Phase 2 Environmental Site Assessment

Kurri Kurri Aluminium Smelter

Prepared for:
Norsk Hydro ASA

On behalf of:

Prepared by:
ENVIRON Australia Pty Ltd

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EXECUTIVE SUMMARY

This report presents the results of a Phase 2 Environmental Site Assessment (ESA) completed at the Hydro Aluminium Kurri Kurri Smelter and the adjoining buffer zone, located off Hart Road, Loxford, New South Wales (NSW), 2326, hereinafter referred to as 'the site'. The work has been undertaken at the request of Mr Bernt Malme, Norsk Hydro (the "Client").

The investigation comprised a review of historical and background data, site inspections and soil and groundwater sample collection and analysis. Data was reviewed in accordance with the current regulatory framework in NSW. The investigation was undertaken of an operational site and is considered a preliminary investigation. The purpose of the investigation was to evaluate soil and groundwater concentrations that may represent a risk to human health at the site, and human health and the environment within the buffer zone. The investigation is not considered sufficient to assess the suitability of the site for other uses.

An initial site walkover and desktop study identified twenty potential areas of concern. These areas were investigated through the drilling of 31 boreholes, installation of 21 wells, collection of 45 surface soil samples, 14 sediment samples, and 28 groundwater samples. Soil, groundwater and sediment samples were analysed for a range of potential contaminants of concern. Investigation of the groundwater impact to the north east of the Alcan Mound involved a desktop review of data collected by the Newcastle University.

The investigation identified nine areas of concern that require further evaluation as follows.

<u>Alcan Mound</u>

Contamination of groundwater by leachate down-gradient of the Alcan Mound is occurring and toxicity to flora is evidenced by the observed dieback. The concentrations of fluoride in groundwater have been shown to decrease in the immediate vicinity of the mound following site capping, indicating that a reduction of the contaminant loading is occurring. The presence of this contamination is considered by ENVIRON to potentially trigger the duty to report the site as potentially contaminated to the EPA. The EPA advise that under section 60 of the CLM Act, a person whose activities have contaminated land or a landowner whose land has been contaminated is required to notify the EPA when they become aware of the contamination. ENVIRON note that Development Approval 118/692/102 was submitted in 1993 for the capping of the Alcan Mound and that this approval included consultation with the EPA.

Remediation of the Alcan Mound and associated groundwater plume is potentially required and a range of remediation or removal options are available. Prior to remediation, a detailed investigation is required that includes the following elements:

- Investigation of the plume to determine extent, particularly to the east of E4, and volume of contaminant present. This can include a short term pumping trial to assess the volume of water within the shallow sand aquifer.
- Investigation of soil concentrations in the zone of dieback to assess if soils in this area will require remediation;

- Assessment of the actual cause of dieback. It has thus far been assumed that the cause is fluoride however other contaminants are present at significant concentrations;
- Pump test of impacted high concentration groundwater in order to evaluate recharge of this area or determine that it constitutes a residual water reservoir trapped at that part of the Alcan Mound.
- Undertake an options study for remediation of the Alcan Mound. Options include encapsulating in-situ, encapsulating at a secondary location on-site and off-site disposal. The options study should include a cost and feasibility evaluation as well as outlining long term responsibility to Hydro and site restrictions.

Anode Waste Pile

Further investigation and delineation of PAH and fluoride impacts to soil should be undertaken following removal of the waste pile from this area. A detailed scope of work can be developed at that time. Remediation of this area may be required depending on the concentrations identified and the site use.

East Surge Pond and associated drainage line

Contamination to this portion of the drainage system originates from the activities of the carbon plant and/or the presence of the Anode Waste Pile. Remediation of sediments is therefore recommended after change of use, and/ or following the removal of the pile, cessation of the carbon plant, or following the implementation of controls to minimize sediment runoff to the drainage system.

Diesel Spray Area

Contamination of surface soils has occurred in this area from spraying of cathode bars with diesel prior to use. To prevent further contamination it is recommended that spraying of diesel cease. Remediation of this area is required and could be undertaken with low risk of future impacts from plant operations. Remediation will require:

- Delineation of the extent of contamination through additional sampling (or at the time of investigations);
- Excavation to stockpile pending waste classification;
- Waste classification;
- Disposal to landfill on the basis of the waste classification, or treatment on site to allow disposal to landfill.

Carbon Plant

Elevated PAH identified at the green-mix area of the carbon plant require further evaluation following cessation of plant operations. If remediation is determined to be required for the future use of the area this will likely involve excavation, waste classification and disposal to landfill or treatment on site.

Glen Ayr Drift

Access restrictions to the Glen Ayr drift should be imposed immediately to prevent further illegal dumping. Removal of waste to landfill is required by the site owner in the absence of identification of the polluter. Waste can be disposed to a licensed solid waste landfill.

Remediation should include development of a management plan that allows for appropriate response measures in the event that wastes not included in the solid waste characterizations are identified and appropriately disposed, for example bonded asbestos fragments.

Clay Borrow Pit

Wastes disposed to the clay borrow pit includes waste stockpiled above ground and wastes buried within the former borrow pit. The materials disposed contain low total and leachable concentrations of contaminants. However, the current waste disposal practice is not in accordance with the POEO Act and the presence of the material is aesthetically detrimental. Remediation or removal is required and a detailed and costed remedial options study should be undertaken to determine the appropriate option.

One option includes the crushing and reuse of the refractory brick under a specific exemption for refractory brick. The close proximity of the Hunter Express Way may offer a reuse opportunity if acted upon quickly.

Fluoride in soil and groundwater

Concentrations of fluoride at the site and within the buffer zone are considered to be at concentrations warranting further site specific toxicological evaluation. This recommendation is consistent with the EPA guidance in the absence of a NSW or Australian guideline.

Aluminium in groundwater

Concentrations of aluminium were determined above the applicable site guideline in groundwater. A desktop risk evaluation should be undertaken to evaluate the potential for ecological harm to result from the concentrations identified.

1 Introduction

This report presents the results of a Phase 2 Environmental Site Assessment (ESA) completed at the Hydro Aluminium Kurri Kurri Smelter and the adjoining buffer zone, located off Hart Road, Loxford, New South Wales, 2326. The Hydro Aluminium Kurri Kurri Smelter is hereinafter referred to as 'the site'. The work has been undertaken at the request of Mr Bernt Malme, Norsk Hydro (the "Client").

1.1 Objectives and Scope of Work

The objective of the Phase 2 ESA is to assess potential soil and groundwater contamination at the site that could impact on the use of the site for commercial/ industrial land-use, or cause impact to human health and the environment off site within the buffer zone.

The scope of works included the following:

- A review of previous environmental and geotechnical reports followed by a data gap analysis;
- Identification of potential areas of concern (PAECs) and contaminants of concern (COCs);
- Identification of sampling locations for soil and groundwater based on data gap analysis, PAECs and COCs;
- Preparation of a Sampling, Analysis and Quality Plan (SAQP) that outlined soil and groundwater sampling requirements following identification of PAECs and COCs and detailed the proposed quality assurance/ quality control (QA/QC) requirements, including Data Quality Objectives (DQOs); Data Quality Indicators (DQIs); assessment criteria and other relevant information.
- Soil and groundwater sampling and analysis;
- Data interpretation including comparison against relevant guidelines and a discussion of the implication of criteria exceedance and reporting.

1.2 Limitations

The scope of the Phase 2 Environmental Site Assessment was based on ENVIRON's proposal dated 6 February 2012.

Specific assumptions and limitations identified by ENVIRON as being relevant are set out in the report. The methodology adopted and sources of information used by ENVIRON are outlined in our scope of work. ENVIRON has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions made by others.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

1.3 Acknowledgements

ENVIRON would like to thank the site personnel for their support and open discussions in particular the Kurri Kurri EHS Manager Alex Fry and the Environment Officer and Buffer Zone Supervisor Kerry McNaughton. Additionally, ENVIRON would like to thank Dr Brett Turner and the University of Newcastle for the provision of extensive site information.

2 Site Description

2.1 Site Location

The site is located approximately 30 km west of the town of Newcastle and 150 km north of Sydney, in New South Wales, Australia.

The Site address is:

Hart Road
Loxford
New South Wales 2327
AUSTRALIA

The site includes a 60ha plant area and is described by 10 different allotments, Lots 318, 319, 411, 412, 413, 414, 415, 769, 776 in DP 755231, and Lot 3 in DP 456769; and a 2,500ha buffer zone described by approximately 75 different allotments. The buffer zone is used in part for agricultural purposes under lease and agistment arrangements. Houses within the buffer zone are either owned privately or owned by Hydro. A site location plan is provided in Figure 1.

Figure 1: Kurri Kurri Smelter, NSW, Australia; blue outline = buffer zone, red outline = plant area

Land uses surrounding the Buffer Zone comprise the following:

- To the north: rural/ agricultural land;
- To the east: the township of Heddon Greta;
- To the west: rural/ agricultural land;
- To the south: sewerage treatment works followed by township of Kurri Kurri.
- The site is situated within the Hunter Valley region known for grape growing and coal mining.

To the northwest, an area used for exploiting clay for cover of the Alcan Mound has been operated in the buffer zone.

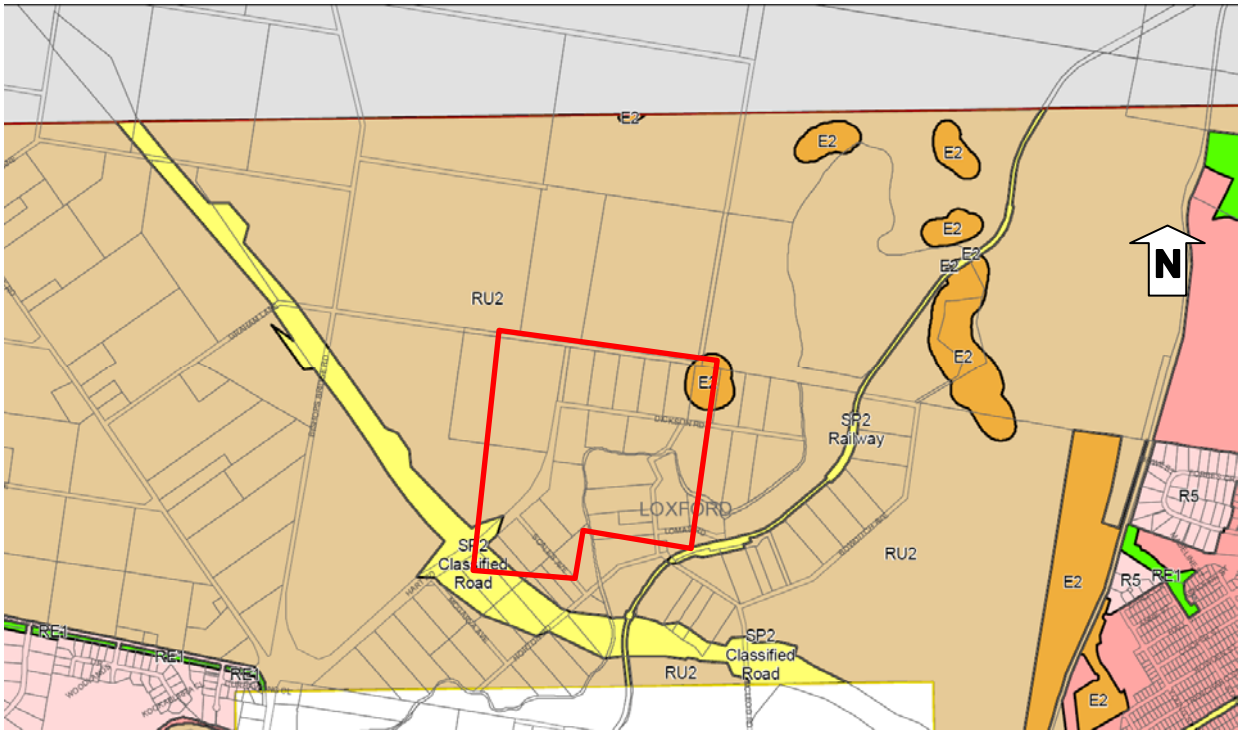

Figure 2: Zoning Map Of Kurri Kurri Smelter as of January 2012;
RU2 = Rural Landscape Zoning; red outline approximate Smelter area;
yellow = corridor of new freeway

The site is zoned 'RU2 Rural Landscape' under the Cessnock Local Environmental Plan (LEP) 2011. The objectives of the RU2 Rural Landscape zoning posted are:

- To encourage sustainable primary industry production by maintaining and enhancing the natural resource base;
- To maintain the rural landscape character of the land;
- To provide for a range of compatible land uses, including extensive agriculture;
- To enable other forms of development that are associated with rural activity and require an isolated location or support tourism and recreation; and

- To ensure that the type and intensity of development is appropriate in relation to the rural capability and suitability of the land, the preservation of the agricultural, mineral and extractive production potential of the land, the rural environment (including scenic resources) and the costs of providing services and amenities.

It is noted the current site use is permissible under existing use rights as established within the NSW *Environmental Planning and Assessment Act 1979.*

2.2 Site Operations

The site encompasses a three pot-line aluminum smelter with 360 pots and a capacity of up to 170,000 tonnes per annum. Pot Line 1 was taken out of active production in January 2012 reducing the capacity by 120 pots.

The overall process comprises four main operational areas:

- Carbon Plant, where ring furnaces are used to bake anodes. The Anode Plant is included in the Carbon Plant;
- Anode Plant, where carbon anodes are manufactured. The anode plant includes the Greenmix Plant, the Baking Furnaces and the Rodding Plant;
- Potrooms, where alumina is reduced to molten aluminium in three pot-lines; and
- Casthouse, where molten metal is cast into ingots and billets.

Ancillary facilities comprise the storage of alumina, petroleum coke, tar pitch, appropriate dry air scrubbers, diesel storage, compressed air supply, process water treatment, support services and maintenance installations. Figure 3 shows the site layout.

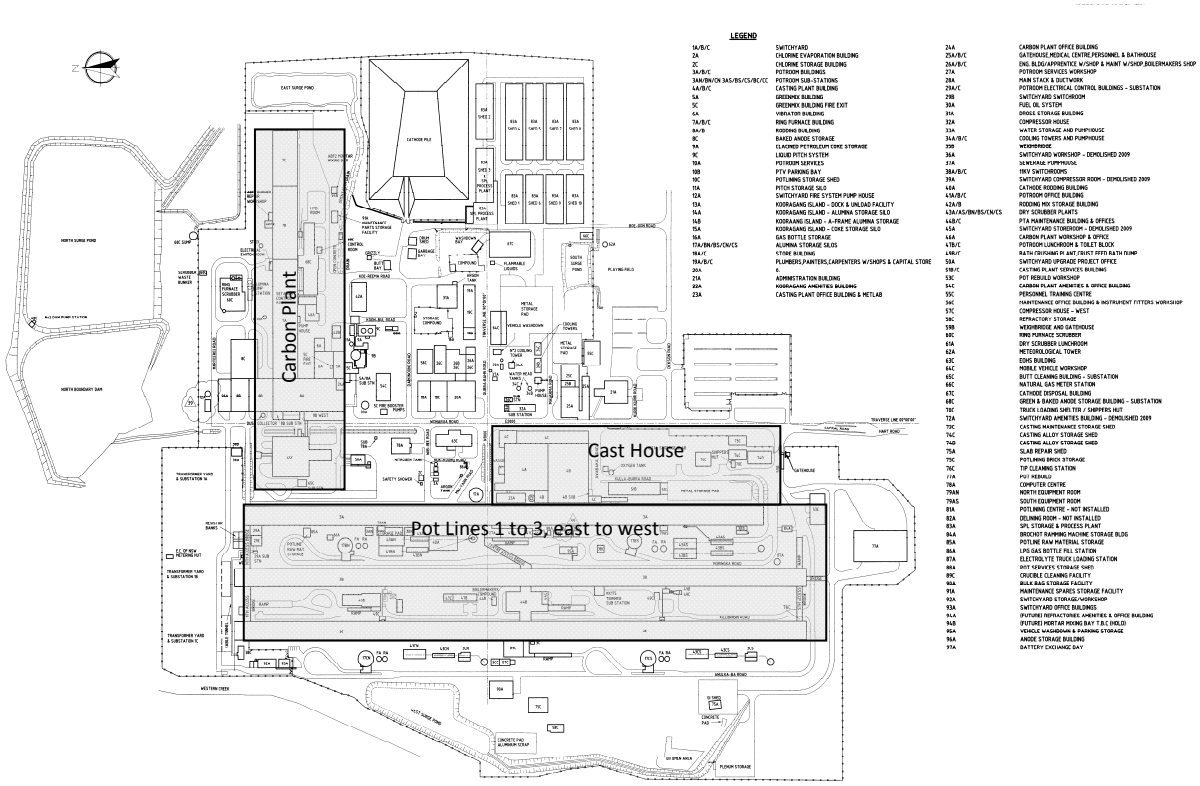

Figure 3: Kurri Kurri Smelter, NSW, Australia

2.2.1 Operations History

The facility was built on previously undeveloped agricultural land (red outline in Figure 1). A buffer zone of land (blue outline in Figure 1) was purchased around the planned facility reflecting the estimated distribution of fluoride emissions at the time of the initial environmental assessment and permitting.

The site was developed in 1969 by Alcan Australia Ltd., later Capral Aluminium, with pot-lines commissioned in 1969 (Line 1 – 120 cells; expanded in 1973 to 50,000 tonnes per annum), in 1979 (Line 2 – 120 cells), and in 1985 (Line 3 – 120 cells) for a final capacity of 180,000 tonnes per annum.

The site was purchased by VAW in 2000, and became part of Hydro with the purchase of VAW in 2001.

2.2.2 Planning Approvals

The site operates under Licence EPL 1548 which licences the carrying out of aluminium production >10,000 T and metal waste generation of >100 T generated or stored.

Three planning approvals have also been granted at the site throughout the period of operations as follows:

- 5th November 1980 the Minister for Environment and Planning granted development approval for the proposed expansion of the Kurri Kurri Smelter by construction of a third pot line. The approval includes 51 consent conditions relating to the upgrade and the operations at the site.
- 11th January 1993 the Council of the City of Cessnock granted approval for the upgrade of waste storage facilities including capping of the Alcan Mound and construction of above ground sheds for future storage of Spent Pot Liner. There are 37 consent conditions relating to the capping of the Alcan Mound and construction of the storage sheds.
- 21st August 2002 the Minister for Planning granted approval for the upgrade of the Anode Plant and upgrades to Pot Line 1. A series of consent conditions were included on this approval.

2.3 Site Setting

2.3.1 Topography

The site is located between low residual hills to the west of the buffer zone and low lying swampy land to the north and east of the buffer zone. Low lying areas were filled to create a flat, elevated platform at approximately 14mAHD for construction. The site is relatively flat with a gentle slope from west to east, from the plant area towards the surrounding water courses.

Landforms in the north and east of the buffer zone comprise low-lying swamps, with many surface water drainage ponds and creeks, interspersed with topographical rises comprising residual soils. In the south and west of the buffer zone, the landform is predominantly residual hills with gully formations draining to the north and east.

2.3.2 Regional Geology

According to the review of the regional geology described on the Sydney Basin Geological Sheet, the site and buffer zone are underlain by siltstone, marl and minor sandstone from the Permian aged Rutherford Formation (Dalwood Group) in the Sydney Basin.

The Sydney Basin is a sedimentary basin consisting of Permian and Triassic sedimentary rocks, which extends from Newcastle in the north to Batemans Bay in the south and to Lithgow, just west of the Blue Mountains. The basin overlies older basement rocks of the Lachlan Fold Belt. The sedimentary rocks of the basin generally consist of near horizontal sandstones and shales, with some recent igneous dykes. Only minor folding and faulting has occurred since these sedimentary rock sequences first formed. The Dalwood Group is stratigraphically located near the base of the Sydney Basin below both the Greta Coal Measures and Newcastle Coal Measures and was deposited in a marine environment.

Undifferentiated Quaternary alluvium occurs in the northeast of the buffer zone associated with surface water bodies. Quaternary sediments which are associated with Swamp Creek (located to the west of the site), Wentworth Swamps and the Hunter River consist of gravel, sand, silt and clay.

2.3.3 Site Geology

Dames and Moore (1992) describe the results of geotechnical investigations performed at the site between 1966 and 1986. They indicate the south western and western portions of the site as being underlain by residual soils comprising silty clays derived from the weathering of the underlying bedrock, while the eastern and north eastern portions of the site are underlain by alluvial soils comprising silty clays, sands and gravels deposited by the Swamp Creek and Wentworth swamps alluvial systems. Sequencing and thickness of the alluvial soils underlying the site are understood to be variable and complex, with the soil type changing significantly over relatively short distances both vertically and laterally; this is seen as a result of the nature of the deposition of the alluvial sediments in an alluvial environment where the river system is meandering and migrating across a floodplain.

Geotechnical investigations (Dames and Moore, 1992) indicate depth to bedrock at the site ranges from approximately 3 m in the residual soils on the western margins, to approximately 10 to 15 m in the alluvial soils on the northern and eastern boundaries, respectively. Subsurface soils in the area of the onsite Alcan Mound consist of alluvial clays, silty clays and sands in excess of 15 m depth; organic clays and peats were also encountered within two boreholes at depths of approximately 10 m. Organic clays were encountered in excess of 5 m thick. Dames and Moore reported that geotechnical data indicated the presence of permeable soil horizons in the natural soils beneath the Alcan Mound.

It is noted that the Greta Coal Measures outcrop in a narrow, northeast trending band located to the east of the buffer zone. The Greta Coal Measures outcrop extends through a portion of land owned by Hydro that is not part of the Buffer Zone. The former Glen Ayr colliery is located in this portion of land and can be identified by areas of mine subsidence.

The geology at the site is shown in Figure 4.

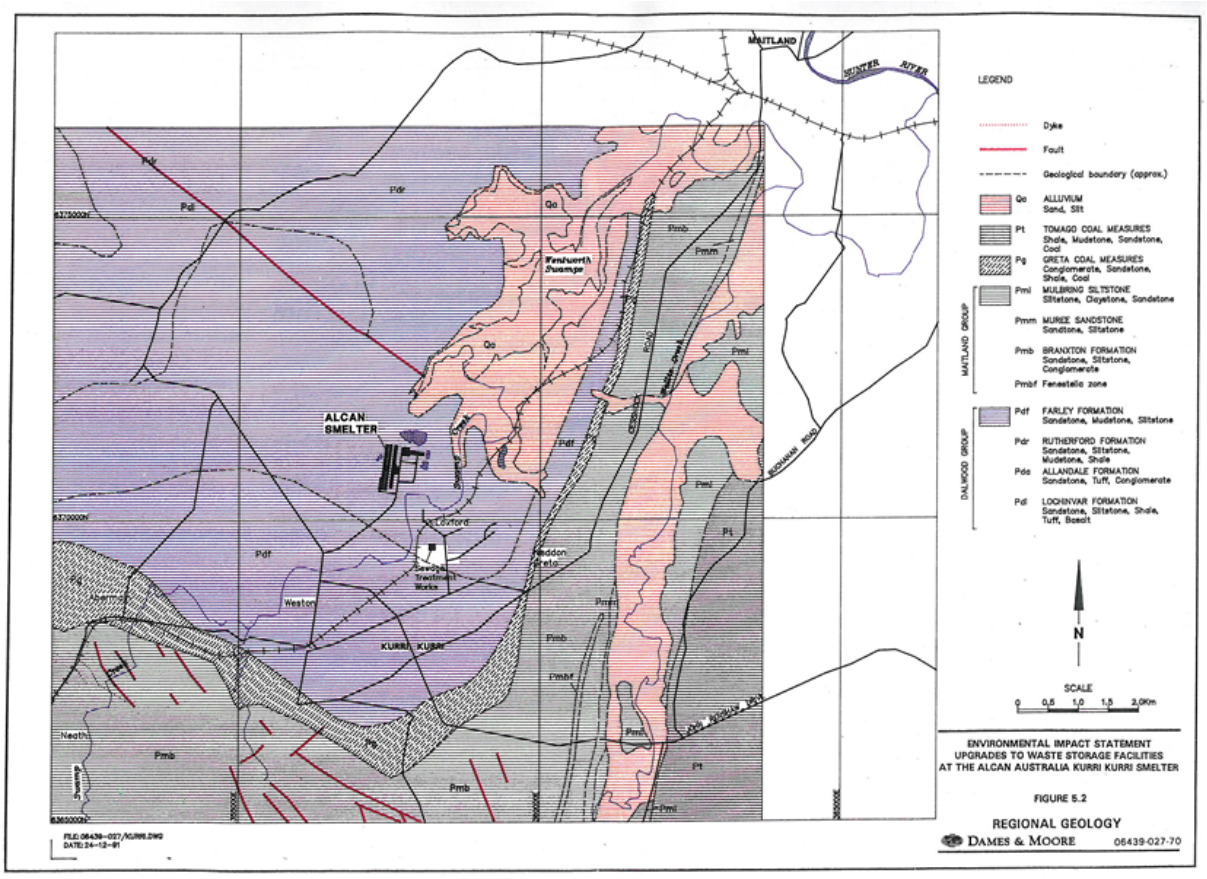

Figure 4: Geological Map Kurri Kurri – from Dames & Moore 1992 - EIS

2.3.4 Site Hydrology

There are five storage ponds located at the site as shown on Figure 3. Surface water from the site is directed to these storage ponds via open channels and some concrete subsurface drainage lines. Surface water ponds known as ‘East’, ‘West’ and ‘South’ are pumped to the North dams where surface water is discharged to an irrigation area under license. Surface water dams were constructed by excavation into the residual underlying extremely weathered bedrock.

The closest surface water receptor is a natural drainage area called Swamp Creek located approximately 1km to the northeast of the site within the buffer zone(refer to Figure 1). This drainage area discharges to Wentworth Swamp which in turn discharges to the Hunter River approximately 15km northeast of the site near Maitland.

The site’s sensitivity with respect to surface water is considered to be moderate given the relatively short distance to the drainage area that discharges to the Hunter River and the extraction of water from the Hunter River for use, including urban water supply.

2.3.5 Hydrogeology

Regionally groundwater is expected to follow the topography and flow northeast towards surface water bodies that feed into the Hunter River.

According to the Office of Industry and Investment, NSW, there are 17 licensed groundwater abstractions (bores) located within the buffer zone. There are no other licensed groundwater bores within 2km of the site. There is a group of seven groundwater bores located just over 2km to the northwest of the site.

Fourteen of the on-site bores are located within the Rutherford Formation close to or north-east of the evaporation ponds. The remaining three on-site bores are located within Quaternary Alluvium on the western bank of Swamp Creek. Data associated with these bores is limited, with no information regarding the depth of the bores, water bearing zone, or standing water depth. One bore indicates it was installed in 1999.

The Hunter River Alluvium Groundwater Management Unit (GMU) is an important groundwater resource to the region. Groundwater extraction for irrigation, urban supply, drought supply, stock, domestic and commercial/ industrial use occurs, with volumes in excess of 10,000ML per annum extracted from the Hunter River Alluvium GMU. Aquifer storage and recovery is also an important use of this GMU.

3 Review of Previous Reports

3.1 Geotechnical Reports

Five geotechnical reports were completed by Douglas Partners Pty Ltd in May 1993, September 2001, August 2002, December 2002 and January 2003 in relation to the ring furnace reconstructions within the Carbon Plant.

A summary of these reports is included in Appendix A.

3.2 Groundwater Investigations

Several groundwater investigations have been completed at the location of the Alcan Mound, where spent cathode waste was stockpiled from 1969 until 1992, and which has been identified as leaching fluoride and cyanide into groundwater down gradient of the mound.

Groundwater investigations were completed by Dames and Moore in November 1991 and December 1991, including the installation of piezometers down gradient of the Alcan Mound, and an assessment of surface water quality in Swamp Creek. Dames and Moore completed an Environmental Impact Statement (EIS) for upgrades to the waste storage facilities at the Kurri Kurri Smelter in May 1992, including the capping of the Alcan Mound.

Groundwater investigations were completed by Douglas Partners in 1993, which included the drilling of cone penetrometer tests (CPTs) along the down gradient edge of the Alcan Mound.

Each investigation is summarized in Appendix A.

The University of Newcastle in consultation with Hydro management has undertaken a study of the leachate migration from the Alcan Mound since 2000. The study has included the following components:

1. Investigation of the subsurface profile through drilling and cone penetrometer testing (CPT) to facilitate the development of a conceptual site model (CSM);

2. Groundwater and surface water sampling for fluoride, cations and anions, pH and electrical conductivity with analysis undertaken by the University;

3. Groundwater sampling on two occasions the latest being in 2010 for a comprehensive suite of analytes with analysis undertaken by a commercial laboratory;

4. Water level gauging to determine flow directions;

5. Limited permeability analysis of the sub surface strata;

6. Construction of drawings showing groundwater flow directions and contaminant isopleths;

7. Benchscale testing and pilot trials for treatment of fluoride containing groundwater with calcite;

8. Investigation of the relationship between the East Surge Pond and the groundwater regime to the east of the Site.

A review of the data provided is included in Appendix A.

Historical photographs showing the Alcan Mound prior to capping that were included in the University of Newcastle reports are provided below. The historical photographs show water within the bund walls during capping.

Plate 1: Showing water within the bund walls during capping, also shows the size of the East Surge Pond at the rear of the Alcan Mound.

Plate 2: Showing water at the north east corner of the Alcan Mound during capping.

Plate 3: Showing water at the north east corner of the Alcan Mound during capping.

4 Potential Areas and Contaminants of Concern

4.1 Potential Sources of Soil and Groundwater Contamination

Aluminium smelting is the process of dissolving alumina in an electrolytic bath of molten cryolite (sodium aluminium fluoride) within a large carbon or graphite lined steel container (pot). An electric current flows between a carbon anode (positive), made of petroleum coke and pitch, and a cathode (negative), formed by thick carbon or graphite lining of the pot.

Primary operational areas comprise the Carbon Plant, Pot Rooms and the Cast House. Each is discussed in the following.

The Carbon Plant produces the anode from a mixture of coke, pitch and recycled anode butts to produce a green anode. This is then baked within a ring furnace prior to the addition of a cast iron rod, and dispatched to the Pot Rooms. The ring furnace is gas heated however was previously oil heated. The oil tank was situated within the area of the site used for vehicle refueling and is shown in Plate 5.

Plate 5: Location of the former bulk fuel oil tank adjacent to the washbay and refueling area.

The smelter has three pot lines where alumina and cryolite are placed within the pots and current added. Molten aluminium is siphoned from each pot and taken to the Cast House.

The Cast House produces cast aluminum products to product specification often including the addition of alloys. The cast house uses chlorine gas to avoid oxidation during the casting process. The gas is captured when the casting chamber is filled. Wastes include dross and swarf which have high aluminium content and are sent for recycling off-site.

4.2 Potential Areas of Concern

Potential areas of concern (PAECs) identified at the site from site walkovers and review of previous reports include:

- The Alcan Mound, where spent pot linings (SPL) and other site wastes have been disposed of on-site by stockpiling and capping. Spent cathodes have leached fluoride and cyanide into groundwater down gradient of the Alcan Mound;
- The storage sheds constructed for the storage of spent cathodes. The use of sheds should prevent leaching of fluoride and cyanide from the spent cathodes. Possibility of deposition of fluoride and cyanide dusts during transport and handling;
- Soil impacts in the plant area from the anode plant, the anode storage pile, the wash bay, impacted open and unlined drains and small lubrication areas. The estimated potentially impacted area is 30,000m^2.
- Aerial deposition of fluoride over the buffer zone has the potential to result in surface soil contamination;
- The five on-site ponds contain sludge that need to be characterized in relation to potential contamination;
- Waste material storage and disposal on-site and on adjacent buffer land, including deposition of waste materials at the clay borrow pit and illegal dumping of wastes at the Glen Ayr Drift;
- The switch yard where transformer oils may result in contamination by hydrocarbons and PCBs depending on the age of the facility;
- The diesel spray area where diesel is used to treat rust coatings from cathode rods prior to reuse;
- The former pot rebuilding area, a historical area used for scraping and rebuilding of pots;
- The maintenance contractor's storage compound, where degreasers, paints, oils and greases are used and stored;
- The irrigation area, where stormwater from the site is irrigated.

4.3 Contaminants of Potential Concern

Contaminants of potential concern relating to the production of aluminum and ancillary operations at the site include:

- Fluoride;
- Cyanide;
- Total Petroleum Hydrocarbons (TPH);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Aluminium.

Other subordinate potential contaminants may include:

- Heavy Metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg);
- Pesticides (Organochlorine Pesticides and Organophosphorous Pesticides);
- Asbestos;
- PCBs.

5 Site Investigations

5.1 Project Planning Phase

5.1.1 Site Walkover

The Project Manager, Fiona Robinson and Project Director, Chris Keller visited the site in March 2012 to conduct a thorough site walkover. The site walkover was accompanied by the Hydro Environmental Manager (Alex Fry) and Environmental Officer (Kerry McNaughton) and included a tour of the site and of accessible parts of the buffer zone.

The objective of the site walkover was to observe site features and assess potential areas of concern, as follows:

- Current conditions of the site, including layout of production buildings, workshops, waste storage areas and an understanding of plant operations;
- Evidence of localized hydrocarbon impacts around the refueling area, workshops and wash-down areas;
- Evidence of impacts to ground surfaces, including staining or discoloration;
- Current condition of accessible areas of the buffer zone, including evidence of disturbances to local topography suggesting that filling or dumping activities may have taken place.

The results of the site walkover are discussed in Appendix C.

5.1.2 Preparation of SAQP

The SAQP (ENVIRON, March 2011) was prepared prior to completing fieldwork and incorporated the findings of the site walkover.

The SAQP identified soil and groundwater sampling requirements following identification of potential Areas of Concern and Contaminants of Concern and detailed the proposed Data Quality Objectives (DQOs); Data Quality Indicators (DQIs); assessment criteria and other relevant information.

5.2 Project Fieldwork Phase

5.2.1 Soil and Groundwater Sampling

A summary of the completed fieldwork for each of the PAECs identified in Section 4.2 is provided in Table 5.1. The sampling locations and densities indicate the potential risk of soil and/ or groundwater contamination at each PAEC.

PAECs were investigated through the drilling of 31 boreholes, installation of 21 wells, collection of 45 surface soil samples and 14 sediment samples, and 28 groundwater samples. Soil, groundwater and sediment samples were analysed for a range of potential contaminants of concern. Investigation of the groundwater impact to the north east of Mount Alcan involved a desktop review of data collected by the Newcastle University.

The PAECs are shown in Figure 5. Site photographs are included in Appendix B. A description of the field methodologies is included in Appendix C.

Table 5.1: Completed Fieldwork Schedule

No.	PAEC	Description	Issue	CoCs/ Analysis	Sampling
1	Alcan Mound Leachate Area	Historical stockpiling of spent cathode and other wastes. The stockpile was capped in 1995.	Impacts to surface water, groundwater and biota	Fluoride, Sodium, pH, PAHs, Heavy Metals	Nil Review existing sampling information available from the University of Newcastle for this area. No further sampling proposed at this time.
2	Anode Waste Pile	Ahead of schedule anodes, some mixed product including metals. Dust suppression historically undertaken using surge pond water and potable water. The surface is unsealed.	Potential for leaching of contaminants to groundwater. Potential for contaminants impacts to shallow soil.	Fluoride, PAHs, Heavy Metals, Cyanide	Push tube sampling at two locations (MW12, MW13). Two samples of surface fill, two samples of natural soils. Two groundwater samples from upper groundwater zone.
3	Refuelling area	Refuelling of vehicles, historical heavy fuel oil tank understood to have been located in garden bed.	Impacts to soil and groundwater.	TPH, PAHs, Heavy Metals, Fluoride	Four sampling locations, including two monitoring wells (MW7, MW8, SB15, SB16). Soil samples collected at two depths at each location. Two groundwater samples.
4	Diesel Spray Area	Use of diesel to treat rust coatings from cathode rods prior to reuse.	Impacts to soil and groundwater.	TPH, PAHs	Four sampling locations, including two monitoring wells (MW19, MW20, SB17, SB18). Soil samples collected at two depths at each location. Two groundwater samples.
5	Drainage Lines	Unlined drainage channels receive runoff from around the site	Potential for contaminated sediments to remain.	Fluoride, PAHs, Heavy Metals, Cyanide	Collect six sediment samples and six samples of underlying natural soils to allow evaluation of sediment depth (D5 to D8, D8 Base, D9, D10).

Table 5.1: Completed Fieldwork Schedule

No.	PAEC	Description	Issue	CoCs/ Analysis	Sampling
6	East Surge Pond	Received runoff from the eastern part of the site and south surge pond.	Potential for contaminated sediments to remain.	Fluoride, PAHs, Heavy Metals, Cyanide	Push tube sampling at four locations to assess depth of sediment (D11, D11-1, D12, D12-1). Collection of two composite sediment samples and two base (clay) samples for analysis.
7	Northern Dams 1 and 2	Receives water transferred by pump from the East and West Surge Ponds and surface water drains north of the ring furnace. Previously water was discharged by overland flow from the East Surge Pond to the North Dam. Water is discharged to the irrigation area within the buffer zone.	Potential for contaminated sediments to remain. The rate of sedimentation is expected to have decreased in recent years due to transfer by pumping.	Fluoride, PAHs, Heavy Metals, Cyanide	Push tube sampling at 10 locations to assess depth of sediment (ND1 to ND10). Collection of four composite sediment samples (Composite 1 to Composite 4) and two base (clay) samples for analysis.
8	Carbon Plant	Use of pitch, anode, coke and dust. Previously used fuel oil was heavy oil.	Impacts to shallow soil and groundwater.	Fluoride, PAHs, Heavy Metals, Cyanide	Eight sampling locations surrounding the Carbon Plant in target areas, including five groundwater wells to monitor the shallow aquifer (MW14 to MW18, SB11 to SB13). Soil samples collected at two depths at each location. Groundwater samples to be collected from existing on Site wells S3A and S3B and a groundwater sump.

Table 5.1: Completed Fieldwork Schedule

No.	PAEC	Description	Issue	CoCs/ Analysis	Sampling
9	Cathode Bar Washdown Area	High pressure spray trial for cathode bars, potential for contamination of surface soils. Surface is unsealed but appears to be hardstand.	Potential for contaminants to impact shallow soils.	Fluoride, Heavy Metals, Sodium	Push tube sampling at one location (SB9). One sample of surface fill, one sample of natural soils.
10	Flammable Liquids Store	Open grassed area adjacent to flammable liquids store and rear of treated Regain material store.	Potential for contaminants to impact shallow soils and groundwater.	Fluoride, PAHs, SVOCs, Heavy Metals, Cyanide	Two sampling locations, including two monitoring wells (MW9, MW10). Two samples of surface fill, two samples of natural soils. Two groundwater samples from upper groundwater zone.
11	Washdown Bay	Currently used for cathode bar cleaning.	Potential for contaminants to impact shallow soils and groundwater.	Fluoride, PAHs, Heavy Metals, Cyanide	Two sampling locations, including one monitoring well (MW11, SB10). Two samples of surface fill, two samples of natural soils. One groundwater sample from upper groundwater zone.
12	Pot Lines 2 and 3	Dust deposition from pot lines, PCBs in transformers.	Impacts to surface soils.	PCBs, Fluoride, Heavy Metals	Four shallow sampling locations, collected by hand auger (SB1 to SB4).
13	SPL Storage Sheds	Storage of SPL in six large, ventilated sheds.	Potential for contaminants to impact shallow soils from dust suppression and roof runoff.	Fluoride, Heavy Metals	Shallow soil sampling at four locations (SB5 to SB8).

Table 5.1: Completed Fieldwork Schedule

No.	PAEC	Description	Issue	CoCs/ Analysis	Sampling
14	South Surge Pond	Receives runoff from the car park area	Potential for contaminated sediments to remain.	Fluoride, PAHs, Heavy Metals, Cyanide	Collect two grab samples from the sides of the dam (D3, D4).
15	West Surge Pond	Received runoff from storage area and from Pot Lines	Potential for contaminated sediments to remain.	Fluoride, PAHs, Heavy Metals, Cyanide	Collect two grab samples from the sides of the dam (D1, D2).
16	Switch Yard	Transformer oil.	Impacts to shallow soil.	PCBs, VOCs	Collection of one surface soil sample (SB20i).
17	Contractors Storage Compound	Use of degreasers, paints, oils and grease.	Impacts to soil and groundwater.	SVOCs, Heavy Metals, Fluoride	Push tube sampling at one location (SB14). Collection of two samples.
18	Pot Rebuild Area	Historical workshop area for melting and rebuilding pots.	Impacts to soil and groundwater.	SVOCs, Heavy Metals, Fluoride	One sampling location, including one monitoring well (MW21).
19	Clay Borrow Pit	This area has been historically filled with inert materials, however refractory brick and bitumen were evident on the surface.	Potential impacts to groundwater and aesthetic impacts.	SVOCs, Heavy Metals, Fluoride	Four groundwater monitoring wells in low lying areas surrounding the pit (MW01, MW03 to MW05). Piezometers to monitor the shallow groundwater aquifer.
20	Glen Ayr Drift infilling	This area has been filled, currently and in the past, with inert material from the site.	Potential impacts to groundwater and aesthetic impacts.	SVOCs, Heavy Metals, Fluoride	Two soil sampling locations within gully (GA1, GA2). Site survey for the presence of asbestos containing materials and other hazardous substances.
21	Irrigation Area	Irrigation of site stormwater	Impacts to shallow soils	Fluoride, Sodium, PAHs, Heavy Metals, Cyanide	Six sampling locations, collected by hand auger (SB20 to SB25).

Table 5.1: Completed Fieldwork Schedule

No.	PAEC	Description	Issue	CoCs/ Analysis	Sampling
22	General Buffer Zone	Dust deposition	Impacts to shallow soils	Fluoride, Heavy Metals	12 shallow sampling locations, collected by hand auger (SB26 to SB37).
23	Background Well	Installation of well into shallow aquifer for evaluation of background water quality		Fluoride, PAHs, SVOCs, Heavy Metals, Cyanide	One sampling location, including one monitoring well (MW06).

FIGURE 5 - PAECs

5.2.2 Laboratory Testing

Laboratory analysis was undertaken by ALS Environmental (ALS) as the primary laboratory and Envirolab as the secondary laboratory. Both laboratories are NATA accredited for the analysis undertaken.

The completed analysis schedule is included in the COC/Analysis column in Table 5.1. Laboratory certificates and chain of custody information is included in Appendix H.

6 Assessment Criteria

6.1 Soil Assessment Criteria

The assessment criteria proposed for the assessment of soil contamination were sourced from the following references:

- NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme (Second Edition);
- NSW EPA (1994) Guidelines for Assessing Service Station Sites
- NEPC (1999) National Environmental Protection (Assessment of Site Contamination) Measure (NEPM).

NEPM (1999) and NSW DEC (2006) provide health-based soil investigation levels (HILs) and ecological-based investigation levels (EILs) for various land-uses, as follows:

A. 'Standard' residential with gardens and accessible soil (home-grown produce contributing 10% of fruit and vegetable intake; no poultry), including children's day-care centres, preschools and primary schools, or town houses or villas;

B. Residential with minimal access to soil including high rise apartments and flats;

C. Parks, recreational open space, playing fields including secondary schools;

D. Commercial or industrial.

The objective of the staged Phase 2 ESA is to assess soil and groundwater contamination at the site, an industrial facility, and to assess potential future land-uses with regard to soil contamination within the buffer zone. As such, soil investigation results within the site will be compared against HIL D. Commercial or Industrial Land-use. The EILs do not apply for commercial/ industrial land-use. Soil investigation results from the buffer zone will be compared against HIL A, Standard Residential and against the EILs. There are no guidelines for agricultural landuse.

The applicable soil assessment criteria are presented in Table 6.1.

Table 6.1: Soil Assessment Criteria (mg/kg).

Contaminant	Commercial/ Industrial Landuse	Residential with accessible soil	EILs
Arsenic	500	100	20
Cadmium	100	20	3
Chromium	60%	12%	400
Copper	5000	1000	100
Lead	1500	300	600

Table 6.1: Soil Assessment Criteria (mg/kg).			
Contaminant	**Commercial/ Industrial Landuse**	**Residential with accessible soil**	**EILs**
Nickel	3000	600	60
Zinc	35,000	7,000	200
Mercury	75	15	1
TPH C6-C9	65	-	-
TPH C10-C36	1000	-	-
Benzene	1	-	-
Toluene	1.4	-	-
Ethyl Benzene	3.1	-	-
Xylene	14	-	-
Benzo(a)pyrene	5	1	-
Total PAHs	100	20	-
Cyanides (complex)	2500	500	-

6.1.1 Fluoride and Aluminium in Soils

NEPM (1999) and NSW DEC (2006) do not provide a criteria for fluoride or aluminium in soils in Australia. NEPM (1999) Schedule B(1) Guidelines on the Investigation Levels for Soil and Groundwater indicates that appropriate investigation levels need to be developed when investigation values are not available for a contaminant of concern.

The development of an appropriate investigation level to assess fluoride and aluminium at the site has not been completed as part of this investigation as the significance of fluoride and aluminium concentrations in soil is currently unknown. For this investigation, a desktop review of guideline criteria used in other countries has been undertaken to provide a range of screening levels for fluoride and aluminium. The range of screening levels for fluoride and aluminium are presented in Table 6.2.

International industrial/ commercial guidelines will be used as a preliminary screening tool for fluoride and aluminium results for the site. International agricultural and fauna (applicable to undisturbed bushland) guidelines will be used as a preliminary screening tool for fluoride results within the buffer zone. The International guidelines for residential use was adopted as the preliminary screening level for aluminium results in the buffer zone.

Fluoride and aluminium concentrations will be compared to these preliminary screening levels to assess the significance of the measured concentrations. International guidelines are not directly comparable to site conditions and professional judgment is used to determine the need for further evaluation, for example the development of site specific guidelines for fluoride and aluminium.

Table 6.2: International Soil Assessment Criteria for Fluoride (mg/kg).					
	US EPA (Region 9) Preliminary Remedial Goals	Dutch (2000)	Canadian Environmental Soil Quality Guidelines	Germany	Scotland
Soil (target)	-	500	-	-	-
Soil (fauna)	-	-	-	250	-
Soil (agricultural)	-	-	200	-	-
Soil (residential)	3700	-	400	3750	500
Soil (Playgrounds)	-	-	-	750	-
Soil (industrial/ commercial)	37,000	-	2000	15,000	-
International Soil Assessment Criteria for Aluminium (mg/kg).					
	US EPA (Region 9) Preliminary Remedial Goals	Dutch (2000)	Canadian Environmental Soil Quality Guidelines	Germany	Scotland
Soil (target)	-	-	-	-	-
Soil (fauna)	-	-	-	-	-
Soil (agricultural)	-	-	-	-	-
Soil (residential)	77, 000	-	-	-	-
Soil (Playgrounds)	-	-	-	-	-
Soil (industrial/ commercial)	990,000	-	-	-	-

6.2 Groundwater Assessment Criteria

The assessment criteria proposed for the assessment of groundwater contamination are sourced from the following references:

- NSW DEC (2007) Guidelines for the Assessment and Management of Groundwater Contamination.
- ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

6.2.1 Potential Beneficial Uses

NSW DEC (2007) indicates that for assessing groundwater quality, it is first necessary to assess the beneficial uses of groundwater and surface water down gradient of the site.

As discussed in Section 2.3.4, there are five storage ponds located at the site. The closest surface water receptor is a natural drainage area called Swamp Creek located to the north-east of the site within an area of the buffer zone used for farming. This drainage area discharges to the Hunter River approximately 15km north-east of the site near Maitland.

Surface water within Swamp Creek is described generally neutral, ranging between pH 7.0 and 7.8 and conductivity was generally fresh, ranging from 626µS/cm to 1520µS/cm. This surface water body is considered to be a fresh water receptor.

Groundwater is expected to follow the topography and flow north-east towards surface water bodies that feed into the Hunter River.

According to the Office of Industry and Investment, NSW, there are 17 licensed groundwater abstractions (bores) located within the site, which are known to be associated with monitoring of groundwater impact. There are no other licensed groundwater bores within 2km of the Site.

Potential beneficial uses of groundwater down gradient of the site include:

- Discharge into Swamp Creek, which supports aquatic ecosystems and potentially flows in the Hunter River;
- Extraction of water from Swamp Creek may also be used for stock watering and/ or irrigation.

6.2.2 Appropriate Criteria for Groundwater

Based on the review of potential beneficial uses of groundwater and surface water, the criteria for protection of aquatic ecosystems, irrigation and stock watering will be used.

The investigation levels presented in ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality are considered applicable for the protection of aquatic ecosystems of receiving waters. ANZECC (2000) advocates and Site-specific approach to developing guideline trigger values based on such factors as local biological affects data and the current levels of disturbance of the ecosystem. The guidelines present ‘low risk trigger values’ which are defined as concentrations of key performance parameters below which there is a low risk of adverse biological effects. If these trigger values are exceeded, then further action is required which may include further site-specific investigations to assess potential contamination or management/ remedial action.

Low risk trigger values are presented in Table 3.4.1 of ANZECC (2000) for the protection of 80-99% of species in fresh and marine waters, with trigger values depending on the health of the receiving waters.

Groundwater results will be compared against trigger values for the protection of 95% of freshwater species. ANZECC (2000) indicates there is currently insufficient data to derive a

high reliability trigger value for TPH but propose a low reliability trigger value of 7µg/L. This guideline is considered by industry to be overly conservative and is well below the TPH detection limit that most laboratories can achieve. Therefore the limit of reporting (LOR) will be adopted as a screening trigger for TPH.

Trigger values for cadmium, copper, nickel, lead and zinc can be modified for hardness, as the bioavailability of these heavy metals decreases with increasing hardness. Hardness ($CaCO_3$) was tested in up gradient wells at the Clay Borrow Pit, with results indicating extremely hard water (>400mg/L $CaCO_3$). Trigger values modified for extremely hard waters have been used, as per Table 3.4.3 of ANZECC (2000).

Investigation levels for livestock drinking water are not available for organic contaminants, such a TPH and PAHs. In the absence of available investigation levels, human health drinking water levels will be used from NHMRC (2004) Australian Drinking Water Guidelines for screening criteria.

Anecdotal information indicates that 5mg/L is adopted as a trigger concentration for fluoride in groundwater at a nearby aluminium smelter. This guideline value has been adopted in this evaluation, however will require further review for suitability for use at this site.

A summary of the assessment criteria for groundwater are provided in Table 6.3.

Table 6.3: Groundwater Assessment Criteria (µg/L).

Contaminant	95% Protection for Aquatic Ecosystems	Irrigation	Stock Watering
Aluminium	55	5000	5000
Arsenic (AsIII)	24	100	500
Cadmium	2	10	10
Chromium (CrIII)	1	100	1000
Copper	126	200	1000
Lead	91.8	2000	100
Nickel	99	200	1000
Zinc	720	2000	20,000
Mercury	0.6	2	2
TPH C6-C36	LOR	LOR	LOR
Benzene	950	-	-
Toluene	180	-	800 (25)
Ethyl Benzene	140	-	300 (3)
Xylene	350/200	-	600 (20)
Benzo(a)pyrene	0.1	-	0.01
Naphthalene	16	-	-

Table 6.3: Groundwater Assessment Criteria (µg/L).			
Contaminant	**95% Protection for Aquatic Ecosystems**	**Irrigation**	**Stock Watering**
PAHs	3	-	-
Fluoride	5000	1000	2000
Cyanide (free)	7	-	-

7 Quality Assurance/ Quality Control

The fieldwork program was undertaken in accordance with the DQOs and DQIs outlined in the SAQP (ENVIRON, March 2012).

A quality assurance assessment of the DQIs for this report is presented in Appendix G. An assessment was made of data completeness, comparability, representativeness, precision and accuracy based on field and laboratory considerations, as outlined in NSW DEC (2006) And NSW EPA (2007) guidelines.

Overall it is considered that the completed investigation works and the data obtained adequately complied with the DQOs stated in the SAQP and that the data is of suitable quality to meet the project objectives.

8 Results

8.1.1 Soil and Groundwater Results

The soil and groundwater analytical results are presented in Tables LR1 to LR4 at the end of this document.

PAECs where soil and/or groundwater contamination was identified are presented in Table 8.3. Sampling locations including areas of identified impacts are shown on Figures 6 and 7.

PAECs not included in Table 8.3 were found to contain concentrations of contaminants of concern below the trigger values. These PAECs are:

- South surge Pond;
- Contractors storage compounds;
- The ground surface surrounding the SPL storage sheds;
- The ground surface surrounding the switch yard.

The compounds aluminium, arsenic, cadmium, chromium (total), copper, nickel, lead, zinc, mercury, cyanide and PCBs were **not** identified in any soil or sediment sample above the trigger values or preliminary screening tools (aluminium). **On the basis of the results these compounds are not considered to be contaminants of concern at the site or in the buffer zone.**

Fluoride concentrations in soil and sediment samples on site ranged between 60 and 47,100mg/kg. Preliminary screening levels for industrial land use range between 2000mg/kg and 37,000mg/kg for industrial landuse. Comparison to international guidelines was used as a preliminary screening tool to assess the requirement for developing a site-specific investigation level. Given the fluoride concentrations on the site exceed the highest international criteria, it is considered that further evaluation of an appropriate fluoride guideline for the site is required.

Fluoride concentrations in soil samples from the buffer zone ranged between 70 and 520mg/kg with a 95% Upper Confidence Limit is 336mg/kg. Preliminary screening levels for agricultural and fauna range between 200mg/kg to 250mg/kg. Further evaluation of an appropriate fluoride guideline is required in the buffer zone. Consideration should also be given to potential future residential use.

The compounds mercury, PCB, OCP, OPP, cyanides (total and free) were not identified above trigger values in groundwater samples collected at the site and the buffer zone. On the basis of the results these compounds are not considered to be contaminants of concern at the site or in the buffer zone.

Concentrations of nickel, copper and zinc in groundwater were found in bores located outside of the plant or within residual soils (MW06 and MW21). The concentrations of these metals are not considered to be related to site activities.

Figure 6 – Site Sampling Locations

Figure 7 – Buffer Zone Sampling Locations

Table 8.3: Identified Soil and/or Groundwater Contamination

No.	PAEC	Identified Soil Contamination	Identified Groundwater Contamination
1	Alcan Mound Leachate Area (Due to University of Newcastle investigations, ENVIRON did not re-sample this area.	Impacts to surface water, groundwater and biota.	Fluoride plume extends approximately 300m from north east corner of the Alcan Mound.
2	Anode Waste Pile	BaP (16.1-29.4mg/kg at 0-0.4m depth) and Total PAHs (165-458mg/kg at 0-0.4m depth) in shallow fill material beneath the anode pile above the guidelines of 5mg/kg and 100mg/kg respectively. Fluoride concentrations in fill samples range between 1010mg/kg and 47100mg/kg to a depth of 0.6m.	PAHs exceeded ANZECC (2000) criteria in shallow estuarine sands aquifer (BaP at 6.64µg/L, fluoranthane at 4.8µg/L) and deeper aquifer (BaP at 0.4µg/L). Concentrations are marginally above the site guidelines. Aluminium (2150-13600µg/L), chromium (4µg/L) and fluoride (43000µg/L) in shallow groundwater above the site guidelines. Heavy metal concentrations in MW12 have been disregarded due to sample turbidity.
3	Refuelling area	TPH concentrations of 3360mg/kg at 0.15-0.3m depth in shallow soil elevated above the adopted guideline of 1000mg/kg. Fluoride concentrations in fill samples range between 90mg/kg and 3240mg/kg in soils between 0m and 0.3m depth. Fluoride concentrations in underlying natural soils of 60mg/kg to 830mg/kg.	TPH concentrations of 330µg/L above the site guidelines of 7µg/L. Aluminium (1050µg/L) and chromium (2µg/L) above the site guidelines. Metal concentrations are consistent with background locations.
4	Diesel Spray Area	Elevated TPH concentrations ranging between 2020mg/kg and 3760mg/kg above the adopted guideline of 1000mg/kg. Elevated BaP concentrations ranging between 19.2mg/kg and 101mg/kg and Total PAH concentrations of 205mg/kg and 963mg/kg in shallow fill material above the site guidelines of 5mg/kg and 100mg/kg respectively.	None identified.
5	Drainage Lines	Elevated BaP concentrations ranging between 15.1mg/kg	N/A

Table 8.3: Identified Soil and/or Groundwater Contamination

No.	PAEC	Identified Soil Contamination	Identified Groundwater Contamination
		and 85.6mg/kg and Total PAH concentrations ranging between 123mg/kg and 996mg/kg in sediment in drainage lines adjacent to Anode Waste Pile above the site guidelines. Fluoride concentrations in sediment ranging between 520mg/kg and 7350mg/kg.	
6	East Surge Pond	Elevated BaP ranging between 16mg/kg and 21.7mg/kg and Total PAH concentration ranging between 171mg/kg and 475mg/kg in sediments above the site guidelines. Fluoride concentrations in sediment ranging between 210mg/kg and 3010mg/kg. Fluoride concentrations in natural soil of 210mg/kg.	N/A
7	Northern Dams 1 and 2	Elevated concentrations of BaP (7.4mg/kg) and PAH (122mg/kg) in one composite sample. Average concentrations indicate acceptable concentrations present. Fluoride concentrations in sediment ranging between 860mg/kg and 1880mg/kg. Fluoride concentrations in natural soils ranging between 340mg/kg and 7350mg/kg.	N/A
8	Carbon Plant	Elevated concentrations of BaP (33.6mg/kg) and Total PAHs (387mg/kg) in shallow fill material adjacent to the green mix plant above the site guidelines. Fluoride concentrations in shallow fill ranging between 150mg/kg and 7740mg/kg. Fluoride concentrations in natural soil ranging between 60mg/kg and 650mg/kg.	PAHs exceeded ANZECC (2000) criteria down gradient of liquid pitch plant (BaP at 0.22µg/L, anthracene at 0.6µg/L). Elevated aluminium (110-3260µg/L), chromium (3µg/L) and fluoride (12000-35000µg/L) concentrations above the site guidelines.
9	Cathode Bar Washdown Area	Elevated concentrations of BaP (8.9mg/kg) and Total PAHs (149mg/kg) in shallow fill material above the site guidelines. Fluoride concentrations in shallow fill of 10600mg/kg.	N/A

Table 8.3: Identified Soil and/or Groundwater Contamination

No.	PAEC	Identified Soil Contamination	Identified Groundwater Contamination
		Fluoride concentrations in underlying topsoil of 190mg/kg.	
10	Flammable Liquids Store	Fluoride concentrations in shallow fill ranging between 700mg/kg and 16200mg/kg from 0.1m to 0.4m depth.	Metal concentrations are consistent with background locations.
11	Washdown Bay	Fluoride concentrations in shallow fill ranging between 960mg/kg and 39000mg/kg from 0m to 0.8m depth.	Elevated concentrations of aluminium (380µg/L), arsenic (18µg/L) and chromium (2µg/L) above site guidelines. Metal concentrations are consistent with background locations.
12	Pot Lines 2 and 3	Fluoride concentrations in shallow fill ranging from 13400mg/kg and 41900mg/kg from 0m to 0.05m depth.	N/A
15	West Surge Pond	Fluoride concentrations in sediment ranging from 5850mg/kg to 38500mg/kg.	N/A
18	Pot Rebuild Area	None identified. Fluoride concentrations of 190mg/kg in shallow fill.	Heavy Metal concentrations in groundwater considered to be natural background concentrations.
19	Clay Borrow Pit	None identified. Fluoride concentrations ranging between 190mg/kg and 2120mg/kg in shallow fill.	Elevated concentrations of aluminium (590-2530µg/L), cadmium (2.7-3.1µg/L), nickel (420-938µg/L), zinc (847-1840µg/L) and fluoride (5500-15000µg/L).
20	Glen Ayr Drift infilling	None identified. Illegal dumping is a waste issue and an aesthetic issue.	N/A
21	Irrigation Area	Elevated BaP concentration of 1.2mg/kg in shallow soil above the residential guideline of 1mg/kg. Elevated zinc concentration of 26mg/kg in shallow soil above the phytotoxicity-based guideline (EIL) of 200mg/kg. Fluoride concentrations in surface soils ranging between	N/A

Table 8.3: Identified Soil and/or Groundwater Contamination

No.	PAEC	Identified Soil Contamination	Identified Groundwater Contamination
		200mg/kg and 510mg/kg.	
22	General Buffer Zone	Fluoride concentrations in surface soils ranging from 60mg/kg and 520mg/kg.	N/A
N/A – not applicable			

9 Discussion

9.1 Conceptual Site Model

The site is situated at the foot of a low residual hill and within a low-lying estuarine swamp environment. The original landform was filled to provide a level, raised platform for construction. Fill material comprised sands, refractory brick waste and carbon waste. The fill material was placed over estuarine sands and high plasticity clay. The site is capped with concrete or bitumen surfacing with soil access points around garden beds and limited grassed areas.

Groundwater at the site was identified at shallow depths within the estuarine sands, between 1m and 5m bgs and flowing north to north east across the site. The presence of the deep ring furnace construction, which extends to bedrock, affects groundwater flow directions in this area, causing diversion of groundwater around the structure and localized groundwater mounding to the south of the structure. A shallow sand aquifer extending from the surface to depths of up to 2.0m is presented to the east of Alcan Mound. Groundwater seepage has been observed down-gradient of this area towards the north east. Groundwater flows within the estuarine sands of up to 14m/year have been estimated. Groundwater with the estuarine sands is not used at the site and is not considered a suitable aquifer for use down-gradient of the site.

The buffer zone includes low residual hills to the west and south and a low-lying swampy area to the north and east. The low-lying swampy area contains numerous dams and water courses which are accessible to livestock. A shallow aquifer is present within these estuarine sands and movement of groundwater from the site is expected to occur through the sand lenses to the north and north east. Discharge of groundwater to the surface water bodies is expected to occur. A separate confined aquifer at a higher elevation was identified in the western portion of the buffer zone within residual clays. The estuarine aquifers on site appear isolated from the underlying and surrounding residual clay and bedrock aquifers. A conceptual drawing of the site hydrogeology and geology is shown in Figure 8.

Activities undertaken within the buffer zone comprise cattle grazing, poultry farming, motor sports, residential use and irrigation of storm-water from the site. The remaining buffer zone is undeveloped and comprises bush land, easements and fire trails.

The site model has identified that the populations potentially exposed to site contaminants comprise human health, livestock and flora and fauna within the buffer zone. Exposure to contaminants on site is limited by site capping and restrictions to groundwater access under the current site use. Re-evaluation of this risk may be required in the event of a change of site use.

Figure 8

9.2 Characteristics and Extent of Identified Soil and Groundwater Contamination

Areas of environmental concern identified at the site and buffer zone are described in the following. These areas are shown on Figure 9.

Alcan Mound

The Alcan Mound is the source of the fluoride plume found in shallow groundwater down gradient of the northeast corner of the mound. Numerous studies have been completed by University of Newcastle on the plume and ENVIRON did not complete additional sampling in this area, however did undertake a review of the existing data. The groundwater plume has impacted on vegetation in two areas. The plume is estimated to extend approximately 300m to the north east of the mound. Fluoride concentrations in monitoring wells immediately downgradient of the mound have decreased from around 1,400mg/L in 1998 to around 400mg/L in 2011.

Anode Waste Pile

The Anode Waste Pile is considered to be a source of PAH and fluoride contamination in shallow fill material and PAH contamination in both the shallow and deeper estuarine aquifers (MW12, MW13). PAH contamination (BaP maximum 29.4mg/kg and Total PAH maximum 458mg/kg at 0-0.2m depth) in soil is limited to shallow fill within the immediate vicinity of the Anode Waste Pile. PAH concentrations in soil are more than 2.5 times the criteria and are therefore considered to be a 'hot spot'. This contamination hot spot would require remediation prior to redevelopment of the site. PAH concentrations in groundwater within the deeper aquifer (BaP at 0.4µg/L) were approximately ten times lower than those in the shallow aquifer (BaP at 6.64µg/L).

Further investigation of the extent of soil impact should be undertaken following removal of the pile. Remediation of groundwater is not likely to be required as the concentrations are low and likely to naturally attenuate following removal of the contaminant source.

Metals in groundwater identified at this location are consistent with naturally occurring concentrations. It is noted that MW12 was not field filtered due to high turbidity and this is the likely cause of the elevated metals concentrations in this sample.

East Surge Pond and Drainage Sediments

Concentrations of PAH (maximum 996mg/kg in D6 at 0-0.2m depth) and fluoride (maximum 7350mg/kg in D7) were identified in sediment samples collected from within the East Surge Pond and within the drain discharging to the pond (D6,D7,D8,D11,D12). PAH concentrations are above the guideline a require remediation. The significance of fluoride concentrations requires further evaluation as part of the site wide fluoride evaluation.

The drainage line and sediment dam receives storm-water runoff from both the carbon plant and the Anode Waste Pile and ongoing site activities may further contribute to contamination. The presence of contamination under the current site use does not represent a risk to human health as the sediments are isolated from human contact by

fencing. However, it is recommended that remediation of these sediments be undertaken during routine maintenance or following a change in site use.

Diesel Spray Area

Shallow fill material at the Diesel Spray Area is contaminated with PAH (maximum 963mg/kg) and TPH (maximum 3760mg/kg). The source of the TPH contamination is considered to be the spraying of diesel onto the ground surface. The source of the PAH contamination is unknown. The TPH and PAH contamination is limited to shallow fill since deeper samples did not return concentrations above the laboratory limits of reporting, however the lateral extent of the PAH contamination is unknown. As both the PAH and TPH concentrations in soil are more than 2.5 times the criteria, this contamination is considered to be a 'hot spot'. This contamination hot spot would require delineation and remediation prior to redevelopment of the site.

One drain sample (D10) collected down gradient of this area identified fluoride at a concentration of 3330mg/kg. The significance of fluoride concentrations requires further evaluation as part of the site wide fluoride evaluation.

Carbon Plant

Soil PAH concentrations (BaP at 33.6mg/kg and Total PAH at 387mg/kg) were identified at sample location MW18 adjacent to the green-mix plant at depth of 0-0.2m. The vertical extent of the PAH contamination is limited to fill materials and has not extended into underlying natural soils which returned analysis results below the laboratory limit of reporting at depth of 0.8-1.0m. Impact to groundwater was not detected. The lateral extent is unknown, as only one borehole was drilled in this area. As the BaP and Total PAH concentrations exceed 2.5 times the criteria, this contamination is considered to be a 'hot spot'. This contamination hot spot would require delineation and remediation prior to redevelopment of the site.

Concentrations of PAH in groundwater were identified in one groundwater monitoring well (MW16) installed down-gradient of the liquid pitch storage area exceeding the site criteria, with BaP at 0.22µg/L and Anthracene of 0.6µg/L. PAH contamination was not identified in soils in this area. Groundwater concentrations in surrounding wells (MW17,MW18, MWA, MWB and Sump) did not detect the presence of Benzo(a)pyrene in groundwater. The absence of impact in surrounding wells and no observed concentrations in soil at this location indicates that impact from the storage and use of liquid pitch is not significant. No further investigation is required at this time.

Fluoride was identified in filled soils surrounding the bake furnaces (2350-3950mg/kg at 0.1-0.4m depth) and at the green-mix plant (7740mg/kg at 0-0.2m depth). Preliminary screening of fluoride concentrations at the site indicates that a site-specific investigation level needs to be developed to assess fluoride contamination. Fluoride (12000-35000µg/L) and aluminium (270-3260µg/L) were identified in groundwater exceeding the criteria. Further investigation is required to assess the significance of these concentrations. With the exception of aluminium, metals concentrations identified in groundwater are consistent with naturally occurring concentrations.

Cathode Bar Washdown Bay

PAH (BaP maximum 8.9mg/kg and Total PAH maximum 149mg/kg at 0.5-0.6m depth) and fluoride (10600-39000mg/kg at 0.2-0.6m depth) were identified in filled soils in the vicinity of the cathode bar wash-down bay. The vertical extent of the PAH contamination is limited to fill materials and has not extended into underlying natural soils. The lateral extent is limited to the area immediately surrounding the wash-down bay. The levels of PAH contaminants identified (BaP maximum 8.9mg/kg and Total PAH maximum 149mg/kg at 0.5-0.6m depth) are not considered hotspots as the concentrations do not exceed 2.5 times the guidelines. On this basis, remediation is not likely to be required.

Washdown Bay

Aluminium (maximum 380µg/L), arsenic (18µg/L) and chromium (2µg/L) were detected in groundwater beneath the washdown bay. Arsenic and chromium are marginally above the site guidelines and not identified in other groundwater wells or in soils. No further evaluation of groundwater is required.

Other Metals in groundwater identified at this location are consistent with naturally occurring concentrations.

North Dam 1

One composite sample collected from North Dam 1 (Composite 1) identified concentrations of BaP of 7.4mg/kg and PAH of 122 mg/kg, which is marginally above the guideline of 5 mg/kg and 100mg/kg respectively. The remaining three samples identified concentrations well below the guidelines. The concentrations detected are not considered significant and do not warrant further investigation or remediation.

Refuelling Area

TPH was identified in soil (3360mg/kg at 0.15-0.3m depth) and in groundwater (330µg/L) at one sample location at the refueling area. This TPH contamination was limited to surface soils as TPH concentrations in natural soils from 0.4-0.6m depth were below the laboratory limit of reporting. The lateral extent of the petroleum hydrocarbon contamination appears limited to the immediate area surrounding the source of contamination. The concentration detected is not considered significant on an industrial site and further investigation is not required at this time.

The heavy fraction hydrocarbons in groundwater were not encountered down gradient of this area and the extent of contamination is considered limited to the immediate area around the bowser and adjacent wash-bay. This groundwater contamination is not likely to migrate off-site given its location. It is considered that this contamination will naturally attenuate over time and no further remediation or investigation is required at this time. Metals concentrations identified in groundwater are consistent with background concentrations.

Elevated concentrations of fluoride in soil were identified in one sample (MW07) in the refueling area. The significance of fluoride concentrations requires further evaluation as part of the site wide fluoride evaluation.

Pot Lines

Fluoride was detected in all four surface soil samples collected between Pot Lines 2 and 3 at concentrations ranging between 13400mg/kg and 41900mg/kg. Preliminary screening of fluoride concentrations at the site indicates that a site-specific investigation level needs to be developed to assess fluoride contamination.

Flammable Liquids Store

Fluoride was detected in one sample (16200mg/kg at 0.2-0.4m depth) collected from the area surrounding the flammable liquids store. Preliminary screening of fluoride concentrations at the site indicates that a site-specific investigation level needs to be developed to assess fluoride contamination.

Metals in groundwater identified at this location are consistent with naturally occurring concentrations.

Western Surge Pond

Fluoride was detected in two samples (5850mg/kg and 38500mg/kg) collected from the western surge pond. This contamination has likely resulted from the close proximity of the surge pond to the pot lines and the practice of dewatering ‘white waste’ to this pond.

Glen Ayr Drift

Landfilling of concrete by Hydro and illegal dumping of household and demolition wastes at Glen Ayr drift is considered to be an aesthetic issue that will need to be addressed prior to redevelopment of the site.

Clay Borrow Pit

Landfilling of refractory bricks and a small volume of concrete and bitumen at the Clay Borrow Pit is considered to be an aesthetic issue that will need to be addressed prior to redevelopment of the site. Evaluation of groundwater quality from within the in-filled borrow pit (MW05) found elevated concentrations of fluoride (15,000µg/L), copper (3µg/L), nickel (15µg/L) and zinc (30µg/L). The concentrations of copper, nickel and zinc are consistent with levels detected at the background bore (MW06). The fluoride concentration, compared to a background concentration of 1000µg/L in MW06, is considered to be elevated.

Groundwater wells surrounding the Clay Borrow Pit (MW03 and MW04) identified concentrations of aluminium (maximum 2530µg/L), fluoride (maximum 5500µg/L), cadmium (maximum 3.1µg/L), nickel (maximum 938µg/L) and zinc (1840µg/L) exceeding the criteria and above concentrations found in MW05. Wells MW03 and MW04 are situated in residual soils and upgradient of the Borrow Pit. A second round of sampling was completed in August 2012, which confirmed the results of the initial sampling. The concentrations of the analytes detected are above levels considered to be natural occurring however, given the upgradient location of the wells the elevated metals concentrations are not considered to be associated with activities at the site or from the placement of fill in the Clay Borrow Pit. It is noted that the surrounding land consists of virgin bushland of the buffer zone and there are no identified industrial facilities up gradient of the Clay Borrow Pit that could provide a source for the elevated metals concentrations.

Remediation of the clay borrow pit is required to removal aesthetic impact from the presence of these materials and to mitigate possible impacts to groundwater. Dumping of waste outside of licensed landfill is also illegal and removal of the waste may be required under the POEO Act.

Buffer Zone (including Irrigation Area)

One sample collected from the irrigation area identified minor concentrations of BaP (1.2mg/kg) at a depth of 0-0.05m exceeding the criteria for residential landuse. Further investigation is not warranted given the marginal exceedence and the unknown future landuse.

Fluoride was detected at concentrations ranging between 70mg/kg and 520mg/kg. Preliminary screening of fluoride concentrations at the site indicates that a site-specific investigation level needs to be developed to assess fluoride concentrations specific for this site use.

9.3 Evaluation of Duty to Report Triggers in accordance with the Contaminated Land Management Act

Under Section 60 of the Contaminated Land Management Act any person whose activities have contaminated land or a landowner whose land has become contaminated is required to notify the EPA when they become aware of the contamination. A two step process is adopted to determine the requirement to report the site under the Act.

Step 1. Are there any indicators of contamination?

Step 1 assesses the historical and current site activities, neighbour and site complaints and observations of the site and surrounds to assess the potential for contamination to be present. Indicators of contamination that are present at the site include the observed areas of die back in the Buffer Zone to the east of the Alcan Mound which indicates a toxic response in flora. The occurrence of dieback is considered to be sufficient evidence to conclude that the site should be reported to the EPA. Notwithstanding this conclusion, further investigation of the whole site has been undertaken to investigate the nature of contaminants in soil and groundwater.

Step 2 Assessing the site.

Step 2 involves investigating contaminant concentrations at the site and evaluating against triggers. This investigation forms the basis of this report, and trigger concentrations are outlined in Section 6. The evaluation identified elevated concentrations in soils and groundwater as presented in Section 9. However, concentrations are not triggers in isolation and consideration is also given to:

- The concentration of the contaminant is in excess of the triggers and a person has been or will foreseeably be exposed to the contaminant. Concentrations of fluoride and PAHs in soils exceed the trigger concentrations. Exposure to personnel is considered unlikely given the large sealed areas across the site which act to restrict contaminant exposure. Exposure would occur in short durations at the time of site

maintenance including site excavation or sediment removal. These activities can be managed through a site management plan to mitigate risks.

- The contamination has entered neighbouring land above trigger levels and will foreseeably continue to remain above the trigger concentration. In this instance the buffer zone is considered 'off site'. Sampling of soils around the buffer zone indicate that trigger concentrations are exceeded but that exceedances are low. For PAHs risk of exposure is unlikely due to restricted access to the irrigation area. It is also likely that PAH concentrations would attenuate naturally with time. The significance of Fluoride within the buffer zone requires a specific assessment to develop an appropriate guideline. There has been no soil sampling in the areas of dieback or down-gradient of the Alcan Mound and therefore it is unclear if soil concentrations in this area are significant and warrant remediation.

- The contaminant has entered groundwater or will foreseeably enter groundwater and will be present at concentrations above triggers and will remain at concentrations above triggers. Elevated concentrations of Fluoride and Aluminium were detected on site at concentrations above adopted trigger values. These contaminants will foreseeably remain at these concentrations without remediation or mitigation. Concentrations of TPH and PAH were identified marginally above the triggers. These concentrations are likely to naturally attenuate over time.

- The contaminant has entered surface water or groundwater containing the contaminant will, or forseeably will, discharge to surface water and will be present at concentrations above triggers and will remain at concentrations above triggers. Based on the concentration data observed and trend analysis undertaken, concentrations of fluoride in groundwater are above the adopted trigger concentrations, although decreasing trends are observed. These concentrations are likely to remain above criteria in the absence of mitigation and remediation actions.

- ENVIRON considers that the site requires notification as significantly contaminated to the EPA on the basis of observed dieback in the buffer zone, fluoride, ammonia and cyanide concentrations in groundwater down-gradient of the Alcan Mound. The concentrations of fluoride in soils on the site and the buffer zone and in groundwater require specific risk based evaluation to develop a suitable trigger value for evaluation.

ENVIRON note that disclosure of the contaminant plume was made to the regulatory authorities during the development application process granted in 1992. As part of this process an Environmental Impact Statement was prepared (Dames and Moore) Cessnock City Council sought input from the EPA, amongst other agencies. At that stage the presence of contaminated leachate and associated impacts were recognised and the capping program initiated to reduce impacts to the environment. Hence, one could also be of the opinion that a disclosure to EPA has already taken place. The issue should be assessed by legal counsel prior to any action taken.

- Figure 9

10 Recommendations and Conclusions

Of the PAECs investigated nine areas of concern requiring further investigation or remediation were identified. These are described in the following.

Alcan Mound

Contamination of groundwater by leachate down-gradient of the Alcan Mound is occurring and toxicity to flora is evidenced by the observed dieback. The concentrations of fluoride in groundwater have been shown to decrease in the immediate vicinity of the mound following site capping, indicating that a reduction of the contaminant loading is occurring. The presence of this contamination is considered by ENVIRON to potentially trigger the duty to report the site as potentially contaminated to the EPA. The EPA advise that under section 60 of the CLM Act, a person whose activities have contaminated land or a landowner whose land has been contaminated is required to notify the EPA when they become aware of the contamination. ENVIRON note that Development Approval 118/692/102 was submitted in 1993 for the capping of the Alcan Mound and that this approval included consultation with the EPA.

Remediation of the Alcan Mound and associated groundwater plume is potentially required and a range of remediation or removal options are available. Prior to remediation, a detailed investigation is required that includes the following elements:

- Investigation of the plume to determine extent, particularly to the east of E4, and volume of contaminant present. This can include a short term pumping trial to assess volume of water within the shallow sand aquifer.
- Investigation of soil concentration in the zone of dieback to assess if soils in this area will require remediation;
- Assessment of the actual cause of dieback. It has thus far been assumed that the cause is fluoride however other contaminants are present at significant concentrations;
- Pump test of impacted high concentration groundwater in order to evaluate recharge of this area or determine that it constitutes a residual water reservoir trapped at that part of the Alcan Mound.
- Undertake an options study for remediation of the Alcan Mound. Options include encapsulating in-situ, encapsulating at a secondary location on site and off-site disposal. The options study should include a cost and feasibility evaluation as well as outlining long term responsibility to Hydro and site restrictions.

Anode Waste Pile

Further investigation and delineation of PAH and fluoride impacts to soil should be undertaken following removal of the waste pile from this area. A detailed scope of work can be developed at that time. Remediation of this area may be required depending on the concentrations identified and the site use.

East Surge Pond and associated drainage line

Contamination to this portion of the drainage system originates from the activities of the carbon plant and/or the presence of the Anode Waste Pile. Remediation of sediments is therefore recommended after change of use, and/ or following the removal of the pile, cessation of the carbon plant, or following the implementation of controls to minimize sediment runoff to the drainage system.

Diesel Spray Area

Contamination of surface soils has occurred in this area from spraying of cathode bars with diesel prior to use. To prevent further contamination it is recommended that spraying of diesel cease. Remediation of this area is required and could be undertaken with low risk of future impacts from plant operations. Remediation will require:

- Delineation of the extent of contamination through additional sampling (or at the time of investigations);
- Excavation to stockpile pending waste classification;
- Waste classification;
- Disposal to landfill on the basis of the waste classification, or treatment on site to allow disposal to landfill.

Carbon Plant

Elevated PAH identified at the green-mix area of the carbon plant require further evaluation following cessation of plant operations. If remediation is determined to be required by future use concept of the area this will likely involve excavation, waste classification and disposal to landfill or treatment on site.

Glen Ayr Drift

Access restrictions to the Glen Ayr drift should be imposed immediately to prevent further illegal dumping. Removal of waste to landfill is required by the site owner in the absence of identification of the polluter. Waste can be disposed to a licensed solid waste landfill.

Remediation should include development of a management plan that allows for appropriate response measures in the event that wastes not included in the solid waste characterizations are identified and appropriately disposed, for example bonded asbestos fragments.

Clay Borrow Pit

Wastes disposed to the clay borrow pit includes waste stockpiled above ground and waste buried within the former borrow pit. The materials disposed contain low total and leachable concentrations of contaminants. However, the current waste disposal practice is not in accordance with the POEO Act and the presence of the material is aesthetically detrimental. Remediation or removal is required and a detailed and costed remedial options study should be undertaken to determine the appropriate option.

One option includes the crushing and reuse of the refractory brick under a specific exemption for refractory. The close proximity of the Hunter Express Way may offer a reuse opportunity if acted upon quickly.

Fluoride in soil and groundwater

Concentrations of fluoride at the site and within the buffer zone are considered to be at concentrations warranting further site specific toxicological evaluation. This recommendation is consistent with the EPA guidance in the absence of an NSW or Australian guideline.

Aluminium in groundwater

Concentrations of aluminium were determined above the applicable site guideline in groundwater. A desktop risk evaluation should be undertaken to evaluate the potential for ecological harm to result from the concentrations identified.