Appendix F

Contaminated land

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Appendix F.1 – Acid Sulfate Soil Management Plan (PB, 2016)

Appendix F.2 – Remediation Action Plan (PB, 2016)

City of Sydney Council

East West Relief Road – Acid Sulfate Soil Management Plan

RFT 9213

1 May 2014

PARSONS BRINCKERHOFF

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Glossary

Acronym	Definition
AASS	Actual acid sulfate soil
ANZECC	Australian and New Zealand Environment and Conservation Council
ASS	Acid sulfate soil
ASSMAC	Acid Sulfate Soil Management Advisory Committee
ASSMP	Acid sulfate soil management plan
CEMP	Construction and environmental management plan
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
EPA	Environment Protection Authority
mAHD	Metres Australian Height Datum
mBGL	Metres below ground level
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
PASS	Potential acid sulfate soil
RAP	Remediation action plan
Spos	Peroxide oxidisable sulphur
TPA	Total potential acidity
TSA	total sulfuric acidity
NV	Neutralising value
ENV	Effective neutralising value
VENM	Virgin excavated natural material
TSS	Total suspended solids
TDS	Total dissolved solids

1. Introduction

1.1 Background

City of Sydney Council (Council) engaged Parsons Brinckerhoff Australia (Parsons Brinckerhoff) to prepare an acid sulfate soil (ASS) management plan (ASSMP) for the proposed East West Relief Route (EWRR) as part of RFT 9213. The proposed route, hereafter referred as “the site”, is located across numerous sites between Botany Road, O’Riordan Street and Bourke Road, Alexandria as defined in Figure 1. Parsons Brinckerhoff understands that as part of proposed works, excavation will be required under the proposed route to facilitate the installation of a new trunk drain for Sydney Water.

Based on the Commonwealth Scientific and Industrial Research Organisation’s (CSIRO) Acid Sulfate Soil Risk Map, the risk of disturbing ASS is considered to be low at the site. However, as the site is located in a between 10 and 15 metres Australian Height Datum (mAHD)) and land within 1 km of the site was identified to have high probability of ASS occurrence, the site is classified as Class 3 and Class 5 Acid Sulfate Soil area in the City of Sydney Council’s local environmental Plan (LEP, 2012). The LEP states that Class 3 land requires development consent for, ‘works more than 1 metre below the natural ground surface’ or ‘works by which the watertable is likely to be lowered more than 1 metre below the natural ground surface’. Class 5 requires development consent for, ‘works with 500 metres of adjacent Class 1, 2, 3 or 4 land that is below 5 mAHD and by which the watertable is likely to be lowered below 1 mAHD on adjacent Class 1,2,3 or 4 land.’

Taking into account the proposed plan and the potential for groundwater to be encountered across the site during excavations, an ASSMP is therefore considered necessary to provide a framework for managing possible encounter with ASS during the excavation works.

1.2 Purpose and objective

This ASSMP has been developed for the purpose of guiding construction activity and site management to mitigate the impacts of potential and actual ASS (PASS or AASS) on the surrounding environment. It contains the following management measures:

- excavation procedures
- spoil storage and treatment
- dewatering and groundwater management
- bunding and measures for protection of surrounding areas from the potential risk of acid contamination
- a contingency strategy.

The objective of the plan is to comply with all statutory requirements and implement all necessary environmental controls to minimise and manage impacts to the environment from the disturbance of PASS or AASS. This ASSMP should be used in conjunction with the remedial action plan and any future construction environmental management plan (CEMP) and spoil management plan for the site.

1.3 Structure of this ASSMP

This ASSMP describes the safeguards and management systems for the construction phase of the project with regards to ASS. The structure of the ASSMP is described below:

- Section 2: Site details – Provides a summary of the site location and subsurface conditions observed during the previous investigation works

- Section 3: Occurrence of ASS – Provides an overview of the ASS investigation works undertaken at the site to date
- Section 4: ASSMP implementation – Documents the project roles and responsibilities, communication and training requirements for the project
- Section 5: ASS management– Documents the site ASS management strategies required to mitigate the potential environmental issues and impacts of the works
- Section 6: Contingency strategy – Details emergency response procedures and provides the contingency measures for the project.

1.4 Legislation

1.4.1 Legislative documents

The management of ASS is coordinated by the NSW Acid Sulfate Soil Management Advisory Committee (ASSMAC). This committee is made up of representatives from various government organisations and other affected parties.

This plan has been compiled generally in accordance with the Acid Sulfate Soil Manual (ASSMAC, 1998) which aims to guide the management of ASS. In addition, the following guidelines were considered when preparing this plan:

- Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*
- National Environment Protection Council (NEPC) 2013, *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1) (NEPM).*
- NSW Environmental protection authority (EPA) 1995, *Sampling Design Guidelines.*
- NSW EPA 1997, *Guidelines for Consultants Reporting on Contaminated Sites.*
- NSW EPA 1999, *Guidelines on Significant Risk of Harm and the Duty to Report.*
- NSW Department of environment and conservation (DEC) 2006, *Guidelines for the NSW Site Auditor Scheme (2nd Edition).*
- NSW Department of environment and climate change (DECC) 2008, *Waste Classification Guidelines Part 4: Acid Sulfate Soils.*
- QLD Department of Natural Resources and Mines 2002, *Queensland Acid Sulfate Soil Technical Manual*.

1.4.2 Approvals and licences

ASSMAC (1998) indicates that development consent must be obtained prior to proceeding with intrusive works in areas of potential ASS. This involves obtaining approval of this ASSMP prior to undertaking the works.

The NSW DECC (2008) *Waste Classification Guidelines Part 4: Acid Sulfate Soils* indicate that with regard to the disposal of ASS, the receiving landfills should be licensed appropriately as per the following:

- If excavating and disposing of PASS the receiving landfill must be licensed by the NSW EPA to dispose of PASS below the water table.

- If excavating and disposing of AASS, including PASS that has dried out or undergone any oxidation of its sulfidic minerals, the material will require treatment/neutralisation and subsequent waste classification on site. Following waste classification, the receiving landfill must be licensed to accept that class of waste.

Fines for individuals and organisations apply for pollution offences including the release of acidic, contaminated water into the environment under the NSW Protection of the Environment Operations Act (POEO Act, 1997).

2. Site identification

2.1 Site description

The EWRR will be constructed as part of the Green Square Town Centre (GSTC) to improve east-west road connectivity by providing a link from Bowden St, across Bourke Rd, O'Riordan St and Botany Rd, into the GSTC (via Geddes Avenue).

Construction of the EWRR will also facilitate the installation of the Green Square trunk stormwater drainage system by accommodating this system under the proposed road reserve alignment. The installation of the stormwater trunk main is required to allow the future development of the GSTC and Epsom Park Precinct.

A site location plan is provided in Figure 1. Based on this figure, the site identification detail is provided in Table 2.1.

Table 2.1 Site identification detail

Site name	Proposed East West Relief Route
Site address (addresses which EWRR intersects)	334-336 and 338 Botany Road, 9-13, 20 and 22 O'Riordan Street and 44-54 Bourke Road, Alexandria NSW
Lot and DP (sites which EWRR intersects)	Lot 101 DP 569709, Lot 1 DP 739598, Lot 1 DP 1004389, Lots 7, 9, 10 11 DP 214410, SP 34626 and Lot 37 DP 817055
Area	Approximately 1.02 ha
Current site uses	Variety of light industrial and commercial; transportation depot and workshop, furniture warehouse, carpark, Ausgrid depot, decommissioned Mobil service station, Hoya Lens head office and laboratory.
Proposed site use	Road corridor

The proposed EWRR route stretches over a number of properties between Botany Road and Bourke Street, Alexandria. The intrusive investigation was undertaken to the east of the alignment on Botany Road in the site which is currently used as a bus transportation yard. It is mostly open and flat, surfaced by bitumen and concrete. The northern edge of the yard is confined by existing buildings that appear to partially extend over the property boundary. The property is bounded by other properties on the southern and western sides and by Botany road on the eastern side.

The site has a concrete entrance ramp in the north-east corner that extends approximately 20 m into the site from Botany Road and falls at a grade of approximately 1:40 into the site. The south-east corner of the site adjacent to this ramp is elevated approximately 0.5 m above the remainder of the site. The western portion of the site is flat, there is a 2.9 m retaining wall that extends halfway along the western boundary of the site, and this wall is then met by an adjacent building that covers the remainder of the western edge of the site. Adjacent to the building is the decommissioned Mobil service station site. This site no longer has fuel infrastructure and fronts O'Riordan Street.

2.2 Sensitive receptors

Sensitive receptors identified within a 500 m radius of the site include:

- underlying soil and groundwater ecosystems
- surface water body (Sheas Creek) which flows into Alexandria Canal; receives stormwater and rainfall runoff from the site and surrounds
- site users including on-site and off-site employees, construction tradesmen and visitors; and including occupiers of commercial buildings and/or residential properties down-gradient and adjacent to the site.

2.3 Topography

Based on site inspection and the “Proposed Road Alignment Works Plan 2” provided by Council, the natural topography of the site is a uniform downhill slope running from eastern Botany Road entrance (approximately 15 mAHD) to the western edge of the site (approx. 11 mAHD). The existing level of the site is between 14 and 15 mAHD.

The nearest surface water bodies are Shea’s Creek, Alexandria Canal and Botany Bay, located 220 m to the west, 750 m to the south-west and 5 km to the south-west, respectively.

2.4 Geology and hydrogeology

Regional geological information was obtained from the Department of Mineral Resources – Geological Survey of New South Wales (1983) 1:100 000 Geological Series Sheet 9130. This indicates that the site is underlain by quaternary deposits comprised of medium- to fine-grained marine sands with podsols. The sand is underlain at depth by the Mesozoic Ashfield Shale of the Wianamatta Group, consisting of black to dark grey shale and laminate.

During the current and previous site investigations, the lithology encountered at the site was described as fill underlain by silty or sandy clay. Beneath this layer, there is variation across the site. To the west sands extend to the maximum investigation depth of 11 mBGL at BH09a, and to the east shale was encountered at a shallow depth of approximately 4.5 mBGL (BH03) and extended to the maximum investigation depth of 9.40 mBGL at BH07.

Coffey Environments, formerly IT Environmental, described the regional geology as having low to moderate yield less than 5 litres per second (IT Environmental, 2006; Coffey Environments, 2009). The groundwater is inferred to flow in a westerly direction towards Shea’s creek.

Groundwater gauged in the two newly installed monitoring wells (BH06 and BH09) ranged between 6.20 mBGL and 2.20 mBGL. This is consistent with the results from the historical reports of the Mobil site (IT Environmental, 2006) which measured standing water at approximately 3 mBGL.

3. Occurrence of ASS

3.1 Overview of ASS

ASS are soils which contain iron sulfides. The predominant ASS sulfidic mineral is pyrite (FeS_2), an iron disulfide. The exposure of pyrite to oxygen and water leads to the generation of sulfuric acid. The subsequent acidic leachate can then lead to mobilisation of heavy metals such as aluminium and iron into water bodies. Therefore, as their mobility increases with lowering pH values, drainage waters from areas of ASS may affect water quality, and can lead to the death or disease of aquatic organisms.

AASS are ASS which are already acidic and are presently generating acid by oxidation of pyrite. AASS generally have field pH values of less than 4 when tested in a suspension of distilled water.

PASS are ASS containing unoxidised or reduced pyrite. Therefore, the potential remains for future oxidation of pyrite (and acid generation).

A review of the Department of Land and Water Conservation 1:25,000 Botany Bay Acid Sulfate Soil Risk Map (Edition Two, 1997) indicates that the site is located in an area generally mapped as ‘disturbed terrain’ where the elevation is 2 to 4 metres.

Disturbed terrain may include filled areas, which often occur during reclamation of low lying swamps for urban development. Other disturbed terrain includes areas which have been mined or dredged, or have undergone heavy ground disturbance through general urban development or construction of dams or levees. Soil investigations are required to assess these areas for ASS potential.

3.2 Assessment criteria

The following assessment criteria for field and laboratory testing have been developed with reference to the ASSMAC Assessment Guidelines (1998).

ASS are usually found in estuarine environments up to 10 mAHD and generally consist of clays and sands containing pyritic material. The field indicators of ASS include:

- iron staining on any drain surfaces
- unusually clear or milky green water discharging from the site
- jarosite horizons or mottling due to iron in the subsurface
- corrosion of concrete or steel structures
- presence of any sulfurous odours.

The analytical results will be assessed against the following criteria taken from ASSMAC (1998) and summarised in Table 3.1. Action criteria for ASSMAC (1998) are based on texture and clay content of the soil being analysed and the total volume of soil to be disturbed. For the purpose of this investigation the adopted action criteria is for medium texture soils. As the potential amount of ASS requiring excavation, if any, is unknown both the criteria for 1 to 1,000 T disturbed and for >1,000 T disturbed have been considered. The action criteria applied will depend on the amount of ASS encountered during the work. Table 3.1 outlines the assessment criteria.

Table 3.1 ASSMAC (1998) adopted action criteria

Test	Units	Action criteria for medium textured soils (medium to heavy clays and silty clays)	
		1 to 1,000 T disturbed	>1,000 T disturbed
S_{POS}	%	0.06	0.03
TPA	mol H+/tonne	36	18
TSA	mol H+/tonne	36	18

Notes:

(1) S_{POS} – Peroxide oxidisable sulfur

(2) TPA – Titratable peroxide acidity

(3) TSA – Titratable sulfidic acidity

Adopted from the NSW Acid Sulfate Soils Management Advisory Committee (1998) – Acid Sulfate Soils Assessment Guidelines

3.3 Contamination assessment report (Parsons Brinckerhoff, 2014)

As part of the contamination assessment, field and suspension peroxide oxidation combined acidity & sulfur (SPOCAS) testing was undertaken at a selected borehole on the site to get an indication of the subsurface conditions.

Table 3.2 Field results

SAMPLE	DEPTH (mBGL)	MEDIUM	pH_{field}	pH_{ox}	Reaction	Colour change	PASS	AASS
Parsons Brinckerhoff (2014)								
BH01	4.0-4.1	Silty clay	5.96	3.15	Moderate	Slight	Yes	No

Notes:

pH_{field} –pH of the soil when tested using a 1:5 soil water suspension

pH_{ox} – pH of the soil after oxidation with 30% hydrogen peroxide

Table 3.3 Laboratory results

SAMPLE	DEPTH (mBGL)	MEDIUM	S_P	S_{KCl}	S_{POS}	TAA	TPA	TSA
			% (w/w)			mol H+/tonne		
Parsons Brinckerhoff (2014)								
BH01	4.0-4.1	Silty clay	0.02	0.008	0.01	35	32	<5
Assessment Criteria								
Action Criteria (1-1,000 tonnes)	Sands to loamy sands		-	-	**0.03**	-	**18**	-
	Sandy loams to light clays		-	-	**0.06**	-	**36**	-
	Medium to heavy clays		-	-	**0.1**	-	**62**	-

SAMPLE	DEPTH (mBGL)	MEDIUM	S_P	S_{KCl}	S_{POS}	TAA	TPA	TSA
			% (w/w)			mol H+/tonne		
Action Criteria (>1,000 tonnes)	Sands to loamy sands		-	-	**0.03**	-	**18**	-
	Sandy loams to light clays		-	-	**0.03**	-	**18**	-
	Medium to heavy clays		-	-	**0.03**	-	**18**	-

Notes:
S_p –
S_{KCl} –
S_{POS} –
TAA –
TPA –
TSA –

3.3.1 Conclusions and recommendations

Based on the ASS sampling undertaken during the investigation laboratory results indicated that the underlying natural silty clay materials contained some ASS at BH01, in the eastern portion of the site which exceeds the action criteria for disturbance of greater than 1,000 T of material. Additional ASS may be present in other areas of the site where testing has not been undertaken.

An ASSMP is required to be in place prior to the commencement of any excavation works to be undertaken in known ASS (with the exception of further assessment, if required) as per ASSMAC (1998). This ASSMP outlines mitigation measures to be undertaken during the works to minimise disturbance of ASS materials. In addition, areas where there has been no ASS assessment should be considered to potentially contain ASS and should be managed in accordance with this plan.

4. ASSMP implementation

4.1 Responsibilities

A copy of this ASSMP should be made available for all relevant personnel working on this project. A copy should be kept on site for reference during the works. Table 4.1 details each stakeholders' responsibilities while involved with the project.

Under the NSW POEO Act (1997), it is an offence to cause harm to the environment. A major pollution offence is punishable by a fine of $1,000,000 or more in the case of a corporation, and $250,000 or more for an individual.

Table 4.1 Summary of responsibilities

Position/ organisation	Reports to	Summary of responsibilities
City of Sydney Council	Regulatory Authorities (as required)	▪ Engage contractor and environmental consultant. ▪ Provide funding and approvals. ▪ Advise contractor and environmental consultant project managers of Council requirements. ▪ Review documentation provided by the contractor. ▪ Review investigation reports, ASSMP, design documentation and final report(s) prepared by consultant.
Contractor	City of Sydney Council and Regulatory Authorities	▪ Prepare CEMP. ▪ Manage bulk earthworks in accordance with Council contract. ▪ Undertake Principal Contractor role under OHS guidelines and manage OHS systems for the site works. ▪ Administer and manage contracts and work conducted by environmental consultant. ▪ Undertake site works in accordance with the contract. ▪ Undertake the bulk earthworks in a safe manner and ensure the environment is protected at all times during the works. ▪ Implement measures outlined in the CEMP and ASSMP.
Suitably qualified Environmental Consultant	City of Sydney Council and Regulatory Authorities	▪ Provide environmental consulting services in accordance with the Council contract. ▪ Ensure works are undertaken in compliance with the ASSMP and prepare any final environmental report(s) required.

4.2 Training and awareness

All relevant site personnel will undergo a site induction prior to commencement to ensure that staff and contractors are adequately trained to recognise environmental aspects of the work. The induction will incorporate the activities required to manage contamination issues as detailed in this plan.

4.3 Communication

Complaints received from any stakeholders, including members of the community, shall be managed in a professional manner. All complaints received should be referred to the Council project manager who will adopt an appropriate course of action to manage and address the complainant's concerns in a timely manner.

Consultation with government bodies will be the responsibility of Council and the contractor.

Contact details for critical project personnel including the Council project manager, contractor project manager and environment manager should be outlined in the CEMP.

4.4 Work Health and Safety reporting/management

The contractor is to have appropriate incident reporting mechanisms (including near miss reporting) and these are to be incorporated into the site OHS and environmental management plans.

5. ASS management plan

5.1 Overview

The following sections outline management measures and mitigation strategies to be undertaken to manage areas where PASS or AASS materials are present at the site.

5.2 General environmental management

It is noted that general construction environmental management issues are important when managing works, however these items are not addressed in this plan. This ASSMP is specific to the management of PASS or AASS at the site. General environmental management issues should be outlined in the CEMP for the project.

5.3 ASS management strategies

There are a range of control and management measures available when dealing with the possible disturbance of PASS or AASS. Such measures can be implemented individually or jointly as part of a combined approach.

5.3.1 General

The following general strategies are outlined in ASSMAC (1998):

- **Avoidance** – where ASS areas are avoided altogether (total avoidance) or development activities are adjusted so that the more severe areas are left undisturbed (partial avoidance).
- **Oxidation prevention** – ASS are innocuous if they are not allowed to oxidise. Oxidation can be prevented by avoidance, water table control, in situ capping or removal and burial below the water table.
- **Acid neutralisation** – acid present or produced by oxidation in the soil can be controlled by the addition of alkaline agents such as agricultural lime.
- **Leachate treatment** – where the sulfidic content of the soil is very low (quantity), deliberate oxidation with leachate collection and treatment might be appropriate. This method is generally only applicable to sands, given the lengthy drying times for clay, and would require pilot trials prior to implementation.
- **Disposal to Landfill** – the ASS may be removed and disposed of at an appropriate landfill facility. Untreated ASS would require treatment as a contaminated soil for the purpose of transport and disposal.

Due to the probability of encountering ASS for the proposed site works, avoidance of ASS materials is not a viable option and prevention of oxidation is unlikely as it appears that ASS is already present. During the works, Acid neutralisation using lime will be the most feasible solution to manage ASS on the site.

5.3.2 Excavation

The following management considerations should be taken into account when excavating PASS or AASS (ASSMAC, 1998):

- Where the sulfidic layer is < 0.5 m deep, these areas should ideally be left undrained with minimal disturbance (i.e. generally these areas are best left waterlogged).
- Where the sulfidic layer is between 0.5 and 2.0 m deep, drainage and excavation should only be attempted in accordance with a properly designed management plan:
  - if the sulfidic layer is 0.5 to 1 m below the soil surface, excavation should be limited to areas less than 0.3 m deep
  - if the sulfidic layer is 1 to 1.5 m below the soil surface, excavation should be limited to areas less than 0.5 m deep
  - if the sulfidic layer is more than 1.5 m below the surface, excavation should be limited to areas no greater than 1 m deep.
- Where areas are 'scalded' or degraded and devoid of vegetation, no further drainage or excavation should be undertaken. Remediation strategies should be developed.

Should PASS be encountered, the overall remedial strategy to be adopted should include:

- burial of excavated PASS materials below the watertable where possible
- neutralisation of PASS materials where re-use on site above the watertable is required
- disposal of excess PASS material to an appropriate off-site facility where it cannot be reused on-site.

5.3.3 Spoil management

Where ASS materials are excavated, short and long term management of the material is required. If the excavated material is to be stockpiled prior to treatment and/or disposal, provisions should be made for safe storage.

The time between excavation and acid generation depends on a range of variables including, though not limited to, the texture, mineralogy, temperature and bacterial activity of the excavated material. Particular care is required when dealing with sandy sediments, which oxidise and leach more rapidly than clays. Oxidation in clays is often slower than sands due to advective and diffusive oxygen considerations.

Works that involve short term disturbance of ASS should be staged to minimise the costs associated with mitigation measures and the risk posed to the environment. In some circumstances, the sulfidic material can be reburied into anaerobic conditions as quickly as possible prior to acid generation. As a general guide, sandy soils should be reburied into anaerobic conditions within one day while clay soils should be reburied within a couple of days. Neutralising agents should be incorporated with the excavated material prior to reburial to neutralise any acid that may have been or will be produced through oxidation by excavation and reburial.

Guidelines detailing the amount of lime required to treat specific volumes of disturbed ASS are presented in ASSMAC (1998). When estimating lime requirements in accordance with ASSMAC (1998) guidelines, a safety factor of at least 1.5 to 2 times the weight/volume should be applied to allow for inefficient mixing of the lime and its low reactivity. In addition, the purity and effective neutralising values also needs to be included in the estimation of lime requirement, as specified in ASSMAC (1998).

5.3.4 Neutralisation rates

As a guide, PASS materials with a pH less than 6.0 should be considered as AASS and would require immediate neutralisation, while such materials with a pH of 6.0 or greater should be classified as PASS. The pH of the material must be measured using an appropriately calibrated pH meter.

The most common ASS neutralising method involves the addition of sufficient quantities of a neutralising agent to react with acid as it is produced from the gradual oxidation of the ASS. Fine agricultural lime with a pH of 8.2 is the most commonly used neutralising agent. The following factors should be considered when selecting neutralising agents:

- neutralising value (NV) and effective neutralising value (ENV)
- solubility
- pH, chemical constituents, moisture content, contaminants or impurities
- grades of lime, fineness rating or particle size
- purchase price per tonne, delivery costs and size of a full load
- spreading and mixing costs.

Based on the laboratory results for the SPOCAS testing previously undertaken a preliminary liming rate can be determined from the lookup table provided in the ASSMAC (1998) guidelines. This table has been included in Appendix B, which can be used during excavations works to calculate the appropriate dosing rates. As only limited sampling has been undertaken, additional SPOCAS testing should be conducted during the works to confirm the presence of ASS and the appropriate liming rate.

5.3.5 Dewatering and groundwater management

Changes in groundwater levels can have major impacts on the generation and release of sulfuric acid from ASS. Impacts on groundwater will vary according to the material properties of the aquifer, the characteristics of the proposed works and its interaction with the surrounding environment.

Works that lower the watertable can result in the oxidation of ASS leading to the degradation of groundwater quality with reduced pH and increases in soluble metal and sulfate concentrations. Exposure or near exposure of groundwater during excavation increases the potential threat of contamination via sulfide oxidation.

5.4 Control and management measures

Table 5.1 outlines the controls and management measures to be implemented to manage the potential ASS materials at the site. Works are divided into three groups based on the timing of the works:

- management measures to be implemented prior to commencing any excavation works that disturb ASS
- management measures to be implemented on-site during the excavation works
- management measures to be implemented following completion of the excavation works.

Table 5.1 Management of ASS materials

Prior to excavation works disturbing ASS	
Wash bays	Wash bays should be installed at the site to minimise off-site tracking of contaminated materials by machinery. Wash bays should be used prior to trucks/machinery leaving the site or when moving from an excavation area to a clean area of the site. Leachate controls should be employed around wash bays to minimise the spread of contamination. These should include collection of runoff.
Staged excavation planning	Staged excavation works should be implemented to minimise the risks posed to the environment and to minimise oxidation of in situ materials. To achieve this, the excavation area should be excavated systematically as a series of smaller 'cells' rather than one large area. Where ASS materials are left in situ as the uppermost layer and exposed (i.e. not saturated), areas should be either capped with clean virgin excavated natural material (VENM) or concrete as soon as possible prior to moving to the next area. Ideally, the optimum 'cell' size should be calculated based on the area that can be worked on and completed (including capping works) in a single day. Prior to commencement, a works schedule should be prepared indicating when each area will be excavated and capped. Areas should be marked out prior to the excavation works taking place.
During excavation works disturbing ASS	
Excavation	Employ erosion control measures potentially including temporary bunding, covers, silt fences/socks and hay bales around excavations prior to the commencement of intrusive works. Cell areas should be excavated separately to minimise oxidation of in situ materials and to allow for immediate capping where required.
Management of excavated materials	Excavated potential ASS materials may be managed using one (or a combination) of the following methods: ▪ reburial of excavated materials at the site as soon as possible beneath the water table (this may include temporary storage prior to reburial to maintain the saturation of the materials prior to reburial) ▪ neutralisation of excavated materials using a liming product and re-use on site ▪ disposal of excavated materials to an appropriately licensed off-site waste facility as per the NSW DECC (2008) Waste Classification Guidelines Part 4: Acid Sulfate Soils. These options are discussed in further detail below.

Prior to excavation works disturbing ASS	
Re-use of PASS materials	Excavated PASS materials may be re-used on-site by either immediately burying the materials in area of the site below the water table or by neutralising the materials using a liming product prior to re-using the materials on site. **Option 1: Immediate re-burial** Excavated PASS materials may be re-used on-site by burying the materials in an area of the site located below the water table. This must be done within 16 hours of excavation works to avoid acid generation. If the material is to remain exposed at the surface, it should be capped as detailed in the 'capping' section of this table. If the material is required to be stored for longer than 16 hours, then it must either be: ▪ placed in a temporary holding area where it can remain saturated (either below the water table in another area of the site or in an artificial saturated area such as a holding pen filled with water) ▪ treated as per Option 2. **Option 2: On-site treatment and re-use** Where ASS materials are to be re-used on-site in areas not saturated or more than 16 hours after excavation, these materials must be treated prior to re-use. Materials should not be placed at the immediate surface where they are exposed, for aesthetic purposes. Treatment must be undertaken on a developed hardstand area or suitable engineered pad or limed surface. The hardstand area would require appropriate drainage controls to ensure that any runoff is collected. Treatment measures are discussed in Section 6.3. **Option 3: Off-site disposal** If excavated PASS materials cannot be re-used on site, they should be disposed of to a suitably licensed off-site waste facility. This is discussed in further detail in the 'Post excavation works' section of this table.
Capping of excavations	To minimise the generation of acids, open excavations where the uppermost exposed layer contains PASS materials should be capped as soon as possible or left saturated. If capping is necessary, one (or a combination) of the following capping options should be used: ▪ cap with clean, imported VENM (tested to ensure it meets the appropriate criteria for imported VENM materials) ▪ cap with re-used soil from on-site (tested to ensure it is within the adopted site assessment criteria and does not contain ASS) ▪ cap with concrete. Capping should occur within 16 hours to minimise the environmental risks associated with acid generation. It may be necessary to neutralise material that is left exposed for periods exceeding 16 hours. Where concrete or other building materials are to be placed directly in contact with PASS or AASS, appropriate materials should be chosen that are resistant to the long term effects of sulfate and sulfuric acid which may be produced by the soils.
Spoil management	Stockpiles containing PASS materials should be placed to minimise environmental impact from any leachate. ASSMAC (1998) indicates that the design of stockpile(s) should include: ▪ all stockpiles to be bunded ▪ establish leachate collection and treatment systems including an impervious pad on which to place the stockpile ▪ if an impervious pad has not been established under the stockpile, as a precautionary measure, an apron of fine lime should be applied below the stockpile when stockpiling materials for any length of time ▪ minimise the surface area exposed to oxidation – consider using some form of artificial capping if storage is for longer than a few weeks ▪ minimise the amount of water infiltration – consider using some form of artificial capping ▪ establish diversion banks upslope to prevent run-on water ▪ establish sediment control structures to ensure sulfidic material is not eroded – consider using some form of capping. To manage spoil effectively and meet the above requirements, excavated materials should be stored in a designated area at each site and re-used or disposed of off-site as soon as possible following excavation.

Prior to excavation works disturbing ASS	
Dewatering (where required)	Some dewatering may be required due to excavation occurring above the standing water level of the groundwater. Pumped water should be stored in retention basins or fully contained tanks on-site. Stored water may disposed to a suitably licensed off-site waste facility as liquid waste, as per the NSW DECC (2008) *Waste Classification Guidelines*.
Post excavation works	
Disposal of excavated soil/spoil from excavations	Excavated soils containing ASS materials should be disposed of in accordance with the NSW DECC (2008) *Waste Classification Guidelines Part 4: Acid Sulfate Soils*, as follows: ■ For VENM containing PASS (pH of 5.5 or more): ‣ the materials must be kept wet at all times during excavation and subsequent handling, transport and storage ‣ the receiving landfill must be licensed by the NSW EPA to dispose of PASS below the water table ‣ the materials must be received at the receiving landfill within 16 hours of being dug up. For AASS (pH of 5.5 or less) or potential ASS that has dried out, undergone any oxidation of its sulfidic minerals or is not VENM: ■ the materials must be treated (neutralised) on-site through liming, mixing and testing to ensure that the mixing of lime materials is successful. Monitoring of pH should be carried out regularly during and after the neutralisation procedure to establish the effectiveness of the treatment. ■ Following neutralisation, testing should be undertaken to classify the material in accordance with the NSW DECC (2008) *Waste Classification Guidelines*. The receiving landfill must be licensed by the EPA to accept the class of waste as per the classification. The landfill should be informed prior to receiving the waste that the material contained actual ASS and was treated in accordance with the neutralising techniques outlined in ASSMAC (1998). Information should be recorded/filed for each batch of material tested and disposed of off-site. This should include the origin of material, the volume, a description of the materials, laboratory results and disposal certificates.

5.5 Monitoring and reporting

The overall objective of monitoring is to measure the effectiveness of the proposed strategies in achieving the desired outcomes. Monitoring will assist in identifying and addressing any non-conformances and providing information for implementing corrective actions within an appropriate timeframe. Table 5.2 outlines the monitoring and reporting program during the works.

Table 5.2 Monitoring and reporting program

General	Monitoring of ASS control/management procedures including excavation methods, spoil management measures, and dewatering and groundwater management, ASS pollution incident response investigations, management, remediation and reporting as required.
Soil monitoring program	The following will constitute the soil monitoring program during the works: ■ Field pH measurements of all materials excavated should be taken and logged to provide broad coverage of the excavated material types encountered. One sample should be collected per 25 m3 of excavated natural soil materials for on-site pH testing. ■ Field pH readings of 4 or less will indicate that AASS are present with oxidising sulfides, readings of greater than 4 but less than 5.5 indicate that the soils are acidic and may be the result of limited oxidation of sulfides. These materials will require treatment/neutralisation prior to re-use or disposal. ■ Where soils containing PASS are required to be limed, materials should be tested to ensure that the neutralisation process has been successful. Field testing should be undertaken at a rate of one per 50 m3; if changes in liming rates or material are observed additional samples should be collected. Laboratory testing (SPOCAS) should be undertaken at a rate of 25% of field samples to confirm the results.

- For waste disposal:
  - Material is pre-classified as PASS material as per the NSW DECC (2008) Waste Classification Guidelines Part 4: Acid Sulfate Soils providing it is delivered to the receiving waste facility within 16 hours of excavation.
  - Failing this, material will require liming and testing to ensure that the material has been successfully neutralised and to classify the material as per the NSW DECC (2008) Waste Classification Guidelines Part 1: Classifying Waste.

Information should be recorded and filed for each batch of soil tested. Information should include the origin of the material, the volume, a description of the materials, laboratory results and disposal certificates (where appropriate).

Water monitoring program

The following will constitute the water monitoring program during the works:

- Any pumped water from the excavations and runoff collected will be stored in retention basins or fully contained tanks on-site.
- Water samples should be representative of the stored water and may require sampling from different depths, particularly if the water has been stored long enough to allow it to settle. A sufficient quantity of sample, pre-filtered and/or preserved (if required), placed in appropriate sample containers and stored so as to allow a range of chemical analyses to be performed.
- Water stored in basins/tanks should be tested for metals (aluminium, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel and zinc) and cations and anions to characterise the water quality. In addition, the water should be tested for physical parameters on site including dissolved oxygen, electrical conductivity, pH, reduction/oxidation potential, temperature and turbidity.
- If runoff is stored separately to any pumped water, the requirement for site run off can be met via the following water quality criteria being tested for and met prior to off-site discharge of collected runoff:

Water Quality Criteria	Requirement
Total suspended solids	No greater than 1,500 mg/L
pH	Between 6.5 and 9.0
Iron	No greater than 500 µg/L
Aluminium	No greater than 5 µg/L for pH <6.5 and no greater than 100 µg/L for pH >6.5
Oil or grease	No visible oil or grease film

ASSMAC (1998) provides water quality performance criteria. The water quality criteria (based on ANZECC 1992) to be met for the discharge of water into the environment are summarised as follows:

Water Quality Indicators	Fresh Water	Marine Water
Total dissolved solids	0 – 1,500 mg/L	> 1,500 mg/L
pH	6.5 – 9.0	<0.2 unit change
Iron (Total)	500 µg/L	Not Applicable
Aluminium	5 µg/L for pH <6.5	Not Applicable
	100 µg/L for pH >6.5	

6. Contingency strategy

6.1 Incident and emergency response

There is a potential for incidents and emergency response requirements relating to ASS issues, particularly pollution/contamination of surrounding areas and waterways from acid contamination. Some issues that may arise unexpectedly include:

- interception of existing unknown AASS and/or PASS identified through field inspections/measurements or observed adverse reactions with flora and/or fauna (including site workers and public)
- inclement weather or incorrect management practices causing erosion and transportation of AASS and/or PASS materials off-site from stockpiles and active construction excavations.

The emergency response procedures will include:

- immediate containment of acid runoff from stockpiles or areas of excavation by bunding
- communication between the project manager, site managers, supervisors and contractors detailing the pollution incident requiring response/action
- site inspection to assess extent of severity of the emergency/incident
- based on the assessed severity of the incident by Council, the project manager will determine the need to notify regulators potentially including the NSW EPA; notifications should detail the type and extent of potential impacts and remediation requirements
- monitoring and/or management of incidents which may include soil or groundwater sampling and analysis, spill clean-up, investigation materials, correction of erosion control measures and remediation of affected area (if required)
- incident reporting detailing all investigation and remediation actions taken and remediation results carried out
- environmental incidents will be reported immediately to the site supervisor who will contact the project manager. All incidences will be investigated and the appropriate course of action will be taken to address the issues. Serious environmental incidents will be reported to the NSW EPA.

6.2 Non-conformance preventative and corrective action

In the event of a non-conformance, the source and nature of the event will be investigated, the effectiveness of the existing controls reviewed and modified where practical, and necessary strategies will be implemented to minimise further impacts.

6.2.1.1 Occupational health and safety requirements

Prior to undertaking any remediation or excavation, a safe work method statement (SWMS) will be prepared that defines safe procedures to protect the health and safety of personnel.

The SWMS will include the following measures:

- All workers will wear personal protective equipment (PPE) that may include breathing apparatus, protective overalls, gloves, safety boots and hard hat.
- Decontamination facilities made available to ensure workers are free of any contamination prior to leaving the workplace.
- ASS areas are separated from the remaining activities by appropriate fencing and signage. Access to the site is restricted only to personnel directly involved in the works.

6.3 Treatment measures

Where pH testing of excavated soil indicates that it is acid generating, treatment will be required prior to reburial or disposal of the material.

The most common ASS treatment measure relies on blending the soil with sufficient neutralising agent. Most treatment measures will result in a partial oxidation of ASS either deliberately or inadvertently. In most cases, the natural buffering capacity of the soils will initially contribute to the neutralisation of acid produced, however, depending on the sulfide content, additional neutralising material is typically needed.

Oxidation of sulfide and neutralisation should be undertaken using lime or similar agents – fine agricultural lime with a pH of approximately 8.2 is the lowest cost, most widely used, and the safest neutralising material. When estimating lime requirements in accordance with ASSMAC (1998) guidelines, a safety factor of at least 1.5 to 2 times the weight/volume should be applied to allow for inefficient mixing of the lime and its low reactivity. In addition, the purity and effective neutralising values also needs to be included in the estimation of lime requirement, as specified in ASSMAC (1998).

Other more caustic neutralising agents such as magnesium hydroxide (pH 12) or slaked lime (pH 12) pose an environmental risk to estuarine ecosystems from overdosing. In addition, workplace health and safety issues need to be considered when dealing with strongly alkaline neutralising agents such as magnesium hydroxide and slaked lime.

Works that involve the treatment of large quantities of ASS should be undertaken in stages for effective neutralisation management. Where there is a level of uncertainty with the method of lime application, field trials and/or further investigations may be required.

Neutralisation success relies on effective mixing of the neutralising agents and soil. Over the longer term iron, aluminium and gypsum precipitates may coat the neutralising agents, thereby reducing their effectiveness.

The following table provides information regarding mixing methods for neutralising agents and potential and/or actual ASS.

Table 6.1 Mixing method summary

Application	Notes regarding application methods (ASSMAC, 1998)
Broadscale mechanical application	Rotary hoeing and tillage can be used to mix lime into soil over a large area. During the period of mixing, aeration of the soil is likely to increase the rate of acid production, however the lime should prevent a substantial lowering of soil pH and the proliferation of bacteria that accelerate acid production. Such methods are useful in the treatment of agriculture land and stockpiled extracted material to make it suitable for use in land formation or construction.
Dredging application	Lime may be added through hydraulic methods by injecting agricultural or hydrated lime into the dredging pipeline. With heavy clay soils, there are practical difficulties in achieving effective integration of the neutralising materials.
Lime buffers	Establishing a 'lime buffer' at the face of any recent excavation which exposes ASS by sandbagging the face and incorporating lime under and in the sandbags so that the acid leachate flows through the sandbags; backfilling the face with clean fill mixed with lime/sand mix; and excavating a trench behind the face and incorporating a lime/sand mix or barrier so that the acid leachate/water must pass through. Insoluble coatings and preferred pathways may limit the effectiveness of lime buffers.

Full lime treatment and gradual oxidation of ASS involves the quantity of lime required to neutralise all of the sulfidic material present (based on soil analysis results) plus a safety factor of 1.5 (refer to ASSMAC, 1998). This involves spreading out ASS in thin layers (0.15 – 0.3 m) over a thin bed of lime, air drying and mechanically breaking up clods as drying proceeds. When the soil is sufficiently dry, lime is applied and thoroughly mixed. The material is then compacted prior to the treatment of the next layer. Effective drying and mixing of lime with clay is often very difficult. In addition the sulfide distribution in some soils can be highly variable.

The advantage of this method is that although some oxidation occurs during the drying phase, the presence of an excess quantity of lime tends to prevent extreme acidity developing in the soil. When disturbed, unlimed sulfidic soils have a pH <4 providing favourable conditions for the build-up of oxidising bacteria. Under such conditions, chemical oxidation processes may be accelerated by factors greater than a thousand fold through accelerated bacterial pyrite oxidation. A reduced or retarded acid production rate favours the complete neutralisation of acid with the added lime, reducing risk of acid leachate. When the mixed layer is compacted, air and water entry/infiltration is also reduced, further assisting the slowing of oxidation.

Hastened oxidation without lime incorporation (mixing) involves regular moistening of sulfidic soil to enhance bacterial oxidation processes and effectively aerating the soil by mechanical disturbance. It can be used to treat excavated acid sulfate sandy/loamy material with low concentrations of sulfidic material prior to its use in land formation. The method has the potential for a permanent treatment of the sulfidic material but may take an unacceptable period of time, especially in non-sandy materials. This treatment method is very problematic when dealing with marine clays or materials containing high concentrations of sulfidic material.

The approach of hastened oxidation without lime incorporation and neutralising the leachate poses greater environmental risks than the complete lime mixing method. During and after oxidation, the leachate and the soil usually contain toxic quantities of aluminium, iron and magnesium, in addition to acidity. Other heavy metals or contaminants can also be made soluble by the acid leachate. Once the soil has been properly treated by this method, it cannot be considered to be ‘free’ of acid generation potential until fully tested.

Neutralisation using the buffering capacity of estuarine water is not recommended by ASSMAC and it can be considered experimental. This method utilises the natural buffering capacity of seawater to neutralise water acidified by works associated with agriculture, infrastructure and urban development. Estuarine water contains dissolved carbonate and bicarbonate that can effectively neutralise significant quantities of acidity. However, in doing so, it deprives the aquatic ecosystem, particularly crustacea, of an essential component of its nutrient environment.

Vertical mixing and neutralising using the buffering capacity of soil is not recommended by ASSMAC and it can be considered experimental. This method utilises the buffering capacity of the non-ASS upper layers to dilute and neutralise the lower ASS layers. The method also includes the incorporation of lime at the time of mixing, especially in sands. Because of the level of uncertainty regarding the long term viability of the method, this approach should not be considered.

Separating out and treating the sulfidic component is limited to dredging operations where it may be possible to partially or fully separate the acid sulfate fines from the sand resource by mechanical methods such as sluicing or hydrocycloning techniques. This method is particularly attractive when full separation can be easily achieved, as the resource can be considered to be ‘clean’ and require the addition of little or no neutralising agent prior to use.

Disposal of treated potential or actual ASS is to be undertaken in accordance with the NSW DECC (2008) *Waste Classification Guidelines Part 4: Acid Sulfate Soils*.

7. References

- ASSMAC (1998) Acid Sulfate Soil Manual
- Department of Land and Water Conservation (1997) *1:25,000 Botany Bay Acid Sulfate Soil Risk Map (Edition Two)*
- Coffey Environments (2009) Post Phase 2 Environmental Site Assessment Report (off-site) Former Mobil Alexandria Service Station (No03424), 20 O'Riordan Street, Alexandria.
- IT Environmental (2006) Phase 2 Environmental Site Assessment, Mobil Alexandria Service Station (No0324) 20 O'Riordan Street, Alexandria.
- National Environment Protection Council (NEPC) (2013) National Environmental Protection Measure (NEPM) (Assessment of Site Contamination).
- NOHSC (1995) Exposure Standards for Atmospheric Contaminants in the Occupational Environment
- NSW DEC (2006) Guidelines for the NSW Site Auditors Scheme (2nd edition).
- NSW DEC (2007) Guidelines for the assessment and management of groundwater contamination.
- NSW DECCW (Jul 2009) Waste Classification Guidelines; Part 1: Classifying waste.
- NSW DUAP (1998) Managing Land Contamination: Planning Guidelines SEPP55 Remediation of Land.
- NSW EPA (1994) Guidelines for Assessing Service Station Sites.
- NSW EPA (1995) Sampling Design Guidelines.
- NSW EPA (2000) Guidelines for Consultants Reporting on Contaminated Sites.
- NSW EPA (June 2009) Guidelines on the duty to report contamination under the Contaminated Land Management Act 1997.
- Parsons Brinckerhoff (April 2014) Contamination Assessment Report - Draft – East West Relief Road

8. Limitations

Scope of services

This acid sulfate soil management plan (the report) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the client and Parsons Brinckerhoff (scope of services). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on data

In preparing the report, Parsons Brinckerhoff has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, Parsons Brinckerhoff has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Parsons Brinckerhoff will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Parsons Brinckerhoff.

Environmental conclusions

In accordance with the scope of services, Parsons Brinckerhoff has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions.

Also, it should be recognised that site conditions, including the extent and concentration of contaminants, can change with time.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

Report for benefit of client

The report has been prepared for the benefit of the client and no other party. Parsons Brinckerhoff assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of Parsons Brinckerhoff or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

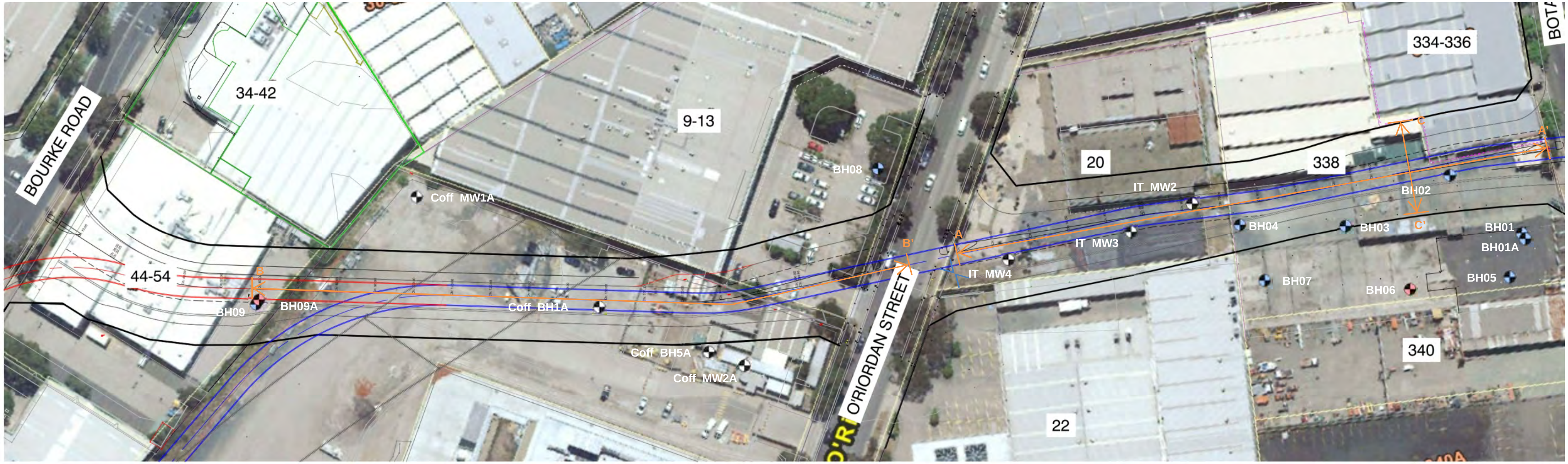
Other limitations

Parsons Brinckerhoff will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

Appendix A

Figure



LEGEND

- BH – Geotechnical and CLM sampling
- BH – Geotechnical, CLM sampling and installation of groundwater monitoring well
- Historical BHs – Coffeys and IT Environmental

Not to Scale

Note: Borehole locations recorded via handheld GPS device and verified using GIS mapping software.

Base map source: City of Sydney – East West road proposed alignment index plan

Figure 1 Site layout and final BH location plan
Proposed East West Relief Route
Green Square, Sydney, NSW.

Appendix B

Calculation sheets

Neutralising Agent Calculation Worksheet

This worksheet can be used to calculate the total amount of neutralising agent required for a site. It can also be used to calculate the total amount of neutralising agent required to treat individual soil units. The worksheet is designed to assist with calculations for aglime and lime sand neutralising agents only and may require modification for use with other neutralising agents.

Step 1: Gather the relevant information project information

Parameter	Definition	Project Specific Value
A	Area of excavation (m^2)	
T	Thickness of soil unit (m)	
V	Volume of soil to be treated (A x T m^3)	
δ	Density of soil (T/m^3)	
%S	Maximum total sulfide concentration of soil unit(%S)	
ENV	Effective neutralizing value of the neutralizing agent used to treat the soil (expressed as a decimal percent)	

Step 2: Calculate the neutralisation rate (NR expressed as kg $CaCO_3$/tonne of soil)

%S x *61.18* / *ENV* = *NR (kg $CaCO_3$/T)*

__________ x __________ / __________ = [ ]

Step 3: Calculate the quantity of neutralising agent required

NR (kg $CaCO_3$/T) x *V (m^3)* x *δ (T/m^3)* = *NA (kg $CaCO_3$)*

__________ x __________ x __________ = [ ]

ENV Calculation Worksheet

DEFINITIONS

Parameter	Definition	Units
NV	Neutralising value of the soil as determined through laboratory analysis using the Calcium Carbonate Equivalence method	%
S	Number of samples analysed	none
NV_{AVE}	Average neutralizing value of the soils	%
PSD	Particle size proportion as determined through laboratory analysis	%
UF	Utilisation factor for different particle sizes	none
ENV	Effective neutralizing value	%

Step 1: Calculate the average NV of the soil

SUM [NV of all samples]	/	*S*	=	*NV_{AVE} (%)*
	/		=	

Step 2: Determine the Utilisation Value of the soil (% $Value_{Total}$)

Step 2.1: Determine the untilisation value for each of the particle size distribution categories.

Particle size	PSD Proportion (%)	x	Utilising Factor	=	%Value
>0.850 mm			0.1		
0.300 – 0.850 mm			0.6		
<0.300			1.0		

Step 2.2: Determine the %Value for the soil

$\%Value_{>0.850}$	+	*$\%Value_{0.300\text{-}0.850}$*	+	*$\%Value_{<0.300}$*	=	*%Value*
	+		+		=	

Step 4: Calculate the ENV of the soil

NV_{AVE}	/	*&Value/100*	=	*ENV (%)*
	/		=	

Containment Pad Calculation Worksheet

This worksheet can be used to determine the amount of neutralising agent (aglime or lime sands) required to construct a containment pad suitable for the stockpiling of acid sulfate soils and to assist in determining suitable dimensions of the containment pad. This worksheet may require modification for use with alternative neutralising agents.

Step 1: Gather the relevant information project information

Parameter	Definition	Project Specific Value
A	Area of excavation (m^2)	
H	Depth of excavation (m)	
V	Volume of excavated material (A x H m^3)	
δ	Density of soil (T/m^3)	
B	Bulking factor post excavation	
%S	Maximum total sulfide concentration of soil to be stockpiled (%S)	
ENV	Effective neutralizing value of the neutralizing agent used for containment pad construction (expressed as a decimal percent)	
CP	Area of the containment pad (m^2)	

Step 2: Calculate the height of the stockpile (SPH expressed as metres)

$V (m^3)$ x *B* / *$CP (m^2)$* = *SPH (m)*

__________ x __________ / __________ = [ ]

Step 3: Calculate the quantity of neutralising agent required (NA expressed as kg $CaCO_3$)

3.1 Calculate the neutralisation rate (NR expressed as kg $CaCO_3$/tonne of soil)

[0.2 x SPH (m)] x *[%S x 30.59]* / *ENV* = *NR (kg $CaCO_3$/T)*

__________ x __________ / __________ = [ ]

3.2 Calculate the volume of neutralising agent required

NR (kg $CaCO_3$/T) x *$V (m^3)$* x *δ (T/m^3)* = *NA (kg $CaCO_3$)*

__________ x __________ x __________ = [ ]

Step 4: Calculate the thickness of the containment pad (T expressed as metres)

[NA (kg $CaCO_3$) / 2000] / *CP (m^2)* = *T (m)*

__________ / __________ = [ ]

Sydney City Council

Remediation Action Plan for East West Relief Route

12 February 2016

PARSONS BRINCKERHOFF
A BALFOUR BEATTY COMPANY

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Glossary

Acronym	Definition
ACM	Asbestos containing material
ASS	Acid sulfate soils
ANZECC	Australian & New Zealand Environment & Conservation Council
BTEX compounds	Benzene, toluene, ethylbenzene and xylene
DP	Deposited Plan
EPA	Environment Protection Authority
ESA	Environmental site assessment
mAHD	Metres Australian Height Datum
mBGL	Metres below ground level
mBTOC	Metres below top of well casing
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measures
NHMRC	National Health & Medical Research Council
PAHs	Polycyclic aromatic hydrocarbon
PCBs	Polychlorinated biphenyls
PID	Photoionisation detector
PPM	Parts per million
PQL	Practical quantitation limit (of chemical concentration)
QA/QC	Quality assurance & quality control
RAP	Remedial action plan
RPD	Relative percent difference
SEPP	State Environmental Planning Policy
SWL	Standing water level
TCLP	Toxicity characteristic leaching procedure
TRH	Total recoverable hydrocarbons

1. Introduction and objectives

1.1 Purpose

Parsons Brinckerhoff Australia Pty Ltd (Parsons Brinckerhoff) has prepared this remedial action plan (RAP) for Sydney City Council to facilitate the construction of the proposed east west relief route (EWRR) that runs between Botany Road and Bourke Street, Alexandria. The location of the EWRR and boundaries of the site considered by this RAP are shown on Figure 1.

The EWRR will be constructed as part of the Green Square Town Centre (GSTC). The GSTC incorporates a new street system that will improve east-west road connectivity by providing a link from Bowden St, across Bourke Rd, O'Riordan St and Botany Rd, into the GSTC (via Geddes Avenue).

Construction of the EWRR will also facilitate the installation of the Green Square trunk stormwater drainage system by accommodating this system under the proposed road reserve alignment. The installation of the stormwater trunk drain is required up front to allow the future development of the GSTC and Epsom Park Precinct.

1.2 Objectives

The primary objective is to remediate contaminated soils to render the site suitable for the construction works to be undertaken and to provide a framework for the work practices and environmental management techniques to be implemented whilst undertaking remediation at the site.

1.3 Scope of RAP

The RAP was prepared in accordance to guidelines provided in the *Guidelines for Consultants Reporting on Contaminated Sites* (NSW Environment Protection Authority (EPA), 1995) and includes:

- a summary of the available information on current contamination status of the site and the risks to human health and the environment posed by this contamination
- a presentation of remedial goals and validation criteria
- the remediation/validation program and outline of the requirements for the validation report that will detail the remediation works undertaken and assess the contamination status and environmental condition of the site following remediation
- the environmental safeguards required to ensure that remedial works are undertaken in such a way as to minimise potential impacts to the environment
- a framework for the health and safety aspects of the remedial site works
- necessary approvals and licences required by regulatory authorities
- a basis of contractor work specifications for the remediation works; however, the RAP does not contain prescriptive instructions on how works shall be performed. The City of Sydney defined GSTC remediation depth profile has been adopted for consistency with other RAPs prepared for the GSTC.

1.4 Technical framework

The RAP has been prepared in general accordance with national and NSW EPA endorsed or approved legislative, health, environmental and safety requirements and the methodologies and technical requirements of:

- ANZECC/NHMRC 1992, *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*.
- Australian Standard AS4482. 1-2005 Guide to the Sampling and Investigation of Potentially Contaminated Soil – Part 1: Non-volatile and Semi-volatile compounds.
- *Contaminated Land Management Act 1997* (NSW), as amended.
- *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM; as amended 2013).
- NSW Department of Environment and Conservation 2006, *Guidelines for the NSW Site Auditor Scheme (2nd edition)*.
- NSW Department of Urban Affairs and Planning 1998, *Managing Land Contamination: Planning Guidelines SEPP 55 Remediation of Land*.
- NSW EPA 2014, *Technical note: Investigation of Service Station Sites*.
- NSW EPA 1995, *Sampling Design Guidelines*.
- NSW EPA 2014, *Waste Classification Guidelines Part 1: Classifying Waste*.
- NSW EPA 2014, *Waste Classification Guidelines Part 4: Acid sulfate soils*.
- NSW Office of Environment and Heritage 2011, *Guidelines for Consultants Reporting on Contaminated Sites*.
- *Work Health and Safety Act 2011* (NSW).

2. Site setting

2.1 Site Identification and description

The proposed EWRR route stretches over a number of properties as shown in Figure 1. The site identification details are provided in Table 2.1.

Table 2.1 Site identification details

Site name	Proposed East West Relief Route
Site address, Lot and DP details (properties which EWRR intersects)	334-336 Botany Road, Alexandria NSW, part Lot 1 DP 739598
	338 Botany Road, Alexandria NSW, part Lot 101 DP 569709
	20 O'Riordan Street, Alexandria NSW, part Lots 7, 9, 10 and 11 DP 214410
	22 O'Riordan Street, Alexandria NSW, part Lot 1 DP 1004389
	9-13 O'Riordan Street, Alexandria NSW, part SP 34626
	15 O'Riordan Street, Alexandria NSW, part 7 DP 818246
	44-54 Bourke Road, Alexandria NSW, part Lot 37 DP 817055
Area	Approximately 1.02 ha
Zoning	All the properties intersected by the EWRR are zoned B7 Business Park under the *Sydney Local Environmental Plan 2012*. This zoning permits commercial and light industrial uses, including roadways.
Current site uses	Variety of light industrial and commercial; transportation depot and workshop, light industrial furniture warehouse, carpark, Ausgrid depot, decommissioned Mobil service station, Hoya Lens head office and laboratory
Proposed site use	Road corridor and installation of a trunk stormwater drainage system beneath this route

2.2 Topography

Based on site inspection and the "Proposed Road Alignment Works Plan 2" provided by Council, the natural topography of the site is a uniform downhill slope running from eastern Botany Road entrance (approximately 15 mAHD) to the western edge of the site (approximately 11 mAHD). The existing level of the site is between 14 and 15 mAHD.

The nearest surface water bodies are Sheas Creek, Alexandria Canal and Botany Bay, located 220 m to the west, 750 m to the south-west and 5 km to the south-west, respectively.

2.3 Geology and hydrogeology

Regional geological information was obtained from the Department of Mineral Resources – Geological Survey of New South Wales (1983) 1:100,000 Geological Series Sheet 9130. This indicates that the site is underlain by quaternary deposits comprised of medium- to fine-grained marine sands with podsols. The sand is underlain at depth by the Mesozoic Ashfield Shale of the Wianamatta Group, consisting of black to dark grey shale and laminate.

During site investigations, the lithology encountered at the site was described as fill underlain by silty or sandy clay. Beneath this layer, there is variation across the site. To the west sands extend to the maximum investigation depth of 11 mBGL and to the east shale was encountered at a shallow depth of approximately 4.5 mBGL and extended to the maximum investigation depth of 9.40 mBGL.

Coffey Environments, formerly IT Environmental, described the regional geology as having low to moderate yield less than 5 litres per second (IT Environmental, 2006; Coffey Environments, 2009). The groundwater is inferred to flow in a westerly direction towards Sheas creek.

Groundwater gauged in the two newly installed monitoring wells (BH06 and BH09) ranged between 2.20 mBGL and 6.20 mBGL. This is consistent with the results from the historical reports of the Mobil site (IT Environmental, 2006) which measured standing water at approximately 3 mBGL.

The NSW Office of Water NSW natural resources website (accessed 16/04/2014) and previous site investigations have identified the site to be located above the Botany Sands Aquifer. This aquifer is present within the marine dune sands and is characterised by relative shallow groundwater.

The site is located within Zone 2 of the groundwater embargo area designated by the NSW Office of Water. The embargo is in place due to historic regional groundwater contamination as a result of industrial activities in the area. Groundwater extraction for domestic uses is prohibited in Zone 2.

Based on a search of the online NSW Government Water Information Groundwater Works Reports (http://www.waterinfo.nsw.gov.au/gw), 15 groundwater bores were identified within a 200 m radius of the site. Details of the individual bores are included in Table 2.2.

Table 2.2 Groundwater bores within 200 m of site

Bore licence ID	Authorised purpose	Approximate distance (m) and direction from site	Date drilled	SWL (mBTOC)	Total depth (mBGL)	Salinity (ppm)
GW112478	Monitoring	96 SE	15/2/2011	3.70	4.50	369
GW112479	Monitoring	79 S	15/2/2011	5.10	7.00	613
GW109790	Monitoring	18 NW	27/03/2004	-	4.00	-
GW109791	Monitoring	32 WNW	17/4/2004	-	4.10	-
GW109792	Monitoring	66 W	17/4/2004	-	4.20	-
GW112480	Monitoring	89 SSE	15/02/2011	5.50	7.00	584
GW106046	Domestic	130 SW	07/06/2005	-	-	-
GW017342	Industrial	177 N	01/12/1946	-	15.50	-
GW017684	Industrial	197 NW	01/09/1941	-	14.90	-

The majority of the bores identified are monitoring wells and there has only been one identified domestic bore, located 130 m to the south-west. As this bore is inside the embargo zone which has been in place since 2003, it is unlikely this is actually a domestic bore or that there are any current domestic users of the groundwater.

2.4 Acid sulfate soils

Acid sulfate soils (ASS) are generally likely to be present in marine and estuarine sediments of the recent (Holocene) geological age, in soils generally less than five metres above mean sea level and within a marine or estuarine setting. These sediments show traces of sulfate, which upon exposure to air can oxidise to form sulfuric acid. The acid reacts with clay minerals and dissolves metal particles in the soil such as iron and aluminium. The resulting acid and dissolved metals that leach from the soil are often toxic to flora and fauna.

The 1:25,000 Botany Bay acid sulfate soils map indicates a low probability of occurrence within the extents of the proposed EWRR corridor. However due to the high water table and possibility of encountering marine sediments on-site, potential acid sulfate soil (PASS) screening was scheduled to be carried out on a selection of samples on-site. Upon completion of drilling one sample was flagged to be potentially acid forming and sent to the laboratory for further analysis.

3. Site background

3.1 Previous reports

3.1.1 Parsons Brinckerhoff contamination assessment report (2015)

The contamination assessment was made up of two main components; a desktop review of all historical data of the Mobil property (20 O'Riordan Street) and the Ausgrid property (15 O'Riordan Street) and an intrusive investigation at the following properties which are part of the site:

- 338 Botany Road
- 9-13 O'Riordan Street (Taxis Combined)
- 42-54 Bourke Road (Hoya Lens).

Results are discussed in Section 3.2.

3.1.2 Ausgrid site – 15 O'Riordan Street, Alexandria

- Contamination Management Pty Ltd (Contamination Management) 2001, *Summary site audit report. SRA site, 15 O'Riordan Street, Green Square*. Site audit statement number WRR102.
- Coffey Environments Australia Pty Ltd (Coffey Environments) 2010, *Site Management Plan for Asbestos Contamination in shallow soils at 15 O'Riordan Street, Alexandria*. (EA Ref CL607) (Coffey Environments, 2010a).
- Coffey Environments 2010, *Clearance report following capping on 15 O'Riordan Street, Alexandria* Coffey Environments, 2010b).

3.1.3 Mobil site – 20 O'Riordan Street, Alexandria

- Kleinfelder 2013, Environmental site assessment Former Mobil Alexandria service station No0324, 20 O'Riordan Street Alexandria, NSW.
- URS Australia Pty Ltd (URS) 2012, Factual Summary, Off-site Well Installation (MW17) and Groundwater Sampling Results Former Mobil Service Station, Alexandria, NSW (No0324).
- Coffey Environments 2011, Tank excavation assessment and soil status report Mobil Alexandria (No0324) 20 O'Riordan Street Alexandria NSW.
- URS 2011, Tank excavation assessment Former Mobil Service Station, Alexandria (No0324),20 O'Riordan Street Alexandria NSW.
- Coffey Environments 2009, Post phase 2 environmental site assessment report (off-site) Former Mobil Alexandria Service Station, (No0324), 20 O'Riordan Street Alexandria NSW 2015.
- IT Environmental 2006, Post phase 2 environmental site assessment report Former Mobil Alexandria Service Station, (No0324), 20 O'Riordan Street Alexandria NSW 2015.
- IT Environmental 2005, Remediation Action Plan, Former Mobil Alexandria Service Station, (No0324), 20 O'Riordan Street Alexandria NSW 2015 (IT Environmental, 2005a).
- IT Environmental 2005, Remediation Action Plan, Update Report for Phase 2 ESA at the Former Mobil Alexandria Service Station (NO0324) (IT Environmental, 2005b)

- IT Environmental 2004, Phase 2 environmental site assessment report, Mobil Alexandria Service Station, (No0324), 20 O'Riordan Street Alexandria NSW 2015.
- IT Environmental 2004, Phase 1 environmental site assessment report, Mobil Alexandria Service Station, (No0324), 20 O'Riordan Street Alexandria NSW 2015.

3.2 Site conditions and history

The site condition and history for each of the properties is presented in the following sections.

3.2.1 Council property, 338 Botany Road

The property at 338 Botany Road Alexandria was most recently used as a bus yard and service centre, although it has since been purchased by Sydney City Council. The site is open and flat with bitumen and concrete cover. The northern portion half of the site is covered by single- and two-level brick buildings. There is an annex in the middle of the yard that is used as a wash bay. The site has a concrete entrance ramp in the north-east corner that extends approximately 20 m into the site from Botany Road. The site has a slight slope from east to west. The south-east corner of the site adjacent to this ramp is elevated approximately 0.5 m above the remainder of the site. The western boundary of the site has a 2.9 m drop which is retained by a brick retaining wall. The retaining wall extends half way along the boundary and is joined to adjacent building wall which runs along the remainder portion of the western boundary of the site.

The primary contaminants of concern for this property comprised:

- total recoverable hydrocarbons (TRH)
- benzene, toluene, ethylbenzene, and xylene (BTEX)
- polycyclic aromatic hydrocarbons (PAHs)
- metals associated with fill material, including arsenic, cadmium, chromium, copper, lead, nickel and zinc.

Fill was encountered in boreholes (Parsons Brinckerhoff, 2015) at depths between 0.16 mBGL and 4.60 mBGL. The fill material generally comprised of sands and gravels with some clay present. The fill also contained ash, slag, concrete rubble, sandstone cobbles and metal fragments.

TRH was detected in soil along the southern property boundary at depths between 0.5 mBGL and 3 mBGL. The concentrations were low, below the assessment criteria for commercial/industrial site use, intrusive maintenance workers and direct contact. PAHs were detected at most locations, generally in the upper 2 m. The concentrations were below assessment criteria (commercial/industrial site use).

Metals were present across the property, with higher concentrations generally found in shallow samples of fill material. No exceedances of criteria were identified.

One groundwater well was installed during the Parsons Brinckerhoff (2015) investigation. Groundwater was encountered during drilling at depths between 4.5 mBGL and 6 mBGL in shale or overlying silty clay. No sampling or analysis of groundwater was undertaken.

3.2.2 334-336 Botany Road

No assessment is known to have been undertaken on this property. The property contains disused brick commercial/light industrial buildings. It is located adjacent to the Council property to the south and west, with other commercial/industrial properties to the north and Botany Road to the east.

No site history is known for this property, although it is expected to be underlain by fill similar to that encountered at nearby properties and contaminants of concern are anticipated to be similar.

3.2.3 Mobil property (Former Mobil Alexandria Service Station), 20 O'Riordan Street

The site was used as a commercial facility starting in 1938, when it was sold to the Australian Fireclay Company Pty Ltd and then changed hands three times until 1970 when it was transferred to ESSO Standard Oil and was operated as a service station until 2001 (IT Environmental, 2004). In 1983, the property was leased to RSL ex-serviceman's Cabs. Over this time it was identified that potential contaminating activities could have been associated with the operation of the service station. It has also been noted that historic contamination may also have occurred as a result of activities by Sydney Smelting and Engineering Company and reportedly uncontrolled fill across the site (URS, 2011)

Historically, the Mobil property contained eight underground storage tanks and one aboveground storage tank (containing liquefied petroleum gas) and associated fuel infrastructure (Coffey, 2011). The bulk of the environmental work and removal of this infrastructure occurred between 2004 and 2008 with additional excavation and validation work occurring in 2009 (URS, 2011), 2011 (Coffey, 2011) and 2013 (Kleinfelder, 2013).

In 2005 a remediation action plan was prepared and identified the current and potential receptors to the property. These included:

- on-site occupants and workers
- workers accessing utility pits on or near the site
- residents and workers in neighbouring offsite properties.

The primary contaminants of concern identified were:

- TRH
- BTEX
- PAHs
- phenols
- metals.

Minor hydrocarbon impact has been identified in the groundwater sampled on-site (IT Environmental, 2006). Lead was identified above the site criteria at MW2, located in the northern part of the alignment at the eastern boundary of the Mobil property. The off-site groundwater investigation (URS, 2012) noted that metal concentrations exceeding the site criteria have been identified around MW10, located north of the alignment. TRH, BTEX compounds and naphthalene were encountered on-site at concentrations above the soil and groundwater investigation levels in the area of the former bowsers. Standing water levels at the site have generally been between 1.5 mBGL and 2 mBGL.

Coffey (2009) conducted an off-site assessment of the soil and groundwater and concluded that zinc, copper, nickel and barium were present at both up and downgradient monitoring locations. Lead was located downgradient of the property; however Coffey Environments concluded that this was not indicative of contamination migration off-site.

Kleinfelder conducted an environmental site assessment to delineate any residual soil contamination following the remediation and excavation of any remaining fuel infrastructure. During this investigation, lead was the only heavy metal exceedance of the soil guidelines, in 17 samples with a maximum result of 60,000 mg/kg. It was suggested in the report (Kleinfelder, 2013) that this concentration could be indicative of background concentrations. Delineation of hydrocarbon impacts was completed with the exception of impact at 0.5 mBGL to the west of BH107 and east of BH113 and the vertical delineation at BH119 in the centre of the Mobil property. During the investigation, an exceedance occurred at BH119 for TRH (C_6-C_{10}) and at BH115 for TRH (C_{16}–C_{34}). Detections of petroleum hydrocarbons below the criteria were frequently reported during this investigation.

It is understood that an auditor has been appointed to conduct a site audit statement (SAS) for the site (URS, 2011). This site audit statement has not been provided to Parsons Brinckerhoff at the time of this report.

3.2.4 22 O'Riordan Street

No assessment is known to have been undertaken on this property. The property is occupied by an automobile repair facility and dealership. It is located adjacent to the Mobil site on the north and the Council property on the east, with O'Riordan Street immediately to the west and Johnson Street to the south. No site history is known for this property, although it is expected to be underlain by fill similar to that encountered at nearby properties.

The primary contaminants of concern at this property are presumed to include:

- TRH
- BTEX
- PAHs
- metals.

Two wells were installed in O'Riordan Street immediately west of the site during investigation of the Mobil property (IT Environmental, 2006; Coffey, 2009). Approximately 2.5 m of fill material comprising sand gravel and silt was encountered, underlain by natural silt and sand. Groundwater was present between 2 mBGL and 3 mBGL in these wells. Soil samples and groundwater samples collected during the installation and subsequent sampling indicated minor hydrocarbons below assessment criteria were present. Lead was present in soil and groundwater; lead in groundwater exceeded ecological criteria although no relevant health-based criteria were exceeded.

3.2.5 Taxis Combined, 9-13 O'Riordan Street

Taxis Combined site is generally flat with concrete covered pavement and parking lots for taxis. The site is bounded by O'Riordan Street to the east, Ausgrid site to the south, and two-storey building to the west and north.

The primary contaminants of concern at this property are presumed to include:

- TRH
- BTEX
- PAHs
- metals.

One borehole was advanced on this property (Parsons Brinckerhoff, 2015). Fill was encountered from beneath the concrete slab to 2.60 mBGL. The fill generally comprised sands and gravels with some silt.

Minor TRH was detected at 2.6 mBGL, below assessment criteria. PAHs were detected at 0.5 mBGL and 2.6 mBGL, below the assessment criteria. Metals were detected below the assessment criteria and in similar ranges to metals results from other properties investigated in the Parsons Brinckerhoff (2015) assessment.

The bore location undertaken during the Parsons Brinckerhoff (2015) assessment encountered groundwater at approximately 4 mBGL during drilling, although a well was not installed.

3.2.6 Ausgrid property, (Former Austral Bronze Company and SRA property), 15 O'Riordan Street

The SAS (Contamination Management, 2001) identified that the Ausgrid property was occupied by Austral Bronze company from the early 1900s to 1989 when it was transferred to Leda Holdings and then transferred to NSW State Rail Authority in 1994. The operations at the Austral Bronze Company were a non-ferrous foundry which was demolished in 1990. The location of the principal foundry works was to the south of the Ausgrid property. The SRA stored equipment, machinery and spoil during the construction of a railway line, of which a 25 m deep shaft was excavated on the site of which machinery and construction equipment would enter the tunnel and spoil would be removed.

The environmental site assessment prepared for the SAS identified hydrocarbon and heavy metal contamination identified in the soil and two underground tanks containing oil were identified. These tanks were not reported to have leaked. An additional source of contamination was the storage of up to 2,000 tonnes of petroleum hydrocarbon and polychlorinated biphenyl (PCB) contaminated soil was temporarily stored on plastic at the property.

Subsequent to the SAS a site investigation undertaken by Coffey Environmental in 2010 (Coffey, 2010a) detected chrysotile asbestos in the form of fibre bundles in 10 out of 21 sampling locations across the property. The reports reviewed did not establish the source of the asbestos contamination. The majority of these samples were located within the surficial fill, 0.0 to 0.3 mBGL. An SMP was developed for the site (Coffey, 2010a) and recommendations including capping the site with a layer of clean soil or hardstand.

Capping works were completed in April 2010 with 50 mm of clean fill, with the conditions that:

- no excavation, civil work or other disturbance of other underlying fill materials be undertaken pending long term remediation of the site
- regular monthly monitoring of the cap be undertaken
- a speed limit be placed on the site
- if any sheds, containers or other areas expose bare soil, this should be capped in accordance with the SMP.

Based on the SAS and the SMP, the following contaminants of concern have been identified for this property:

- TRH
- BTEX
- polychlorinated biphenyls (PCBs)
- metals
- PAHs
- asbestos.

Fill material has been reported to extend to depths of 3 mBGL and at no point in the investigation did fill extend to the groundwater, noted at 3.9 to 5.7 mBGL. Acid sulfate soils were considered be likely to be encountered at depths exceeding 3 to 5 mBGL.

The fill material was reported to contain low to moderate levels of heavy metals which were below the assessment criteria for commercial industrial uses. Lead was elevated in one sample but not considered a hotspot (>250% of the assessment criteria) by the site auditor. Petroleum hydrocarbons were below the site criteria with the exception of location TP13 at 2 m. PAHs were all below the adopted assessment criteria and pesticides and PCBs were not detected in any sample.

The groundwater at the site was present at depths between 3.5 and 5.5 mBGL. Minor levels of heavy metals were detected for chromium, copper and zinc, which were considered to be background concentrations. Similarly, PAH detections were minor and not considered to be derived from an on-site source. Petroleum hydrocarbons, pesticides and PCBs were not identified in the groundwater.

The site auditor has noted three conditions relating to the identification of elevated lead and TRH. These include:

- preparation of a construction environmental management plan for any excavation works on-site
- design of the site to cover all fill, including landscaped areas, hardstand or capping
- waste disposal to be undertaken in accordance with waste classification guidelines.

3.2.7 Hoya Lens, 42-54 Bourke Road

Hoya Lens site is a two storey building site with concrete carpark on the east and south. The site was observed at a lower level to adjacent Ausgrid site. Approximately 1.5 m level difference was observed at the eastern boundary of the site with a batter towards Ausgrid site was observed. The batter was thickly vegetated with small shrubs and plants.

Fill was encountered in BH09a from the surface to 2.20 mBGL. The fill appeared generally contained sands, gravels, some silt and concrete cobbles and boulders. Fill was underlain by sand and sandy clay. Groundwater was present at approximately 2.2 mBGL.

Minor PAHs were present in the fill material, below assessment criteria. Metals were detected, below the assessment criteria, in similar ranges to metals results from other properties investigated in the Parsons Brinckerhoff (2015) assessment.

4. Conceptual site model

4.1 Potential sources of contamination

Known and potential sources of contamination include:

- residual hydrocarbon impact at the Mobil site from fuel infrastructure
- fill across the site to 3 mBGL.

4.2 Contaminants of concern

The contaminants of concern for this investigation are based on the current and historical land use of the site and surrounding properties, and previous site investigations. The following contaminants were identified:

- TRH
- PAHs
- BTEX
- heavy metals (particularly lead, chromium, copper, nickel, zinc and barium)
- asbestos.

4.3 Receptors

The potential environmental receptor for impacts from the site was identified to be Sheas Creek, approximately 220 m to the west; a concrete canal which flows to Alexandria Canal and Botany Bay 5km to the south-west of the site.

The following human receptors were identified:

- construction workers during the works program
- adjoining site users and pedestrians.

4.4 Transport and exposure pathways

The anticipated transport processes for the migration of potential chemicals of concern include:

- airborne generation of fibres
- surface water runoff
- leaching through soil to groundwater
- migration within groundwater
- vapour migration and accumulation.

Anticipated preferential pathways for the migration of chemicals of concern include:

- surface water runoff into local drainage channels

- underground service conduits or trenches
- migration of potentially contaminated groundwater within aquifers underlying the site.

Complete actual or potential exposure pathways were identified for:

- inhalation of hydrocarbon vapour by construction works during excavation works
- dermal contact or incidental ingestion of impacted soil or groundwater or inhalation of vapours by construction workers
- inhalation of airborne asbestos fibres by construction workers and neighbouring site users.

4.5 Extent of contamination

Lead impacts exceeding criteria were identified in shallow fill material along the full length of the proposed road and adjacent areas that were subject to intrusive investigation, extending to a depth of approximately 3 mBGL.

Asbestos contamination has been observed in the fill material across the Ausgrid site to a maximum depth of 2.2 mBGL. Residual hydrocarbon impact is present at the Mobil property, in soil in localised areas to a depth of 3 mBGL and in groundwater within the Mobil site boundary.

Areas of defined contamination are presented on Figure 2.

Groundwater in the vicinity of the Mobil property has been identified as being impacted by hydrocarbons and only limited groundwater assessment has been undertaken across the site. However, based on the details provided by Sydney City Council the maximum cut depth will be approximately 2.5 m on the eastern portion of the Ausgrid property, where groundwater depths are between 3.5 mBGL and 5.5 mBGL. Therefore, groundwater is not anticipated to be encountered during the construction work.

5. Remediation goals and strategy

5.1 General

The preferred order of options for site remediation as stated in the NSW Department of Environment and Conservation (DEC) 2006, Guidelines for the NSW site Auditor Scheme (2nd Edition) is:

- on-site treatment of the soil so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level
- off-site treatment of the soil so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level, after which the soil is returned to site.

If the above options cannot be implemented, then other options that should be considered include:

- removal of contaminated soil to an approved site or facility followed, where necessary, by replacement with clean fill
- consolidation and isolation of the soil on-site by containing with a properly designed barrier (i.e. capping).

If remediation is likely to cause a greater adverse effect than would occur were the site left undisturbed, then remediation should not proceed.

5.2 Objectives of the remediation work

Parsons Brinckerhoff considers that the objectives for the soil remediation at the site are to remediate and/or manage impacted soils at the site to render the site suitable for the proposed EWRR so that it poses no unacceptable risk to human health or the environment. Additionally, in the event that any residual contamination cannot be remediated, a risk-based assessment is proposed to be undertaken to consider the potential risk to future site users or other receptors.

5.3 Remediation options

To achieve the remedial objectives, there are limited methodologies considered to be appropriate, each with a number of advantages and disadvantages. Based on the identified contamination present at the site, the remediation risk management may comprise implementation of one or a combination of the remedial management measures including:

- ongoing management
- encapsulation
- excavation and treatment
- excavation and off-site disposal.

These remedial options are summarised below, with the disadvantages and advantages of each of the feasible options detailed in Table 5.1.

5.3.1 Ongoing management

Ongoing management is considered appropriate for sites where site contamination presents a low or minimal risk to human health and the environment and there is no risk of off-site migration of contaminants. Commonly ongoing management involves an ongoing monitoring program to assess the contaminant conditions at the site and provide assurance that no changes (such as change in the size or orientation of contaminant plumes) are occurring that may impact sensitive receptors. Ongoing management usually also incorporates a remedial contingency plan to be applied should the contaminants present begin to impact receptors.

Ongoing management is considered to be the most suitable for all parts of the site with the exception of the Ausgrid site. The nature of the lead impacted fill material can be suitable managed through safety and environmental management procedures to successfully complete the excavation, and reinstate the lead contaminated fill material (where it has been disturbed due to excavation) underneath the EWRR.

Management of the hydrocarbon and lead contaminated soil at the Mobil site will be contingent on the preparation of a SAS prior to the commencement of the EWRR construction. Following sign off completed by the site auditor, there may still be residual contamination present in the area. This will need to be managed through a construction environmental management plan (CEMP) for the site during excavation works.

5.3.2 Encapsulation

Encapsulation or capping employs a risk minimisation approach similar to ‘ongoing management’, where impacted soils are managed on-site so as not to pose an ongoing risk to the environment or human health. Impacted soils are contained by the placement of clean fill materials and/or a physical barrier on top of the impacted material to prevent exposure to site occupiers or workers. The base of this encapsulation or capping would be clearly marked with a geotextile to indicate that below this depth workers could potentially be exposed to contamination, which would then trigger additional health, safety and environmental controls.

Asbestos-contaminated fill material is currently being managed on the Ausgrid property under the SMP through capping with clean material and/or hardstand. This is considered to be a suitable ongoing management strategy for this material following the completion of the construction works, although a revised SMP should be prepared to reflect the changes to the site. However, during the construction works asbestos-contaminated material will be disturbed and will need to be excavated and stored appropriately on-site. Some of this material can be replaced following the construction and appropriately capped. Excess material will need to be removed off-site for disposal in accordance with the NSW EPA (2014) waste classification guidelines. Waste classification is currently incomplete with only the presence of asbestos identified. Further soil chemical testing will be required to dispose of this material off site.

5.3.3 Excavation and treatment

Based on the contaminants identified (metals and asbestos) treatment is not an appropriate remedial method for the site. In the event that significant hydrocarbon contamination is encountered on the Mobil property or other parts of the site this may be a suitable method of remediation, depending on the contaminant concentrations.

5.3.4 Excavation and off-site disposal

Excavation and disposal of contaminated waste is a frequently used option, typically used when a rapid site remediation program is required or where significant subsurface contamination exists that is potentially impacting on sensitive off-site receptors. Wastes must be classified in accordance with the waste classification guidelines (NSW EPA, 2014).

Excavation and off-site disposal of the impacted soils at the site is considered to be an appropriate remediation option for excess asbestos contaminated material at the site excavated as part of the works.

5.3.5 Evaluation of remedial approaches

Table 5.1 Remediation methodologies

Remediation methodology	Description	Advantages	Disadvantages	Suitable
Excavation and off-site disposal	Excavate impacted materials. Transport directly to a licensed landfill facility. Re-instate site with clean fill material	Fast, impacted material removed immediately No storage or treatment problems Minimal design and management costs	Costs associated with the disposal and importation of clean fill Sustainability issues related to disposal to landfill	Yes
Land farming/ on-site bioremediation	Excavated soils are thoroughly broken down and aerated, mixed with microorganisms and nutrients, stockpiled and aerated in above ground enclosures	Cost effective if soils are utilised on-site Lower disposal costs Limited requirement to import fill material to site Retains material on-site	Not suitable for contaminants identified (metals and asbestos)	May be considered if significant hydrocarbon impact is encountered
Encapsulation/ capping	Risk minimisation approach where impacted soils are managed on-site by capping the ground surface with a clean, impermeable layer of fill material	Relatively fast method Effectively removes risk to human health by eliminating exposure pathways	Contamination would remain in situ, potential migration of contamination to groundwater Suitable for lead and asbestos contamination however will need to be managed with a CEMP The capping layer would require ongoing management	Yes

6. Remediation strategy

6.1 Selected remediation strategy

Based upon the assessment of available remedial technologies, the potential risks to human health and the environment and considering the cost effectiveness of each remedial technique, the recommended remedial strategy for site is managing the risks of the lead and asbestos-contaminated fill through a CEMP for the site during construction and ongoing management of asbestos-contaminated fill through capping and a revised SMP. Some excess material will require off-site disposal or reuse at another Sydney City Council site under the JBS&G 2015, *Excavated Materials Management Plan* (EMMP) and in accordance with NSW EPA approvals.

The selected remedial strategy is designed to render the site suitable for the proposed future use.

6.2 Regulatory framework, approval and licences

All works will be undertaken in accordance with:

- Occupational Health & Safety Act 2000 & Regulations
- WorkCover NSW Requirements, Guidelines and Codes of Practice
- The Protection of the Environment Operations Act 1997
- Protection of the Environment Legislation amendment Act 2011
- The Protection of the Environment Operations (Waste) Regulation 2005
- NSW EPA waste classification guidelines
- City of Sydney Contaminated Land Development Control Plan 2004
- Green Square Town Centre Development Control Plan 2012.

Transporters of contaminated waste are required to be licensed and receiving facilities are required to be licensed for the category of waste they are scheduled to receive. For all asbestos removal works, a licensed asbestos removal contractor must be engaged and an asbestos removal control plan prepared and lodged with Workcover providing notification of the intent to conduct friable asbestos works.

Waste classification documentation and waste dockets from the receiving facility should be kept on file for site validation purposes.

In the event that any other hazardous materials are identified, statutory notification will be required to be provided to WorkCover prior to removal.

6.3 Site preparation

Table 6.1 summarises the measures that should be implemented prior to remediation works at the site.

Table 6.1 Site preparation measures

Item	Description
Access	Access to the site will be controlled by the Principal Contractor and the site will be off limits to all non-essential personnel.
Signage	Signage on the site will be installed detailing site safety requirements and traffic restrictions. Signage at the main access points will include after-hours contact details.
Fencing/hoarding	Perimeter security fencing will be maintained around the site to secure work areas and exclusion zones. Regular maintenance and repair of all fences surrounding the site will be undertaken during the period of the remediation work. For remedial works associated with removal of asbestos contamination, measures should be undertaken in accordance with WorkCover requirements and following the instruction of a removal contractor licenced to remove friable asbestos.
Haul roads/parking areas and traffic management	Transport to and from site will need to consider traffic management options which take into account any access restrictions to the site. At the site, parking for private, pick-up and delivery and site vehicles is already in place. Additional designated areas may need to be marked as appropriate
Decontamination facilities	A decontamination facility for workers (a station with showers, hand and eye washing facilities etc.) should be installed for use during the works. These facilities should be clearly signposted and indicated to site workers during site inductions.
Contractor's facilities	All site facilities required for the remediation works will be established in conformance with relevant regulations and authority's requirements. The following facilities may need to be established at the site: ▪ site offices ▪ temporary site sheds ▪ bins for rubbish generated by personnel.

6.4 Excavation of contaminated soil

The excavation for the roadway and footpath will require excavation to depths of up to 3 m. The excavation to these depths may intersect natural soil in some locations but will primarily be in contaminated fill. It will be a requirement of the construction works that soils are to remain segregated to prevent cross contamination of the natural soils.

The proposed stormwater drainage trunk will be installed by micro-tunnelling, and therefore will not result in significant excavation. Some areas of deeper excavation will be required for the tunnel drive and receival pits and where changes in the horizontal alignment require additional structures. These excavations will intersect natural soil and bedrock in addition to contaminated fill, and proper segregation of the materials must be undertaken.

Excavation of asbestos contaminated soils in the section of the EWRR which passes through the Ausgrid property will be undertaken to the depth required for the construction design or until native soils have been encountered and confirmed by the environmental consultant, whichever occurs first. Natural soils have been encountered around this area at 2.60 mBGL (8.20 mAHD) at BH08 during the Parsons Brinckerhoff investigation (2014) and between 3 and 4 mBGL based on the Coffey investigation (2010) .These soils should be stockpiled separately from other soils and appropriately managed. If deeper excavation is required in this area natural material not impacted by asbestos should be stockpiled and managed separately.

Controls to mitigate the potential risks should be employed, such as wetting the soil during excavation, as necessary. Air monitoring should be undertaken during the excavation work at the site boundaries to ensure that controls are effective.

6.5 Contaminated groundwater

Groundwater in the vicinity of the Mobil site has been identified to be contaminated with hydrocarbons and may pose a risk to workers during deeper excavations undertaken for the trunk drain. The following measures should be put in place to reduce the risk of potential exposure:

- If groundwater is exposed, dewatering should be undertaken to limit potential exposure. Pumped water should be stored in retention basins or fully contained tanks on-site. An environmental scientist will collect a sample to assess the contaminant concentration of the groundwater. If the water is found to be suitable for reuse at the site for dust suppression or other appropriate uses it may be retained and used. This would be appropriate only where no detectable concentrations of concern are identified. Where contaminant concentrations are detected the water should be removed for disposal at an appropriate waste facility.
- All personnel must where the appropriate PPE at all times.
- All personnel must wear disposable nitrile gloves when in contact with material identified as contaminated, personnel must also decontaminate any equipment that has come into contact with contaminated material. Decontamination of equipment/tools should be completed by:
  - rinsing in a large container with fresh water to remove any accumulated soil
  - washing in a second container containing a 5% Decon 90 solution, using scrubbing brush
  - rinsing with fresh water and allowing to dry prior to use.

6.6 Stockpiling

Stockpile management procedures, soil erosion and sedimentation controls and procedures to manage contamination will be applied to all wastes prior to removal off-site. The location of the stockpiles will be selected to fit with the expected stages of the project. Stockpiles will be located in accordance with the following general requirements:

- Stockpiles will only be placed at locations approved by the environmental manager appointed to the project.
- Stockpiles will be strategically located to mitigate environmental impacts while facilitating material handling requirements.
- Contaminated materials will only be stockpiled in non-remediated areas of the site or at locations that do not pose any risk of environmental impairment of the stockpile area or surrounding areas (e.g. hardstand areas).
- Stockpiles will only be constructed in areas of the site that have been located and prepared in accordance with the requirements of this RAP. All such preparatory works will be undertaken prior to the placement of material in the stockpile.
- Stockpiles must be located on sealed surfaces such as sealed concrete, asphalt, high density polyethylene or a mixture of these, to mitigate appropriately potential cross contamination of underlying soil.
- Access routes will be established around the material stockpiles to enable access from adjoining haul roads.
- All contaminated stockpiles will be covered and wet down to prevent dust contamination.

- All asbestos contamination will be managed in accordance with relevant WorkCover and any other regulatory requirements, this will include but is not limited to air monitoring, appropriate signage, and the establishment of an exclusion zone established around the area.

6.7 Reinstatement of contaminated soil

Asbestos-contaminated soil at the Ausgrid property which has been excavated and stockpiled should be reinstated on the Ausgrid property following the completion of the construction works where possible. The reinstatement should be undertaken in accordance with geotechnical design requirements.

During reinstatement controls such as wetting of the soil should be employed to mitigate the potential risks and air monitoring should be undertaken at the site boundaries to confirm controls are effective.

Asbestos-impacted and other contaminated material will be covered with a marker layer, capped with clean fill material and covered by hardstand such as concrete, asphalt or other paving to prevent exposure. The capping layer should be installed below the pavement or footpath. Minimum capping thickness for the various proposed structures will be:

- 550 mm beneath the carriageway
- 850 mm beneath footpaths where deep services will be installed
- 300 mm beneath footpaths where no services present
- 500 mm beneath driveways
- 1,100 mm beneath rain gardens
- 750 mm beneath planted median
- 300 mm beneath concrete unit pavers
- 300 mm beneath the cycleway.

The marker layer must be brightly coloured/highly visible, permeable and durable. Marker layer material will be installed directly above the residual contaminated material before the capping layer is placed. Where services or other structures locally extend deeper than the specified capping depth a localised adjustment to the marker layer will be made by the principal contractor.

In some locations along the EWRR deeper excavations will be required for installation of streetlights or stormwater piping, which will be up to 1.5 m deep. In these areas the marker layer will be placed inside the excavation and any voids filled with clean fill.

Any imported material used in the capping layer should be certified as virgin excavated natural material (VENM) or excavated natural material (ENM), and should be sampled to confirm that it is suitable for the ongoing use of the site. Where excavated material from the site or other GSTC sites is used as capping material under the CMMP (JBS&G, 2015) it must be sampled to confirm that it is suitable for use above the marker layer; i.e. no contamination is present which could present an exposure risk. A survey of the completed level should be undertaken following the placement of the marker layer and the placement of the capping layer to confirm the minimum 0.5 m thickness has been achieved where hardstand is not present.

A revised SMP should be prepared to address ongoing management of the site. This is discussed further in Section 11.

6.8 Disposal of excavated soil

Further assessment is required for excavated soil which will be reused on-site or at other Sydney City Council sites or disposed of off-site. An in situ waste classification has been prepared that indicates that soils range from general solid waste to hazardous waste based on the lead concentrations and special waste due to the presence of asbestos.

It is understood that the NSW EPA has approved the reuse of material from the EWRR at another site being developed as part of the GSTC, the Aquatic Centre. The CMMP (JBS&G, 2015) has been prepared to manage the reuse of excavated material across various GSTC sites; all transport and placement of material should be undertaken in accordance with this plan.

Excess contaminated fill material not to be reused which requires disposal at a commercial landfill will be sampled at the site following excavation and stockpiling in accordance with the stockpile sampling methodology outlines in the NEPM (2013):

- For stockpiles of less than 200 m^3, 1 sample per 25 m^3, with a minimum of 3 samples, will be collected.
- For stockpiles greater than 200 m^3 but less than 3,000 m^3, a minimum of 10 samples will be collected.
- For stockpiles greater than 3,000 m^3, 1 sample per 250 m^3 will be collected.

All samples will be analysed for the contaminants of concern for the site; TRH, BTEX, PAHs, PCBs, metals and asbestos. Results should be compared to the relevant criteria in the NEPM (2013).

Any material which is required to be disposed of off-site as waste, rather than being reused at the site or another GSTC site, will be classified in accordance with Part 1 of the NSW EPA waste classification guidelines prior to removal from site.

Where excavations may encounter potential acid sulfate soil, waste disposal should be undertaken in accordance with the acid sulfate soil management plan (Parsons Brinckerhoff 2014) and Part 4 of the NSW EPA waste classification guidelines.

6.9 Materials tracking

Materials excavated from the site should be tracked in order to provide detailed and accurate information about the location and quantity of all materials both on- and off-site from the time of their excavation until their disposal. The location of disposal locations will be determined by the remediation contractor. For any truck leaving the site, the following information would be recorded:

- origin of material
- material type
- approximate volume
- truck registration number.

This information, along with the landfill docket number, will be provided in the validation report.

6.10 Remedial contingencies

At this stage it is anticipated that the proposed remedial technologies should be effective in dealing with the contamination present, however contingency strategies may be required in the event of certain scenarios. Anticipated potential contingencies are detailed in Table 6.2.

Table 6.2 Remedial contingencies

Scenario	Remedial contingencies/actions required
Highly contaminated soils not identified during previous investigation are encountered	If encountered, work is to be suspended until environmental consultant can further assess impacted soils/materials and associated risks and amend the remediation plans, as necessary, with approval of the project manager of Sydney City Council and the site auditor.
Asbestos wastes are encountered in areas outside of the Ausgrid site	If asbestos is encountered subsurface, a management plan will be prepared. Measures such as watering during excavation will be used to mitigate air borne asbestos fibre release may be employed, along with air monitoring. The management plan would be provided to Sydney City Council and the site auditor for approval. Work to be suspended and asbestos removed by a suitably qualified contactor, in accordance with WorkCover regulations, or other control measures are implemented as required.
Changes in proposed future land uses at the site	A revised RAP will need to be issued, including a review of the remediation works completed for the site.

7. Unexpected finds protocol

Contamination that may not have been detected during previous investigation works may be discovered during the course of excavation works. Such contamination may be discovered due to observations such as:

- odour
- discolouration or staining of soil or rock
- seepage of unusual liquids from soil or rock
- unusual odours or sheens on groundwater
- unusual metal objects
- presence of underground storage tanks
- presence of oil
- presence of waste or rubbish above or below ground
- potential asbestos containing material
- unusual colour in soil
- unusual colour in groundwater.

During removal of building slabs and other site coverings inspection of the underlying soil should be undertaken to identify potential evidence of contamination, such as staining/discolouration, odours, presence of anthropogenic inclusions (for example asbestos-containing material, ash, slag, bitumen, etc.) or oil or hydrocarbon sheen. If any evidence of contamination or materials different from those previously encountered at the site are found further consideration will be undertaken to identify any necessary assessment or actions.

If such contamination is discovered, the following procedure will be implemented:

- excavation will cease in the vicinity of the discovery
- the Principal Contractor will be informed immediately of the event
- excavation should stop and a suitably experienced environmental consultant should undertake an assessment of any unexpected finds and determine any further actions required e.g. sampling and/or validation of material, potential for remediation and/or management
- excavation will not recommence until the extent of the contamination has been assessed and, if necessary, additional controls have been implemented
- the material will be separated from other materials and stockpiled for assessment
- sampling of the materials will be undertaken in accordance with the relevant guidelines
- samples will be analysed for a range of analytes as required
- laboratory results will be assessed to determine the appropriate waste classification of the material
- depending on the classification, material already excavated and stockpiled will be transported to an appropriate waste facility that is licensed to accept waste of the relevant classification or beneficially reused if appropriate.

Any unexpected finds should be documented in the validation report to be prepared at the completion of the work.

8. Validation strategy

8.1 Data quality objectives

Systematic planning is critical to successful implementation of a validation assessment and is used to define the type, quantity and quality of data needed to inform decisions. The United States Environmental Protection Agency (US EPA) has defined a process for establishing data quality objectives (DQOs) (US EPA, 2000a and 2000b), which has been referenced in the NEPM (2013) Schedule B2 – Guideline on Site Characterisation. DQOs ensure that:

- the study objectives are set
- appropriate types of data are collected (based on contemporary land use and contaminants of concern)
- the tolerance levels are set for potential decision making errors.

The DQO process is a seven-step iterative planning approach. The outputs of the DQO process are qualitative and quantitative statements which are developed in the first six steps. They define the purpose of the data collection effort, clarify what the data should represent to satisfy this purpose and specify the performance requirements for the quality of information to be obtained from the data. The output from the first six steps is then used in the seventh step to develop the data collection design that meets all performance criteria and other design requirements and constraints. The DQO process adopted for the groundwater assessment is outlined in Table 8.1.

Table 8.1 Data quality objective process

Step	Description	Outcomes
1	State the problem	Fill material at the site is impacted with lead at concentrations that pose a potential risk to human health for the proposed residential with access to soil land use. Contaminants of concern in natural material are not considered to pose a risk to human health or the environment.
2	Identify the decisions	The decisions to be made are as follows: ▪ Has the identified and potential soil contamination at the site been remediated and/or managed to a level suitable for the respective land uses that would pose no unacceptable risk to human health or the environment? ▪ Is all imported material validated as suitable for the proposed land uses?
3	Identify the inputs to the decision	The inputs required to make the above decisions are as follows: ▪ Previous investigation ▪ RAP outlining the nature and extent of impacted soils requiring remediation ▪ National and NSW EPA endorsed or approved methodologies and technical requirements.
4	Define the study boundaries	The boundaries of the remedial and validation works have been identified as follows: ▪ Spatial boundaries: the spatial boundary of the site is defined as the proposed EWRR that has been defined in Figure 1. The contaminant is vertically delineated to the depth to residual soil or the extent of the excavation for the EWRR. The site boundary is shown on Figure 1. ▪ Temporal boundaries: As the data and information obtained from the previous investigation has been relied upon, then the temporal boundary will be from the date of assessment to the date of acquisition of the final validation laboratory results.

Step	Description	Outcomes
5	Develop a decision rule	The purpose of this step is to define the parameter of interest, specify the action level and combine the outputs of the previous DQO steps into an 'if…then…' decision rule that defines the conditions that would cause the decision maker to choose alternative actions. For the selected remediation strategy outlined in this RAP the decision rules for the remediation are: ▪ Has asbestos-contaminated soil been adequately managed by capping and/or removal from site? ▪ Has lead-contaminated soil been adequately managed by the CEMP during construction?
6	Specify limits on decision errors	The acceptable limits on decision errors to be applied in the investigation and the manner of addressing possible decision errors have been developed based on the data quality indicators (DQIs) of precision, accuracy, representativeness, comparability and completeness. A probability that 95% of data will satisfy the DQIs, therefore a limit on the decision error will be 5% that a conclusive statement may be incorrect. The potential for significant decision errors are to be minimised by completing a robust quality assurance/quality control (QA/QC) program and by completing a validation program that has an appropriate sampling and analytical density for the purposes of the assessment and that representative sampling is undertaken.
7	Optimise the design for obtaining data	The purpose of this step is to identify a resource-effective data collection design for generating data that satisfies the DQOs. This assessment has been designed considering the information and data from the previous assessment. The resource effective data collection design that is expected to satisfy the DQOs is described in detail below. To ensure the design satisfies the DQOs, DQIs (for accuracy, comparability, completeness, precision and reproducibility) have been established to set acceptance limits on field methodologies and laboratory data collected. Compliances and non-compliances to the DQIs are to be assessed.

8.1.1 Data quality indicators

DQIs for sampling techniques and laboratory analyses of collected representative soil samples are defined the acceptable level of error required for this validation assessment. The adopted field methodologies and data obtained will be assessed by reference to DQIs as follows:

- **Accuracy:** A quantitative measure of the closeness of reported data to the true value.
- **Comparability:** A qualitative parameter expressing the confidence with which one data set can be compared with another.
- **Completeness:** A measure of the amount of useable data (expressed as %) from a data collection activity.
- **Representativeness:** The confidence (expressed qualitatively) that data are representative of each media present on the site.
- **Precision:** A quantitative measure of the variability (or reproducibility) of data.

A summary of the field and laboratory DQIs for the validation assessment are provided in Table 8.2 and Table 8.3.

Table 8.2 Data quality indicators – field techniques

Accuracy	▪ Parsons Brinckerhoff standard operating procedures (SOPs) appropriate and complied with ▪ Collection of rinsate blanks
Comparability	▪ Same SOPs used on each occasion ▪ Experienced sampler ▪ Climatic conditions (temperature, rainfall, wind) ▪ Same type of samples collected
Completeness	▪ SOPs appropriate and complied with ▪ All required samples collected
Representativeness	▪ Appropriate media sampled according to RAP
Precision	▪ SOPs appropriate and complied with ▪ Collection of inter-laboratory and intra-laboratory duplicates

Table 8.3 Data quality indicators – laboratory

DQI	Acceptable Limits
Accuracy	
Analysis of:	
Laboratory prepared trip blanks (one per day per batch)	Non-detect for contaminants analysed
Rinsate blanks (one per day)	Non-detect for contaminants analysed
Method blanks	Non-detect for contaminants analysed
Matrix and surrogate spikes and laboratory control samples	Laboratory specific
Matrix spike duplicates	Laboratory specific
Reference materials	Laboratory specific
Reagent blanks	Non-detect for contaminants analysed
Comparability	
Sample analytical methods used (including clean-up)	As per NEPM (NEPC, 2013)
Same units (justify/quantify if different)	-
Same laboratories (justify/quantify if different)	-
Sample PQLs (justify/quantify if different)	< nominated criteria
Completeness	
All critical samples analysed	As per RAP
All required analytes analysed	As per RAP
Appropriate methods and PQLs	As per NEPM (NEPC, 2013)
Sample documentation complete	As per NEPM (NEPC, 2013)
Sample holding times complied with	As per NEPM (NEPC, 2013)

DQI	Acceptable Limits
Representativeness	
All required samples analysed	As per RAP
Precision	
Analysis of:	
Blind (intra-laboratory) duplicates and split (inter-laboratory) duplicates at rate of 1:20 primary samples for the same analysis of primary samples	Volatiles (<50%), semi-non-volatiles (<30%) Variation can be expected to be higher for organics, low concentrations (<5XPQL) or non-homogenous samples.
Laboratory duplicates	Laboratory specific
Laboratory prepared trip spikes (one per day per batch volatiles)	70–130%
National Association of Testing Authorities (NATA) certified laboratories used	As per NEPM (NEPC, 2013)

8.1.2 Standard operating procedures

SOPs to be adhered to during collection of samples for validation and assessment purposes are outlined in Table 8.4.

Table 8.4 SOPs for soil sampling

Activity	Details
Sample collection (general)	Soil samples will be placed directly in laboratory prepared and supplied, acid washed and solvent rinsed glass jars with screw top Teflon-lined lids. Disposable nitrile gloves will be used in the collection of each individual sample. Samples collected from the base and walls of the excavation will be collected using a hand trowel. Samples collected from stockpiles of imported material will be collected from a nominal depth of 0.2 m beneath the surface of the stockpile using a hand trowel.
Sample collection (assessment of soils in building and brick/concrete/timber structure)	Sampling will be undertaken in accordance with NEPM (NEPC, 2013) specifically Section 11.3.2 of Schedule B2 – Guideline on Site Characterisation
Quality control samples	Quality control samples will comprise field blind (intra-laboratory) and spilt (inter-laboratory) duplicates, trip spikes (when analysing volatiles) and trip and rinsate blanks.
Sample labelling	All samples collected will be identified by a unique sample identifier. The sample identifier will be included on all sample jars and associated paperwork including field sheets and chain of custody forms. The following labelling system will be used for this project: Sample labels were completed in indelible ink. Sample labels included the following information: ▪ Parsons Brinckerhoff project number ▪ sample identifier ▪ date of sample collection (day/month/year) ▪ initials of sampler. Quality control samples were labelled: ▪ intra- and inter-laboratory duplicates: ‘DUP’ + sequence number (i.e. DUP01, DUP02 etc.) ▪ trip blanks: ‘TB’ + sequence number (i.e. TB01, TB02 etc.) ▪ trip Spikes: ‘TS’ + sequence number (i.e. TS01, TS02 etc.) ▪ rinsate blanks: ‘RB’ + sequence number (i.e. RB01, RB02 etc.).

Activity	Details
Sample preservation	Samples will be immediately stored in an insulated esky chilled with ice to approximately 4º C upon sampling and during transit to the laboratory.
Sample handling	Samples will be submitted to the laboratory accompanied by a chain of custody form.
Calibration	All equipment will be calibrated prior to use in accordance with the manufactures instructions.
Decontamination procedure	Equipment will be decontaminated prior to collecting each sample using 'Decon 90' detergent solution and rinsing with potable water.

8.2 Characterisation sampling

Material excavated as part of the construction of the drain and roadway and which is proposed to be retained on-site and capped will be sampled for contaminants of concern at a rate meeting the stockpile sampling requirements of the NEPM (2013) to confirm that the proposed capping strategy will provide suitable control for the contamination identified. The NEPM stockpile sampling density requires sampling at 1 per 25 m^3 for up to 200 m^3 of soil, a minimum of 10 samples for between 200 m^3 and 3,000 m^3 of soil and 1 per 250 m^3 for greater than 3,000 m^3 of soil disturbed.

8.3 Imported fill material sampling

Any imported fill, whether VENM, ENM or other imported material, should be accompanied by relevant documentation. The source site of the material should be inspected and material sampled at a rate of one sample per 100 m^3, with a minimum of 10 samples taken from each product imported.

Imported fill samples would be submitted for analysis of TRH, BTEX, PAHs, PCBs, metals and pesticides. Results of the analysis should be below detection for hydrocarbons, other organics and pesticides and in the range of background concentrations for metals.

All documentation verifying the status of imported materials should be included in the validation report including any documentation relation to exemptions).

8.4 Validation reporting

Following the remediation works a final report will be prepared in accordance with the Guidelines for Consultants Reporting on Contaminated Sites. The validation report will detail the extent and nature of the remedial works undertaken, characterisation and disposal of contaminated soils, reinstatement and capping of asbestos-contaminated soils, the validation of imported clean fill and topsoil (if any) and will consider the overall status of the site.

The report should include the following sections:

- scope of works
- site identification and history
- site conditions and surrounding environment
- previous investigation results
- summary of the RAP
- validation criteria
- nature and extent of the remediation undertaken

- sampling and analysis plan and sampling methodology
- field and laboratory QA/QC
- results of sampling of waste materials and imported fill materials
- contractor supplied information (such as waste disposal documentation)
- discussion of the land use suitability at the completion of remedial works.

To enable the validation report to be produced, the contractor must supply:

- the quantities and types of waste disposed of
- details of the receiving facility/facilities accepting waste from the site
- disposal dockets for the waste disposed
- details of any imported materials (including VENM certification, laboratory results, origin and supplier, exemption details, quantities and areas of placement).

9. Validation criteria

The proposed future land use for the site is for the proposed EWRR. HILs, and ecological investigation levels (EILs) have been adopted from Schedule B1 of the NEPM guidelines (NEPC, 2013) as validation criteria, where available. Criteria relevant to a commercial industrial site have been considered appropriate for the site.

Health investigation levels (HILs) are applied to assess human health risk via all relevant exposure pathways of exposure for selected metals and organic substances. HILs are concentrations below which contaminants in soils are not considered to adversely affect human health. Health screening levels (HSLs) are applied to assess human health risk via inhalation of volatile hydrocarbon vapours.

Ecological investigation levels and ecological screening levels (EILs and ESLs) will be adopted to assess the risk from contaminants of concern to the environment.

Imported fill material will be analysed for a broad range of potential contaminants. To assess imported fill, HILs, HSLs, EILs and ESLs have been adopted from Schedule B1 of the NEPM guidelines (NEPC, 2013) as validation criteria, where available. Criteria relevant to a commercial industrial site have been adopted.

The soil validation criteria to be adopted are summarised in Table 9.1.

Table 9.1 Adopted assessment criteria

Analyte	Soil HILs(1)	Soil HSLs			EILs(1)	ESLs(1)
Exposure pathway	**All**	**Direct contact(2) commercial industrial**	**Direct contact(2) intrusive maintenance**	**Vapour intrusion(1) 0-1 m**	**Surface runoff and uptake**	
Arsenic	100	-		-	100	-
Cadmium	20	-		-	-	-
Chromium (VI)	100	-		-	TBC^	-
Copper	6,000	-		-	TBC^	-
Lead	300	-		-	1,100	-
Mercury (inorganic)	40	-		-	-	-
Nickel	400	-		-	TBC^	-
Zinc	7,400	-		-	TBC^	-
C_6-C_{10} less BTEX (F1)	-	26,000	82,000	260	-	180
>C_{10}-C_{16} less naphthalene (F2)	-	20,000	62,000	NL	-	120
TRH >C_{16}-C_{34}	-	27,000	85,000	-	-	300
TRH >C_{34}-C_{40}	-	38,000	120,000	-	-	2800
Benzene	-	430	1,100	3	-	50

Analyte	Soil HILs(1)	Soil HSLs			EILs(1)	ESLs(1)
Exposure pathway	**All**	**Direct contact(2) commercial industrial**	**Direct contact(2) intrusive maintenance**	**Vapour intrusion(1) 0-1 m**	**Surface runoff and uptake**	
Toluene	-	99,000	120,000	NL	-	85
Ethylbenzene	-	27,000	85,000	NL	-	70
Xylene	-	81,000	130,000	NL	-	105
Benzo(a)pyrene	-	-	-	-	-	0.7
Carcinogenic PAHs (as B(a)P TEQ)	3	-	-	-	-	-
Naphthalene	-	11,000	29,000-	-	170	-
Total PAHs	300	-	-	-	-	-

(1) NEPM Schedule B1: Guidelines on investigation levels for soil and groundwater (NEPC, 2013)
(2) CRC CARE Technical document no. 10 (Friebel and Nadebaum, 2011)

NL Not limiting
TBC^ To be confirmed following analytical results for pH, cation exchange capacity (CEC), organic content and clay content.

10. Construction environmental management plan

A CEMP should be developed for the site works to ensure that the on-site and off-site environment is not adversely impacted during the proposed construction works. The CEMP should address the potential migration pathways and take into consideration the issues discussed in Table 10.1.

Table 10.1 Items to be addressed in the CEMP

Item	Description/requirements
Working hours	It is anticipated that works will be undertaken during normal working hours. It is assumed for the purpose of the RAP that normal working hours will be as follows: ▪ Monday to Friday: 7:00 am to 6.00 pm. ▪ Saturday: 8:00 am to 1.00 pm. ▪ Sunday and public holidays: no work unless approved by the principal contractor.
Odour and vapour	No odours or vapours are anticipated to be produced during these works. Should distinct odours be detected, site works should cease until the odours can be reduced or controlled. Control measures could be implemented, including the following: ▪ workers should be fitted with appropriate respirators for continuation of site works in the area ▪ wetting down the excavated material with the use of water sprays (and/or commercial odour suppressants if required) ▪ all contaminated material loaded onto trucks for off-site disposal to be securely covered.
Dust	During earthworks, dust minimisation systems shall be put in place by the contractor, such as water carts or sprinkler systems to prevent airborne migration of dust and contaminates. All stockpiled soil will be covered to minimise dust generation.
Noise	Increased noise levels may result from the use of additional mechanical equipment on the site during the course of the project. To mitigate any noise, which may arise as a result of site works, all works will be carried out in accordance with all applicable state and local noise regulations and will be monitored through discussion with local residents. Any excavation works would only be undertaken during normal working hours.
Surface water management	During the period of site works any open excavations will be minimised in size and bunded as required with sand bags or hay bales. Stockpiled soils will be removed from site once classified, in the interim soils will be suitably covered and bundled to prevent run off of contaminated water or soil to the surrounding environment, including storm drains. Control measures should be established to prevent surface water runoff entering and leaving excavation and stockpile areas. Control measures may include: ▪ temporary bunding or diversion drains ▪ plastic sheeting placed under stockpiles ▪ silt fences/hay bales to surround stockpiles ▪ protection of existing drains with silt fencing/hay bales. These mitigation measures should be regularly inspected to ensure that they are in good condition and if necessary upgraded where their performance is deteriorating.
Subsurface seepage and accumulated excavation water	Water accumulated in excavations will be sampled for the appropriate contaminants of concern and upon receipt of the analytical results, management or disposal options will be formulated.
Sediment	Drains, gutters, roads and access ways shall be maintained free of sediment to the satisfaction of Council. Where required, gutters and roadways shall be swept regularly to maintain them free from sediment. Control measures, as for surface water should be implemented and maintained.

Item	Description/requirements
Refuelling/storage of fuels/oils/ hazardous substances/ dangerous goods	Any handling, storage and/or disposal of fuel, oil and other chemicals will be undertaken in accordance with the AS1940 – 2004: The Storage and Handling of Flammable and Combustible Liquids and/or the NSW DECC (2009) Waste Classification Guidelines. All potentially hazardous substances onsite should have an appropriate material safety data sheet (MSDS) to be kept with the site management plan. If fuels are to be stored onsite or refuelling of plant of machinery is necessary, this should be done in appropriate areas such as designated storage trays or hardstand. Drip trays should be used to prevent spills impacting the ground surface during refuelling activities. Appropriate spill response kits should be accessible for use in the event of a leak or spill.

10.1 Contingency management

Contingency plans for anticipated situations that may arise during the course of the remediation work are presented in Table 10.2

Table 10.2 Contingency management plan

Item	Description
Chemical/fuel spill	Stop work, notify the relevant contacts. Use accessible soil or appropriate absorbent material on site to absorb the spill (if practicable). Stockpile the impacted material in a secure location, sample and determine the appropriate disposal/treatment option.
Excessive dust	Use water spray to suppress the dust or stop work until dust abates.
Excessive noise	Identify the source, isolate the source if possible, modify the actions of the source or erect temporary noise barriers if required.
Excessive odours/vapours	Stage works to minimise odours/vapours. If excessive odours/vapours are being generated, stop works and monitor ambient air across site for organic vapours and odours at site boundaries. Implement control measures including respirators for on-site workers, use of odour suppressants, wetting down of excavated material.
Excessive rainfall	Ensure sediment and surface water controls are operating correctly. If possible divert surface water away from active work areas/excavations. Cover stockpiles.
Water in excavations	Collect samples and assess against relevant assessment criteria, to enable disposal options to be formulated.
Leaking machinery or equipment	Stop the identified leak (if possible). Clean up the spill with absorbent material. Stockpile the impacted material in a secure location, sample and determine the appropriate disposal/treatment option.
Failure of erosion/sediment control	Stop work, repair failed control measure.
Unearthing unexpected materials, fill or waste	Stop activities, contact the client and environmental consultant project managers. Excavated material should be stockpiled separately for sampling and assessment. Prepare a management plan to address the issue, if required.
Equipment failures	Ensure that spare equipment is on hand at site, or that the failed equipment can be serviced by site personnel or a local contractor.
Complaint management	Notify the client and environmental consultant project managers following complaint. Report complaint as per management procedures. Implement control measures to address reason of complaint (if possible).

11. Work health and safety

As part of the work health and safety (WHS) plan to be prepared for the works, the health and safety of site workers and nearby site users should be addressed when considering site security, excavation safety, vibration, noise, odour and dust levels. The plan should address the risks during the remediation works and ensure they are addressed. The plan should cover site specific requirements associated with the lead contamination present within surficial soil at the site which would likely include the use of personal protective equipment and dust suppression measures where necessary.

All work associated with the remediation of the site should conform at a minimum, to the requirements of the NSW Work Health and Safety Act 2011 and associated regulations.

Typically the OHS plan should address the following issues:

- regulatory requirements
- responsibilities
- hazard identification and control
- air monitoring (including action levels) during excavation and construction (if necessary)
- noise
- odours
- chemical hazard control
- handling procedures
- PPE
- work zones
- decontamination procedures
- emergency response plans
- contingency plans
- incident reporting.

The plan should include emergency contact numbers such as police, fire brigade, hospital and contact details for all relevant personnel. Response to any incidents occurring on site should be in accordance with the plan.

12. Site management plan update

Following the completion of the construction and remediation work the SMP currently in place for the Ausgrid property will need to be revised to account for the change in conditions. The revised SMP must contain:

- site details and background, including a conceptual site model
- legislative/regulatory framework
- responsibilities of the owner, contractors and primary stakeholders
- document controls
- licensing and approval requirements
- training and induction requirements
- record keeping requirements
- emergency contacts and response procedures
- risk assessment
- environment management activities and controls
- performance criteria, monitoring and reporting
- auditing, review and corrective action requirements
- plans/maps detailing the areas to be managed
- any forms or checklists required for monitoring, reporting, auditing or recordkeeping.

13. Limitations

Scope of services

This environmental site assessment report (the report) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the client and Parsons Brinckerhoff (scope of services). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on data

In preparing the report, Parsons Brinckerhoff has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, Parsons Brinckerhoff has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, `conclusions and/or recommendations in the report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Parsons Brinckerhoff will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Parsons Brinckerhoff.

Environmental conclusions

In accordance with the scope of services, Parsons Brinckerhoff has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions.

Also, it should be recognised that site conditions, including the extent and concentration of contaminants, can change with time.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

Report for benefit of client

The report has been prepared for the benefit of the client (and no other party), but may be relied upon by the Environment Protection Authority acting in its capacity as the administering authority (as defined in the Environmental Protection Act 1994 (QLD) (EP Act). Parsons Brinckerhoff assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of Parsons Brinckerhoff or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Except as provided below parties other than the client should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

The Environment Protection Authority in its capacity as the administering authority (as defined in the EP Act) may consider and rely upon the report for the purposes of making a decision under Section 396 of the EP Act and for the administration of matters under and in accordance with that section.

Other limitations

Parsons Brinckerhoff will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

14. References

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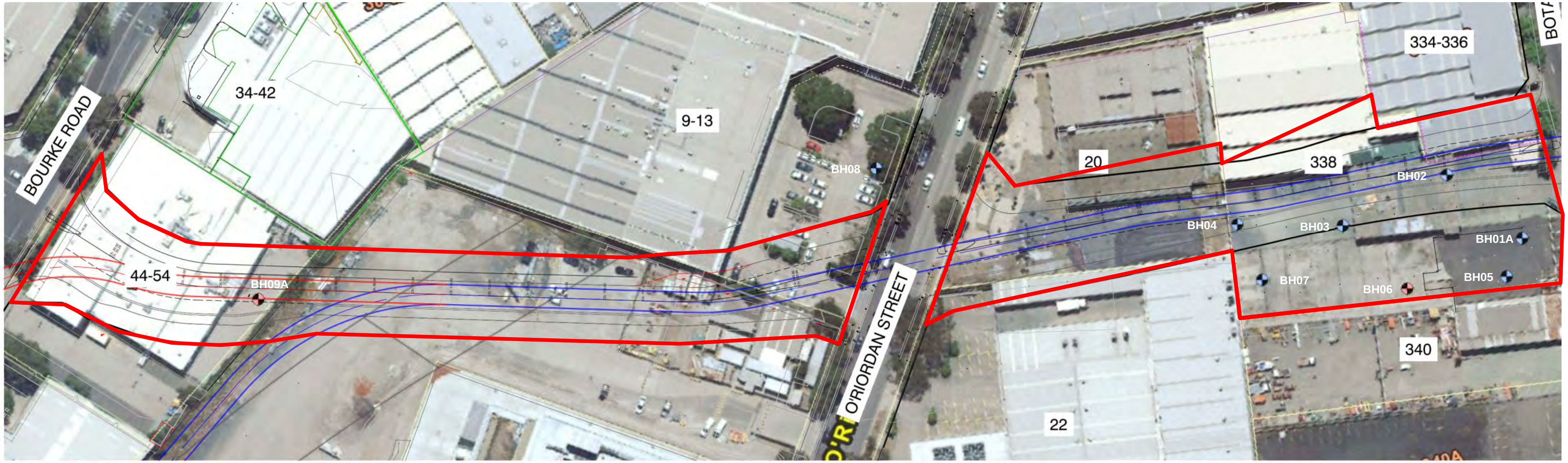
Figures



LEGEND

Site boundary/remedial extent

BH – Geotechnical and CLM sampling

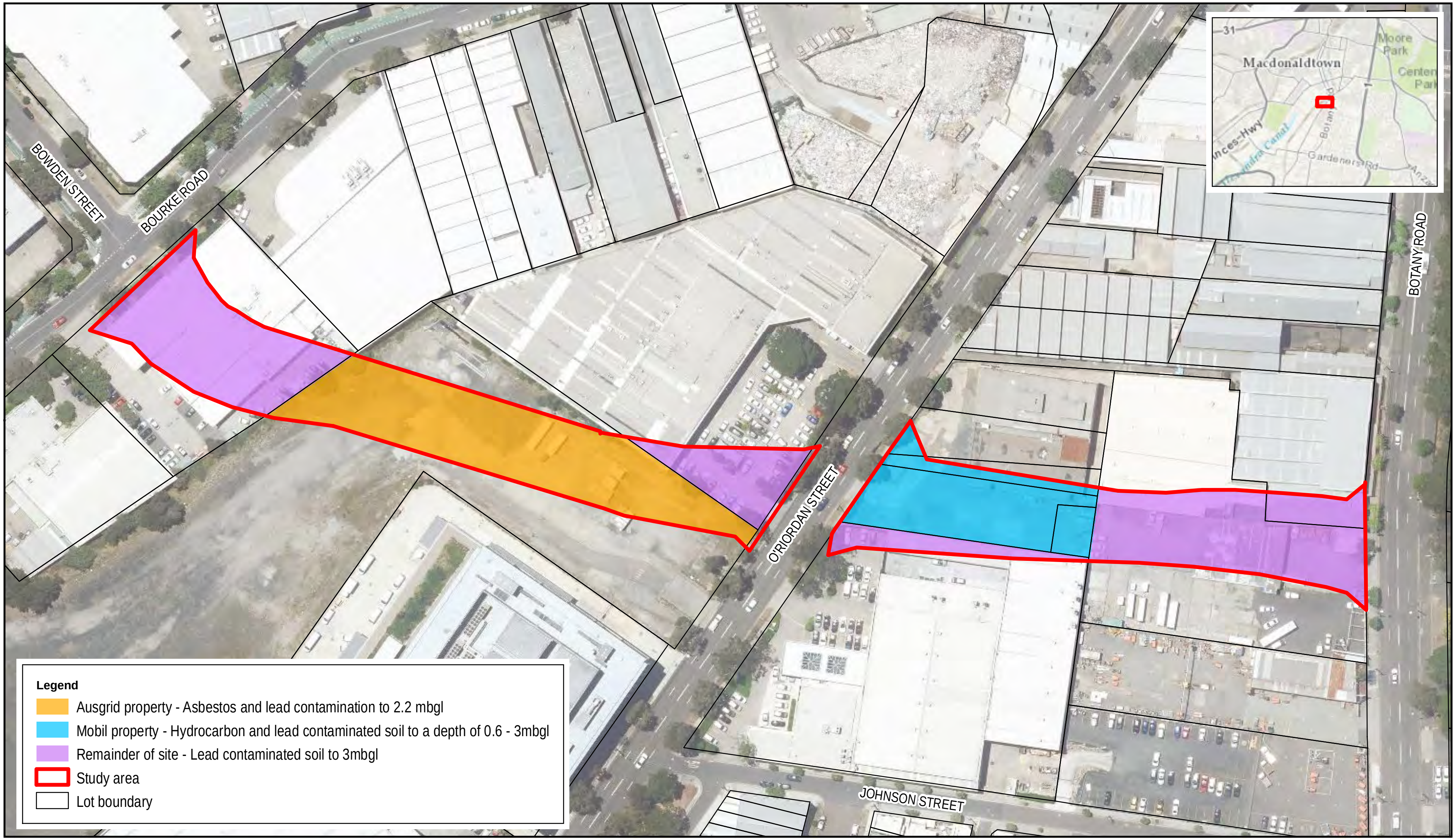
BH – Geotechnical, CLM sampling and installation of groundwater monitoring well

Note: Borehole locations recorded via handheld GPS device. Locations are accurate to +/- 5m.

Not to Scale

Base map source: City of Sydney – East West road proposed alignment index plan

Figure 1 Site layout plan
Proposed East West Relief Route
Green Square, Sydney, NSW.



CITY OF SYDNEY
Sydney City Council

Data source
Sources Esri DeLorme HERE TomTom Intermap increment P Corp. GEBCO USGS FAO NPS NRCAN GeoBase IGN Kadaster NL Ordnance Survey Esri Japan METI Esri China (Hong Kong) swisstopo and the GIS User Community

Map no: 2161101A_GIS_F001_A1
Author: - suansrir
Published by: - SuansriR
Date: 29/06/2015

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Scale ratio correct when printed at A4
Projection Transverse Mercator
Coordinate system GDA 1994 MGA Zone 56

Remediation Action Plan for East West Relief Route
Figure 2
Areas of concern

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