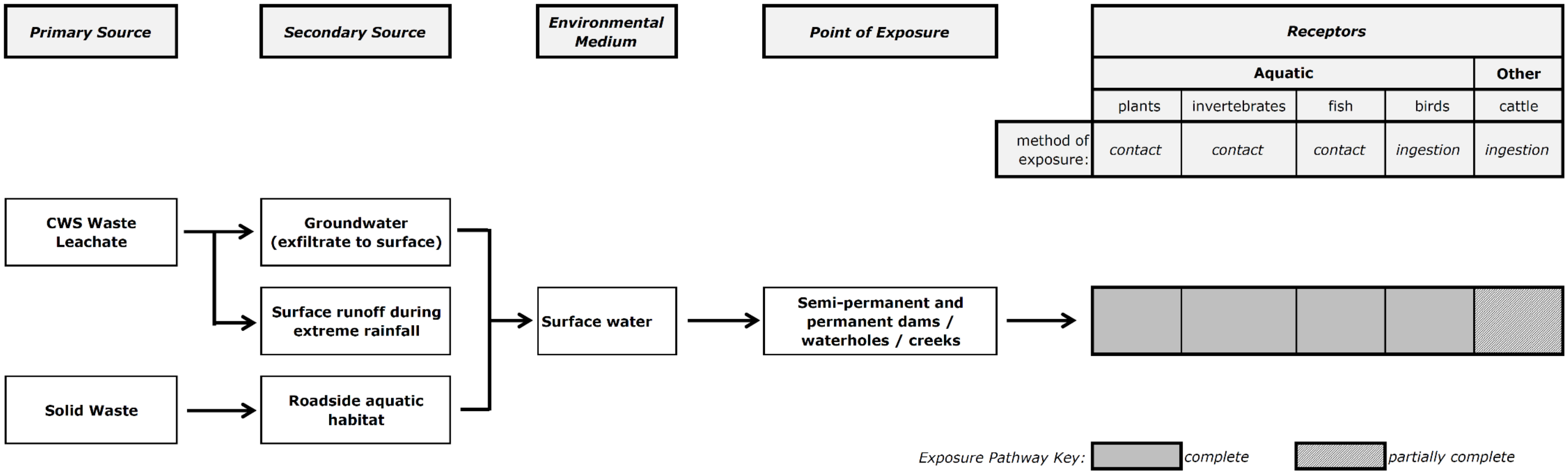
This report has been prepared exclusively for Hydro Aluminium Kurri Kurri Pty Ltd and may not be relied upon by any other person or entity without Ramboll Environ's express written permission.

APPENDIX E-1
FIGURES

HYDRO ALUMINIUM KURRI KURRI: Ecological Risk Assessment

SMELTER SITE LAYOUT

RAMBOLL ENVIRON JOB NO: AS130525 DATE: September 2017 **FIGURE E1**



HYDRO ALUMINIUM KURRI KURRI: Ecological Risk Assessment

CSM Exposure Pathway Flow Chart

RAMBOLL ENVIRON

JOB NO: AS130525

DATE: September 2017

FIGURE E2