Remediation Remediation Development Application, SSD 6617-2014, Barangaroo Hickson Road, EPA Declaration Area No. 21122

Lend Lease Millers Point Pty Ltd

09-Mar-2016

Air Quality Impact Assessment Report

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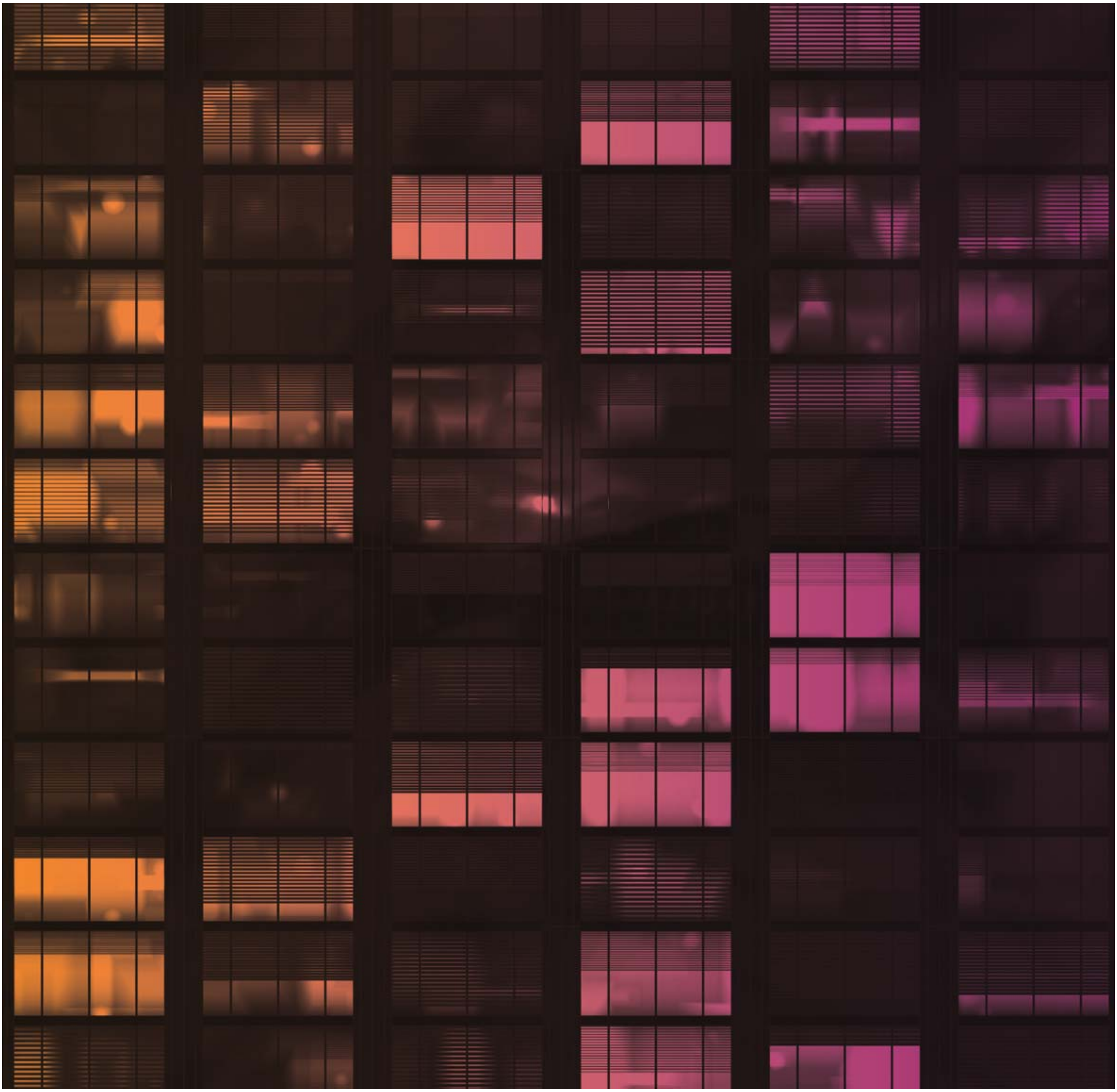

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Client: Lend Lease Millers Point Pty Ltd

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Revision B	14-Aug-2015	Final Document	David Rollings Principal Air Quality Engineer	
Revision C	2-Feb-2015	Draft Document following EPA Comments	David Rollings Principal Air Quality Engineer	
Revision D	9-Mar-2016	Final AQIA Update	David Rollings Principal Air Quality Engineer	

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Glossary of Terms

Term	Description
Block 4 Remediation Area	Portion of the Declaration Area situated within Barangaroo South.
Block 5 Remediation Area	Portion of the Declaration Area located within Barangaroo Central (including remediation of some land adjacent to the Declaration Area on the west)
BTEX	Benzene, toluene, ethylbenzene and xylenes
DEC	Department of Environment and Conservation
EPA	Environment Protection Authority
EPA Declaration Area	Remediation Site Declaration 21122
EPL	Environment Protection Licence
Ex-situ Remediation Methodology	Excavation of contamination followed by off-site disposal (with off-site pre-treatment where required)
Hickson Road Remediation Area	Portion of the Declaration Area situated within the Hickson Road reserve
In-situ Remediation Methodology	Remediation using *in-situ* chemical oxidation and/or extraction (product recovery). Process would be undertaken using ISCO (surfactant enhanced *in-situ* chemical oxidation) or a similar method.
ISCO	*In-situ* chemical oxidation
Lend Lease	Lend Lease (Millers Point) Pty Ltd
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
OU	Odour units. 1 OU is equal to the odour threshold of a particular odour, which is the concentration at which a particular odour can be detected by half the members of an odour panel.
PAHs	Polycyclic aromatic hydrocarbons.
PM_{10}	Particulate matter with an average diameter less than 10 micrometres
RAP	Remedial Action Plan
SISCO	Surfactant enhanced *in-situ* chemical oxidation
Site	Area required for the purpose of the Hickson Road Remediation Development Application identified as: - Hickson Road Remediation Area - Any other areas of Barangaroo or Hickson Road required for staging and undertaking the remediation and stormwater diversion works
Site Remediation Area	The Hickson Road Remediation Area.
SVOCs	Semi volatile organic compounds
TSP	Total suspended particulates
USEPA	United States Environmental Protection Agency
VOCs	Volatile organic compounds

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) has been commissioned by Lend Lease Millers Point (Lend Lease) to prepare an Air Quality Impact Assessment (AQIA) to accompany a Development Application for the remediation of part of Hickson Road at Millers Point (SSD 6617). The Development Application has been submitted to the Minister for Planning pursuant to Part 4 of *the Environmental Planning and Assessment Act, 1979*. This AQIA has been updated to respond to submissions made by the NSW EPA during public exhibition of the Application.

The area of Hickson Road to be remediated is the subject of NSW EPA Remediation Site declaration 21122.

1.1 Scope of Works

The Secretary's Environmental Assessment Requirements (SEARs) were issued for the project on 18 August 2014. The AQIA was to include:

- *the identification of the pollutants of concern, including individual toxic air pollutants, dust and odours;*
- *the identification and assessment of all relevant fugitive and point source emissions;*
- *appropriate coverage of all aspects of the remediation, including the excavation, storage, transport and treatment of contaminated material;*
- *proposed air quality management and monitoring procedures during the remediation; and*
- *consideration of requirements of the Protection of the Environment Operations (Clean Air) Regulation 2010.*

The SEARs also specified that the assessment was to be undertaken in accordance with the EPA's Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (DEC, 2005) and make appropriate reference to the Assessment and Management of Odour from Stationary Sources in NSW: Technical Framework 2006 and Assessment and Management of Odour from Stationary Sources in NSW: Technical Notes 2006 documents, also published by the Environment Protection Authority (EPA).

As such, this AQIA:

- Identifies the pollutants of potential concern (referred to as chemicals of potential concern);
- Identifies and assesses relevant fugitive and point source emissions, including those associated with excavation, storage, transport and treatment of contaminated material; and
- Recommends air quality management and monitoring procedures for use during the remediation works.

Dispersion modelling of the proposed remediation activities was undertaken using the CALPUFF model. The assessment was undertaken in accordance with and/or in reference to the following documents:

- *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* 2005, published by the Environment Protection Authority (EPA);
- *Assessment and Management of Odour from Stationary Sources in NSW: Technical Framework 2006*;
- *Assessment and Management of Odour from Stationary Sources in NSW: Technical Notes 2006*; and
- *Protection of the Environment Operations (Clean Air) Regulation* 2010.

Potential impacts of the proposed works were assessed through the analysis of two scenarios, which represented the expected highest activity levels of all on-site activities that may be occurring during Hickson Road remediation works for each of the potential remediation options (*in-situ* [preferred] and *ex-situ* [alternative]). Based on staging information provided by Lend Lease, the following concurrent activities are expected to represent the worst-case emissions during the Hickson Road works, and were assessed through dispersion modelling:

- Hickson Road remediation activities;
- Block 5 excavation;
- Block 4 remediation activities;
- The operation of an on-site water treatment plant;
- Construction of the Commercial building C1; and

- Stage 1C Remediation and Bulk Earthworks.

Meteorological and terrain files and receptor locations were updated from those used in previous Barangaroo assessments to reflect the most recent available information. Relevant source characteristics used in previous assessments undertaken by AECOM for the Barangaroo development were used in this assessment for consistency.

2.0 Site Description

2.1 Hickson Road and Adjoining Barangaroo Development

Barangaroo is located on the north western edge of the Sydney Central Business District (CBD), bounded by Sydney Harbour to the west and north, the historic precinct of Millers Point (for the northern half), The Rocks and the Sydney Harbour Bridge approach to the east; and bounded to the south by a range of new development dominated by large CBD commercial tenants. The location is shown in **Figure 1**.

The 22 hectare (ha) Barangaroo site is roughly rectangular in shape and has frontage to the harbour foreshore of 1.4 km. Hickson Road delineates the eastern boundary.

The Barangaroo Concept Plan (as modified) is the statutory planning approval to guide the urban renewal of Barangaroo, and currently provides for the development of a mixed use precinct comprising commercial, retail, residential and community development and new public open space / public domain.

The Barangaroo Delivery Authority is the state government authority managing and delivering the development of Barangaroo.

2.2 EPA Declaration Area (#21122)

In May 2009, the EPA determined that a portion of land at Millers Point (part of the Barangaroo Site and an adjacent portion of Hickson Road) was contaminated in such a way as to present a significant risk of harm to human health and the environment. As a consequence, the EPA declared the area to be a remediation site (Declaration Number 21122; Area Number 3221) under the Contaminated Land Management Act 1997.

The Remediation Site Declaration 21122 indicates that the area of the declaration (Declaration Area) coincides with the known footprint of the former Millers Point gasworks facilities. This area is located on part of Barangaroo and part of Hickson Road adjacent to Barangaroo.

In accordance with Declaration Number 21122, the Declaration Area comprises:

- Part Lot 200 DP 1204948 and Part Lot 101 DP 1204946 (formerly known as Part Lot 5 and Part Lot 3 DP 876514), Hickson Road, Millers Point, NSW 2000.
- Part of Hickson Road adjacent to:
  - 30 - 34 Hickson Road (Lot 11, DP1065410);
  - 36 Hickson Road (Lot 5, DP873158); and
  - 38 Hickson Road (SP72797) Millers Point.

The NSW EPA has issued a Management Order (No. 20151402) to the Barangaroo Delivery Authority (BDA) for the remediation of the EPA declared area (including the portion of Hickson Rd subject to SSD 6617) An independent, EPA-accredited Site Auditor has been appointed to undertake review of proposed remediation works and prepare statutory audit statements prior to and following completion of remediation.

For the purposes of planning and staging, the EPA Declaration Area is divided into the following three areas:

- Block 4 Remediation Area - the part of the Declaration Area on Barangaroo South;
- Block 5 Remediation Area - the part of the Declaration Area on Barangaroo Central; and
- Hickson Road Remediation Area - the part of the Declaration Area located on Hickson Road.

The current Development Application for which this AQIA was prepared is for the Hickson Road Remediation Area only. Remediation works associated with the Block 4 and Block 5 Remediation Areas were the subject of separate development applications.

2.3 Summary of Site History and Key Contaminants

The Millers Point gasworks operated on the Declaration Area between 1840 and 1921. The Site has subsequently been used for various activities, but predominantly a commercial port facility and public road.

When the EPA declared parts of Barangaroo and Hickson Road a "Remediation Site", it described the nature of contamination as gasworks waste with the following particular substances: polycyclic aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene and total xylenes (BTEX); total petroleum hydrocarbons (TPH); ammonia and cyanide.

The *VMP/Block 4 Remedial Action Plan* (RAP) (AECOM, 2013) provides more specific details regarding the type, magnitude and location of ground contamination of the site as identified in previous site investigations.

2.4 Definition of Site

For the purposes of the Hickson Rd Remediation Development Application, the site includes the area of Hickson Road to be remediated (Site Remediation Area), plus any adjacent land used for the staging and undertaking of the proposed remediation. The Site Remediation Area comprises the part of Hickson Road within the Declaration Area that requires remediation, per the RAP.

2.5 Remedial Action Plan and Methodology

The proposed remediation of the Declaration Area is detailed in the *VMP/Block 4 RAP* (AECOM, 2013) (AECOM 2013). The *VMP/Block 4 RAP* (AECOM, 2013) included two potential methodology options for Hickson Rd:

- Preferred - *In-situ* remediation (chemical oxidation); or
- Alternative - *Ex-situ* remediation (excavate, off-site disposal and backfill).

The Development Application for Hickson Road Remediation includes undertaking either the preferred or the alternative method above, with the final method to be selected following agreement with the EPA.

2.6 Role of Lend Lease

Lend Lease was contracted by the Barangaroo Delivery Authority to undertake remediation of the Declaration Area, which includes the Hickson Rd Remediation Area. Lend Lease was also appointed by the Barangaroo Delivery Authority as the Proponent to undertake the development for Barangaroo South.

2.7 Surrounding Land Use and Receptors

The Site is Hickson Road, which is bordered by Block 4 and Block 5 of Barangaroo on the western side and by offices and residential buildings on the eastern side. Details of the sensitive receptors considered in this assessment are provided in **Section 6.6**.

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AECOM

BARANGAROO SITE LOCATION
Air Quality Impact Assessment
Hickson Road, Millers Point NSW

FIGURE 1

3.0 Project Description

The following sections summarise the works proposed as part of the Hickson Road Remediation Development Application for the preferred and alternate remediation methods. Hickson Road is to remain open to traffic for both options, with required temporary road closures/diversion in place during remediation works.

3.1 Preferred Method – *In Situ* Remediation

The preferred remediation method for required Hickson Road areas is to use *in-situ* chemical oxidation/product extraction. The *in-situ* remediation method will be SISCO/SEPR (Surfactant Enhanced In-Situ Chemical Oxidation and Surfactant Enhanced Product Recovery) or a similar *in-situ* oxidation process.

The *in-situ* remediation process involves the installation of subsurface wells and piping in Hickson Road and a temporary staging compound in the road reserve, which will facilitate the controlled injection of chemical mixtures into the ground to treat required areas of gasworks contamination *in-situ*.

The works are summarised below:

- Localised pruning of street trees where required to facilitate works.
- Undertaking temporary lane/traffic diversion as required during works.
- Undertaking local service diversion or protection as required.
- Maintaining access to the driveways of 30 and 38 The Bond properties located on Hickson Road.
- Installation of remediation infrastructure (wells and piping) in Hickson Road.
- Installation of a temporary remediation compound/staging area in Hickson Road reserve.
- Installation of boundary groundwater control walls where required.
- Undertaking *in-situ* chemical oxidation remediation through controlled injection and extraction.
- Management of extracted fluids through: limited storage/treatment within the Hickson Rd site; transfer to a temporary water treatment plant on the Barangaroo site; or tankering offsite.
- If required, undertaking localised excavation under excavation enclosures and off-site disposal. Odour control enclosures would be used for significant excavation works, with alternative suitable odour controls applied for minor excavation works. Alternative controls would include limiting exposed excavations, and/or use of foams, covers and odour suppressants
- Undertaking detailed environmental monitoring (air, noise, water) for the duration of works.
- Validating the remediation per the *VMP/Block 4 RAP* (AECOM, 2013), including groundwater monitoring where required.
- Decommissioning sub-surface well/piping infrastructure (capping and leaving *in-situ*).
- Re-surfacing required areas of road/pavement.

3.2 Alternative Method – *Ex Situ* Remediation

If the preferred *in-situ* method is not undertaken, the alternative, *ex-situ*, remediation method would be used. For the *ex-situ* method, remediation would be undertaken through selective excavation of required Hickson Road areas (including footpath) followed by off-site disposal (and treatment where required) of material at licensed facilities, backfilling and re-instatement of road/footpath. Approximately 16,000 m^3 of material would be excavated. The works are summarised below:

- Removal of street trees where required to facilitate excavation works.
- Undertaking temporary lane / traffic diversion as required during works.
- Undertaking local service diversion or protection as required.
- Maintaining access to the driveways of 30 and 38 The Bond located on Hickson Road.
- Undertaking remediation in two main stages (east and west):

- Temporarily closing one half of Hickson Road and undertaking remediation while traffic is diverted to other half.
- Re-instatement of access to the remediated half of Hickson Road, and re-diverting traffic to complete remaining stage.

- Installation of boundary groundwater control walls and walls to facilitate staged excavation, where required.
- Installation of excavation enclosures over the excavation area (in stages as required).
- Excavation of gasworks contamination in stages, where required, from beneath road/footpath.
- Excavation of rock, if required, to facilitate access to deep contamination within the annulus trench.
- Transfer of excavation water to a water treatment plant for treatment
- Transfer of excavated material directly off-site to a licensed facility for treatment and/or landfill disposal as envisaged by Sections 13.3 and 14.1 of the *VMP/Block 4 RAP* (AECOM, 2013). All loads would be appropriately sealed to prevent odour and dust emissions during transport (for example through the use of odour suppressant foam, such as Rusmar AC-645 or equivalent (refer to Product Guides in **Appendix A**). Any off-site treatment works would be undertaken at a licenced treatment facility, and, as such, the emissions associated with treatment would be subject to that facility's EPA licence conditions.
- Undertaking detailed environmental monitoring (e.g. air, noise) for the duration of works
- Validation of the remediation per the *VMP/Block 4 RAP* (AECOM, 2013).
- Backfilling excavations with suitable imported fill or suitable excavated soil.
- Decommissioning of excavation enclosures.
- Re-surfacing of road / pavement.
- Planting of new street trees to replace those removed.
- Removal of temporary traffic diversions.

Regular cleaning/sweeping of the roads will be required as part of the remediation excavation activities to ensure silt build up does not occur. Lend Lease proposes to cover haulage trucks prior to exiting the temporary excavation enclosures and trucks would be decontaminated (where required) prior to moving.

3.3 Environmental Controls

Due to the scale of the works and close proximity to sensitive receptors, the effectiveness of environmental controls and environmental management is critical to the overall success of the project. The EPA recommended that environmental management at Barangaroo should focus on source controls rather than end of pipe controls. Primary management was, therefore, the focus of proposed mitigation strategies; a number of secondary (end of pipe) controls are also recommended where necessary.

3.3.1 Sediment Controls

Sediment can lead to dust generation; as such, management measures for sediment are management measures for air emissions. In accordance with the EPA recommendations, the most effective sediment management measures will be based on source controls. As a contingency for failure of source controls, a number of secondary controls should be constructed. A list of primary (source) controls and secondary controls in the *City of Sydney Guidelines to Erosion and Sediment Control on Building Sites* are provided in **Table 1.**

Table 1 Sediment Control Options

Category	Control Device	Location
Source controls	Temporary excavation enclosures	Remediation excavations
	Gutter	Excavation enclosures/temporary buildings
	Sediment sumps	Inside excavation enclosures
	Runoff diversion	Perimeter of excavation enclosures and stockpile areas

Category	Control Device	Location
	Tarping/mulching/gravel armouring	External stockpiles and exposed soils, haulage trucks
Secondary controls	Wheel wash	Site exit
	Shaker grids	Exits to temporary excavation enclosures
	Sediment fence	Stormwater inlets, stockpile perimeters
	Sediment sock	Stormwater inlets, stockpile perimeters
	Straw bales	Stormwater inlets, stockpile perimeters

3.3.2 Temporary Excavation Enclosures

To the extent practicable, Lend Lease has committed to undertaking the *ex-situ* remediation option works within temporary excavation enclosures fitted with emission control systems (filters). The purpose of the excavation enclosures is to minimise the release of malodorous and potentially harmful emissions during *ex-situ* remediation works. The excavation enclosures would act as the predominant primary control of all environmental emissions at the Site. Excavation enclosures would be established above *ex-situ* remediation works, essentially isolating these work areas from the external environment. The excavation enclosures would be constructed of impervious material, generally creating a seal between the internal and external atmosphere, and would include stormwater interception devices where practicable.

Structure dimensions will be developed based on three primary goals, which are to:

- Cover and isolate potentially odorous works areas;
- Ensure adequate size to facilitate production rates sufficient to maintain the remediation works program; and
- Encapsulate a volume of air able to be reasonably ventilated and filtered.

3.3.3 Filtration Systems

The temporary excavation enclosures would be serviced by a number of filtration systems and fresh air fans. The filtration systems would be designed to reduce emissions to concentrations compliant with the relevant environmental standards and/or approved site emission criteria for Barangaroo South and would:

- Maintain fresh air circulation and an appropriate safe working environment inside excavation enclosures; and
- Reduce the concentration of potentially harmful gas and dust concentrations and malodorous emissions exiting structures.

In accordance with previous assessments, the system is expected to be designed to achieve two to three complete air exchanges per hour within the structures, which will require the use of many filtration units. The systems would primarily consist of appropriately sized granular activated carbon (GAC) filters with particulate pre-filters. Multiple GAC filters (minimum of two) would be required to prevent fugitive emissions during filter exchanges. Filter saturation and changeover frequency would be based on stack emission monitoring. It is expected that filter changeover will be required approximately every two to three months.

The final design and detailing of filtration systems would be subject to further design development.

3.3.4 Sealed Trucks during Off-site Transport

All excavated odorous material taken off site would be treated to minimise potential emissions of dust or odour. For example, odour suppressant foam (such as Rusmar AC-645 or equivalent) or similar materials would be used to seal the loads. As confirmed in the *Hickson Road Remediation DA (SSD 6517-2014) – Preliminary Methodology for Off-site Transport and Treatment of Hazardous Waste* letter (AECOM, 2015), the proposed off site transport is consistent with the *VMP/Block 4 RAP* (AECOM, 2013) and compliant with both the NSW EPA (2014) *Waste Classification Guidelines* and the amended *Protection of the Environment Operations (Waste) Regulation* (2014).

All liquid waste trucks transporting material off-site from in-situ or ex-situ works will be sealed and not expected to be a source of odour.

3.3.5 Management Controls for Retention Wall Construction

The Preliminary Air Quality and Odour Control Plan described in **Table 2** provides an overview of the minimum odour controls to be implemented during retention wall construction as part of SSD 6617, when working in areas where gasworks tar or other odorous material is present. Prior to commencing works, detailed design of controls will be prepared based on selected contractor methodology, and provided to EPA for review and comment.

Table 2 Preliminary Air Quality and Odour Control Plan for the Hickson Road Perimeter Retention Wall

Proposed Works	Perimeter Retention Wall (PRW) construction for Hickson Road Remediation
Purpose of Works	Groundwater control and/or soil retention
Type of Works	PRW type to be determined following procurement. Anticipated to comprise: Secant or contiguous concrete piles
Potential Odour Source	Sub-surface tar that may be encountered and removed during retention wall construction
Preliminary Odour Control Methodology	
Primary Controls	Minimise the quantity of free tar exposed during works, to minimise odour generation / air emissions. The following air quality/odour control measures are proposed (to the extent practical), at locations where tar is anticipated:
Use construction method that limits odour generation	For piling method, limit the extent of open excavation at any one time to a discrete hole (generally up to 1200 mm diameter). Drill each hole using a rotary auger and then fill with concrete slurry. This method would limit the amount of tar exposed at any one time, thereby minimising odour generation / air quality emissions.
Secondary Controls	Implement measures that control the impact of odours that are generated from the works. The following air quality/odour control measures are proposed (to the extent practical), at locations where tar is anticipated:
Manage odour from spoil arisings / stockpiles	- Use a dedicated labour resource to manage odours in work area. - Install an A-Class hoarding including additional vertical barriers (where required), around the work area and adequately sealing to help minimise risk of odour off-site. - Use odour suppressants (e.g. BioSolve) or misting sprays in or around the work area. - Spray odorous spoil / drill arisings with foaming agents (e.g. Rusmar) once brought to the surface. - Cover stockpiles with tarps, non-odorous material or foaming agents, or place into sealed drums. - Where possible, solid covers will be used in preference to suppressant foams/sprays. - Dispose of stockpiles off-site as soon as practicable. - Use water spray on excavated or stockpiled material to mitigate particulate emissions. - Cover open excavations overnight. - Collect and treat run-off water, or promptly store in sealed containers.
Manage trucks to minimise fugitive odours	- Load material promptly and with care to reduce loading times and spillage. - Use sealed trucks to control potential for spilling material through the site or off-site. - Cover loads prior to leaving loading zones, with odour suppressant foam and automatic tarps. Where possible, solid covers will be used in preference to suppressant foams and sprays. - Immediately clean truck and loading areas upon loading. - Use truck and wheel wash facilities prior to leaving the site.
Implement monitoring and response	- Undertake detailed odour monitoring on and off-site to allow works/controls to be modified as required. - Undertake weather monitoring and modify works based on weather conditions, if required.

3.3.6 Management of Dust

Backfilling works have the potential to generate dust emissions. Such emissions would be adequately managed through standard construction measures, such as watering of material when visible dust is present, and suspending activities during high wind conditions.

3.3.7 Works Outside Excavation Enclosures

For potential activities that may occur outside the excavation enclosures, an analysis of the project has been undertaken to identify whether any tasks may be undertaken outside the enclosures.

Insitu Activities

Due to the limited potential for odour generation, all activities associated with the In-situ remediation option will be undertaken outside an odour enclosure. Where potential odour generation (although limited) is expected, odour control measures will be employed as follows:

1. Installation of groundwater control walls on 36 Hickson Rd boundary, where required. Emissions will be controlled per the Perimeter Retention Wall Preliminary Air Quality and Odour Control Plan (Table 2 and **Appendix H**).
2. Drilling to install wells and undertake sampling - emissions will be controlled as per actions outlined in the Hickson Rd ISCO Ground Breaking Works - Preliminary Air/Odour Control Plan (refer **Appendix G**).
3. Services investigation / pot-holing works – per (2) above.
4. Shallow excavation/trenching as required – per (2) above.

In relation to dot points 2 to 4 above, it is worth noting that spoil removal will be generally limited to discrete boreholes and shallow excavation.

Exsitu Activities

All excavation and loading of contaminated soil will be conducted inside an odour enclosure. The following potential activities may be conducted outside an enclosure:

- Site mobilisation and shallow services investigation/diversion.
- Installation of groundwater control walls on 36 Hickson Rd boundary (where required).
- Installation of retaining walls to separate the excavation stages (for example, east / west).

In these specific cases, alternative odour control measures will be employed, where required. Mitigation measures have been listed in the Perimeter Retention Wall Preliminary Air Quality and Odour Control Plan (Table 2 and Appendix H).

3.4 Decontamination Area

3.4.1 Personnel

Decontamination units would be established at the primary entrance/exit to each temporary excavation enclosure (for the alternative *ex-situ* method), or at another suitable location for the preferred in-situ method (if required), and should include:

- Potable water supply, running water and industrial hand wash;
- Waste bins;
- Supply of fresh personal protective equipment (PPE);
- Emergency shower (for inclusion based on risk assessment and Material Safety Data Sheets [MSDSs]); and
- Change area.

3.4.2 Plant

Decontamination would be required when earthmoving plant has been working with contaminated material and is due to be removed from site or transferred to a clean validated area. The plant decontamination area would consist of the following:

- A nominated hardstand area with adequate drainage (may be established inside excavation enclosures for *ex-situ* method);
- A drainage trap and pump system to allow all contaminated washout to be captured and pumped to water treatment system;
- Sediment controls around drains to intercept gross pollutants;

- Adequate water supply and high pressure cleaner;
- Waste bins; and
- Cleaning tools and detergent.

3.5 Site Access

Remediation works would be demarcated with temporary fencing and appropriate construction and traffic warning signage to restrict public access to the Site Remediation Area, as well as unauthorised access of general construction personnel to remediation areas and confined spaces. All confined spaces and other high risk areas of the Site Remediation Area would be identified and signposted/barricaded to restrict access and warn personnel of the risk. Confined spaces would be identified using the definition provided in AS2865-2009 and based on a risk assessment prior to the commencement of remediation works.

3.6 Potential Impacts

The proposed works may generate particulate emissions associated with excavation and materials handling. Heavy metals within the soil may be released to the air attached to the dust. The works will primarily use electrical and diesel-powered plant and equipment. The combustion of diesel fuel generates a range of pollutant emissions, primarily oxides of nitrogen (NO_X) and particulate matter (including PM_{10} and TSP), as well as volatile organic compounds (VOCs) (particularly benzene, toluene, ethylbenzene, and xylenes, which are known collectively as BTEX). Other emissions, such as carbon monoxide and sulfur dioxide, are also emitted from combustion engines, but were not assessed as they were considered to be lower risk than particulate and NO_X emissions due to their generally higher trigger values. When exposed to air, the contaminated material is also expected to generate gaseous emissions of the contaminants and associated odours (both *in-situ* and *ex-situ* works).

For the purposes of this AQIA, chemicals of potential concern were defined as chemicals that have been detected on the site in concentrations greater than relevant human health screening criteria. The pollutants assessed were:

- Nitrogen dioxide (NO_2);
- Particulate matter (TSP and PM_{10});
- BTEX;
- Phenol;
- Heavy metals (cadmium, chromium VI, copper, lead, mercury, nickel, zinc) attached to TSP;
- Benzo(a)pyrene;
- Naphthalene; and
- Odour.

The potential health effects of the pollutants of interest are summarised in **Appendix B**. It should be noted that $PM_{2.5}$ was not assessed. Following discussion with the EPA, it was decided that the relative contribution of the site would be low compared to existing $PM_{2.5}$ sources in the area, specifically local traffic, and that this pollutant did not, therefore, require assessment.

The off-site transport and treatment of the excavated material also have the potential to result in air emissions. Emissions associated with transport operations will be minimised through the management practices outlined in **Section 3.3.4**. The material would be treated at a licensed facility; as such, any emissions would be managed in accordance with the operating conditions of the facility specified by the Environment Protection Licence. These potential emission sources were not assessed through dispersion modelling.

Asbestos was not assessed in this AQIA. Management of asbestos encountered on the site would be in accordance with the site Asbestos Management Plan to be prepared for the works, which should include monitoring works. It should be noted that the Odour Control Structures proposed to be used for excavation of contaminated materials were designed to capture odorous emissions, not asbestos fibres.

3.7 Impact Assessment Criteria

The EPA has specified ground level concentration criteria that are intended to minimise the adverse effects of airborne pollutants on sensitive receptors (DEC, 2005). The ambient air quality criteria for the pollutants considered in this assessment are shown in **Table 3** (combustion products, dust and soil contaminants) and **Table 4** (odorous compounds).

Table 3 EPA Impact Assessment Criteria – Combustion Products, Dust and Soil Contaminants

Pollutant	Averaging Period	Criteria ($\mu g/m^3$)
Combustion Products and Dust		
Nitrogen dioxide (NO_2)	1 hour	246
	Annual	62
Total suspended particulates (TSP)	Annual	90
Fine particulate matter (PM_{10})	24 hours	50
	Annual	30
Soil Contaminants		
Arsenic	1 hour	0.09
Benzene	1 hour	29
Beryllium	1 hour	0.004
Cadmium	1 hour	0.018
Chromium VI	1 hour	0.09
Copper (dust and mist)	1 hour	18
Cyanide	1 hour	90
Ethylbenzene	1 hour	8,000
Lead	Annual	0.5
Manganese	1 hour	18
Mercury (organic)	1 hour	0.18
Naphthalene	1 hour	440*
Nickel	1 hour	0.18
Phenol	1 hour	20
Polycyclic aromatic compounds (PAHs) (as benzo[α]pyrene)	1 hour	0.4
Toluene	1 hour	360
Xylenes	1 hour	190
Zinc (as zinc chloride fumes)	1 hour	18

*As adopted for previous Barangaroo assessments undertaken by AECOM (e.g. AECOM, 2010a). Criterion is equivalent to the odour threshold for naphthalene.

The EPA's odour assessment criteria for complex mixtures of odorous air pollutants (DEC, 2005) are shown in **Table 4**. These criteria take into account individual sensitivity to odour in the community, and use a statistical approach for determining the appropriate criterion for a particular site based on the size of the surrounding population. As population size increases, the likelihood of sensitive individuals being within that population also increases; as such, areas with larger populations require more stringent criteria.

Table 4 EPA Impact Assessment Criteria – Complex Odours

Population	Criteria (OU)*
Urban (≥ ~2000) and/or schools and hospitals	2
~ 500	3
~ 125	4
~ 30	5
~ 10	6
Single residence (≤ ~2)	7
*99th percentile nose response time. OU refers to odour units.	

An odour assessment criterion of 2 OU was adopted for this assessment due to the urban nature of the area surrounding the project site. The following pollutants were combined and assessed as a complex mix of odour:

- BTEX (including 1,2,4-trimethylbenzene; 1,3,5-trimethylbenzene and isopropylbenzene);
- Cyanide;
- Naphthalene;
- Phenols (2-methylphenol; 4-chloro-3-methylphenol and phenol);
- Dibenzofuran; and
- Styrene.

3.8 Potential Emission Sources

Details of plant and equipment expected to be used during the remediation works considered in this assessment (including those associated with the remediation of Block 4 and Block 5 and the building of C1 and Stage 1C (Crown Tower) were provided by Lend Lease. They include excavators, front end loaders, bulldozers, bobcats, screens, crushers and generators. Pollutants of interest are discussed in **Section 4.0**.

3.8.1 Hickson Road Ex-situ Works

The potential Hickson Road ex-situ remediation works method, which involves the excavation and handling of odorous materials, would occur inside excavation enclosures, and the associated emissions would be emitted from stacks associated with the excavation enclosures following filtration. Trucks would be used to transport materials from the excavation enclosures to off-site treatment and/or disposal destinations; these emissions would occur outside the excavation enclosures and, as such, would be directly vented to atmosphere. Other equipment expected to be used during excavation works, such as the water pumps and fans, would be expected to be powered by mains electricity and, as such, would not generate combustion products during their operation.

3.8.2 Hickson Road In-Situ Works

Excavation enclosures are not expected to be required, and are not, therefore, proposed to be used for the in-situ method (e.g. soil boring, trenching, ISCO operation), unless significant excavation of odorous material is required (which is not currently proposed).

There is the potential for limited, short-term odours to occur during drilling/well installation, but these would be mitigated using methods similar to those described in Section 3.3.5 (e.g. use of odour suppressants or misting sprays in or around the work area; spraying odorous materials with foaming agents, covering stockpiles with tarps, non-odorous material or foaming agents, or placing materials into sealed drums). The primary emissions from the source would be from the ISCO stack.

3.8.3 Other Works

Further emission source details are provided in **Section 5.4**, including details of sources associated with works on site expected to be undertaken concurrently with the Hickson Road remediation works.

It should be noted that this assessment considered the worst-case emissions associated with the Hickson Road works, which were considered to be those occurring during the Hickson Road remediation activities. Emissions associated with the construction of retaining walls, such as dust and combustion emissions from piling rigs, were not considered in this assessment as they would be undertaken at different stages of the works, and are expected to have lesser emissions than those occurring during the remediation stages. Similarly, backfilling operations, which are expected to be of relatively short duration and manageable through standard management practices, were also not assessed.

3.9 Indicative Staging

The indicative staging of the Hickson Road remediation works, provided by Lend Lease in July 2015, is summarised in **Table 5**. Works are summarised for both the *in-situ* and *ex-situ* remediation methods.

The remediation activities are expected to result in greater air emissions than the preparatory and finishing works. A number of plant and trucks are expected to be required for all stages of the works. While greater numbers of trucks are expected during the establishment phases (up to 20 per day), this level of vehicle movement was considered to be a minor source of emissions compared to the emissions associated with remediation activities. Plant such as backhoes, concrete cutters and forklifts are also required during the establishment phases but, again, these plant were considered to be minor sources of air emissions in comparison to the remediation activities.

The *in-situ* method would be conducted over a period between November 2016 and August 2018.The greatest levels of air emissions associated with the *in-situ* method are expected to occur in Stage 3 (March 2017 to August 2017) and Stage 4 (September 2017 to February 2018), when the remediation works are scheduled to occur. As the eastern side of Hickson Road is located closest to sensitive receptors, the Stage 3 works were considered to represent the worst-case emissions associated with the in-situ remediation method for Hickson Road.

Slightly longer than the in-situ method the *ex-situ* method would be conducted over a period between November 2016 and October 2018. For the alternate method, the excavation works are expected to generate the greatest level of air emissions; as such, Stage 2 (March 2017 to September 2017) and Stage 5 (May 2018 to July 2018) are expected to be the periods of greatest activity. The Stage 2 works, when the eastern half of Hickson Road would be excavated, were considered to represent the likely worst case air emissions for the *ex-situ* method.

Table 5 Barangaroo Development Staging Summary – Hickson Road - *In-situ* and *Ex-situ* Remediation Methods

***In-situ* Method (Nov 16 to Aug 18)**			
Indicative Works Staging		**Indicative Duration**	**Works Summary**
Stage 1	Nov 16 - Dec 16	1 month	**Installation – west half**
			Temporary removal of street parking for works
			Install wells and infrastructure
			Temporary traffic diversions
Stage 2	Jan 17 - Feb 17	2 months	**Installation – east half**
			Install wells and infrastructure
			Install groundwater control walls
			Set-up compound in road reserve
			Temporary traffic diversions
Stage 3	Mar 17 - Aug 17	6 months	**Remediation – east half**
			Undertake ISCO remediation
Stage 4	Sep 17 - Feb 18	6 months	**Remediation – west half**
			Undertake ISCO remediation
Stage 5	Mar 18 - Aug 18	6 months	Validate remediation
			Decommission wells / restore road (staged)
			Reinstate street parking
***Ex-situ* Method (Nov 16 to Oct 18)**			

Indicative Works Staging		Indicative Duration	Works Summary
Stage 1	Nov 16 - Feb 17	3 months	**East half – Establishment/commissioning**
			Temporary removal of street parking for works
			Removal of street trees
			Divert traffic to west half
			Service diversion where required
			Install retention systems
			Install & commission odour structures
			Install dewatering infrastructure
Stage 2	Mar 17 - Sep 17	6 months	**East half - remediation**
			Excavate and dispose of fill off-site
			Dewatering
Stage 3	Oct 17 - Dec 17	2 months	**East half - remediation**
			Validate excavations
			Backfill excavations
			Road/footpath restoration
			Decommission odour structures
Stage 4	Jan 18 - Apr 18	3 months	**West half - Establishment/commissioning**
			Divert traffic to east half
			Removal of street trees
			Service diversion where required
			Adjust existing retention systems
			Install and commission odour structures
			Install dewatering infrastructure
Stage 5	May 18 - Jul 18	2 months	**West half – remediation**
			Excavate and dispose of fill off-site
			Dewatering
Stage 6	Aug 18 - Oct 18	2 months	**West half – remediation**
			Validate excavations
			Backfill excavations
			Road/footpath restoration
			Decommission odour structures
			Reinstate street parking and trees

Other construction works would be occurring as part of the Barangaroo development at the same time as the proposed Hickson Road remediation works. A summary of the indicative staging of other works associated with the development is provided in **Table 6**, together with details of whether the works are expected to overlap with the Hickson Road remediation activities.

Table 6 Barangaroo Development Staging Summary – Other Works[1]

Project	Indicative Duration	Overlap with Hickson Road Works	
		In-situ	*Ex-situ*
Works adjacent to Hickson Road			
Block 4 Remediation Works	Aug 2015 – Nov 2017	Stages 1-4	Stage 1-3
Block 5 Remediation Works	Nov 2015 - Oct 2017	Stages 1-4	Stage 1-3
T1 Commercial Building	Mar 2014 – Sep 2016	No	No
T3 Commercial Building	Oct 2013 – Apr 2016	No	No
R1 Construction	Sept 2015 – June 2016	No	No
R4A Tower Construction (Stage 1B)	Dec 2019 – Apr 2022	No	No
R4B Tower Construction (Stage 1B)	Jan 2021 – Jan 2023	No	No
R5 Tower Construction (Stage 1B)	Aug 2021 – Jul 2023	No	No
R7 Construction	Jul 2015 – April 2016	No	No
R8/R9 Residential Buildings Construction	Jan 2014 – Nov 2015	No	No
Stage 1A Public Domain works	Jul 2014 – Mar 2016	No	No
C1 Above GF Only (GF + 6 floors)	Nov 2016 – Feb 2018	Stages 1-4	Stages 1-4
Stage 1B Basement*	Jun 2017 – Mar 2021	Stages 3-5	Stages 2-6
Stage 1C Remediation and Earthworks	Dec 2015 – Mar 2018	Stages 1-5	Stage 1-4
Stage 1C Hotel Construction	Jun 2016 – Nov 2019	Stages 1-5	Stage 1-6
Works external to Barangaroo South			
Wynyard Walk Bridge	Apr 2013 – Sep 2015	No	No
Barangaroo Ferry Warf	Apr 2015 – Aug 2016	No	No
Barangaroo Central – Waterfront Promenade	Mar 2014 - Jul 2015	No	No
* At the time of writing, the AQIA (with associated impacts and controls) for the Stage 1B Basement was yet to be finalised. Accordingly, Stage 1B Basement works are not modelled as a concurrent activity in the cumulative impact assessment in this AQIA. Cumulative impacts from the Stage 1B Basement works will be including in the Stage 1B Basement AQIA.			

Based on the staging information presented above, the worst-case concurrent activities associated with each of the potential remediation options for Hickson Road considered in this assessment are as follows:

- Remediation of eastern side of Hickson Road (*in-situ* or *ex-situ*);
- Block 4 remediation;
- Block 5 remediation;
- Construction of the C1 building; and
- Stage 1C remediation and earthworks;

An on-site water treatment plant is also expected to be operational during the remediation activities.

[1] Information provided in **Table 6** is based on the estimated staging plan at the time of the original AQIA issued in August 2015. The revised estimated commencement of some projects has since extended by approx. 5-6 months. These changes to the staging plan do not affect the cumulative impact assessment in this AQIA, as the resultant overlap with Hickson Road remains consistent, and the worst scenarios modelled (below) occur concurrently.

4.0 Existing Environment

4.1 Regional Air Quality

The EPA operates a network of air quality monitoring stations around the state. The closest station to the site is located at Rozelle (approximately 3.5 km to the west). Ambient pollutant concentrations recorded at this station in 2013 were adopted for this assessment for consistency with the meteorological data.

Three exceedances of the EPA's 24 hour PM_{10} assessment criterion were recorded at Rozelle in 2013, relating to concentrations of 58.5 $\mu g/m^3$ (the maximum recorded 24 hour PM_{10} concentration as shown in **Table 7**), 57.0 $\mu g/m^3$, and 50.7 $\mu g/m^3$. As such, the cumulative concentrations predicted for this assessment will contain three exceedances due to elevated background concentrations.

Ambient TSP concentrations have not been monitored at Rozelle since 2004. The ratio of PM_{10} to TSP from Rozelle for 2004 (the last recorded year of TSP monitoring at Rozelle) was used with the ambient annual PM_{10} concentration from Rozelle in 2008 to estimate the annual TSP concentration. The ratio of PM_{10} to TSP for 2004 was calculated to be 49 % at Rozelle (i.e. 49 % of TSP in the region monitored by Rozelle was PM_{10}), which, when applied to the 2013 ambient annual PM_{10} concentration of 18.3 $\mu g/m^3$, equates to an annual TSP concentration of 37.4 $\mu g/m^3$.

The background concentrations used in the AQIA are summarised in **Table 7**. It should be noted that contemporaneous assessments of 24 hour PM_{10} and 1 hour NO_2 were conducted as part of the modelling assessment, which added actual measured pollutant concentrations for each averaging period to the corresponding concentrations predicted by the dispersion modelling; as such, the background concentrations associated with these pollutants and averaging periods provided in **Table 7** were not applied to every hour of the modelling period.

Table 7 Ambient Pollutant Concentrations, Rozelle Monitoring Station

Air Emission	Averaging Period	Background Concentration ($\mu g/m^3$)	Assessment Criteria ($\mu g/m^3$)
NO_2 [1]	1 hour maximum	131.6	246
	Annual	20.2	62
PM_{10}	24 hour maximum	58.5	50
	Annual	18.3	30
TSP [2]	Annual	37.4	90
Ozone [3]	1 hour maximum	143.1	214
	4 hour maximum	114.7	171
	Annual	31.7	-

[1] NO_2 contemporaneous background data used to predict background concentrations using the OLM detailed in **Section 5.8.2**
[2] Calculated from annual PM_{10} concentration as described in text.
[3] Ozone concentrations used for NO_2 contemporaneous assessment calculations. Ozone was not modelled as a pollutant.

4.2 Climate

The Bureau of Meteorology (BOM) collects meteorological data from various sites in the Sydney Basin. The station at Observatory Hill is less than 200 m from the eastern boundary of the Barangaroo Site, while Fort Denison is approximately 2 km to the east of the site. The meteorological data collected from these two stations is complementary and, together, provides an indication of the climate in the immediate area around Barangaroo. Long term data averages recorded between 1859 and June 2014 are summarised in **Appendix C**.

Average maximum temperatures in summer range from 25.2 °C to 25.9 °C, while minimum temperatures range from 17.5 °C to 18.8 °C. In winter, the average maximum temperature ranges from 16.3 °C to 17.8 °C and the average minimum temperature ranges from 8.0 °C to 9.3 °C.

The annual average humidity reading collected at 9 am from the site is 69 %, and at 3 pm the annual average is 57 %. Rainfall data collected at Observatory Hill shows, on average, that the wettest months are January to June, with average rainfall of greater than 100 mm for each of the intervening months.

4.3 Terrain

The Barangaroo Site is located on Sydney Harbour. The ground surface of the entire Barangaroo Site is at an elevation of approximately 2 - 5 m (AHD). The surrounding landform (outside the bounds of the site) rises rapidly to the east, with a 10 m high sandstone cliff situated east of Hickson Road and Sussex Street. This is the most substantial natural terrain feature in the area; high rise buildings may potentially also affect wind patterns in the project site.

5.0 Dispersion Modelling Methodology

5.1 Overview

Dispersion modelling was undertaken to predict the potential effects of the remediation and excavation works associated with the Hickson Road Declaration Area. The following sections outline details of the dispersion model used and its inputs (specifically meteorology, terrain, building parameters, modelling scenarios, source characteristics and emissions inventory), sensitive receptor locations, and the methodology used in the estimation of pollutant concentrations.

The modelling was conducted in accordance with and/or in consideration of the following statutory documents:

- Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (DEC, 2005);
- Assessment and Management of Odour from Stationary Sources in NSW: Technical Framework 2006;
- Assessment and Management of Odour from Stationary Sources in NSW: Technical Notes 2006; and
- Protection of the Environment Operations (Clean Air) Regulation 2010.

5.2 Dispersion Model

The CALPUFF dispersion model was used in the AQIA in accordance with the EPA Approved Methods (DEC, 2005). CALPUFF is a non steady-state, three-dimensional Gaussian puff model developed for the US Environmental Protection Agency (USEPA) for use in situations where basic Gaussian plume models are not effective, such as areas with complex meteorological or topographical conditions, including coastal areas with re-circulating sea breezes. Input parameters used in the CALPUFF dispersion modelling are summarised in **Table 8**.

Table 8 CALPUFF Input Parameters

Parameter	Input
CALPUFF version	6.42
Modelling domain	40 km x 40 km with 0.3 km spacing
Terrain data	Included in CALMET
Building wake data	Building dimensions entered via BPIP
Dispersion algorithm	Dispersion coeff. Used turbulence computer from micrometeorology. Used PDF Method for sigma-z in the convective BL.
Hours modelled	8760 hours (365 days)
Meteorological data period	1 January 2013 – 31 December 2013

Inputs to CALPUFF are discussed in the following sections.

5.2.1 Meteorology

The CALMET meteorological model uses meteorological observations to generate three dimensional wind fields on an hourly time step at a grid of points covering the area under investigation. Topographical features and land use factors are then used to further refine the wind fields, which are subsequently used in the CALPUFF dispersion model.

Local meteorological and topographical data were used to develop the CALMET wind fields to ensure the data used in the dispersion modelling were representative of local conditions. Prognostic meteorological data generated by the WRF model and the following local meteorological data recorded by the BOM were used as inputs to CALMET:

- Observatory Hill - rainfall and temperature;
- Fort Denison - wind speed and direction; and
- Sydney Airport - wind speed, wind direction, temperature, relative humidity and solar radiation.

The WRF data, which were prepared by Lakes Environmental, were used to define the upper air meteorology for the area surrounding Barangaroo, and were entered into CALMET for the site meteorological conditions, together with the surface meteorological data recorded at Sydney Airport, Observatory Hill and Fort Denison. Analyses of the data are provided in **Appendix C**.

5.2.2 Terrain

The NASA Shuttle Radar Topographic Mission (SRTM) provides digital elevation data (DEM) for over 80 % of the globe. The SRTM data are available as 3 arc second DEMs, which provide a resolution of approximately 90 m. The vertical error of the DEMs is reported to be less than 16 m.

Digital terrain data required by CALMET were obtained from the global SRTM database through the CALPUFF View user interface for the modelling domain.

5.3 Modelling Scenarios

Two scenarios were assessed as part of the Hickson Road AQIA. The two scenarios considered the expected highest activity levels associated with each of the potential remediation methods and the other concurrent site activities that may occur. The concurrent activities expected to occur during the Hickson Road remediation works are summarised below for each scenario assessed.

Table 9 Modelled Scenarios

Scenario	Description
Scenario 1: *In-situ* Remediation of Hickson Road	
Scenario 1a	- *In-situ* remediation of Hickson Road modelled at expected emissions
Scenario 1b	- *In-situ* remediation of Hickson Road modelled at POEO Limits
Scenario 1c	- *In-situ* remediation of Hickson Road; and - Other construction activities occurring at Barangaroo including: • Block 4 remediation; • Block 5 remediation; • C1 building construction; and • Operation of the on-site water treatment plant. • Stage 1C Remediation and Bulk Earthworks
***Scenario 2: Ex-situ* Remediation of Hickson Road**	
Scenario 2a	- *Ex-situ* remediation of Hickson Road
Scenario 2b	- *Ex-situ* remediation of Hickson Road; - Other construction activities occurring at Barangaroo including: • Block 4 remediation; • Block 5 remediation; • C1 building construction; and • Operation of the on-site water treatment plant. • Stage 1C Remediation and Bulk Earthworks

Limited excavation works will be required for the *in-situ* method, including trenching and soil boring/well installation. Further excavation/disposal of gasworks material may also be undertaken if required to complete remediation. Suitable odour controls such as limiting exposed excavations, use of foams, covers and odour suppressants would be applied for minor excavation works. For significant excavation of odorous material, an excavation enclosure would be used and subject to the same controls as would be applied for the *ex-situ* methodology. As the amount of potential excavation works is small in relation to those assessed in Scenario 2 (*ex-situ* remediation), and as the emissions from the ISCO process are also relatively small, the Scenario 2 results are considered to represent the worst-case expected emissions associated with excavation activities.

As outlined above in Table 9, in addition to the construction activities directly associated with the Hickson Road remediation and other remediation and earthworks activities being undertaken by Lendlease (Block 4 remediation and Block 5 remediation), the Stage 1C Remediation and Bulk Earthworks is expected to occur concurrently for both modelled scenarios. These impacts have been assessed in the *South Barangaroo Stage 1C Remediation and Earthworks Air Quality Impact Assessment* (Wilkinson Murray 2015). Predicted impacts have been modelled based on the Wilkinson Murray 2015 report and added to the predicted impacts from Scenario 1b and Scenario 2b to determine cumulative impacts from all concurrent activities and are described in **Section 6.1**.

Other works associated with the Hickson Road works as described in **Section 3.9** were not expected to occur concurrently with the remediation works, and were not, therefore, included in the modelling scenario.

5.3.1 Assumptions

All emission sources associated with the Hickson Road (and concurrent Block 4 and Block 5) remediation works assessed by dispersion modelling were assumed to be contained within the excavation enclosures (excavation) with the exception of trucks hauling materials off-site for disposal (modelled as volume sources) and the emissions from the ISCO treatment for Scenario 1. Emissions from plant, equipment and activities within the tents were estimated using emission factors, summed, and assumed to be filtered before being released to the atmosphere. Each excavation enclosure was assumed to release emissions at a constant rate from a single stack. Emissions associated with the water treatment plant were assumed to be the same as those used in AECOM (2011) for a water flow rate of 25 L/s.

The methodology used to develop emissions for the Bulk Excavation and Car Parking works (AECOM, 2010a) was used for this assessment for consistency. Emissions from activities such as materials handling were estimated using emission factors and equations in the following National Pollutant Inventory Emission Estimation Technique manuals:

- Australian Government. (2012). *National Pollutant Inventory Emission Estimation Technique Manual for Mining, Version 3.1. Commonwealth of Australia: Canberra*.
- Australian Government. (2008). *National Pollutant Inventory Emission Estimation Technique Manual for Combustion Engines, Version 3.0. Commonwealth of Australia: Canberra*.

Emission factors for wheel-generated dust were obtained from US EPA (2011). Additional emission factors for specific construction plant and equipment were sourced from a report on a large construction project (Pacific Institute, 2001), which was accepted by the US EPA and references the South Coast Air Quality Management District (California Environmental Quality Act) Air Quality Handbook. Stack parameters for trucks, which were used in previous assessments (SKM, 2005), were also used for the point sources. A detailed emissions inventory showing calculations can be provided on request.

It should be noted that on-site treatment of excavated material is not currently proposed to be undertaken and, as such, was not included in this assessment. If on-site treatment is required, such as through the use of a pugmill within an OCS, further assessment would be necessary to determine whether the emissions assessed by this study are representative of the emissions associated with the on-site treatment. If not, further dispersion modelling may be required

5.4 Source Characteristics

The source characteristics used in the dispersion modelling are described in the following sections. For the potential ex-situ method, the stacks are proposed to be located on the western side of the excavation enclosures, i.e. the side furthest from the sensitive receptors on Hickson Road. It should be noted that the generators used to power the filtration units were assumed to be vented through the excavation enclosure stacks (located on the western side of the structures); as such, the emissions from these plant were assumed to be filtered before release to atmosphere. Each excavation enclosure was assumed to be powered by two generators. All information was based on data provided by Lend Lease.

5.4.1 Hickson Road

Emissions associated with the *in-situ* remediation associated with the ISCO process were modelled as a point source. The process streams feeding the process vents is shown in **Figures 2** and **3**.

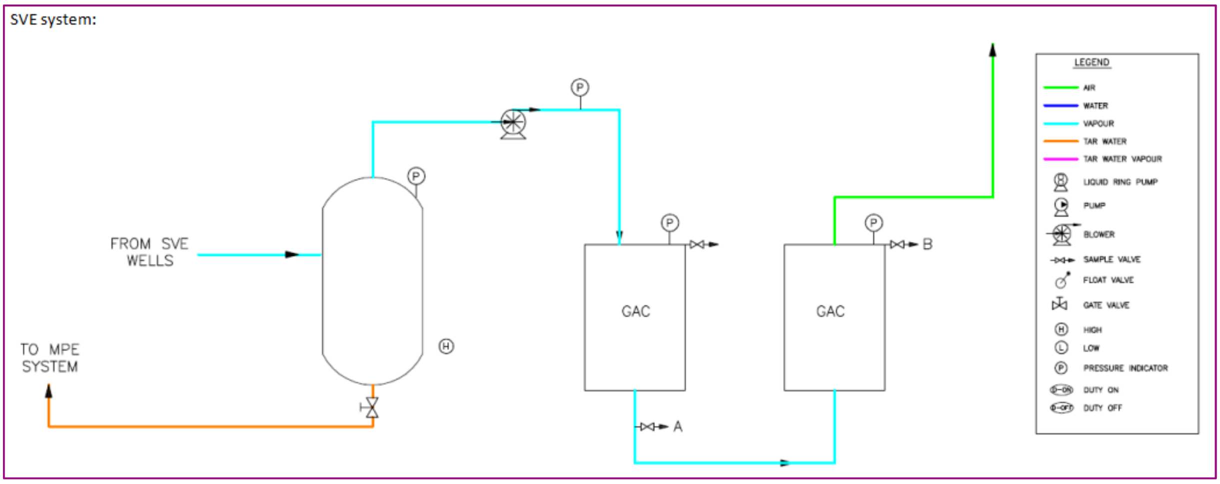

Figure 2 **SVE System Schematic**

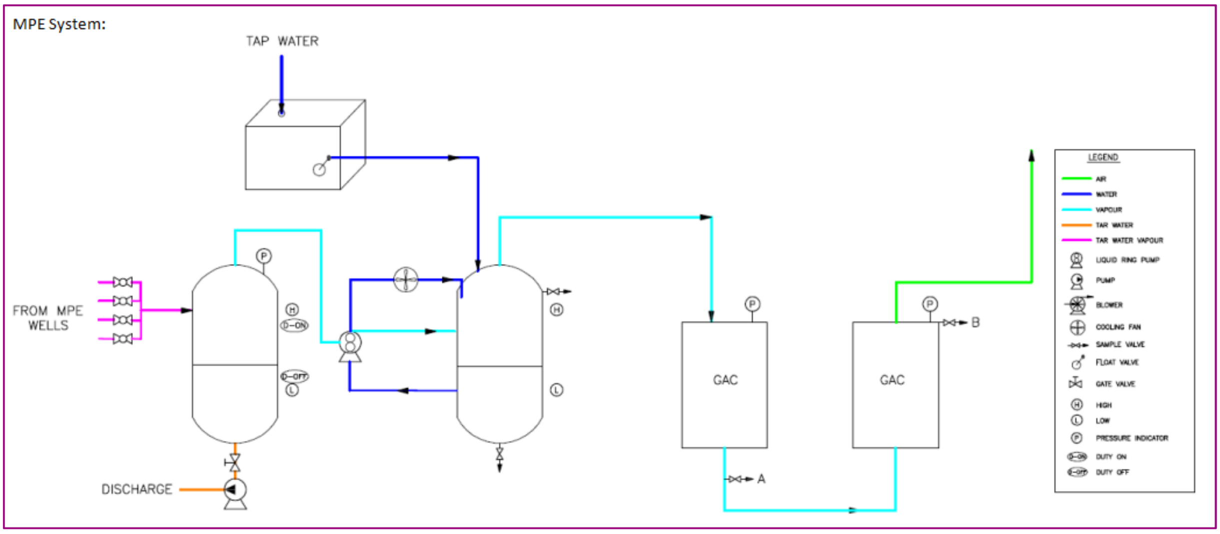

Figure 3 **MPE System Schematic**

For the modelling of ISCO stacks the emission inventory was updated as detailed in **Table 10**. Note that the SVE and MPE exhausts are assumed to be situated together in a single stack bundle on the western edge of the ISCO area (refer **Figure 1**) and have been modelled as such. All emissions for Scenario 1 are assumed to pass through a Granulated Activated Charcoal (GAC) filtration system with an assumed efficiency of 99% reduction for VOC's.

The specific compound emission rates for the POEO Limits modelling (for Scenario 1b) have been created assuming the 20mg/m^3 (20,000ug/m^3) POEO limit VOC as n-propane equivalent at the exhaust (post GAC), and adjusted according to the molecular weight of the target compound. Each emission rate assumed 100% of pollutant is reported as one pollutant only i.e. 20mg/m^3 as n-propane converted to 35.4mg/m^3 of Benzene.

Characteristics of the point source (soil vapour recovery stack) are provided below.

Table 10 Hickson Road Excavation Soil Vapour Recovery Stack Characteristics – Scenario 1 (typical and POEO Limits)

Details	Value	Units
Stack height	4	m
Velocity	17.7	m/s
Diameter	0.10	m
Volumetric flow rate	0.14	m^3/s
Temperature	296	K

The Hickson Road excavations for the scenario 2 were assumed to be undertaken for 10 hours per day at a rate of 350 tonnes per day for emission calculation purposes, but were modelled as constant emission sources. Details of the equipment and stack characteristics are provided in **Table 11** and **Table 12** respectively. The excavation enclosure stack was assumed to be located on the western side of the excavation enclosure structure.

Table 11 Hickson Road Excavation Equipment – Scenario 2

Plant/equipment	Number	Notes
Excavator	1	
Skid screen bobcat	1	loader
Trucks	33	trips per day (off site)

Table 12 Hickson Road Excavation Enclosure Stack Characteristics – Scenario 2

Details	Value	Units
Tent height	11	m
Stack height	4	m
Velocity	25	m/s
Exit area	0.3	m^2
Diameter	0.64	m
Volumetric flow rate	7.94	m^3/s
Temperature	25	^oC

5.4.2 Block 4

The Block 4 excavations were assumed to be undertaken for 10 hours per day at a rate of 1600 tonnes per day. Details of the equipment and stack characteristics are provided in **Table 11** and **Table 12** respectively. The OCS stack was assumed to be located on the western side of the OCS structure.

Table 13 Block 4 Excavation Equipment

Plant/equipment	Number	Notes
Excavator	3	2 x 30 t; 1 x 20 t
Bulldozer	1	
Front end loader	1	
Skid screen bobcat	1	loader
Powerscreen	1	screen
Crusher	1	crusher
Trucks	125	trips per day (to treatment tent)

Table 14 Block 4 Excavation OCS Stack Characteristics

Details	Value	Units
Tent height	14	m
Stack height	4	m
Velocity	25	m/s
Diameter	0.76	m
Volumetric flow rate	11.2	m^3/s
Temperature	298	K

5.4.3 Block 5

The Block 5 excavations were assumed to be undertaken for 10 hours per d ay at a rate of 1000tonnes per day. Details of the equipment and stack characteristics are provided in **Table 15** and **Table 16** respectively. The OCS stack was assumed to be located on the western side of the OCS structure.

Table 15 Block 5 Excavation Equipment

Plant/equipment	Number	Notes
Excavator	3	2 x 30 t; 1 x 20 t
Bulldozer	1	
Front end loader	1	
Skid screen bobcat	1	loader
Powerscreen	1	screen
Trucks	50	trips per day (off site)

Table 16 Block 5 Excavation OCS Stack Characteristics

Details	Value	Units
Tent height	14	m
Stack height	4	m
Velocity	25	m/s
Diameter	0.76	m
Volumetric flow rate	11.2	m^3/s
Temperature	25	^oC

5.4.4 Water Treatment Plant

The Water Treatment Plant (WTP) may have two point sources: the inlet tank displacement valve (ITDV) and the air strippers discharge stack (ASDS). Details of these sources are provided in **Table 17**.

Table 17 Water Treatment Plant Stack Characteristics

Source	Eastings (km)	Northings (km)	Base Elevation (m)	Stack Height (m)	Stack Temp (°C)	Diameter (m)	Stack Velocity (m/s)	Source VFR (m^3/s)
ITDV	333.573	6251.675	6	2.77	15.6	0.10	3.2	0.03
ASDS	333.632	6251.779	6	2.77	15.6	0.42	8.2	1.13

5.4.5 Commercial Building C1

Source characteristics of the emission sources for Building C1 are outlined in **Table 18**. Forklifts and concrete pumps were modelled as ground level point sources. There were assumed to be one forklift and one concrete pump associated with the C1 building works.

Table 18 Emission Source Characteristics – Building C1

Source	Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)
Forklift	3	5	0.3	14.6	624.2
Concrete pump	3	5	0.1	14.6	624.2

5.4.6 Trucks

For this assessment, trucks associated with Block 4 and Block 5 excavations were assumed to move all excavated material from the excavation areas off site. Emissions associated with each area were summed and modelled as volume sources. The haulage routes were assumed to be paved, which is likely as the hardstand will be maintained as much as possible to control odour emissions from the site, and excavated areas will be contained within tents. As such, wheel-generated dust is likely to be negligible. In order to provide a measure of conservativeness, emission rates associated with wheel-generated dust were calculated using the AP-42 emission factors for paved roads for concrete batching plant published by the US EPA (2011).

It should be noted that the assessment only addressed truck emissions within the site boundary. As stated in **Section 3.3.4**, emissions associated with transport would be mitigated through sealing the trucks.

Table 19 Trucks - Source Information

Activity	On-site Haul Distance (m)	Number of Trucks/Day	Number of Volume Sources Modelled
Block 4 Trucks	270	67	4
Block 5 Trucks	100	41	4

5.4.7 Stage 1C Remediation and Earthworks

As described in **Section 5.3,** dispersion modelling for the remediation, earthworks and construction activities for Stage 1C were undertaken by Murray Wilkinson in June 2015. For information on source characteristics refer to the Wilkinson Murray 2015 report.

Predicted impacts from Stage 1C have been modelled based on the Wilkinson Murray 2015 report and added to the predicted impacts from Scenario 1b and Scenario 2b to determine cumulative impacts from all concurrent activities and are described in **Section 6.1**.

5.5 Emissions Inventory

Emissions from plant and equipment to be used on site were estimated using factors published by the Australian Government for use in the National Pollutant Inventory, measured vehicle emissions from the M5 Freeway Project (SKM, 2002) and emission factors published for a large construction project (Pacific Institute, 2001).

Expected operational times for construction are 7 am – 6 pm Monday to Friday and 7 am – 5 pm Saturdays. No works are expected on Sundays. For modelling purposes, emission rates were entered into the model for all activities for hours 7am to 6pm. Applying these emission times may over-predict the ground level concentrations over the long term as their will be no emissions on Sundays but is a conservative modelling approach.

The excavation enclosures were each assumed to be serviced by two filtration units (activated charcoal). The reduction efficiencies applied for particulates, VOCs and odour were developed following liaison with a contractor. The NO_X reduction efficiencies were based on published literature (Nelson and Babyak, 1996). The total reduction efficiencies assumed for each excavation enclosure, which are consistent with those used in previous assessments, are provided in

Table 20.

Table 20 Excavation Enclosure Filtration Unit Efficiency

Pollutant	Reduction %	Notes
NO_X	75	Assumed two filters at 50 % reduction per unit
PM_{10}	98	Assumed total efficiency
TSP	98	Assumed total efficiency
VOCs	99.8	Assumed two filters at 99 % reduction per unit
Odour*	99.8	Assumed two filters at 99 % reduction per unit

VOC Emissions

A number of contaminants present at the site are VOCs. The EPA does not have a criterion for total VOCs or for many of the contaminant pollutants. VOCs/potential volatile compounds identified on site (BTEX, naphthalene, phenol, SVOCs and VOCs) were summed to provide total VOC emission rates, which were used in the modelling. The emission rates were calculated for the Hickson Road, Block 4 and Block 5 areas on the basis of the average concentrations of VOCs detected within the Declaration Area, the volume of excavated material and the duration of the excavations.

VOC emissions associated with the soil contamination were estimated using the percentage of the pollutants in the soil samples as shown in **Table 21** (AECOM, 2010b). It should be noted that the percentages shown in **Table 21** do not add up to100 %, as only those species with EPA criteria are shown; these were the only VOC species assessed. Emissions of these pollutants associated with soil remediation activities were entered directly into the dispersion model.

Table 21 VOC Components

Pollutant	Percentage of Total VOC Emissions (%)
Benzene	0.9
Ethylbenzene	0.7
Toluene	1.3
Xylenes	2.9
Naphthalene	60.7
Phenol	3.4

Odour Emissions

Potentially odorous contaminants were selected based on the results of soil sampling undertaken by AECOM for the site (AECOM 2010b). Of the detected contaminant species, only those with an assessment criterion in the EPA Approved Methods (DEC, 2005) were included in the calculations.

Odour modelling was undertaken using the same methodology as that used for the assessment of the Bulk Excavation and Carparking works phase of the project (AECOM, 2010a). In brief, odour flux data specified by a previous odour assessment for a large-scale contaminated lands project at Homebush for Lednez (Duthie, 2002) were used with contaminant concentration data from the Declaration Area to develop site-specific emission rates. The odorous contaminants identified on site through soil sampling and vapour testing were:

- Benzene;
- Toluene;
- Ethylbenzene;
- Total xylenes;
- Cyanide;
- Naphthalene; and

- Trichlorofluoromethane.

Odour emissions were then calculated as shown in **Appendix D** using the relative concentrations of the pollutants listed above. Cyanide and trichlorofluoromethane were only modelled as odour.

Odour concentrations affect people over very short time scales, typically less than one second in duration. CALPUFF does not have the capacity to model pollutant concentrations at these times scales with the data available for this assessment; as such, the total hourly concentration was converted to a one second concentration through the application of a peak to mean ratio. The odour emission rates used in the dispersion modelling included a peak to mean ratio of 2.3 (applicable for wake-affected stacks), applied in accordance with the EPA's Approved Methods (DEC, 2005). Only near-field effects were considered. The site odour flux used in the calculations was 16.4 $OU/m^2.s$; this was used with the Block 4 and Block 5 OCS areas to calculate the odour emission rates. Following discussion with Lend Lease, half of the OCS areas were assumed to actively emit odour at any time (3,244 m^2 for Block 4 and 1,550 m^2 for Block 5).

5.5.1 Hickson Road

Details of the emission rates for the Hickson Road sources are provided in **Table 22** (soil vapour recovery stack, Scenario 1) and **Table 24** (excavation enclosure, Scenario 2). The stack in Scenario 1 was assumed to be serviced by a filter with a VOC removal efficiency of 99 % based on previous advice provided by Lend Lease. Emission rates from the Soil Vapour Recovery stack have also been modelled at their POEO limits to allow a demonstration that even at the expected stack limits, exceedances of the assessment criteria are not expected. Emission rates at the calculated POEO limit are outlined in **Table 23**.

Table 22 Hickson Road Soil Vapour Recovery Stack Emission Rates – Scenario 1 (*In-situ* Remediation), Typical Operation

Pollutant	Total Emission Rates (g/s)	
	Before filtration	After filtration*
Benzene	8.88E-07	8.88E-09
Ethylbenzene	1.21E-07	1.21E-09
Toluene	7.85E-06	7.85E-08
Total xylenes	3.63E-06	3.63E-08
Naphthalene	5.32E-05	5.32E-07
* Assuming 99 % reduction in VOCs		

Table 23 Scenario 1 (POEO Limits) - ISCO Stack Emission Concentrations and Emission (MPE and SVE stacks)

Pollutant	Assumed Process Gas Concentration (post GAC filter) ($\mu g/m^3$)	ISCO Stack Emission rate (g/s)
n-Propane[1]	20,000	NA
Benzene	35424	0.004920
Ethyl Benzene	48259	0.006703
Toluene	41882	0.005817
Xylene	48255	0.006702
Naphthalene	58259	0.008092
[1] POEO Limit is 20 mg/m^3 (20,000$\mu g/m^3$) of VOC as n-Propane. All individual VOC species were calculated based on a conversion between n-propane and the individual VOC species		

Table 24 Hickson Road Excavation Enclosure Stack Emission Rates – Scenario 2 (*Ex-situ* Remediation)

Pollutant	Total Emission Rates	
	Before filtration	After filtration
NOx (g/s)	1.16	0.29
PM_{10} (g/s)	0.16	0.03

Pollutant	Total Emission Rates	
	Before filtration	After filtration
TSP (g/s)	0.51	0.01
Odour (OU/s)	17,220	34.4
VOCs combustion emissions (g/s)	3.26	0.0007
Benzene (g/s)	0.05	0.00010
Ethylbenzene (g/s)	0.04	0.00008
Toluene (g/s)	0.07	0.00014
Total xylenes (g/s)	0.16	0.0003
Naphthalene (g/s)	3.28	0.007
Phenol (g/s)	0.18	0.0004
* Peak to mean ratio of 2.3 applied to odour emissions		

5.5.2 Block 4

Details of the emission rates for the Block 4 excavation OCS are provided in **Table 25**.

Table 25 Block 4 Excavation OCS Stack Emission Rates

Pollutant	Total Emission Rates	
	Before filtration	After filtration
NO_X (g/s)	2.75	0.69
PM_{10} (g/s)	0.9	0.029
TSP (g/s)	2.96	0.096
Combustion VOC (g/s)	0.2	0.011
Odour (OU/s)*	53,202	106.4
Benzene	0.05	0.00010
Ethylbenzene	0.04	0.00008
Toluene	0.07	0.00014
Total xylenes	0.16	0.0003
Naphthalene	3.28	0.007
Phenol	0.18	0.0004
* Peak to mean ratio of 2.3 applied to odour emissions		

As described in **Section 5.4.6**, truck emissions were apportioned to four volume sources. The emission rates per volume source associated with Block 4 are provided in **Table 26**. The particulate emissions represent combustion emissions only.

Table 26 Block 4 Truck Emissions

Pollutant	ER (g/s/source)
NO_X	0.00014
PM_{10}	0.000009
TSP	0.000009
VOCs	0.000013

5.5.3 Block 5

Details of the emission rates for the Block 5 excavation OCS are provided in **Table 27**.

Table 27 Treatment Tent Stack Emission Rates

Pollutant	Total Emission Rates	
	Before filtration	After filtration
NOx (g/s)	2.74	0.69
PM_{10} (g/s)	0.49	0.010
TSP (g/s)	1.54	0.031
Odour (OU/s)	25,420	51
VOCs combustion emissions (g/s)	0.27	0.00054
Benzene	0.0490	0.00010
Ethylbenzene	0.038	0.00008
Toluene	0.0700	0.00014
Total xylenes	0.16	0.00031
Naphthalene	3.28	0.0066
Phenol	0.18	0.00037
* Peak to mean ratio of 2.3 applied to odour emissions		

As described in **Section 5.4.6**, truck emissions were apportioned to four volume sources. The emission rates per volume source associated with the Block 5 are provided in **Table 28**.

Table 28 Block 5 Truck Emissions

Pollutant	ER (g/s/source)
NO_X	0.00022
PM_{10}	0.000015
TSP	0.000015
VOC	0.00002

5.5.4 Water Treatment Plant

As described in AECOM (2011), the primary pollutants of interest associated with the operation of the WTP are VOCs (BTEX) (as a surrogate for odour) and naphthalene. Emission rates for the two associated point sources are provided in **Table 29**.

Table 29 Water Treatment Plant Emission Rates

Pollutant	Emission Rate (g/s)	
	ITDV	ASDS
Benzene	0.0010	0.009
Toluene	0.0004	0.004
Ethylbenzene	0.0001	0.001
Xylenes	0.0002	0.001
Naphthalene	0.0071	0.062

The emission rates correspond to a stripping efficiency of 99 % and a water flow rate of 25 L/s.

5.5.5 Commercial Building C1

The construction of this building was modelled as per AECOM (2012) with the exception of the cranes, which were formerly assumed to operate using diesel engines. Cranes onsite are and would continue to be run on mains power and, as such, were excluded from the assessment. Forklifts, which are dual fuel (LPG and diesel or unleaded petrol) and predominantly run on LPG, were conservatively assumed to operate solely on diesel fuel.

Emission rates for building construction sources are outlined in **Table 30**. All plant was assumed to remain at ground level. All emission sources associated with the building were modelled as point sources.

Table 30 Emission Rates – Building C1

Source	Emission Rates (g/s)		
	NO_X	PM_{10}	TSP
Forklifts	0.19	0.01	0.01
Concrete pumps	0.36	0.001	0.001

5.5.6 Stage 1C Remediation and Earthworks

As described in **Section 5.3** dispersion modelling for the remediation, earthworks and construction activities for Stage 1C were undertaken by Murray Wilkinson in July 2015. For information on emission estimations refer to the Wilkinson Murray 2015 report.

Predicted impacts have been modelled based on the Wilkinson Murray 2015 report and added to the predicted impacts from Scenario 1b and Scenario 2b to determine cumulative impacts from all concurrent activities and are described in **Section 6.1**.

5.6 Sensitive Receptors

The EPA considers sensitive receptors to be areas where people are likely to either live or work, or engage in recreational activities (DEC, 2005). The receptors assessed in this report were selected to be the most representative sensitive receptors in proximity to the proposed works. A total of 111 receptors were assessed, which were primarily located along the eastern side of Hickson Road at various heights, with some located specifically on the site boundary. The receptor locations are shown in **Figure 4, Figure 5** and are detailed in **Appendix E**.

It should be noted that some of the buildings in Stage 1a of the Barangaroo project may be occupied at the time remediation of Hickson Road commences; these receptors were modelled in this assessment and are shown in **Figure 4**.

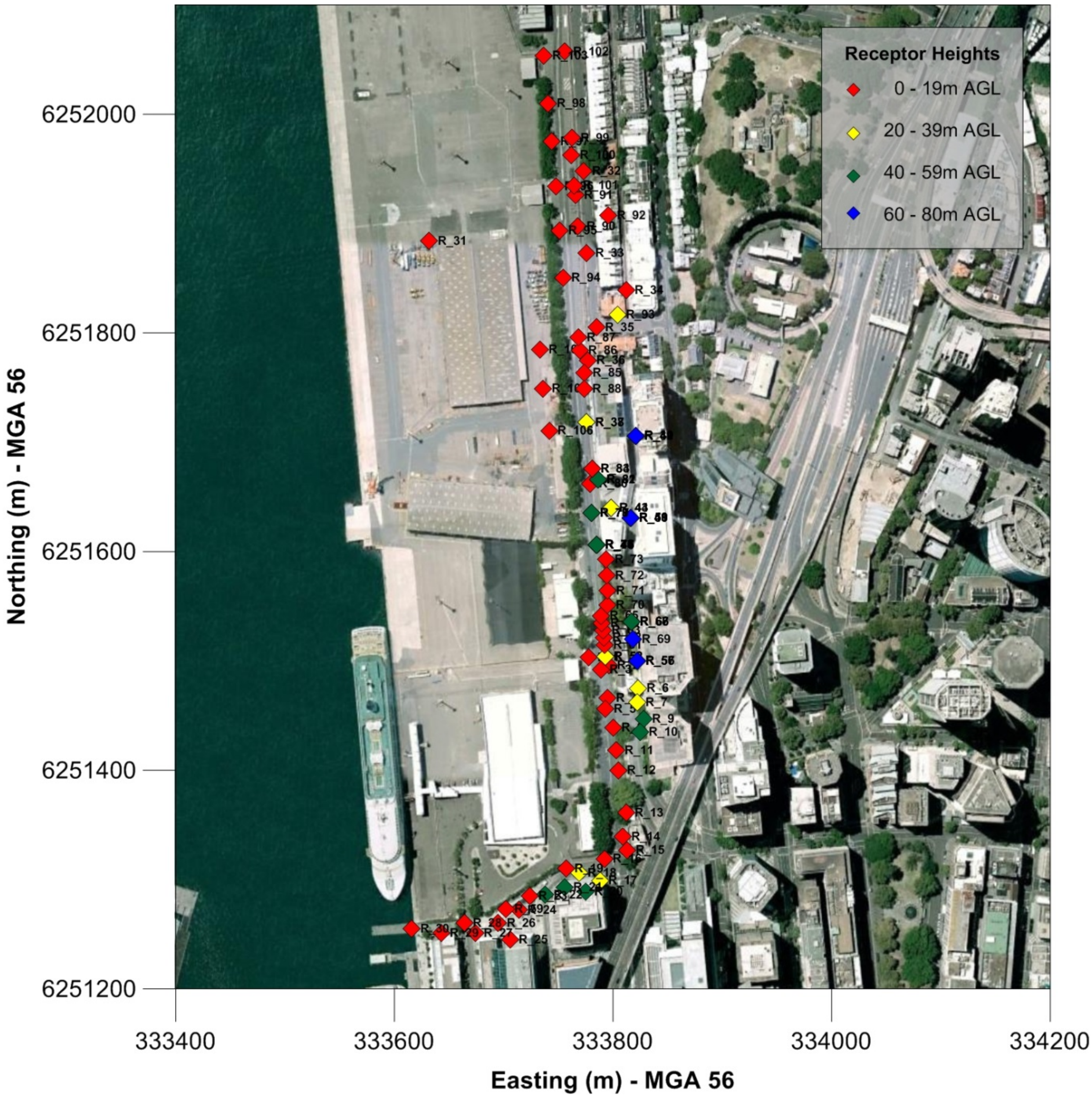

Figure 4 Sensitive Receptor Locations – Site Boundary

Figure 5 Sensitive Receptor Locations – Northern Boundary of Stage 1A

5.7 Prediction of Cumulative Impacts

For NO_2, PM_{10} and TSP, DEC (2005) specifies that AQIAs are to assess the cumulative impacts of a proposal against their impact assessment criteria. This involves adding existing background pollutant levels and expected pollutant levels from other concurrent developments to maximum pollutant concentrations of these pollutants predicted by dispersion modelling.

The cumulative assessment comprised the addition of the maximum measured data described in **Section 4.1** (assumed ambient pollutant concentrations) for TSP to predicted pollutant concentrations, and comparison of the results to the relevant criteria. For 1 hour PM_{10} and NO_2, contemporaneous assessments were made using data for the modelling period from the EPA's Rozelle monitoring station data summarised in **Section 4.1**.

Pollutant concentrations associated with the concurrent remediation works for Block 4 and Block 5, operation of the water treatment plant and construction works for building C1 were included in the dispersion model. As discussed in **Section 5.3** predicted incremental impacts from the remediation, excavation and construction works for Stage 1C described in the Wilkinson Murray 2015 report have been added to the predicted model impacts described in this report to determine the cumulative impacts from all concurrent activities.

5.8 Assessment of Contaminants

5.8.1 Metals, Benzo(a)pyrene and Cyanide

The concentrations of heavy metals, benzo(a)pyrene and cyanide at sensitive receptor locations were estimated using the predicted ground level concentrations of TSP. The proportion of heavy metals and cyanide in the soils (AECOM, 2010b) was applied to the TSP model predictions to derive an estimated concentration for each metal. The concentrations of heavy metals identified on site through the various sampling programs are summarised in **Table 31**; these were converted to a proportion of metals in soil to enable the estimation of heavy metal concentrations from the TSP results.

Table 31 Site-Specific Soil Concentrations of Miscellaneous Toxic Pollutants

Pollutant	Average Concentration (mg/kg)	Proportion of Metals in Soil (%)
Arsenic	4	0.0004
Benzo(a)pyrene	21	0.002
Beryllium	0.51	0.00005
Cadmium	0.56	0.00006
Chromium (III+VI)	17	0.002
Copper	51	0.005
Cyanide	21	0.002
Lead	239	0.02
Manganese	159	0.02
Mercury	0.27	0.00003
Nickel	12	0.001
Zinc	127	0.01

5.8.2 Conversion of NO_x to NO_2

Nitrogen oxides are produced in most combustion processes and are formed during the oxidation of nitrogen in fuel and nitrogen in the air. During high-temperature processes, a variety of oxides are formed including nitric oxide (NO) and NO_2. NO will generally comprise 95 % of the NO_X by volume at the point of emission. The remaining NO_X will consist of NO_2. Ultimately, however, all nitric oxides emitted into the atmosphere are oxidised to NO_2 and then further to other higher oxides of nitrogen.

The USEPA's Ozone Limiting Method (OLM) was used to predict ground-level concentrations of 1 hour NO_2. The OLM is based on the assumption that approximately 10 % of the initial NO_X emissions are emitted as NO_2. If the ozone (O_3) concentration is greater than 90 % of the predicted NO_X concentrations, all the NO_X is assumed to be converted to NO_2,otherwise NO_2 concentrations are predicted using the equation $NO_2 = 46/48 * O_3 + 0.1 * NO_X$. This method assumes instant conversion of NO to NO_2 in the plume, which overestimates concentrations close to the source since conversion usually occurs over periods of hours. This method is described in detail in DEC (2005). Background O_3 data from the Rozelle monitoring station (refer to **Section 5.1**) were used to convert the modelled NO_2 concentrations in accordance with the EPA approved OLM (Method 2, Level 2 Assessment; DEC, 2005). For annual NO_2, all NO_X was conservatively assumed to be NO_2

6.0 Results

The results of the dispersion modelling are shown in **Table 32** and **Table 33**. The results show:

- The maximum project contribution from Hickson Road in-situ and ex-situ remediation works (Scenario 1a and Scenario 2a respectively);
- The maximum project contribution from Hickson Road in-situ remediation works emitted at emission limits (Scenario 1b);
- The cumulative pollutant concentrations from Scenario 1c and 2b which include:
  - Hickson Road remediation works (in-situ and ex-situ remediation works)
  - Block 4 and Block 5 remediation works;
  - Operation of the water treatment plant; and
  - Construction of commercial building C1.
  - Construction of Stage 1C; and
- The cumulative pollutant concentrations from Scenario 1c and 2b and background concentrations

6.1 Modelling Predictions

The highest project contributions (pollutant concentrations associated with the project) predicted at any sensitive receptor assessed are provided in **Table 32** for Scenario 1 (*in-situ* remediation – preferred option) and **Table 33** for Scenario 2 (*ex-situ* remediation – alternative option). These contributions represent the 100th percentile for NO_2, PM_{10} and TSP; the 99.9th percentile for benzene, ethylbenzene, toluene, xylenes, naphthalene and phenol; and the 99th percentile for odour. Note that no emissions of NO_2 and Particulates have been assumed for the In-situ remediation scenario as there are no sources of these pollutants during the operation of the ISCO facility.

Cumulative pollutant concentrations, representing the project contribution, other on-site activities not directly linked with but operating at the same time as the Hickson Road remediation plus background pollutant concentrations are provided for NO_2, PM_{10} and TSP as required by the EPA. For TSP, the ambient concentration was estimated from the PM_{10} concentration as described in **Section 4.1**. For 1 hour NO_2 and 24 hour PM_{10}, contemporaneous assessments were undertaken, where the measured background pollutant concentrations for each hour/24 hours of the modelling period were matched to the hourly/24 hour modelling predictions.

The EPA criteria for air toxics apply at and beyond the boundary of the facility. The concentrations reported below represent the highest 99.9th percentile concentrations for any sensitive receptor assessed, which include receptors located on the boundary.

As shown, no exceedances of the EPA criteria were predicted to occur at any sensitive receptor location assessed for TSP, air toxics or odour. Slight exceedances of the 1 hour and 24 hour criteria for NO_2 and PM_{10} respectively were predicted when taking into account the background pollutant concentrations. There were no exceedances of the annual criteria for NO_2 and PM_{10}.

Table 32 Dispersion Modelling Results – Scenario 1 (*In-situ* Remediation – Preferred Option)

Pollutant	Averaging Period	Units	Maximum Predicted Contribution		Cumulative Concentration (Hickson Road plus additional activities)				Criteria
			Hickson Road (Scenario 1a)	Hickson Road (Scenario 1b)	B4, B5, C1 & WTP, and Stage 1C (Scenario 1c)	Scenario 1b & Background	Scenario 1a and Scenario 1c	Scenario 1b and Scenario 1c	
Benzene	99.9th 1 hour	µg/m^3	0.000030	16.4	9.19	N/A	9.19	25.6	***29***
Ethylbenzene	99.9th 1 hour	µg/m^3	0.000040	22.3	1.02	N/A	1.02	23.3	***8,000***
Toluene	99.9th 1 hour	µg/m^3	0.00026	19.4	4.08	N/A	4.08	23.5	***360***
Xylenes	99.9th 1 hour	µg/m^3	0.00012	22.3	1.05	N/A	1.05	23.4	***190***
Naphthalene	99.9th 1 hour	µg/m^3	0.0018	27.0	63.37	N/A	63.37	90.4	***440***
Exceedances denoted in **bold type**.									

Table 33 Dispersion Modelling Results – Scenario 2 (*Ex-situ* Remediation – Alternative Option)

Pollutant	Averaging Period	Units	Maximum Predicted Contribution	Cumulative Concentration (Hickson Road plus additional activities)		Criteria
			Hickson Road (Scenario 2a)	B4, B5, C1, Stage 1C & WTP (Scenario 2b)	Scenario 2b & Background	
NO_2	Max 1 hour average*	µg/m^3	181.9	203.5	**249.2**	***246***
	Annual average	µg/m^3	12.7	25.8	46.0	***62***
PM_{10}	Max 24 hour average*	µg/m^3	2	22.7	**80**	***50***
	Annual average	µg/m^3	1	3.2	22	***30***
TSP	Annual average	µg/m^3	7	14	60	***90***
Benzene	99.9th 1 hour	µg/m^3	0.24	9.17	N/A	***29***
Ethylbenzene	99.9th 1 hour	µg/m^3	0.19	1.02	N/A	***8,000***
Toluene	99.9th 1 hour	µg/m^3	0.33	4.07	N/A	***360***
Xylenes	99.9th 1 hour	µg/m^3	0.71	1.05	N/A	***190***
Naphthalene	99.9th 1 hour	µg/m^3	16.45	63.22	N/A	***440***
Phenol	99.9th 1 hour	µg/m^3	0.94	1.08	N/A	***20***
Odour	99th Percentile NRT	OU	0.06	0.09	N/A	***2***

* Maximum cumulative concentration calculated contemporaneously

Does not include background concentration.

NRT = Nose response time

Exceedances denoted in **bold type**.

6.1.1 NO2

The maximum predicted cumulative one hour NO_2 concentration is inclusive of all onsite construction activities, background concentration and Stage 1C of 249.2 $\mu g/m^3$ for the ex-situ modelling scenario. The predicted one hour NO_2 concentration while predicted to exceed the NO_2 criteria only does so at one receptor location for the ex-situ option only. This corresponds to 0.02% of the year; thus the occurrence predicted exceedances would be considered infrequent.

An analysis was undertaken to further investigate the predicted exceedance in NO_2 concentrations. The analysis suggested that the exceedance of one hour NO_2 is likely to be caused by a combination of conservative emission factors, conservative equipment utilisation rates and the placement of forklift sources on the site boundary. The real operations will be expected to be result in less conservative operations and given the predicted exceedance are very close to compliance, exceedance of the criteria is not expected to occur in reality.

The following assumptions are considered to have built a substantial layer of conservatism into the modelling, which is likely to result in over prediction of NO_2 concentrations. On this basis, monitoring of the NO_2 is not considered necessary.

- Placing major contributing sources of NO_x on the site boundary, including forklifts associated with the C2 building.
- Assuming forklifts will be diesel powered, when they will likely be dual powered and are expected to primarily operate on LPG.
- Assuming all mobile construction equipment will operate continuously within the construction hours of 7am to 6 pm, seven days per week all year.

6.1.2 PM10 & TSP

The maximum predicted cumulative 24 hour PM_{10} concentration inclusive of all onsite construction activities, background concentration and Stage 1C was 80 $\mu g/m^3$ for Scenario 2, which represented an exceedance of the PM_{10} assessment criteria. The relative contribution from the Hickson Road activities however, are not considered to be significant given the maximum contribution at all receptors is 2 ug/m^3 against a cumulative concentration of 80$\mu g/m^3$. The modelling predicted no additional exceedances of the criterion at nearby sensitive receptors due to the Hickson road operations. Further details are provided in **Appendix F**.

6.1.3 Metals, Benzo(a)pyrene and Cyanide

The concentrations of metals, benzo(a)pyrene and cyanide were estimated based on the highest 99.9th percentile one hour TSP concentration at all sensitive receptor locations for scenario 2 only (scenario 1 had no particulate source and hence no source of heavy metals from the site). TSP Concentrations were 56 $\mu g/m^3$ and 173 $\mu g/m^3$ for Scenario 2a and Scenario 2b. It should be noted that these results are not presented in the tables above as there are no one hour criteria for TSP. Results are shown in **Table 34** (Scenario 2). No exceedances were predicted.

Table 34 Predicted Pollutant Concentrations – Metals – Scenario 2 (*Ex-situ* Remediation – Alternative Option)

Pollutant	Estimated Maximum Concentrations (99.9th percentile) (µg/m3)		
	Hickson Road (Scenario 2a)	HR, B4, B5, C1, Stage 1C & WTP (Scenario 2b)	Criteria (99.9th percentile) ($\mu g/m^3$)
Arsenic	0.0002	0.00069	0.1
Benzo(a)pyrene	0.001	0.0035	0.4
Beryllium	0.00003	0.00009	0.004
Cadmium	0.00003	0.00010	0.018
Chromium (III+VI)	0.001	0.0035	0.09
Copper	0.003	0.0086	18
Cyanide	0.001	0.0035	90

Pollutant	Estimated Maximum Concentrations (99.9th percentile) (µg/m3)		
	Hickson Road (Scenario 2a)	HR, B4, B5, C1, Stage 1C & WTP (Scenario 2b)	Criteria (99.9th percentile) (µg/m^3)
Lead	0.01	0.035	0.5
Manganese	0.01	0.035	18
Mercury	0.00002	0.00005	0.18
Nickel	0.0006	0.0017	0.18
Zinc	0.006	0.017	18

6.1.4 Odour Mitigation Capture Efficiency Sensitivity Analysis

A sensitivity analysis was conducted as part of the AQIA submitted for the Remediation and Landforming Works (AECOM, 2014) to determine the effect of modifications to the odour reduction efficiency of the filters on the excavation enclosure stacks. The original modelling was conducted assuming a 99.8 % reduction efficiency; additional runs were undertaken for reduction efficiencies of 99 %, 95 % and 90 % for individual stacks (for Block 4). Results showed that the capture efficiencies modelled did not affect the level of compliance i.e. with efficiencies between 90 and 99.8% compliance was achieved for Block 4 (and given similarities between the odour control structures for Block 5 as well).

In addition to the examination of the potential performance of the individual stacks in isolation from other operational odour control structures, a sensitivity analysis was undertaken whereby the cumulative performance of the odour control stacks for Blocks 4, Block 5 and Hickson road were considered. The assumptions made when undertaking the analysis were as follows:

- Constant odour emission rates from each of the 3 stacks based around expected odour emissions listed above in **Table 24** (Hickson Road), **Table 25** (Block 4) and **Table 27** (Block 5).
- Mitigation efficiencies modelled were for all three stacks were assumed to be the same
- Modelled mitigation efficiencies were set at 90%, 95%, 96%, 97%, 98%, 99% and 99.8%.

The objective of the sensitivity analysis was to identify the lowest odour mitigation efficiency that the three stacks could operate and still maintain compliance with the 2OU odour criteria at all sensitive receptor locations. In addition, the odour concentration is then able to be used as a measure of the operational performance of the odour control structures and allow the regulation of the emissions from the operations. To this end, odour concentrations have also been provided for the results listed below in **Table 35**.

Table 35 Cumulative Odour Sensitivity Analysis Results

Reduction Efficiency	Odour Emission Rate			Odour Emission Concentration			Max Odour Concentration
(%)	B4	B5	HR	B4	B5	HR	99th Percentile
0	53202.0	25420.0	17220.0	4750.2	2269.6	2168.8	-
90	5320.2	2542.0	1722.0	475.0	227.0	216.9	4.7
95	2660.1	1271.0	861.0	237.5	113.5	108.4	2.3
96	2128.1	1016.8	688.8	190.0	90.8	86.8	1.9
97	1596.1	762.6	516.6	142.5	68.1	65.1	1.4
98	1064.0	508.4	344.4	95.0	45.4	43.4	0.9
99	532.0	254.2	172.2	47.5	22.7	21.7	0.5
99.8	106.4	50.8	34.4	9.5	4.5	4.3	0.1

Given the level of compliance noted for the different reduction efficiencies, it is concluded that provided the level of reduction efficiency remains above 96% for all three odour control stacks then compliance with the 2 OU criteria is expected to be maintained and the risk of odour complaints is minimised to an appropriate degree. Given the reliance of the modelling on odour concentration rather than reduction efficiency[2], it is recommended that ambient and stack odour sampling be undertaken to demonstrate compliance with the modelling rather than demonstrating stack reduction efficiencies.

It should be noted that a minimum typical odour capture efficiency of 98-99% is common with activated charcoal and it is expected that a 96% capture efficiency should be able to be achieved.

Lend Lease will prepare a Breakthrough Management Procedure to be implemented in the unlikely event that the filters or stacks fail, or that VOC breakthrough occurs. This procedure would be similar in nature to that prepared for the Stage 1A works.

6.1.5 Limitations

Best efforts were made to estimate the likely numbers, operational parameters (including operational hours and handling volumes) and emissions of plant and equipment in the AQIA. The numbers used were based on information available from Lend Lease at the time of preparation of this report, and may change to reflect the detailed design of the remediation activities.

If major changes are proposed to pollutant emitting activities during the remediation works, further modelling may be required to assess the effects of those changes on local air quality.

6.2 Recommended Air Quality Management and Mitigation

Mitigation and work practices that should be implemented at the site to minimise pollutant emissions are described below. These measures are intended to reduce risks to human health and nuisance impacts. The proposed monitoring works should be undertaken for the duration of the remediation and land forming works. The management and mitigation strategies, contingency measures and monitoring works will be consistent with the requirements of Environment Protection Licence (EPL) 13336, which will be varied following the granting of project approval for the proposed remediation works.

6.3 Mitigation Measures

Mitigation measures will be implemented based on the reactive management program and the nature of the works being undertaken on site at any time. The proposed mitigation measures are listed below.

All works

- Mains power will be used where available and suitable.
- The dust, VOC and meteorological monitoring program will be continued as per **Section 6.5**.
- Vehicle engines will be turned off while parked on site.
- Vehicular access will be confined to designated access roads. Haul road lengths will be minimised.
- Equipment, plant and machinery will be appropriately tuned, modified or maintained to minimise visible smoke and emissions.
- If off-site treatment is undertaken, all trucks transporting the untreated and potentially odorous spoil will be appropriately sealed to minimise odour and dust emissions during transport (for example through the use of odour suppressant foam, such as Rusmar AC-645 or equivalent [refer to Product Guides in **Appendix A**]). Any off-site treatment would be undertaken at a licenced treatment facility, in accordance with that facility's EPA licence conditions.
- Odour control measures will be used during retention wall works, such as covering exposed soil or using odour suppressants and foam (such as Rusmar AC-645 or equivalent; refer to **Appendix A**).
- Site speed limits will be implemented.
- Exposed areas will be minimised as much as practical.

[2] A lower efficiency may occur once the OCS is built, but from a lower overall odour concentration meaning the same odour emission concentration may occur, resulting in the same level of compliance. The final stack odour concentration is the best measure of whether the built OCS complies with odour criteria.

- Loads will be covered during transport.
- Good housekeeping practices will be implemented to minimise dust on hardstand areas.
- Spills will be immediately cleaned up.
- The complaints management system will be maintained.
- Work practices will be adjusted (as required) based on wind observations and real time monitoring results.
- Water sprays and/or surfactants will be used wherever and whenever necessary.
- Windbreak barriers will be erected at the site boundary.
- General environmental controls will be installed for excavation works, including bunding and sediment controls.
- Vehicles/plant would be decontaminated in a wheel wash/cleaning area prior to moving to other areas of site or off-site. Waste water from the decontamination activities would be transferred to the water treatment plant.
- Exposed surfaces and roads will be watered as required.

Ex-situ works

- All excavation, materials handling will be undertaken within the sealed excavation enclosures, which will be maintained under negative pressure.
- A minimum of two GAC filters will be installed in series for each emission stack in the excavation enclosures as per the modelling assumptions. The GACs chosen will be suitable for the contaminants being treated.
- Prior to commencement of the relevant stage of works where excavation enclosures will be used, a detailed design plan of the structures, the air discharge point and emission control system, will be submitted to the EPA for review and comment. The detailed design plan will include the following information:
    - Performance specifications, including particle and VOC control efficiency for the proposed technology;
    - Proposed monitoring to confirm the performance of the proposed VOC control technology; and
    - The proposed methodology to detect carbon bed breakthrough.
- The stack heights, pollutant concentrations and minimum velocities assumed in the modelling will be achieved.
- Stacks will be located on the western sides of excavation enclosures as assumed in the modelling.
- The excavation enclosures will be maintained to their design specifications. Regular checking and maintenance of excavation enclosure filtration systems will be undertaken.
- Generator emissions will be vented through the excavation enclosure stacks.

An Air Quality and Odour Management Sub-Plan would be prepared to include mitigation measures from this AQIA, and that it would include air quality monitoring. The Sub-Plan would contain measures to reflect variations in cumulative emissions from construction activities across Barangaroo.

These measures are intended to reduce risks to human health and nuisance impacts. The proposed monitoring works should be undertaken for the duration of the remediation and land forming works. The management and mitigation strategies, contingency measures and monitoring works will be consistent with the requirements of Environment Protection Licence (EPL) 13336, which will be varied following the granting of project approval for the proposed remediation works.

6.4 Contingency Measures

When monitoring systems continuously measure pollutant concentrations, an early warning system based on trigger levels can be used to minimise adverse impacts on the environment. The trigger levels are generally set below a relevant assessment criterion.

A reactive management plan was developed for the site, based on a three-stage approach:

- Investigate: Identification of the likely reasons for the elevated pollutant concentration and formulation of a contingency response for the action stage;
- Action: Implementation of the measures formulated in the investigative stage and review of their effectiveness; and
- Stop Work: All air polluting works associated with the remediation of Hickson Road should stop at this stage until the measured pollutant levels are below the action level to avoid an exceedance of the pollutant criterion.

The reactive management procedure for PM_{10} across the Barangaroo South site is provided in **Table 36**.

Table 36 Reactive Management Procedure – PM_{10}

Reactive Management Procedure				
Trigger Stage	Averaging Period	Trigger Value ($\mu g/m^3$)	Primary Responsibility	Action Required
1 Investigate	1 hour	85	Environment Manager	Environmental Manager to undertake review of possible dust sources operating during the average period. Identify possible measures for these activities; action if deemed necessary.
	3 hour	80		
2 Action	1 hour	470		Environment Manager to attend site and ensure implementation of the control actions identified in stage 1. Effectiveness of control actions to be reviewed and escalate where appropriate. Identify long-term solutions to dust issues. Complete Lend Lease Environmental Response Form.
	3 hour	160		
3 Stop Work	1 hour	940		Targeted shut down of dust-generating activities until the measured pollutant levels are below the stated Action period trigger value. Complete Lend Lease Environmental Response Form.
	3 hour	320		

6.5 Air Quality Monitoring Program

Ambient air quality monitoring around the Barangaroo site has been undertaken since October 2011 in accordance with the Air Quality and Odour Management Sub-Plan and EPL for the site. The monitoring has the following objectives:

- Allow a real time assessment of the various activities on the site, which can then be related back to operational changes to reduce off-site impacts; and to
- Allow reactive dust mitigation measures to be implemented based on real time monitoring data.

The monitoring is undertaken generally in accordance with the following guidelines and Australian Standards:

- The EPA's *Approved Methods for Sampling and Analysis of Air Pollutants in New South Wales* (DEC, 2007);
- AS/NZS 3580.9.3:2015 *Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - Total suspended particulate matter (TSP) - High volume sampler gravimetric method*;
- AS 3580.9.8-2008 *Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - PM_{10} continuous direct mass method using a tapered element oscillating microbalance analyser*;
- AS/NZS 3580.14:2014 *Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment*; and
- AS 2923-1987 *Ambient air - Guide for measurement of horizontal wind for air quality applications*.

Details of the relevant monitoring equipment and locations are provided in **Table 37** and **Figure 6**. These monitoring plans vary depending on the types of work undertaken. The works are always carried out in accordance with the site's EPL.

The Air Quality and Odour Management Sub-Plan for the works would include the actions outlined in **Table 2** along with the following information:

- LL will incorporate and implement industry practice emission controls and process design, including consideration of movement of contaminated material immediately into an enclosure (where possible) and other contingency measures, to ensure emissions generated outside the excavation enclosure/s are minimised to the maximum extent practicable.
- an ambient air monitoring program and reactive management strategy, including real-time meteorological monitoring for management purposes, fit for purpose odour monitoring, and the implementation of appropriate particulate triggers to further develop the reactive management strategy for air pollution mitigation;
- details of all proposed air quality emission control measures including:
  - timeframe for implementation of all identified emission controls;
  - key performance indicator(s) for emission controls;
  - monitoring method(s), including location, frequency and duration;
  - response mechanisms;
  - responsibilities for demonstrating and reporting achievement of key performance indicator(s);
  - record keeping and complaints response register; and
  - compliance reporting.

Table 37 Ambient Monitoring Agenda

Parameter	Equipment	Frequency	Locations	EPA Criteria	Sampling Method	Timing
TSP	HVAS	24 hours every 6 days	EPL points 5, 8, 13	90 µg/m^3 as an annual average	AM-15 AS 3580.9.3: 2015	During ex-situ remediation works*
PM_{10}	TEOM	Continuous	EPL points 5, 8, 13	50 µg/m^3 as a 24 hour average** 30 µg/m^3 as an annual average	AM-22 AS 3580.9.8-2008	During ex-situ remediation works*
Heavy Metals	HVAS	24 hours every 6 days	EPL points 5, 8, 13	***	AM-15 AS 3580.9.3: 2015	During ex-situ remediation works*
PAH (speciated)	HVAS	24 hours every 6 days	EPL points 5, 8, 13	N/A	AM-15 AS 3580.9.3: 2015	During ex-situ remediation works*
VOC (speciated)	Summa	As needed	As needed	***	USEPA TO-15	Throughout remediation*
VOCs	PID	Daily	EPL points 5, 8, 13	N/A	N/A	Throughout remediation*
Odour	Field Olfactometer	Morning, followed by afternoon if odour exceeds trigger level	Odour locations 2 to 5	N/A	N/A	Throughout remediation*

Parameter	Equipment	Frequency	Locations	EPA Criteria	Sampling Method	Timing
Met station	-	Continuous	EPL point 5	Site complies with *Approved Methods*	AM 4 AS 3580.14-2014	Throughout remediation*

* Or as agreed with the EPA
** 24 hour average of a calendar day defined as midnight to midnight.
*** Too many criteria to list; criteria based on DEC (2005)

It should be noted that continuous monitoring of VOC is not proposed. This has been discussed with EPA in relation to Blocks 4 and 5 and an agreement reached in relation to ongoing VOC monitoring being undertaken using PID's as outlined above in **Table 37**.

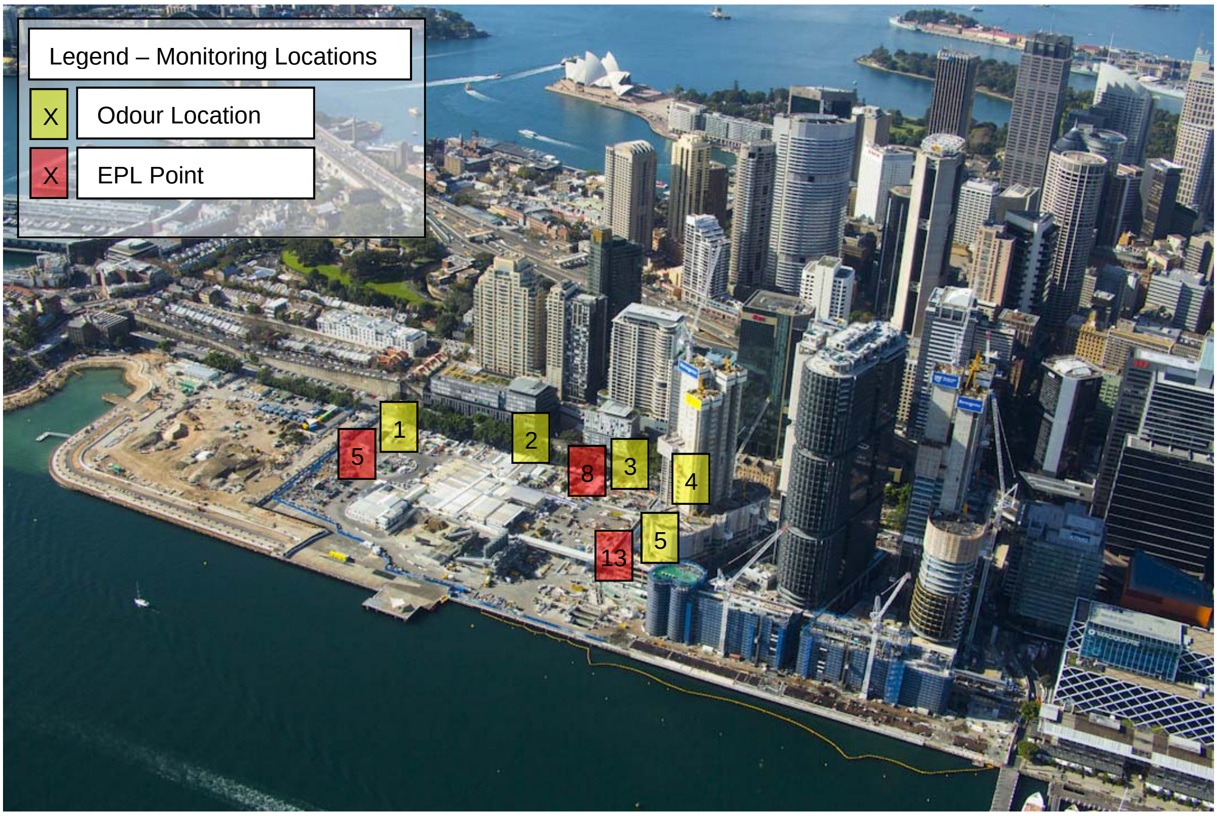

Figure 6 **Approximate Existing Barangaroo South Monitoring Locations**

The Air Quality Management Plan would address emissions of NO_X, particulates, VOCs and PAHs, which would be tested via stack emission testing undertaken in accordance with the *Approved Methods for Sampling and Analysis of Air Pollutants in New South Wales* (DEC, 2007). VOC monitoring to detect breakthrough of the OCS filters would also be undertaken. Suggested concentration limits and sampling frequencies are provided in **Table 38**; the final nature of the sampling program would be determined by the EPA and specified in the EPL.

Table 38 Suggested Monitoring Frequency and Concentration Limits for Excavation Enclosures

Pollutant	100^{th} Percentile Concentration Limit	Monitoring Frequency
Total particulates	20 mg/Nm^3	Post-commissioning stack testing followed by stack test sampling every alternate month
VOCs as n-propane equivalent	20 mg/Nm^3	
VOCs as n-propane equivalent	20 mg/Nm^3	Post-commissioning CEMS between OCS filters to detect and manage any carbon bed breakthrough

As per the last table row above, inter-bed monitoring would be undertaken to identify potential carbon bed breakthrough of the OCS filters in accordance with a Breakthrough Management Procedure, which would be prepared by the remediation contractor. The Plan would be similar to that prepared for Stage 1A works, and would include information on the granulated activated carbon treatment units, breakthrough monitoring procedures, operation and replacement procedures, and responsibilities.

7.0 Conclusion

AECOM undertook an air quality impact assessment of the proposed remediation of the Hickson Road Remediation Area at the Barangaroo site. A cumulative assessment was also undertaken to address the potential overlap of Hickson Road remediation works with the remediation works at Block 4 and Block 5, construction of building C1 and Stage 1C Remediation and Bulk Earthworks and the operation of a water treatment plant. Dispersion modelling was undertaken using the CALPUFF model to predict pollutant concentrations at sensitive receptor locations located close to the site. The following pollutants were assessed:

- NO_2;
- Particulates (TSP and PM_{10});
- BTEX;
- Phenol;
- Heavy metals (cadmium, chromium VI, copper, lead, mercury, nickel, zinc) attached to TSP;
- Benzo(a)pyrene;
- Naphthalene; and
- Odour.

Two scenarios were considered, which addressed the preferred and alternative remediation methods for the Hickson Road area and the concurrent activities described above. These modelling scenarios were further broken down to account for the Hickson Road impacts in isolation and the Hickson Road impacts and concurrent site remediation and construction activities, to which background and project contributions from Stage 1C remediation and earthworks.

Exceedances of the one hour NO_2 and 24 hour PM_{10} criteria were predicted to occur for both scenarios assessed. These exceedances were considered to be a result of conservative assumptions and emission factors used in the dispersion modelling, and the proximity of receptors to the proposed works. The predicted pollutant concentrations at sensitive receptors were lower than those predicted for other, approved, aspects of the Barangaroo development.

Lend Lease operates a reactive dust mitigation system at the Barangaroo South site, which includes ambient pollution monitoring, is directly linked to real-time warnings and incorporates work procedures to ensure that action is taken to reduce dust levels when they are elevated and at risk of exceeding acceptable air pollution levels. The system has been operational on the Barangaroo South site for a few years, and will continue to operate throughout the duration of the Hickson Road works. Lend Lease uses its air quality monitoring network and operational procedures to ensure site emissions are mitigated to an appropriate level and that adverse impacts (i.e. exceedances of ambient air quality criteria) are minimised at sensitive receptor locations as a result of site operations.

Lend Lease has demonstrated that it can undertake significant materials handling activities with substantial plant and equipment numbers on site while minimising emissions through this reactive management and monitoring system. As such, provided the existing monitoring and management plan for the Site is modified to incorporate the proposed Hickson Road remediation activities, adverse effects on air quality from the proposed remediation activities are not expected to occur. Any residual odours associated with the transport of odorous material - following the covering of loads and use of odour suppressants - are expected to be minimal and transient in nature and are not, therefore, expected to adversely affect sensitive receptors.

8.0 References

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Appendix A

Rusmar Product Guides

Appendix A Rusmar Product Guides

PRODUCT DATA SHEET

LONG DURATION FOAM AC-645

GENERAL DESCRIPTION

AC-645 Long Duration Foam is a patented product which produces a thick, long-lasting, viscous foam barrier for immediate control of dust, odors and volatile organic compounds (VOCs). AC-645 is designed for use with Rusmar Pneumatic Foam Units.

AC-645 foam is recognized by the Environmental Protection Agency and the U.S. Army Corps of Engineers as providing superior emission control for a period up to 17 hours. AC-645 has been specified for use at Superfund and other hazardous waste sites across the United States and Canada.

FEATURES

- Biodegradable
- Will not add to treatment costs
- No ambient temperature limitations
- Easy to use
- More effective than tarps
- Non-reactive
- Non-hazardous
- Safe for workers and the environment
- Requires only water dilution
- No clean up necessary
- Non-combustible
- Covers any contamination source

APPLICATIONS

The primary application for AC-645 is control of odors, VOCs and dust during active excavation and for overnight coverage of contaminated soils at hazardous waste sites. AC-645 can also be applied on top of liquid surfaces.

SPECIAL ODOR CONTROL PROBLEMS

The remediation of hazardous waste sites often includes excavation of soil contaminated with odorous compounds. AC-645 has little or no odor itself, although a pleasant wintergreen or vanilla scent can be added. It forms a barrier between contaminants and the atmosphere and can be applied during active excavation to provide an immediate and effective barrier to minimize odors. It is completely biodegradable and poses no threat to workers, neighboring residents or ground water. AC-645 will not add to soil volume or treatment costs.

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LONG DURATION FOAM AC-645

AC-645 can also be applied on top of trucks for emission control during transport of materials such as contaminated soils or sewage sludge. Ammonia tests performed on trucks containing sewage sludge resulted in a drop of concentration levels from 170 ppm prior to foaming down to 6 ppm after coverage with AC-645.

- Minimizes worker exposure
- Maintains fence-line odor and VOC emission limits
- Works on lagoon and pond closures
- Can be applied to near vertical or liquid surfaces

FUGITIVE DUST

At hazardous waste sites, fugitive dust can present a health hazard. AC-645 can be applied on top of the dusty material to prevent any wind-borne emissions. There is no need to mobilize equipment to immediately cover with soil or tarps. The Pneumatic Foam Unit can be filled and placed at the site to be used at a moment's notice.

EMERGENCY SPILL CLEAN UP

In emergency spills, odor and VOC control is often difficult because of the terrain and accident conditions. AC-645 Long Duration Foam can be applied to any shaped object, as well as steep slopes, water, mud, snow and ice. It is non-flammable and non-reactive - difficult spill problems can be accommodated.

METHOD OF APPLICATION

AC-645 Long Duration Foam is supplied in either 450 pound (55 gal.) drums or by bulk load (approximately 46,000 pounds). Bulk shipments can be stored outside in a Rusmar Bulk Storage-Dilution System. The Bulk Storage and Dilution system is comprised of a 7000 gallon heated and stirred chemical storage tank and a microprocessor to accurately dilute and transfer the chemical. AC-645 is designed to be applied with a Rusmar Pneumatic Foam Unit. The Pneumatic Foam Units are available in a variety of sizes to accommodate a range of site conditions and application needs.

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Appendix B

Chemicals of Potential Interest

Appendix B Chemicals of Potential Interest

For the purposes of this AQIA, pollutants of interest were defined as chemicals that have been detected on the site in concentrations greater than relevant human health screening criteria. The pollutants considered were:

- Nitrogen dioxide (NO_2);
- Particulate matter;
- Heavy metals (cadmium, chromium VI, copper, lead, mercury, nickel, zinc);
- BTEX (benzene, toluene, ethylbenzene and xylenes – types of VOCs);
- Benzo(a)pyrene;
- Naphthalene);
- Phenol; and
- Odour.

The potential health effects of the pollutants of interest are summarised below. Details were obtained from the National Pollutant Inventory (NPI, 2010) unless otherwise specified.

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a brownish gas with a pungent odour. It exists in the atmosphere in equilibrium with nitric oxide. The mixture of these two gases is commonly referred to as NO_x. NO_x is a product of combustion processes. In urban areas, motor vehicles and industrial combustion processes are the major sources of ambient NO_x. NO_2 can cause damage to the human respiratory tract, increasing a person's susceptibility to respiratory infections and asthma. NO_2 can also cause damage to plants, especially in the present of other pollutants such as ozone and sulfur dioxide. NO_x are also primary ingredients in the reactions that lead to photochemical smog formation.

Particulate Matter

Suspended particulate matter may be emitted from site via combustion activities (i.e. vehicle and plant operations) and site preparation, excavation and remediation works.

Airborne particles are commonly differentiated according to size based on their equivalent aerodynamic diameter. Particles with a diameter of less than or equal to 50 micrometres (μm) are collectively referred to as total suspended particulates (TSP). TSP primarily causes aesthetic impacts associated with settling on surfaces, which also causes soiling and discolouration. Uncontrolled emissions of these large particles, however, can cause some irritation of mucosal membranes and can increase health risks from ingestion if contaminated. Particles with diameters less than or equal to 10 μm (known as PM_{10} or fine particles) tend to remain suspended in the air for longer periods than larger particles, and can penetrate into human lungs.

Exposure to particulate matter has been linked to a variety of health effects, including respiratory problems (such as coughing, aggravated asthma and chronic bronchitis) and non-fatal heart attacks.

Heavy Metals

A variety of heavy metals were detected at the site. The metals detected at site for which soil and groundwater assessment criteria were exceeded are discussed below.

Cadmium

Cadmium is a naturally-occurring element found in the earth's crust. The combustion of coal and other fossil fuels can result in airborne emissions of cadmium compounds, but are typically confined to the local area surrounding the emissions source, with a lifespan of 5 -15 days in particle form. Cadmium can be inhaled or ingested.

Cadmium is considered to be a probable carcinogen, with evidence suggesting it causes cancers of the kidney and prostate in humans, and lung and testicular cancer in animals. It is a known teratogen (i.e. at certain exposures can cause defects or malformations in developing embryos/foetuses) and may cause reproductive damage. Prolonged exposure to low concentrations of cadmium can cause permanent kidney damage, while high exposures can cause rapid respiratory damage resulting in shortness of breath, chest pain and fluid build-up in the lungs, as well as gastrointestinal symptoms such as nausea, vomiting, cramps and diarrhoea. Long-term exposure can result in symptoms such as anaemia, fatigue, and loss of the sense of smell. The general public is typically exposed to cadmium through food, since food material may take up and retain cadmium, and through smoking of tobacco. The toxicity of cadmium is affected by water hardness in freshwater, with greater toxicity associated with softer water.

Chromium VI

When chromium VI is released into the atmosphere as particulate matter from the manufacture/disposal of products or the combustion of fossil fuels, it is entrained in the air for up to ten days before settling in soil and water, adhering strongly to soil particles, where only small amounts dissolve.

While chromium III is an essential element, compounds of chromium VI are usually highly toxic. Inhalation of chromium VI can damage and cause adverse health symptoms of the respiratory and gastrointestinal systems, potentially leading to asthma and other allergic reactions. Long-term exposure to airborne chromium VI can adversely affect the immune system and cause cancer. Dermal contact can lead to skin ulcers, redness and swelling.

Chromium VI can have high to moderate acute toxic effects on plants, birds and land animals, resulting in low growth rates or death. Chromium VI is persistent and is thought to bioaccumulate in aquatic life.

Copper

Copper is a naturally occurring substance that is an essential trace element for both animals and plants. Copper can be inhaled or ingested. Most copper released to air, water, sediment and soil strongly binds to other particles, which greatly reduces its toxicity.

Exposure to high levels of copper can, however, be harmful, and cause irritation to the nasal passages, mouth, eyes and throat, while ingestion of high concentrations can cause nausea, vomiting, liver and kidney damage and, possibly, death. Copper is classified as a hazardous substance by the office of the Australian Safety and Compensation Council.

Lead

Lead is a naturally occurring substance that can enter the body by inhalation or ingestion, and primarily affects the nervous system. Excessive exposure to lead causes symptoms such as paralysis, anaemia, abdominal pain, brain and kidney damage and death. Lead can affect reproduction as well as the mental and physical development of children. Lead may be released as particles into the atmosphere, including through windblown dust and bush fires. Lead usually attaches to particles of organic matter, clay, soil or sand, and can accumulate in tissues.

Mercury

Mercury is a naturally occurring element found in rocks and ores. Mercury chloride acts like a particle, while elemental mercury may be found as a gas in the atmosphere. It is naturally released into the atmosphere by evaporation from soils and water and volcanic eruptions. Significant anthropogenic sources of mercury are the burning of fossil fuels, municipal landfills, sewage, metal refining and chemical manufacturing.

Mercury can enter the body through inhalation, ingestion or dermal contact. The nervous system is very sensitive to all forms of mercury. Exposure can potentially causing permanent damage to the brain, eyes, kidneys and developing foetuses, and can cause fluid build-up in the lungs that can be fatal. Dermal contact can burns to the skin.

Mercury is highly toxic to aquatic life, with both acute and chronic effects. Mercury accumulates in body tissue; consumption of contaminated fish can poison humans and possibly birds and land animals. It is also highly persistent in water and the environment. It should be noted that mercury has not been frequently detected on site (AECOM, 2010b).

Nickel

Nickel is an abundant, naturally-occurring element found in soil, water and food, typically found in combination with other elements such as arsenic, antimony and sulphur. Nickel is emitted to atmosphere from both natural and anthropogenic sources, such as combustion of fossil fuels, steel production, incineration and sewage treatment. Nickel can be transported as fine particulate matter, which is washed out of the air by rain into soil and water. Nickel is found in soils and sediments, and is kept soluble by organic matter.

Nickel and its compounds can be inhaled or ingested, with food and water being the primary sources of exposure for most people, as well as tobacco smoke. Inhalation of high concentrations of nickel can result in effects on the respiratory system, potentially causing sinus cancer, and nickel dust irritates the eyes, nose and throat.

Zinc

Zinc is a naturally occurring element found in all foods as well as rocks, soil, air, water, plants, animals and humans. Trace amounts are essential for human health. It is found in a variety of compounds, the properties of which vary greatly. The metal has a strong tendency to form complexes with inorganic and organic compounds. Zinc is used in a range of manufacturing, industrial and applications such as fungicides, antiseptics, water-repellants, lubricants and concrete.

Zinc attaches to dust particles in the air and to soil and sediment particles, and can be inhaled or ingested. Excessive zinc ingestion can lead to nausea, vomiting, anaemia, and damage to the pancreas. Zinc dust irritates mucous membranes, while solid zinc compounds can irritate the skin and eyes.

VOCs

Organic compounds with a vapour pressure at 20 °C exceeding 0.13 kPa are referred to as VOCs. VOCs have been implicated as a major precursor in the production of photochemical smog, which causes atmospheric haze, eye irritation and respiratory problems. VOC emissions are typical for oil processing, petrochemical and chemical plants and include emissions from point sources (storage tanks and filling stations vents) and fugitive emissions from pipelines and process equipment leaks. A variety of VOCs were detected at the site, which may be released during the proposed activities.

BTEX

BTEX are a category of volatile organic compounds (VOCs). VOCs are organic compounds with a vapour pressure at 20 °C exceeding 0.13 kPa. These compounds have been implicated as a precursor in the production of photochemical smog, which may cause atmospheric haze, eye irritation and respiratory effects. VOC emissions are typical for oil processing, petrochemical and chemical plants and include emissions from point sources (storage tanks and filling stations vents) and fugitive emissions from pipelines and process equipment leaks.

Benzene

Benzene is an airborne substance that can be washed out of the air by rain, and evaporated into the air. It will decompose in soil or water when oxygen is present. Benzene exposure commonly occurs through inhalation of air containing the substance. It can also enter the body through the skin, although it is poorly absorbed this way. Low levels of benzene exposure may result from tobacco smoke and car exhaust.

Benzene is considered to be a toxic health hazard and a carcinogen. Human exposure to very high levels for even brief periods of time can potentially result in death. Lower level exposure can cause skin and eye irritation, drowsiness, dizziness, headaches and vomiting, and over longer periods damage to the immune system, leukaemia and birth defects.

Toluene

Toluene (methylbenzene) is a highly volatile chemical that quickly evaporates to a gas if released as a liquid. After a few days, the substance breaks down in air into chemicals that are harmful to human health. Bacteria in soil and water also break down toluene. Due to relatively fast degradation, toluene emissions are typically confined to the local area in which it is emitted. Toluene is a component of petrol and paints, and is also found in tobacco smoke. Human exposure typically occurs through breathing contaminated air, but toluene can also be ingested or absorbed through the skin (in liquid form). Toluene usually leaves the body within twelve hours.

Short-term exposure to high levels of toluene can cause dizziness, sleepiness, unconsciousness and sometimes death. Long-term exposure can cause kidney damage and permanent brain damage that can lead to speech, vision and hearing problems, as well as loss of muscle and memory functions.

Ethylbenzene

Ethylbenzene is a highly volatile substance, so is typically present in air. Ethylbenzene rapidly enters the body through the lungs and digestive tract. The substance has both acute and chronic toxic effects on animals and plants, including shortened lifespan, reproductive problems and behaviour changes. Exposure to high concentrations can cause dizziness, paralysis, breathing difficulties and death. Chronic health effects in humans can last for months or years. Ethylbenzene is present in petroleum, pesticides, cleaning products and solvents.

Xylenes

Xylenes are flammable liquids that are moderately soluble in water. They are quickly degraded by sunlight when released to air, and rapidly evaporate when released to soil or water. They are used as solvents and in petrol and chemical manufacturing.

Xylenes can enter the body through inhalation or skin absorption (liquid form), and can cause irritation of the eyes and nose, stomach problems, memory and concentration problems, nausea and dizziness. Excessively high-level exposure can cause death.

Phenol

Phenol is found as a solid or a thick liquid, and is usually colourless or pink. It has a characteristic odour likened sweet tar. Phenol is a common component of oil refinery wastes, and is also used as a disinfectant, a reagent, and in the manufacture of products such as fertilisers and paints.

Phenol can be inhaled, ingested, or enter through the skin. Exposure can result in irritation or burns, and acute poisoning can result in respiratory failure. Phenol is acutely toxic to animals, birds and fish, and can cause a low growth rate or death in plants.

Cyanide

Cyanide is a naturally occurring element that is essential for a healthy diet (as cyanocobalmin, or vitamin B12). Compounds are released into the atmosphere (from natural or human processes) as gaseous or particulate matter, which settles into the soil or water, with most compounds being water soluble. Cyanides break down in a matter of days in water but are persistent in air. Exposure can occur from ingestion of food or water or smoking, or air pollution from silver and gold mining operations, chemical processing facilities, steel and iron industries, high motor vehicle traffic areas and the like. Pesticides and rodenticides can also contain cyanide.

It is very toxic to humans, and exposure by inhalation can cause rapid death. Brief exposures to lower concentrations may result in symptoms such as shortness of breath, convulsions and unconsciousness, while long-term exposure to low concentrations can result in deafness, vision and coordination problems. Exposure to high levels for short periods can result in damage to the respiratory, cardiovascular and central nervous systems and quickly cause death. As cyanide was only detected in very small concentrations at the site (i.e. at concentrations approximately 1,000 times less than relevant assessment criteria[3]), cyanide is not expected to be a significant issue at the site.

Cyanides are also highly toxic to aquatic life, birds and animals over short periods. While cyanides have high chronic toxicity to aquatic life, insufficient data exist to determine chronic toxicity to land organisms. Cyanides are not expected to bioaccumulate.

Cyanide was not identified as pollutant of concern in AECOM (2010)[4], but was included in this assessment for completeness.

Benzo(a)pyrene

Benzo(a)pyrene is a polycyclic aromatic hydrocarbon (PAH). PAHs contain at least two fused benzene rings and are commonly formed by the incomplete combustion of fossil fuels and other organic materials. They travel through the atmosphere as a gas or attached to dust particles. Some PAHs readily evaporate into the air. The compounds can break down over days or weeks by reacting with sunlight and other chemicals in air, but do not dissolve easily in water. PAHs are moderately persistent in the environment and can bioaccumulate.

PAHs can be inhaled or ingested, and can also be absorbed through the skin. Exposure can cause irritation of eyes and nose and other mucous membranes, headaches, nausea, damage to blood cells, liver and kidneys, and (in very high levels) may be life threatening. A number of PAHs are listed as probably or possibly carcinogenic to humans by the International Agency for Research on Cancer. They can have high acute and chronic toxicity effects on animals and aquatic life, with some also affecting agricultural and ornamental crops. Benzo(a)pyrene is one of the most toxic PAHs, and, as it typically found in the atmosphere with other PAHs, is often used as an indicator for the PAH group of pollutants.

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[3] NEPC. (1999). National Environment Protection (Assessment of Site Contamination) Measure (NEPM). National Environment Protection Council.
[4] AECOM. (2010). Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area. AECOM, May, 2010

Naphthalene

Naphthalene is a primary chemical of potential concern at the Barangaroo site due to its volatile nature and strong, offensive odour. It is produced from coal tar and petroleum, and is used for the production of chemicals, dyes and as a moth-repellent. It can be absorbed through inhalation, ingestion and dermal contact. Short-term exposure can cause lesions of blood cells (haemolysis), while long-term exposure can result in chronic haemolytic anaemia. Inhalation can generate symptoms such as headache, confusion, nausea, vomiting and sweating. Skin irritation and dermatitis can result from dermal contact. Naphthalene exposure can cause cataracts in the eyes, while ingestion can cause abdominal cramps, nausea, vomiting, diarrhoea and death in young infants. It is considered possible carcinogenic to humans and carcinogenic in animals. The substance is very toxic to aquatic organisms. Naphthalene may cause long-term effects in the aquatic environment[5].

Odour

Odour is a sensory response to the inhalation of one or more chemicals in the air we breathe. A person’s perception of an odour can vary significantly depending on the sensitivity of the person, the acuteness of the person’s sense of smell and the connotations that the odour bestows on that person. Odour may affect a person’s quality of life and can have a large range of effects including stress and other physical symptoms. Odorous compounds detected at the site include ethylbenzene, xylenes and naphthalene.

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[5] International Programme on Chemical Safety Poisons Information Monograph 363; http://www.inchem.org/documents/pims/chemical/pim363.htm; accessed 19 May 2010

Appendix C

Climate Averages and Meteorological Analyses

Appendix C Climate Averages and Meteorological Analyses

Average climate data recorded at the Observatory Hill meteorological station between 1859 and 2014 are shown in the following table. These data are summarised in **Section 4.2**.

Average Climate Data – Observatory Hill, 1859 – 2014 (June)

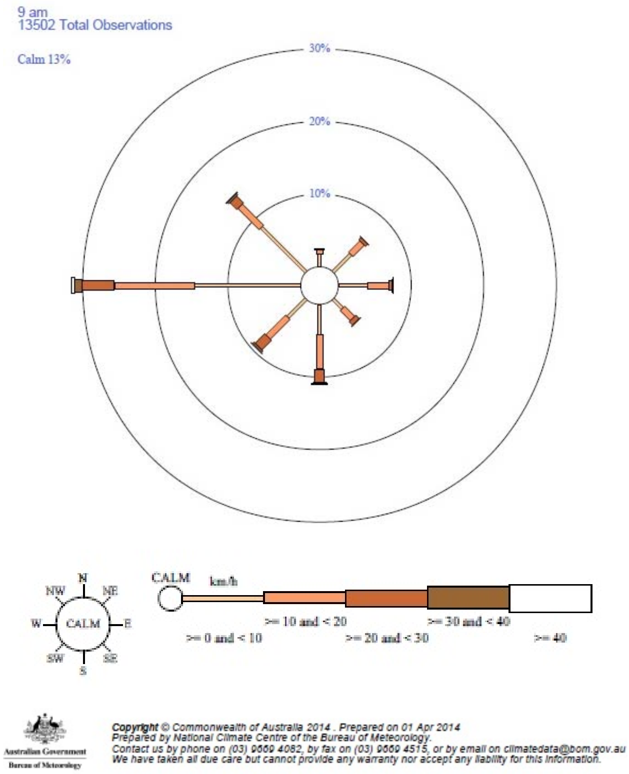
Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average temperature													
Maximum (°C)	25.9	26	24.7	22.4	19.4	16.9	16	18	20	22	24	25	21.7
Minimum (°C)	18.7	19	17.6	14.7	11.5	9.3	8	9	11	14	16	18	13.8
Rainfall													
Mean rainfall (mm)	101	118	130	127	120	132	98	80	68	77	84	77	1213
Average 9 am conditions													
Temperature (°C)	22.5	22	21.1	18.2	14.6	11.9	11	13	16	19	20	22	17.5
Relative humidity (%)	71	74	74	72	74	74	71	66	62	61	66	67	69
Wind speed (km/h)	8.6	8.2	7.9	8.8	10.5	11.9	13	13	12	12	11	9.8	10.6
3 pm conditions													
Temperature (°C)	24.8	25	24	22	19.4	16.9	16	18	19	21	22	24	21
Relative humidity (%)	62	64	62	59	57	57	51	49	51	56	58	59	57
Wind speed (km/h)	17.9	17	15.2	13.8	12.7	13.6	15	18	18	19	19	20	16.6

The following discusses the meteorological data from the CALMET data file for the year 2013 in terms of wind speed and wind direction.

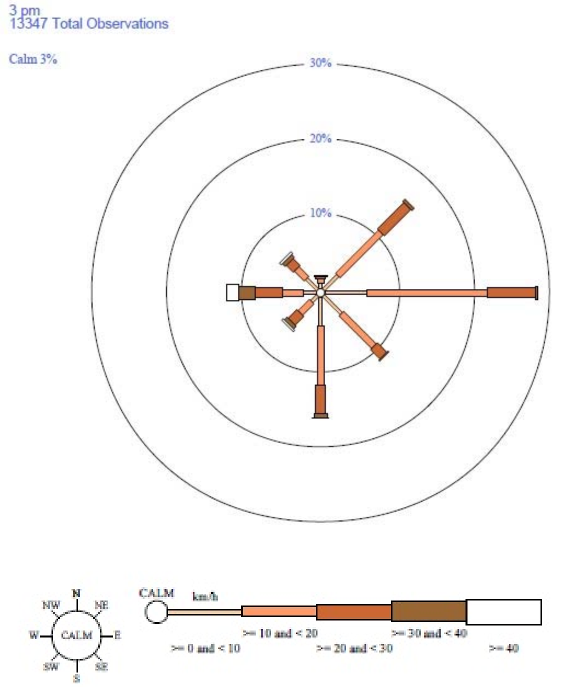
The Bureau of Meteorology (BoM) operates a network of meteorological monitoring stations around the country. The closest station to the site that measures long-term parameters is located at Observatory Hill, Sydney, approximately 200 m northeast of the Site and is considered a good representation of the regional climate.

Wind Rose

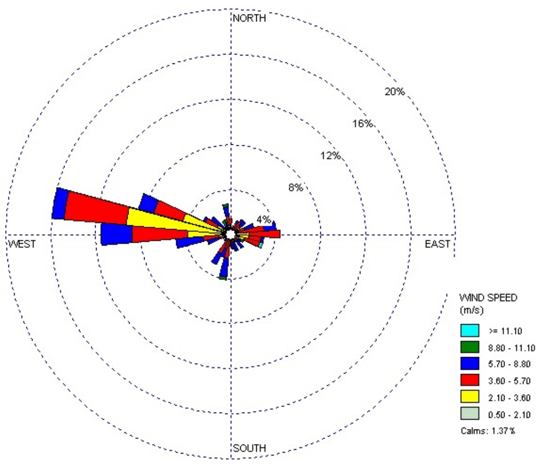
Wind speed and direction are important variables in dispersion modelling, as they dictate the direction and distance pollutant plumes travel. A comparison of wind roses from the meteorological data used in the dispersion modelling and the data from Observatory Hill was conducted. The 9 am and 3 pm wind roses for each data source are shown in the table below. The 9 am data sets were comparable in wind direction, although the prognostic data, as expected, predicted fewer calm periods than the historical measured data (1.4% vs13 %). The prognostic wind speeds were lower than the measured wind speeds. At 3 pm, again, the wind directions were similar, with a high proportion of winds from the northeast. The proportion of calm periods (0.82% vs 3%) and wind speeds were again higher in the measured data set.



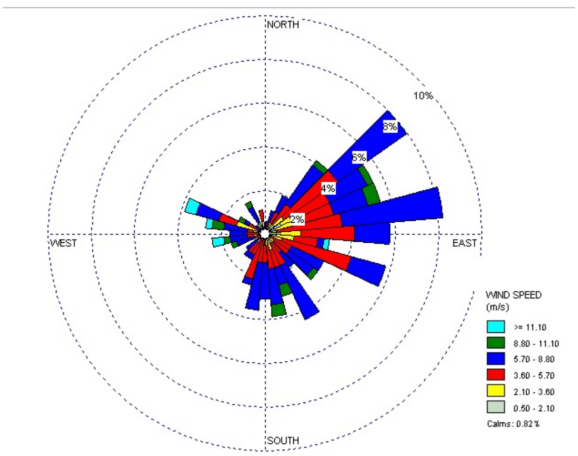
9 am wind rose – Observatory Hill (1955 – 1992)



3 pm wind rose – Observatory Hill (1955 – 1992)



9 am wind rose – CALMET, 2013



3 pm wind rose – CALMET, 2013

Wind Speed

The frequency distribution of hourly averaged wind speed values from the 2013 CALMET data generated for the assessment is shown in **Figure B1**. As shown, wind speeds in the area are medium strength, with speeds between 2 and 9 m/s occurring for around 80% of the time. The average wind speed is 4.2 m/s and the maximum wind speed is 15 m/s. Given the relative coastal location of the station, the high percentage of strong winds is expected.

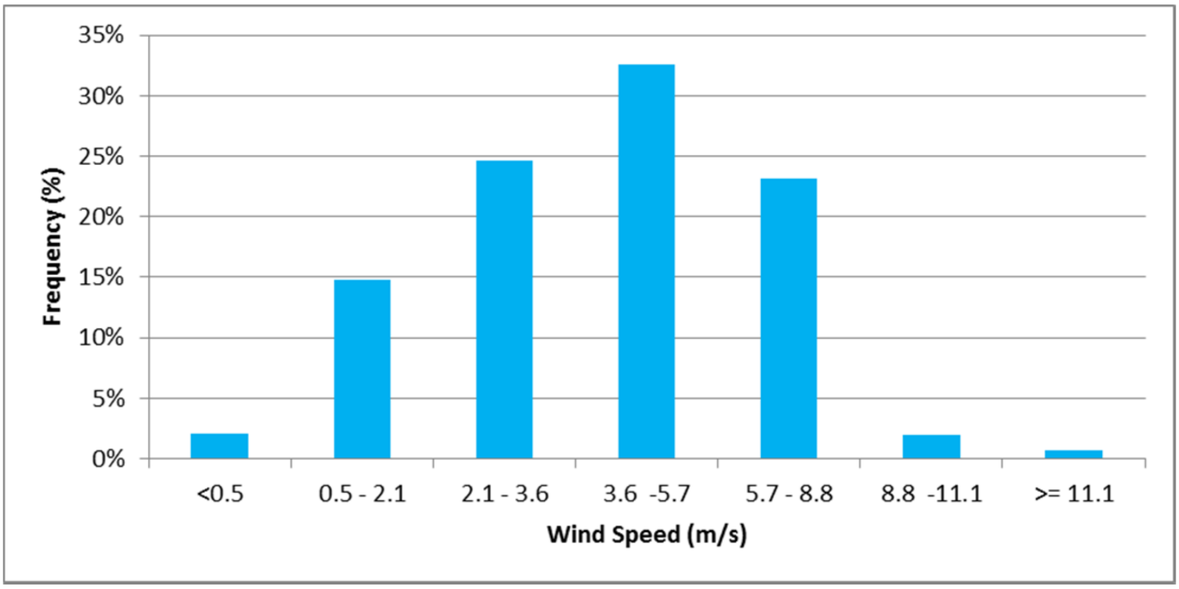


Figure B1 Frequency Distribution of Wind Speed – Barangaroo CALMET 2013

Figure B2 shows the distribution of average wind speeds by hour of day. Higher wind speeds tend to occur during the daytime between 10 am and 7 pm, with a peak around 2 pm. This is a typical diurnal pattern.

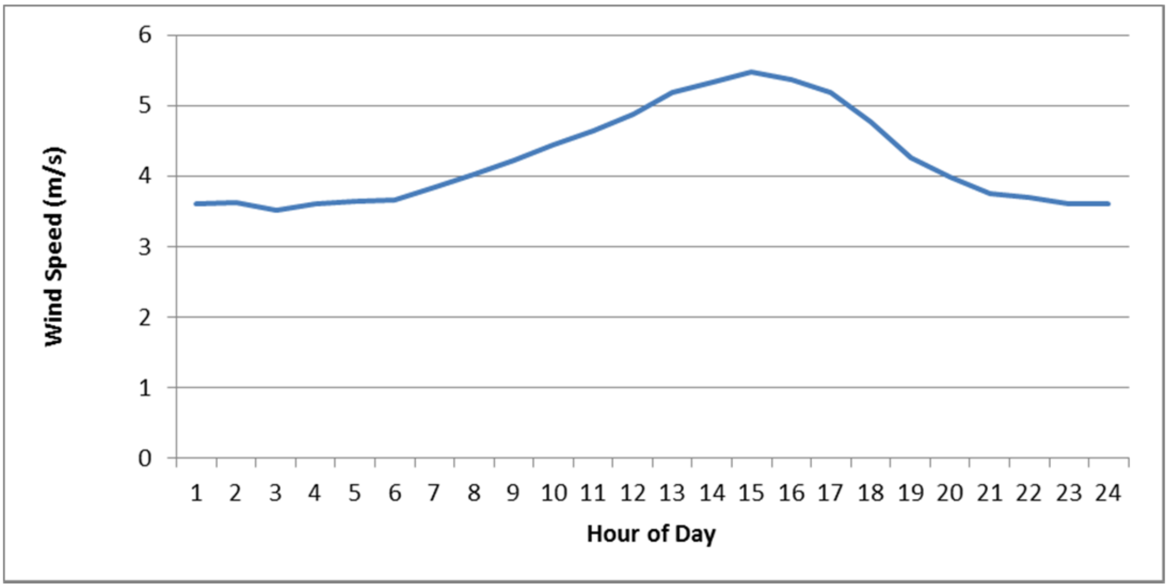


Figure B2 Wind Speed by Hour of Day – Barangaroo CALMET 2013

Appendix D

Soil Sampling Results Summary

Appendix D Soil Sampling Results Summary

The data used in the development of the VOC and odour emission rates are provided below. As described in **Section** Error! Reference source not found., the VOC emission rates varied for each excavation location based on the volume of material excavated and the duration of the works. Only the pollutants for which odour thresholds were found were used to estimate odour emission rates. Data were sourced from AECOM (2010b).

Soil Contaminant Sampling Results - VOCs

Category	Pollutant	Number of Results	Number of Detects	Average Concentration (mg/kg)	VOCs/Odour
BTEX	Benzene	164	43	5.2	VOCs/odour
	Ethylbenzene	164	38	3.7	VOCs/odour
	Toluene	164	43	7.1	VOCs/odour
	Total xylenes	164	48	16	VOCs/odour
Inorganics	Total cyanide	105	38	21	Odour
PAH/ Phenols	2,4-dimethylphenol	102	28	11	VOCs
	2-methylphenol (o-cresol)	102	20	14	VOCs/odour
	2-nitrophenol	102	0	0.36	VOCs
	3-&4-methylphenol	102	22	27	VOCs
	4-chloro-3-methylphenol	102	1	0.37	VOCs/odour
	Naphthalene	166	96	338	VOCs/odour
	Phenol	102	17	19	VOCs/odour
SVOCs	1-naphthylamine	14	1	0.48	VOCs
	Diallate	13	1	0.49	VOCs
	2-Picoline (2-methylpyridine)	14	1	0.47	VOCs
	3,3-Dichlorobenzidine	14	1	0.5	VOCs
	4-(dimethylamino) azobenzene	14	1	0.48	VOCs
	4-aminobiphenyl	14	1	0.47	VOCs
	Azobenzene	14	1	0.54	VOCs
	Carbazole	14	9	30	VOCs
	Dibenzofuran	14	10	52	VOCs/odour
VOCs	1,2,4-trimethylbenzene	16	10	18	VOCs/odour
	1,3,5-trimethylbenzene	16	9	7	VOCs/odour
	Isopropylbenzene (cumene)	16	3	0.75	VOCs/odour
	n-propylbenzene	16	4	0.71	VOCs
	Styrene	16	7	3.1	VOCs/odour

The calculations for the odour emissions are shown in the table below.

Excavation Odour Flux Estimate

Chemical	Vapour Pressure (mm Hg)#	Odour Threshold#	Reference Soil Concentration (mg/kg)^	Reference Odour Flux (OU/m^2.s)^	Reference Odour Flux to Soil Concentration Ratio (calculated)	Site Average Soil Concentration (mg/kg)	Site Odour Flux (OU/m^2.s) (calculated)
Benzene	95.2	4.79	-	0.64	0.01154	5.2	0.060
Toluene	28.4	10.93	-	0.33	0.00151	7.1	0.011
Ethylbenzene	9.53	10	56.3	0.03	0.000554	3.7	0.002
Total xylenes	6.72	4.78	33.0	0.0001	0.000004	16	0.000
Cyanide	264.3	0.64	-	13.79	0.24	21	5.027
Naphthalene	0.087	0.44	1150	0.0014	0.000001	338	0.000
2-methylphenol (o-cresol)	0.299	0.0012	-	-	0.14021	14	1.963
4-chloro-3-methylphenol	0.08	0.10	-	-	0.0005	0.37	0.000
Phenol	0.3513	0.15	-	-	0.001	19	0.025
Dibenzofuran	0.0175	1.00	-	-	0.00001	52	0.001
1,2,4-trimethylbenzene	2.03	1.97	-	-	0.001	18	0.011
1,3,5-trimethylbenzene	2.3	2.70	-	-	0.000	7	0.003
Isopropylbenzene (cumene)	4.5	0.43	-	-	0.006	0.75	0.005
Styrene	5	1.36	-	-	0.002	3.1	0.007
Sum of components							**7.1**
Total odour emission rate (including peak-to-mean ratio of 2.3)							**16.4**

Various sources; primarily US EPA (www.epa.gov)
^ Duthie (2002)
***** Used to calculate the ratio for all other pollutants except total xylenes and naphthalene, for which ratios were available.

Appendix E

Sensitive Receptor Locations

Appendix E Sensitive Receptor Locations

The coordinates and heights of the sensitive receptors included in the dispersion modelling are provided below.

Sensitive Receptors

X (m)	Y (m)	Base Elevation (m)	Flagpole Height (m)	Description
333769.21	6251503	24.72	0	
333797.95	6251496.14	28.03	18	
333798.76	6251482.52	28.19	0	
333795	6251466	27.37	0	
333802.48	6251454.47	28.17	0	
333823	6251475	32.02	25	
333822	6251462	32.51	25	
333770.57	6251430.63	22.17	0	
333824.26	6251446.73	32.7	48	
333825	6251435	32.62	50	
333803	6251418	27.13	0	
333805	6251400	26.71	0	
333812	6251361	28.29	8	
333809	6251339	28.34	12	
333813	6251327	29.81	15	
333792	6251319	26.07	0	
333788	6251299	25.92	35	
333769	6251306	23.04	35	
333757	6251310	21.58	0	
333775	6251289	24.72	40	
333756	6251293	22.6	48	
333738	6251286	21.7	40	
333724	6251285	17.96	0	
333714	6251272	17.39	10	
333706	6251245	15.59	15	
333695	6251260	16.36	10	
333674	6251251	15.27	12	
333664	6251260	15.01	0	
333643	6251251	13.73	15	
333616	6251255	12.12	0	
333632	6251884	8.47	0	
333773	6251948	13.88	0	Preschool
333776	6251873	12.32	0	

X (m)	Y (m)	Base Elevation (m)	Flagpole Height (m)	Description
333812	6251839	19.48	0	
333785	6251805	17.49	0	
333777	6251775	18.7	0	
333776	6251718	19.95	0	
333776	6251718	19.95	30	
333821	6251706	25.48	0	
333821	6251706	25.48	20	
333821	6251706	25.48	40	
333821	6251706	25.48	60	
333798	6251640	10	0	
333798	6251640	10	20	
333785	6251606	8	0	
333785	6251606	8	20	
333785	6251606	8	30	
333816	6251631	23.51	0	
333816	6251631	23.51	20	
333816	6251631	23.51	40	
333816	6251631	23.51	60	
333797.6	6251504.28	27.88	0	
333797.46	6251504.28	27.87	20	
333822	6251500	31.58	20	
333822	6251500	31.58	40	
333822	6251500	31.58	60	
333822	6251500	31.58	80	
333702	6251273	16.94	0	
333796.86	6251514.31	27.43	0	
333796.15	6251521.36	27.01	0	
333795.11	6251528.39	26.49	0	
333794.59	6251534.7	26.05	0	
333793.69	6251541.58	25.47	0	
333816.87	6251535.93	29.77	0	Stamford on Kent
333816.74	6251535.93	29.75	20	Stamford on Kent
333816.74	6251535.93	29.75	40	Stamford on Kent
333818.5	6251519.83	30.32	60	Stamford on Kent
333792.23	6251551.2	24.58	0	
333791.52	6251563.63	23.95	0	
333790.23	6251577.36	22.62	0	

X (m)	Y (m)	Base Elevation (m)	Flagpole Height (m)	Description
333789.27	6251592.87	21.36	0	
333785	6251606.07	19.99	10	38 Hickson Rd
333785	6251606.48	19.96	30	38 Hickson Rd
333785.2	6251606.07	20.01	50	38 Hickson Rd
333787.11	6251622.97	19.82	0	38 Hickson Rd
333786.91	6251622.66	19.8	20	38 Hickson Rd
333787.22	6251622.97	19.84	40	38 Hickson Rd
333781.79	6251662.1	19.14	0	
333778.34	6251698.39	19.67	20	30 The Bond
333778.34	6251698.92	19.68	40	30 The Bond
333780.84	6251675.8	19.69	30	30 The Bond
333780.84	6251675.8	19.69	10	30 The Bond
333773.59	6251763.63	19.03	0	
333769.62	6251783.99	17.56	0	
333768.24	6251795.73	16.66	0	
333773.42	6251748.79	19.63	0	
333774.56	6251839.7	14.53	0	
333768.02	6251897.49	12.05	0	
333765.67	6251925.99	12.79	0	
333795.74	6251907.43	15.05	10	Observatory Hotel
333804.11	6251816.69	19.56	20	Observatory Hotel
333754.16	6251850.42	11.52	0	
333751.28	6251893.57	11.29	0	
333747.88	6251934.1	12.35	0	
333743.96	6251975.16	13.37	0	
333740.82	6252009.94	13.57	0	
333762.53	6251978.29	14.06	0	
333762	6251962.6	13.74	10	Preschool
333764.62	6251934.89	13.04	0	Preschool
333755.73	6252057.27	13.1	0	
333736.64	6252053.61	12.83	0	
333747.5	6251787.01	15.95	0	
333749.61	6251748.77	18.15	0	
333753.69	6251710.82	18.34	0	
333637.86	6251487.66	6	0	R8 North
333644.92	6251426.13	6	0	R8 South
333650.97	6251383.76	6	0	R9 North

X (m)	Y (m)	Base Elevation (m)	Flagpole Height (m)	Description
333659.04	6251331.31	6	0	R9 South
333680.22	6251357.54	6	0	C5 West
333721.58	6251363.59	6	0	C5 Central
333761.93	6251368.63	6	0	C5 East

Appendix F

Predicted Exceedances

Appendix F Predicted Exceedances

The number of predicted exceedances of the 1 hour NO_2 criterion (total) and the 24 hour PM_{10} criterion (additional to those due to exceedances in the background data) are presented in the following tables for Scenario 2.

Predicted Exceedances: Scenario 2 – *Ex-situ* (alternative) Remediation Methodology

Receptor Coordinates		Flagpole Height (m)	1 hour NO_2 Exceedances	24 Hour PM_{10} Additional Exceedances
X (m)	Y (m)			
333769	6251503	0	0	0
333798	6251496	18	0	0
333799	6251483	0	0	0
333795	6251466	0	0	0
333802	6251454	0	0	0
333823	6251475	25	0	0
333822	6251462	25	0	0
333771	6251431	0	0	0
333824	6251447	48	0	0
333825	6251435	50	0	0
333803	6251418	0	0	0
333805	6251400	0	0	0
333812	6251361	8	0	0
333809	6251339	12	0	0
333813	6251327	15	0	0
333792	6251319	0	0	0
333788	6251299	35	0	0
333769	6251306	35	0	0
333757	6251310	0	0	0
333775	6251289	40	0	0
333756	6251293	48	0	0
333738	6251286	40	0	0
333724	6251285	0	0	0
333714	6251272	10	0	0
333706	6251245	15	0	0
333695	6251260	10	0	0
333674	6251251	12	0	0
333664	6251260	0	0	0
333643	6251251	15	0	0
333616	6251255	0	0	0
333632	6251884	0	0	0
333773	6251948	0	0	0

Receptor Coordinates		Flagpole Height (m)	1 hour NO_2 Exceedances	24 Hour PM_{10} Additional Exceedances
X (m)	Y (m)			
333776	6251873	0	0	0
333812	6251839	0	0	0
333785	6251805	0	0	0
333777	6251775	0	0	0
333776	6251718	0	0	0
333776	6251718	30	0	0
333821	6251706	0	0	0
333821	6251706	20	0	0
333821	6251706	40	0	0
333821	6251706	60	0	0
333798	6251640	0	0	0
333798	6251640	20	0	0
333785	6251606	0	0	0
333785	6251606	20	0	0
333785	6251606	30	0	0
333816	6251631	0	0	0
333816	6251631	20	0	0
333816	6251631	40	0	0
333816	6251631	60	0	0
333798	6251504	0	0	0
333797	6251504	20	0	0
333822	6251500	20	0	0
333822	6251500	40	0	0
333822	6251500	60	0	0
333822	6251500	80	0	0
333702	6251273	0	0	0
333797	6251514	0	0	0
333796	6251521	0	0	0
333795	6251528	0	0	0
333795	6251535	0	0	0
333794	6251542	0	0	0
333817	6251536	0	0	0
333817	6251536	20	0	0
333817	6251536	40	0	0
333819	6251520	60	0	0
333792	6251551	0	0	0

Receptor Coordinates		Flagpole Height (m)	1 hour NO_2 Exceedances	24 Hour PM_{10} Additional Exceedances
X (m)	Y (m)			
333792	6251564	0	0	0
333790	6251577	0	0	0
333789	6251593	0	0	0
333785	6251606	10	0	0
333785	6251606	30	0	0
333785	6251606	50	0	0
333787	6251623	0	0	0
333787	6251623	20	0	0
333787	6251623	40	0	0
333782	6251662	0	0	0
333778	6251698	20	0	0
333778	6251699	40	0	0
333781	6251676	30	1	0
333781	6251676	10	0	0
333774	6251764	0	0	0
333770	6251784	0	0	0
333768	6251796	0	0	0
333773	6251749	0	0	0
333775	6251840	0	0	0
333768	6251897	0	0	0
333766	6251926	0	0	0
333796	6251907	10	0	0
333804	6251817	20	0	0
333754	6251850	0	0	0
333751	6251894	0	0	0
333748	6251934	0	0	0
333744	6251975	0	0	0
333741	6252010	0	0	0
333763	6251978	0	0	0
333762	6251963	10	0	0
333765	6251935	0	0	0
333756	6252057	0	0	0
333737	6252054	0	0	0
333748	6251787	0	0	0
333750	6251749	0	0	0
333754	6251711	0	0	0

Receptor Coordinates		Flagpole Height (m)	1 hour NO_2 Exceedances	24 Hour PM_{10} Additional Exceedances
X (m)	Y (m)			
333638	6251488	0	0	0
333645	6251426	0	0	0
333651	6251384	0	0	0
333659	6251331	0	0	0
333680	6251358	0	0	0
333722	6251364	0	0	0
333754	6251711	0	0	0

Appendix G

ISCO Preliminary Odour Plan

Appendix G ISCO Preliminary Odour Plan

DA SSD 6617

Hickson Rd ISCO Ground Breaking Works - Preliminary Air/Odour Control Plan Jan 2016

This preliminary plan provides an overview of minimum odour controls to be implemented during ground breaking works as part of in-situ chemical oxidation for SSD 6617. Note that works for any Hickson Rd Perimeter Retention Wall construction are covered in a separate PRW Odour Control Plan. Prior to commencing works, detailed design of controls will be prepared based on selected contractor methodology, and provided to EPA for review and comment.

Proposed Works	In-situ Chemical Oxidation (ISCO) for Hickson Rd Remediation
Purpose of Works	In-situ remediation of gasworks contamination
Type of Ground Breaking Works	Typical ground breaking works (excluding retention walls) as part of the in-situ remediation are anticipated to comprise: • Drilling to install wells and undertake sampling • Services investigation / pot-holing works • Shallow excavation/trenching as required.
Potential Odour Source	Sub-surface tar that may be encountered and removed during ground breaking works as part of ISCO.
Preliminary Odour Control Methodology	
Primary Controls	Minimise the quantity of free tar exposed during works, to minimise odour generation. The following air quality/odour control measures are proposed (to the extent practical), at locations where tar is anticipated:
Use of construction method that limits odour generation	• For drilling, the extent of open excavation at any one time will be limited to a discrete hole (generally up to 100mm diameter). This method would limit the amount of tar exposed at any one time, thereby minimising odour generation / air quality impacts. • Wells to be sealed once constructed • Use non-destructive digging techniques where possible, particularly in the vicinity of services
Secondary Controls	Implement measures that control the impact of odours that are generated from the works. The following air quality/odour control measures are proposed (to the extent practical), at locations where tar is anticipated:
Manage odour from spoil arisings / stockpiles	• Site enclosed with hoarding • Use odour suppressants (e.g. BioSolve) or misting sprays in or around the work area. • Spray odorous spoil / drill arisings with foaming agents (e.g. Rusmar or similar) once brought to the surface. • All waste to be stored in sealed containers prior to offsite disposal. • Where possible, solid covers will be used in preference to suppressant foams/sprays. • Dispose of stockpiles/drums off-site as soon as practicable. • Use water spray on excavated or stockpiled material to mitigate particulate emissions. • Sealing of penetrations/excavation at the completion of work shift. • Collect and treat run-off water, or promptly store in sealed containers. • Hard stand areas to be kept clean
Manage trucks to minimise fugitive odours	• Load material promptly and with care to reduce loading times and spillage. • Use sealed trucks to control potential for spilling material through the site or off-site. • Cover loads prior to leaving loading zones, with odour suppressant foam and automatic tarps. Where possible, solid covers will be used in preference to suppressant foams and sprays. • Immediately clean truck and loading areas upon loading. • Use truck and wheel wash facilities prior to leaving the site.
Implement monitoring and response	• Undertake detailed odour monitoring on and off-site to allow works/controls to be modified as required. • Undertake weather monitoring and modify works based on weather conditions, if required.

Appendix H

Perimeter Retention Wall Preliminary Air Quality and Odour Control Plan

Appendix H Perimiter Retention Wall Preliiminary Air Quality and Odour Control Plan

DA SSD 6617

Hickson Rd PRW - Preliminary Air Quality and Odour Control Plan Oct 2014

This preliminary plan provides an overview of minimum odour controls to be implemented during retention wall construction as part of SSD 6617, when working in areas where gasworks tar or other odorous material is present. Prior to commencing works, detailed design of controls will be prepared based on selected contractor methodology, and provided to EPA for review and comment.

Proposed Works	Perimeter Retention Wall (PRW) construction for Hickson Rd Remediation
Purpose of Works	Groundwater control and/or soil retention
Type of Works	PRW type to be determined following procurement. Anticipated to comprise: • Secant or contiguous concrete piles
Potential Odour Source	Sub-surface tar that may be encountered and removed during retention wall construction
Preliminary Odour Control Methodology	
Primary Controls	Minimise the quantity of free tar exposed during works, to minimise odour generation / air emissions. The following air quality/odour control measures are proposed (to the extent practical), at locations where tar is anticipated:
Use construction method that limits odour generation	• For piling method, limit the extent of open excavation at any one time to a discrete hole (generally up to 1200mm diameter). Drill each hole using a rotary auger and then fill with a concrete slurry. This method would limit the amount of tar exposed at any one time, thereby minimising odour generation / air quality impacts.
Secondary Controls	Implement measures that control the impact of odours that are generated from the works. The following air quality/odour control measures are proposed (to the extent practical), at locations where tar is anticipated:
Manage odour from spoil arisings / stockpiles	• Use a dedicated labour resource to manage odours in work area. • Install an A-Class hoarding incl. additional vertical barriers (where required), around the work area and adequately sealed, to help minimise risk of odour off-site. • Use odour suppressants (e.g. BioSolve) or misting sprays in or around the work area. • Spray odorous spoil / drill arisings with foaming agents (e.g. Rusmar) once brought to the surface. • Cover stockpiles with tarps, non-odorous material or foaming agents, or place into sealed drums. • Where possible, solid covers will be used in preference to suppressant foams/sprays. • Dispose of stockpiles off-site as soon as practicable. • Use water spray on excavated or stockpiled material to mitigate particulate emissions. • Cover open excavations overnight. • Collect and treat run-off water, or promptly store in sealed containers.
Manage trucks to minimise fugitive odours	• Load material promptly and with care to reduce loading times and spillage. • Use sealed trucks to control potential for spilling material through the site or off-site. • Cover loads prior to leaving loading zones, with odour suppressant foam and automatic tarps. Where possible, solid covers will be used in preference to suppressant foams and sprays. • Immediately clean truck and loading areas upon loading. • Use truck and wheel wash facilities prior to leaving the site.
Implement monitoring and response	• Undertake detailed odour monitoring on and off-site to allow works/controls to be modified as required. • Undertake weather monitoring and modify works based on weather conditions, if required.