Lend Lease Millers Point Pty Limited
14-Oct-2014

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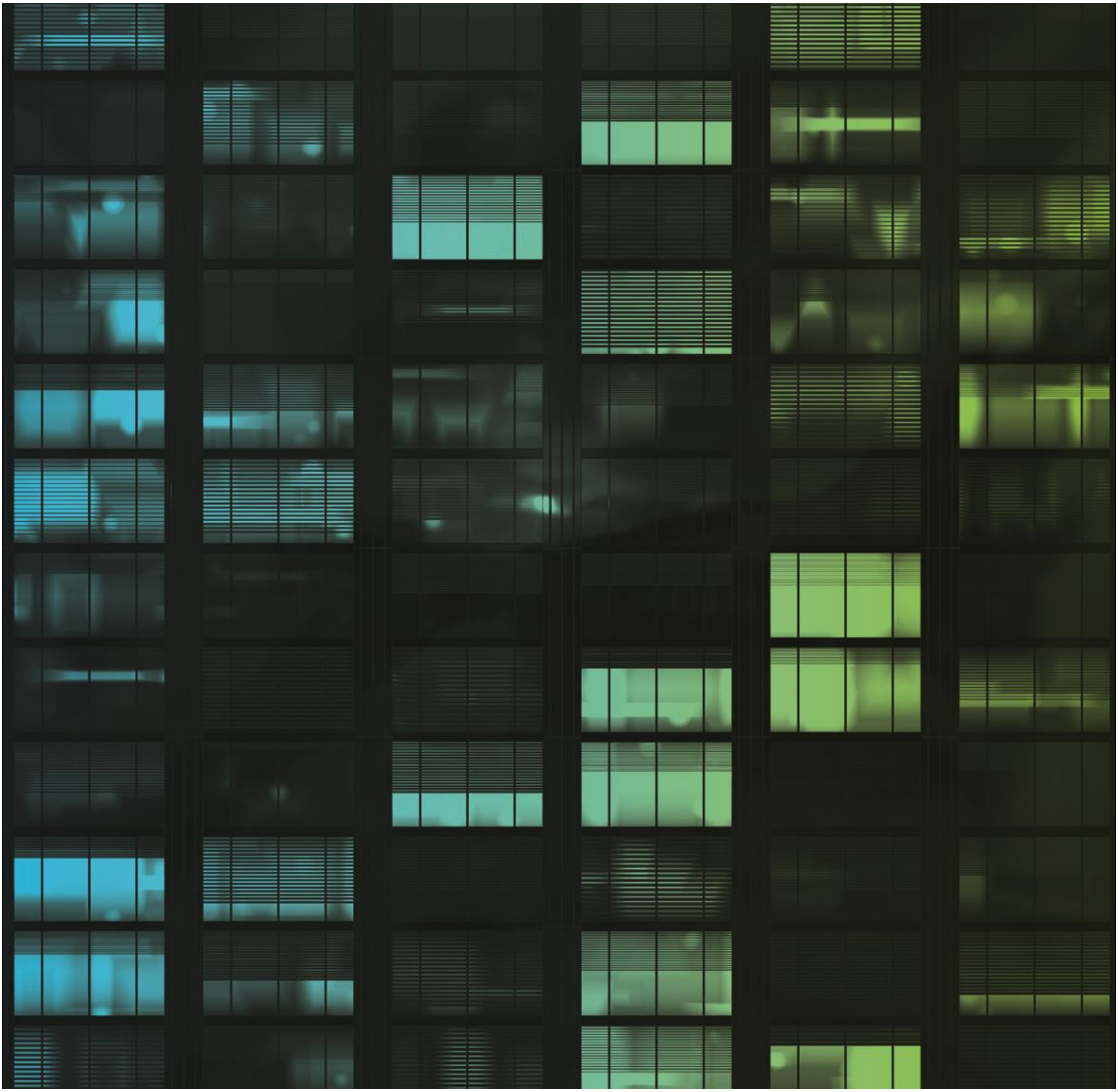
Air Quality Impact Assessment

Barangaroo South Concept Plan Modification 8



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Air Quality Impact Assessment

Barangaroo South Concept Plan Modification 8

Client: Lend Lease Millers Point Pty Limited

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1.0 Introduction

The Barangaroo development is a large urban redevelopment project situated on the western edge of the Sydney CBD. As part of the approvals process, a series of Concept Plans have been developed to allow regulatory Authorities to understand the expected stages of the multi-stage development. This report supports a modification (MOD 8) to Concept Plan (MP06_0162) submitted to the Minister for Planning pursuant to Section 75W of Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The proposed modification is the outcome of negotiations between Lend Lease and the NSW Government, including the Barangaroo Delivery Authority, to relocate the landmark hotel building from the approved location on a pier in Sydney Harbour to a location on land elsewhere on the site. It incorporates both the physical relocation of the hotel and a number of consequent and related changes that are required to maintain an appropriate built form and public domain outcome for the Barangaroo South site.

1.1 Overview of Proposed Modification

The proposed modification to the Concept Plan seeks to:

- Relocate the landmark building (Block Y) extending into the harbour back onto the site in front of the existing Blocks 4A, B and C;
- Revise the layout of Blocks 4A - C;
- Amend the size and location of the Southern Cove and public domain;
- Redistribute the gross floor area (GFA), public domain and land uses across development blocks 1 - 3, 4A - C, X and Y;
- Increase the maximum GFA on the site to provide for additional GFA within the hotel building and residential buildings;
- Increase the height of the buildings within modified 'Block 4' and the relocated Block Y; and
- Amend the conditions of the Concept Approval to reflect the modifications to development.

The modification also proposes to amend Part 12 of Schedule 3 of the Major Development SEPP to reconcile the SEPP with the modifications to the Concept Plan, including amending the location of the RE1 and B4 Mixed Use zones.

1.2 Site Location

Barangaroo is located on the north western edge of the Sydney Central Business District, 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 a range of new development dominated by large CBD commercial tenants to the south.

The Barangaroo site has been divided into three distinct redevelopment areas (from north to south) – the Headland Park, Barangaroo Central and Barangaroo South. Concept Plan (Mod 8) relates only to Barangaroo South as shown in **Figure 1.**

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Figure 1 Indicative Site Boundary for Barangaroo South

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1.3 Project Background

Director-General's Requirements (DGRs) were issued for the Concept Plan Amendment (MP06_0162 MOD 8) on 15 April 2014. Item 14 of the DGRs requires the Environmental Assessment to identify potential air quality and odour impacts and appropriate mitigation measures.

The worst-case impacts associated with the Concept Plan (MP 06_0162 MOD 4) were assessed by AECOM in 2010. The report (AECOM, 2010) addressed the worst-case air emissions associated with the entire development at the Barangaroo South site, excluding the remediation of the Declaration Area, which were considered to be emissions associated with site preparatory and enabling phases of works associated with bulk excavation of the carpark for the Stage 1A works. These preparatory works were completed in November 2013.

The currently approved Concept Plan (MOD 7) included an assessment of air quality impacts (AECOM, 2012). That assessment considered the concurrent construction of residential buildings R8 and R9 and commercial buildings C3, C4 and C5 and the operation of the concrete batching plant. The preparatory works were not included in that assessment as the buildings will be constructed above the carpark and, as such, will commence once the excavation works are completed.

Impacts associated with the remediation of the Declaration Area were not assessed as part of the MOD 4 or MOD 7 assessments because details of the remediation methodology were not known at those times. The Declaration Area works are the subject of three separate assessments -- the Block 4 remediation works assessed in AECOM (2014) have been approved, while the Block 5 and Hickson Road works are currently undergoing assessment. The Block 4 remediation works were, however, determined to be the associated with the greatest level of expected impacts for the Declaration Area as the concrete batching plant, which was found to be the greatest source of potential air emissions (AECOM, 2013b), will be operational for part of those works, but will cease operation before the Block 5 or Hickson Road works commence.

1.4 Scope of Works

AECOM undertook this air quality impact assessment to assess the potential effects on air quality associated with the modified Concept Plan MP06_0162, which was done by assessing the air emissions expected during the time of the greatest overlap of air pollutant-generating activities. Review of the proposed modifications and the staging of the remaining development on the site indicated that the worst-case overlap of air pollution-generating activities is expected to occur during the early part of the Block 4 excavation works. At their peak, these works are expected to consist of:

- Stage 1B Basement (Block 4) remediation and excavation remediation activities;
- Construction works associated with commercial and residential buildings C3, C4, C5, R8 and R9;
- Operation of the on-site concrete batching plant; and
- Operation of the on-site water treatment plant.

As outlined in **Section 1.3**, these activities were assessed in AECOM (2014). Details of that assessment are replicated in this document, and are considered indicative of the worst-case emissions and associated air quality impacts associated with the remaining works to be undertaken on site under the proposed Concept Plan.

The peak activity assessment (AECOM, 2014) consisted of dispersion modelling undertaken using the CALPUFF model to predict pollutant concentrations at sensitive receptor locations located close to the site. The following pollutants were assessed:

- Nitrogen dioxide;
- Particulate matter;
- Heavy metals;
- Volatile organic compounds;
- Polycyclic aromatic hydrocarbons; and
- Odour.

The dispersion model predictions were compared to relevant air quality guidelines to assess the effect of the emissions on existing air quality. The assessment was based on a conventional approach following the procedures outlined in the NSW Environment Protection Authority's (EPA) *Approved Methods for the Modelling and Assessment of Pollutants in NSW* (DEC, 2005).

This report presents the expected pollutant concentrations resulting from the greatest remaining amount of activity associated with the Concept Plan rather than those associated with the proposed modification works. It should be noted that the changes to the Concept Plan proposed under the current modification affect activities to be undertaken after the peak activity period occurs, and the existing monitoring and management procedures implemented by Lend Lease for the Barangaroo project as a whole would continue to be implemented as appropriate throughout the duration of the works on the Barangaroo South site. As such, the air emissions associated with the modified activities would be expected to be lower than the air emissions occurring during the peak activity period. The concentrations of air pollutants at sensitive receptors due to the modified activities would also, therefore, be expected to be lower than the concentrations predicted in this report.

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2.0 Project Location and Development Description

2.1 Site Description, Land Use and Sensitive Receptors

The area of land that is subject to the Concept Plan Modification for the Barangaroo South Site is indicatively shown in **Figure 1**, and is herein referred to as the Site. It comprises an open apron over water and identified in the existing approved Concept Plan as Blocks 1 – 4, and the immediately adjacent public recreation area.

The Site is bordered by Sydney Harbour on the western side and by Hickson Road to the east. The closest receptors are located approximately 25 m to the east of the site boundary, on Hickson Road, and consist of residential and commercial properties. A number of finger wharves containing a mixture of residential and commercial developments are located directly opposite the Site, the closest being approximately 250 m west of the site, while the residential suburb of Balmain East is located approximately 400 m to the west of the northern end of the site. Details of the sensitive receptors incorporated into the dispersion modelling are provided in **Section 5.5**.

2.2 Modification Description

The Concept Plan was last substantially modified in December 2010 under MP06_0162 (MOD 4). The approved modification consisted of changes to the GFA, a redistribution of the land use mix, changes in the height of towers, and the establishment of a pier and landmark building, which extended into the harbour. The current modification, shown in **Figure 2**, seeks to amend the approved Concept Plan as follows:

- Relocate the landmark building (Block Y) from the harbour onto the land in the Barangaroo South site in front of the existing Blocks 4A, B and C;
- Revise the layout of Blocks 4A - C;
- Amend the size and location of the Southern Cove and public domain;
- Redistribute the GFA, public domain and land uses across development Blocks 1 - 3, 4A - C, X and Y;
- Increase the maximum GFA on the site to provide for additional GFA within the hotel building and redistribution of land uses;
- Increase the height of the buildings within modified 'Block 4' and the relocated Block Y; and
- Amend the conditions of the Concept Approval to reflect the modifications to development.

These modifications are not expected to substantially change air emissions expected to be generated from the construction of the proposed development.

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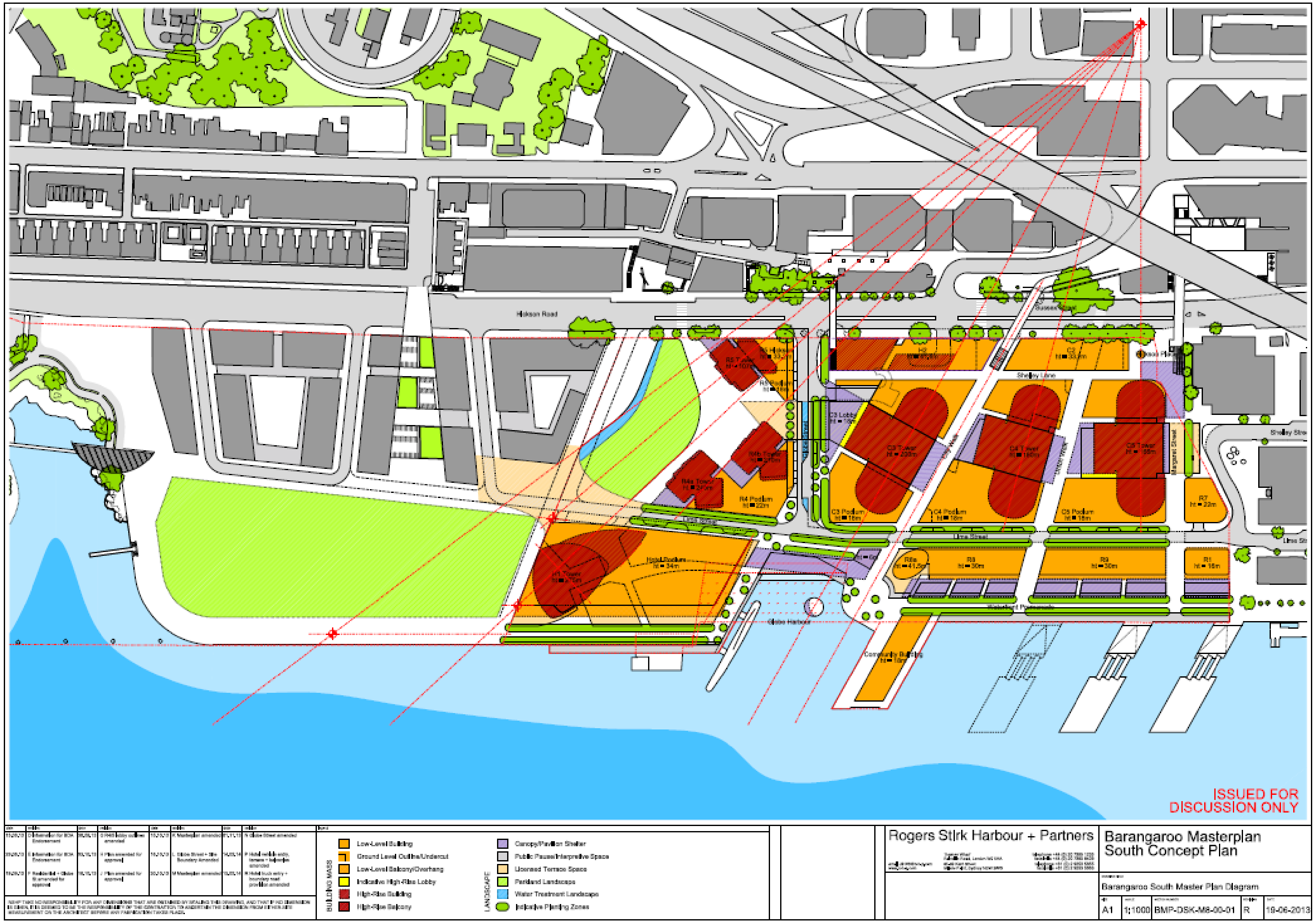

Figure 2 **Barangaroo South Concept Plan**

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2.3 Project Status

Construction works commenced in December 2011. Features currently being constructed include: finalisation of the Stage 1A basement works; commercial buildings Tower 1 (C3), Tower 2 (C4) and Tower 3 (C5); and residential buildings R8 and R9. Additional ongoing and proposed construction works for Blocks 1 - 4 are discussed in **Section 2.5**, which includes a construction programme. The works include:

- Remediation, excavation and basement construction works (Stage 1A and Stage 1B);
- Construction of commercial and residential buildings;
- Construction of a hotel;
- Construction of Globe Harbour; and
- Operation of a concrete batching plant.

A description of the remediation works required as part of Stage1B is presented in **Section 2.4**.

2.4 Stage 1B Basement Excavation and Remediation Works

2.4.1 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 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 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)
  - 38 Hickson Road (SP72797) Millers Point

The Barangaroo Delivery Authority has entered into a Voluntary Management Proposal (VMP) with the EPA associated with the Declaration Area (Approval No. 20101719). Phase 1 of this VMP involves investigative works and undertaking remedial design to determine and obtain agreement on a proposed remediation methodology. Phase 2 of the VMP (to be finalised following Phase 1) will involve the implementation of the agreed remediation works.

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.

2.4.2 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 as 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 Remedial Action Plan (RAP) (AECOM, 2013c) provides more specific details regarding the type, magnitude and location of ground contamination as identified in previous site investigations.

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2.4.3 Definition of Site

The Block 4 Remediation Area includes Development Block 4 (both within and outside the EPA Declaration Area) and the area immediately south of Development Block 4 and north of the Stage 1A basement groundwater retention wall system. A separate Development Application (SSD 5897-2013) prepared by Lend Lease is seeking approval for:

- Remediation of the Block 4 Remediation Area. Areas of the EPA Declaration Area that are outside the Block 4 Remediation Area (i.e. Block 5 and Hickson Rd) will be the subject of separate Development Applications;
- Construction of a basement groundwater retention wall system within part of the Block 4 Remediation Area;
- Remediation within the perimeter of the basement groundwater retention wall for future development use (herein referred to as the Block 4 Development Remediation Works);
- Diversion/augmentation of stormwater drainage infrastructure within the proposed basement groundwater retention wall system and to the south of the proposed basement groundwater retention wall and north of the existing Stage 1A basement; and
- Bulk excavation.

2.4.4 Remedial Action Plan

The proposed remediation of the Site is detailed in the RAP (AECOM, 2013c), including the extent of remediation required and the validation testing and monitoring to be undertaken. Remediation of the Block 4 Remediation Area is proposed to be undertaken using an ex-situ methodology; i.e. excavation of the contaminated soils prior to remediation.

The proposed works also include the augmentation and diversion of existing stormwater drainage infrastructure within the Site. This will involve decommissioning existing pipes and the construction of a new pipe network and associated water treatment system to connect to the existing Sydney Water Pipeline in the western part of the Site.

Separate Phase Gasworks Waste and Tar

For the purposes of this report, and as referred to in the RAP (AECOM, 2013c), gasworks-related contaminated materials will be referred to as Separate Phase Gasworks Waste and Tar, which include the following materials:

- Tar Containing Materials, as per the following definition:
  - Greater than 10% visible coal tar (where coal tar is a phase separated hydrocarbon by-product from coal gasification); and/or
  - Contaminant concentrations exceeding the following limits:
    - Polycyclic aromatic hydrocarbons (PAHs) - 2,000 mg/kg; or
    - Benzo(a)pyrene (B(a)P) - 150 mg/kg.
    - Dense Non Aqueous Phase Liquids.

2.5 Project Staging

A summary of both the ongoing and proposed construction programme, including anticipated start and finish times, is presented in **Table 1**. The programme below is inclusive of all major construction works that may potentially adversely affect air quality.

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Table 1 Summary of Barangaroo Stage 1A and Stage 1B Construction Programme

Construction Activity	Start	Finish
Stage 1A Basement	Quarter 4 2011	Quarter 2 2015
Concrete batching plant	Quarter 4 2011	Quarter 2 2015
Tower 1 (C3)	Quarter 1 2014	Quarter 3 2016
Tower 2 (C4)	Quarter 2 2013	Quarter 3 2015
Tower 3 (C5)	Quarter 3 2013	Quarter 1 2016
C2/C6 Above GF Only (GF+ 6 floors)	Quarter 3 2015	Quarter 3 2016
C8/H2 Above GF Only (GF+ 6 floors)	Quarter 1 2016	Quarter 1 2017
Residential 8 Above GF Only (GF+ 10 floors)	Quarter 2 2014	Quarter 3 2015
Residential 9 Above GF Only (GF+ 10 floors)	Quarter 2 2014	Quarter 3 2015
Stage 1B Basement	Quarter 3 2014	Quarter 2 2019
Tower R4a Construction	Quarter 1 2018	Quarter 3 2020
Tower R4b Construction	Quarter 4 2018	Quarter 3 2020
Tower R5 Construction	Quarter 3 2019	Quarter 2 2021
Hotel	Quarter 1 2016	Quarter 4 2019
Globe Harbour Construction	Quarter 4 2017	Quarter 3 2019

The proposed schedule of construction works was examined in detail to determine the worst case scenario to be assessed. **Table 2** presents a list of scheduled construction activities for the Project separated into six-monthly intervals between April 2014 and June 2018. April 2015 was determined to be the period when the most construction works would be occurring simultaneously and, therefore, was considered to represent the worst-case scenario for assessment. This scenario was assessed in AECOM (2014). Further details of the assumptions made in the modelling and the included activities are provided in **Section 5.0**.

The air quality impacts associated with the Block 5 and Hickson Road remediation works (which form part of the Stage 1B excavation stages) are the subject of separate Project Applications and associated AQIAs, which assess the concurrent remediation of Block 4, Block 5 and Hickson Road areas. The Block 5 and Hickson Road remediation activities are expected to commence after the concrete batch plant has ceased operation at the site. As previous AQIAs have identified that the concrete batching plant is the primary source of pollutant emissions on the site, the initial stages of the Block 4 works are expected to represent greater emissions than for either of the Block 5 and Hickson Road stages. As such, the results reported in this AQIA are considered to represent the worst-case air emissions associated with the remainder of the works covered by the Concept Plan.

Table 2 Scheduled Construction Activities

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Date	Development	Scheduled Construction Works
April 2014	Stage 1A Basement	- Piling
	Tower 2 (C4)	- Core construction - Structural slabs - Facade - Base building integrated finishes
	Tower 3 (C5)	- Core construction
	Residential 8 (Ground Floor plus 10 floors)	- Contraction of structure
	Residential 9 (Ground Floor + 10 floors)	- Contraction of structure
October 2014	Stage 1A Basement	- Structural Framework
	Tower 1 (C3)	- Core construction - Structural slabs - Facade - Base building finishes
	Tower 2 (C4)	- Facade - Base building integrated finishes
	Tower 3 (C5)	- Core construction - Structural slabs - Facade - Base building integrated finishes
	Residential 8 (Ground Floor plus 10 floors)	- Core and structural slabs - Finishes and commissioning
	Residential 9 (Ground Floor + 10 floors)	- Core and structural slabs - Finishes and commissioning
	Stage 1B Basement	- Install perimeter diaphragm wall and initial piling works - Remediation and excavation
April 2015	Stage 1A Basement	- Services and finishes
	Tower 1 (C3)	- Core construction - Structural slabs - Facade - Base building finishes
	Tower 2 (C4)	- Base building , integrated finishes and commissioning
	Tower 3 (C5)	- Facade - Base building finishes
	C2/C6 Above GF Only (GF+ 6 floors)	- Facade
	Residential 8 (Ground Floor plus 10 floors)	- Finishes and commissioning
	Residential 9 (Ground Floor + 10 floors)	- Finishes and commissioning
	Stage 1B Basement	- Remediation and excavation
October 2015	Tower 1 (C3)	- Facade - Base building finishes
	Tower 3 (C5)	- Base building , integrated finishes and commissioning
	C2/C6 Above GF Only (GF+ 6 floors)	- Facade - Base building finishes

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Date	Development	Scheduled Construction Works
	C8/H2 Above GF Only (GF+ 6 floors)	- Facade - Structure - Finishes and commissioning
	Stage 1B Basement	- Remediation and excavation
	Hotel	- Install perimeter diaphragm wall and piling works
April 2016	Tower 1 (C3)	- Base building , integrated finishes and commissioning
	C8/H2 Above GF Only (GF+ 6 floors)	- Structure - Finishes and commissioning
	Stage 1B Basement	- Remediation and excavation
	Hotel	- Remediation and excavation - Hotel tower construction
June 2018	Stage 1B Basement	- Basement structure, finishes and commissioning
	Tower R4a Construction	[Schedule breakdown not available]
	Tower R4b Construction	[Schedule breakdown not available]
	Tower R5 Construction	[Schedule breakdown not available]
	Hotel	- Hotel Tower Construction
	Globe Harbour Construction	[Schedule breakdown not available]

The indicative staging plan is shown in **Figure 3**.

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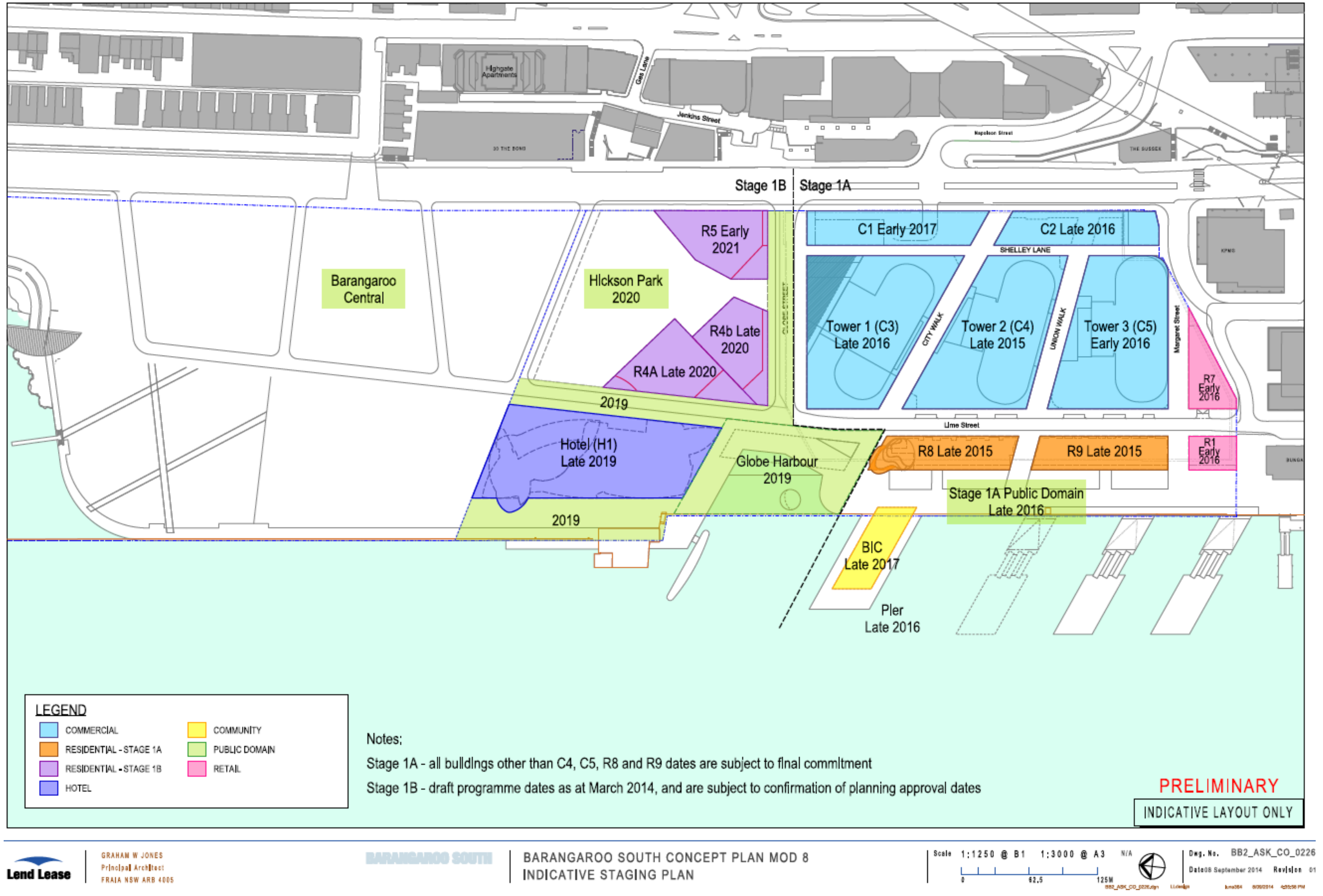

Figure 3 Indicative Staging Plan

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3.0 Pollutants of Interest

For the purposes of this AQIA, pollutants of potential 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;
- VOCs, including BTEX;
- PAHs; and
- Odour.

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

3.1 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, 2005a). 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

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Pollutant	Averaging Period	Criteria (µg/m^3)
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, 2005a) 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	

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.

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 2008 were adopted for this assessment for consistency with previous assessments undertaken for the Barangaroo site.

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 2008 ambient annual PM_{10} concentration of 17.4 $\mu g/m^3$, equates to an estimated annual TSP concentration of 35.5 $\mu g/m^3$.

The background concentrations used in this assessment are summarised in **Table 5**. 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 respective background concentrations provided in **Table 5** were not used in the cumulative assessment and should be considered as indicative concentrations only.

Table 5 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	75.2	246
	Annual	20.7	62
PM_{10}	24 hour maximum	43.1	50
	Annual	17.4	30
TSP [2]	Annual	35.5	90
Ozone [3]	1 hour maximum	109.8	214
	4 hour maximum	93.6	171
	Annual	27.1	-

[1] NO_2 contemporaneous background data used to predict background concentrations using the OLM detailed in **Section 5.7.1**.
[2] Calculated from annual PM10 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 are complementary and, together, provide an indication of the climate in the immediate area around Barangaroo. Long term data averages recorded between 1859 and May 2010 are summarised in **Appendix B**.

Average maximum temperatures in summer range from 25.9 °C to 25.2 °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.

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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, and affects local wind patterns; high rise buildings may also potentially affect wind patterns at the Site.

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5.0 Dispersion Modelling Methodology

5.1 Overview

As stated previously, the air emissions associated with the early stages of the Block 4 excavation works, assessed in AECOM (2014), are expected to represent the worst-case air emissions associated with the remainder of works to be undertaken under the Concept Plan. Details from AECOM (2014) are replicated in the following sections.

The modelling for AECOM (2014) 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, 2005a);
- 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 air dispersion model was used in accordance with the EPA Approved Methods (DEC, 2005a). 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, such as the Site.

The CALPUFF input parameters used in AECOM (2014) are summarised in **Table 6**.

Table 6 CALPUFF Input Parameters

Parameter	Input
CALPUFF version	6.42 - March 2011
Modelling domain	3 km x 3 km
Modelling grid resolution	20 m
Terrain data	Included in CALMET
Building wake data	Not included in model
Dispersion algorithm	PG (Rural, ISC curves) & MP Coeff. (urban)
Hours modelled	8760 hours (365 days)
Meteorological data period	1 January 2008 – 31 December 2008

More details of the 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. Data used in previous air quality assessments for the Barangaroo development, considered representative of local conditions and appropriate for use in dispersion modelling, were used in AECOM (2014) for consistency. Further details are provided in AECOM (2010a).

Meteorological data were obtained from two sources in the area immediately surrounding the Barangaroo Site. Hourly averaged meteorological data for 2008 were sourced from the Rozelle monitoring station (operated by the

EPA) and the Fort Denison and Observatory Hill meteorological stations operated by the Bureau of Meteorology (BOM) for the following parameters:

- Observatory Hill - rainfall and temperature;
- Fort Denison - wind speed and direction; and
- Rozelle - wind speed, wind direction, sigma theta, temperature, relative humidity, and solar radiation.

These data were used as input to CALMET as surface file data. The CSIRO-developed prognostic model, TAPM (The Air Pollution Model), was used to define the upper air meteorology for the area surrounding Barangaroo. TAPM data were entered into CALMET as an initial guess for the Site meteorological conditions, together with the surface meteorological data recorded at Rozelle, Observatory Hill and Fort Denison.

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 for an area of approximately 7.2 km x 7.2 km (corresponding to the innermost grid of the TAPM meteorological data modelling), approximately centred on the site, from the global SRTM database. The 90 m resolution data were included in the CALMET GEO.dat input file and used together with the TAPM, EPA and BOM meteorological data for determination of the three dimensional modelling meteorological data file required by CALPUFF.

The potential impacts of the proposed and approved works were assessed through the analysis of two scenarios. The first scenario represented the expected worst case emissions, while the second represented the more likely scenario as described below.

Scenario 1: Worst Case Cumulative Emissions

This scenario represented the expected highest levels of all on-site activities that may occur during the Block 4 remediation works. It was developed based on information regarding the expected staging of the works provided by Lend Lease. The worst case operational scenario assessed the concurrent occurrence of the following works:

- Block 4 remediation activities;
- Construction works associated with the C3, C4, C5, R8 and R9 buildings;
- Operation of the on-site concrete batching plant; and
- Operation of the on-site water treatment plant.

It should be noted that the construction of retaining walls was not included in the modelling scenarios as previous assessments demonstrated that these works are a minor source of emissions in comparison to the excavation works. As the Stage 1A basement works will be completed by the time the Block 4 works commence, these activities were also excluded from the modelling.

Scenario 2: Likely Case Scenario

In addition to the worst case scenario outlined above, a more realistic scenario was also considered. The C4, C5, R8 and R9 buildings are expected to be at the finishing stages of their construction at the time the Block 4 excavations are undertaken; such works are expected to generate little, if any, air emissions. As such, the second scenario assessed the activities most likely to overlap at the peak activity stage, which were:

- Block 4 remediation activities;
- Construction works associated with the C3 building;
- Operation of the on-site concrete batching plant; and
- Operation of the on-site water treatment plant.

5.2.3 Assumptions

All emission sources associated with the Block 4 remediation works were assumed to be contained within Odour Control Structures (OCSs)/Treatment Tents except for trucks hauling materials between the structures and off-site for disposal or piling rigs used during retention wall construction. Emissions from plant, equipment and activities within the OCSs were estimated using emission factors, summed, and assumed to be filtered before being released to the atmosphere. Each OCS was assumed to release emissions at a constant rate from a single stack. Emissions associated with the construction of the C3, C4, C5, R8 and R9 buildings and the concrete batching plant were the same as those used in AECOM (2012), while emissions associated with the water treatment plant were assumed to be the same as those used in AECOM (2011) for a water flowrate of 25 L/s. Further details regarding the assessment and the activities to be undertaken during the remediation works can be found in AECOM (2014).

5.3 Source Characteristics

The source characteristics used in AECOM (2014) are summarised in the following sections. Indicative source locations used in the modelling are shown in **Figure 4** .

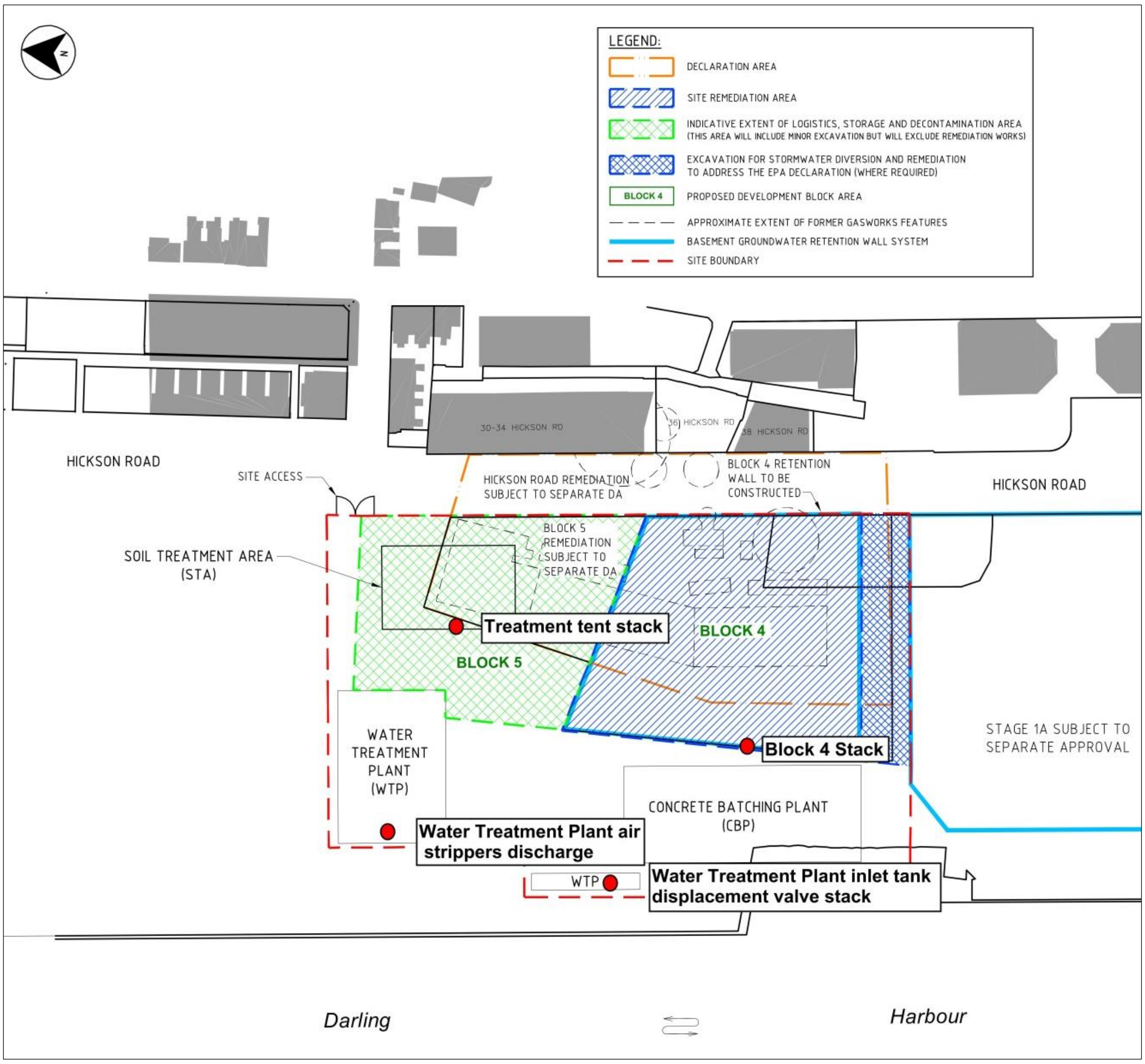

Figure 4 **Indicative Source Locations**

5.3.1 Block 4

For emission calculation purposes, the Block 4 excavations were assumed to be undertaken for 10 hours per day at a rate of 350 tonnes per day. Details of the equipment and stack characteristics are provided in the following tables.

Table 7 **Block 4 Excavation Equipment**

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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 8 Block 4 Excavation OCS Stack Characteristics

Details	Value	Units
Tent height	14	m
Stack height	4	m
Velocity	25	m/s
Exit area	0.45	m^2
Diameter	0.76	m
Volumetric flow rate	11.2	m^3/s
Temperature	25	^oC

5.3.2 Treatment Tent

If on-site remediation is undertaken for Block 4, excavated soil may be transported by truck to a Treatment Tent for treatment. The Treatment Tent would be maintained under negative pressure to contain all emissions generated within it, such that all emissions would be emitted through a stack after being filtered; as such, no fugitive emissions were included in the dispersion modelling for this source. The plant expected to operate within the tent are summarised in **Table 9**. The characteristics of the Treatment Tent emission stack are provided in

Table 10. The Treatment Tent was assumed to operate for ten hours per day processing 35 tonnes per hour.

Table 9 Treatment Tent Equipment

Plant/Equipment	Number	Notes
Excavator	1	
Front end loader	1	
Skid steer bobcat	2	loader
Pug mill	2	screen
Trucks	70	trips per day (off-site)

Table 10 Treatment Tent Stack Characteristics

Details	Value	Units
Tent height	15	m
Stack height	4	m

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Details	Value	Units
Velocity	25	m/s
Exit area	0.82	m^2
Diameter	1.02	m
Volumetric flow rate	20.4	m^3/s
Temperature	25	^oC

5.3.3 Water Treatment Plant

The Water Treatment Plant (WTP) will 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 11**.

Table 11 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

5.3.4 Buildings C3, C4, C5, R8 and R9

Emission source characteristics for the commercial and residential buildings are outlined in **Table 12**. Forklifts and concrete pumps were modelled as ground level point sources. There were assumed to be eighteen concrete trucks in total for these sources (four concrete trucks for each of buildings C3, C4 and C5 and two concrete trucks for both R8 and R9). Two forklifts per building (ten in total) and two concrete pumps per building (ten in total) were also modelled.

Table 12 Emission Source Characteristics – Buildings

Source	Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)
Cement trucks	4	5	0.1	10	349.2
Forklifts	3	5	0.3	14.6	624.2
Concrete pumps	3	5	0.1	14.6	624.2

5.3.5 Trucks

Trucks associated with the Block 4 OCS were assumed to move all excavated material from the excavation areas to the Treatment Tent. Trucks associated with the Treatment Tent were assumed to transport all material off-site for reuse/disposal. 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) (refer to AECOM [2014] for more details).

5.4 Emissions Inventory

Emissions from the 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).

The construction works are expected to occur between the hours of 7 am – 6 pm Monday to Friday and 7 am – 5 pm on Saturdays. No works are expected on Sundays. For modelling purposes, constant emission rates were entered into the model between 7 am – 6 pm, 7 days per week, for all activities, which was a conservative approach that may over-predict the ground level concentrations for annual averaging periods.

The OCSs were each assumed to be serviced by two activated charcoal filtration units. The reduction efficiencies of the filtration units applied for particulates, VOCs and odour were developed following liaison with a contractor. The NO_X reduction efficiencies (where applied) were based on published literature (Nelson and Babyak, 1996). The total reduction efficiencies assumed for each tent are provided in **Table 13**.

Table 13 OCS 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
* This reduction efficiency was examined further by means of a sensitivity analysis outlined in **Section 6.2**		

VOC Emissions

A number of contaminants within the area of the Barangaroo site requiring remediation (the Declaration Area) are VOCs. The EPA does not have a criterion for total VOCs or for many of the contaminant pollutants. VOCs/potential VOCs identified on site (BTEX, PAHs, phenol, semi VOCs and VOCs) were summed to provide total VOC emission rates, which were used in the modelling. Further details are provided in AECOM (2014) and **Section 5.7.3**.

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, 2005a) 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). The contaminants identified on site through soil sampling and vapour testing were:

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

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, 2005a). 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 OCS and Treatment Tent areas to calculate the

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odour emission rates. Half of the OCS area was assumed to actively emit odour at any time (3,244 m^2 for Block 4 and 1,207.5 m^2 for the Treatment Tent).

5.4.1 Block 4

Details of the emission rates for the Block 4 excavation OCS are provided in **Table 14**.

Table 14 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)	1.45	0.029
TSP (g/s)	4.80	0.096
Combustion VOC (g/s)	5.6	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		

Truck emissions were apportioned to a single volume source. The emission rates per volume source associated with Block 4 are provided in **Table 15**.

Table 15 Block 4 Truck Emissions

Pollutant	ER (g/s/source)
NO_X	0.00054
PM_{10}	0.00224
TSP	0.01149
VOCs	0.00005

5.4.2 Treatment Tent

Details of the emission rates for the on-site soil treatment option OCS are provided in **Table 16**.

Table 16 Treatment Tent Stack Emission Rates

Pollutant	Total Emission Rates	
	Before filtration	After filtration
NO_X (g/s)	1.66	0.41

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Pollutant	Total Emission Rates	
	Before filtration	After filtration
PM_{10} (g/s)	0.09	0.002
TSP (g/s)	0.18	0.004
VOC (g/s)	5.56	0.011
Odour (OU/s)	19,803	40
Benzene	0.05	0.00010
Ethylbenzene	0.04	0.00008
Toluene	0.07	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		

Truck emissions were modelled as a single volume source. The emission rates for trucks associated with the Treatment Tent are provided in **Table 17**.

Table 17 Treatment Tent Truck Emissions

Pollutant	ER (g/s/source)
NO_X	0.00008
PM_{10}	0.00618
TSP	0.03209
VOC	0.000001

5.4.3 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 WTP point sources are shown in **Table 18**.

Table 18 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.

5.4.4 Concrete Batching Plant

The concrete batching plant was assumed to be located on a hardstand area, and the concrete trucks were assumed to drive on paved areas. Source characteristics of the concrete batching plant sources are outlined in **Table 19**. Wind erosion and stockpiling were modelled as area sources; the front end loader and materials processing were modelling as volume sources. TSP emission factors are not provided by the NPI for wind erosion, stockpiling and materials processing for concrete batching plants; TSP was assumed to comprise only PM_{10} for these sources.

Table 19 Emission Source Characteristics and Emission Rates – Concrete Batching Plant

Sources	PM_{10} (g/s)	PM10 (g/s/m^2)	TSP (g/s)	TSP (g/s/m^2)	Hours of Operation
Wind erosion - storage bins, eastern side	0.001	0.000004	0.001	0.000004	continuous
Wind erosion - storage bins, southern side	0.001	0.000004	0.001	0.000004	continuous
Stockpiling/dumping raw materials	0.027	0.00006	0.074	0.00017	10 am - 4 pm
Front end loader	0.51	-	0.9	-	7 am - 6 pm
Materials processing	0.38	-	0.38	-	7 am - 6 pm

Details of the calculations and assumptions made for this activity are summarised in **Table 20**.

Table 20 Emission Calculations - Materials Handling

Activity	Value	Units	Notes
Sand and aggregate transfer to bin			
Activity rate	372	t/hour	
Overall control efficiency	90	%	Enclosed conveyor (2/3 sides)
Emissions	0.52	kg/hour	
Cement unloading to elevated storage silo			
Activity rate	38	t/hour	pneumatic
Overall control efficiency	99.9	%	enclosed and filtered
Emissions	0.005	kg/hour	
Weigh hopper loading			
Activity rate	410	t/hour	
Overall control efficiency	99.9	%	enclosed and filtered
Emissions	0.004	kg/hour	
Mixer loading			
Activity rate	423	t/hour	
Overall control efficiency	90	%	enclosed (2/3 sides)
Emissions	0.85	kg/hour	
Total emissions	**1.37**	**kg/hour**	
	0.38	**g/s**	

5.4.5 Buildings C3, C4, C5, R8 and R9

Source characteristics of the emission sources for the buildings are outlined in **Table 21**. All plant were assumed to remain at ground level. All emission sources associated with the buildings were modelled as point sources. Further details can be found in AECOM (2014).

Table 21 Emission Rates – Buildings

Source	Emission Rates (g/s)		
	NO_X	PM_{10}	TSP

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Source	Emission Rates (g/s)		
	NO_X	PM_{10}	TSP
Cement trucks	0.11	0.01	0.01
Forklifts	0.19	0.01	0.01
Concrete pumps	0.36	0.001	0.001

5.5 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, 2005a). The receptors assessed in AECOM (2014) were selected to be the most representative sensitive receptors in proximity to the proposed works. A total of 104 receptors were assessed, which were primarily located along the eastern side of Hickson Road at various heights. The receptor locations are shown in **Figure 5** and detailed in **Appendix C**.

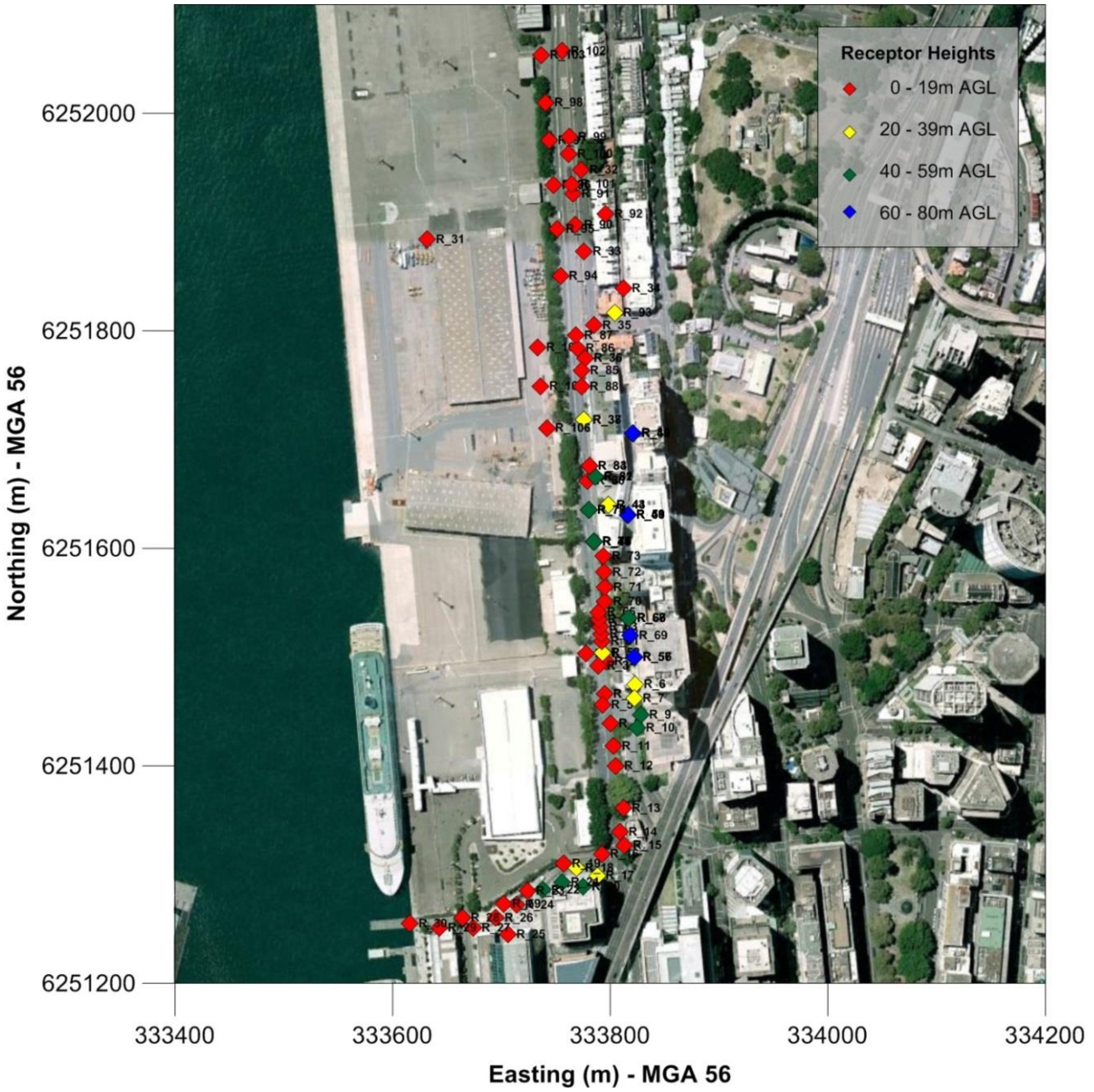

Figure 5 **Sensitive Receptor Locations**

5.6 Prediction of Cumulative Impacts

DEC (2005a) specifies that AQIAs are to assess the cumulative impact of a proposal against the EPA's impact assessment criteria. This involves adding existing background pollutant levels and expected pollutant levels from other concurrent developments to maximum pollutant concentrations of criteria pollutants predicted by dispersion modelling. Criteria pollutants addressed in this assessment were NO_2, PM_{10} and TSP.

In AECOM (2014), the assumed ambient pollutant concentrations of TSP were added to the predicted pollutant concentrations, and the cumulative concentrations were compared to the relevant criterion. For 1 hour PM_{10} and NO_2, contemporaneous assessments were made using hourly data for the modelling period from the EPA's Rozelle monitoring station. Contemporaneous assessments pair ambient pollutant concentrations with the predicted project contributions for each relevant time period. For example, ambient 24 hour PM_{10} concentrations for each day of the modelling period are matched to the corresponding model predictions for those days, and then added to form the cumulative concentration.

Other works on the Barangaroo Site will occur at the same time as the remediation works. Assessment of these sources as outlined in AECOM (2014) is described below.

5.6.1 Basement Works

Works associated with the basement occurring concurrently with the Block 4 remediation and landforming works are expected to involve the installation of services and finishes and, potentially, some structural work. As buildings C3, C4, C5, R8 and R9 will be constructed above the basement area, any residual works associated with the basement would be below ground level and/or of a minor nature in terms of air quality emissions. As such, these sources were not considered in the assessment.

5.6.2 Wynyard Walk

The Wynyard Walk works include demolition, tunnelling, and construction of paved areas and a pedestrian bridge, which can potentially result in the release of dust. Detailed Construction Environmental Management Plans were prepared for Stage 1 and Stage 2 of the works by Thiess (2012, 2013), which include detailed air quality management measures. Provided these measures are implemented, the Wynyard Walk works are not expected to substantially add to the cumulative impacts experienced at sensitive receptors.

5.6.3 Barangaroo Central Waterfront Promenade and Interim Public Domain and Headland Park

The works associated with the Barangaroo Central waterfront promenade and interim public domain area are the works to provide the public domain along the western portion of the Barangaroo Site. The potential air quality impacts associated with these works were assessed in a separate report (JBS, 2012), which also included the contribution from the Headland Park works. The predicted pollutant concentrations associated with those works were added to the concentrations predicted by the dispersion modelling undertaken for AECOM (2014), where applicable, to predict cumulative concentrations.

5.6.4 Block 5 and Hickson Road

The air quality impacts associated with the Block 5 and Hickson Road remediation works are the subject of separate Project Applications and associated AQIAs. As noted in **Section 1.4,** the works assessed in AECOM (2014) are expected to represent greater emission levels than will occur during the Block 5 or Hickson Road remediation stages. It should be noted that the Block 5 and Hickson Road assessments included emissions associated with the Block 4 works.

5.7 Assessment of Contaminants

5.7.1 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 nitrogen dioxide (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 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

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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 (2005a). Background O_3 data from the Rozelle monitoring station (refer to **Section 4.1**) were used to convert the modelled NO_2 concentrations in accordance with the EPA approved OLM (Method 2, Level 2 Assessment; DEC, 2005a).

5.7.2 VOCs

The EPA does not have a criterion for total VOC emissions. VOC emissions associated with the soil contamination were estimated using the percentage of the pollutants in the soil samples as shown in **Table 22** (AECOM, 2010b). It should be noted that the percentages shown in **Table 22** 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 in AECOM (2014). VOC emissions associated with combustion engines were modelled as total VOCs as speciation data were not available.

Table 22 VOC Components

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

5.7.3 Toxic Pollutants

The concentrations of heavy metals, benzo(α)pyrene and cyanide at sensitive receptor locations were estimated using the predicted ground level concentrations of TSP. The proportions of heavy metals and cyanide in the soils (AECOM, 2010b) were 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 23**; these were converted to a proportion of metals in soil to enable the heavy metal concentrations to be estimated from the TSP results.

Table 23 Site-Specific Soil Concentrations of Miscellaneous Toxic Pollutants

Pollutant	Average Concentration (mg/kg)	Proportion of Metals in Soil (%)
Arsenic	4	0.0004
Benzo[α]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

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6.0 Results

The results of the dispersion modelling from AECOM (2014) are shown below. The results show the total cumulative pollutant concentrations of the Block 4 remediation works coupled with a selection of construction emissions from buildings C3, C4, C5, R8 and R9 and the operation of the concrete batching plant and the water treatment plant; these sources are expected to represent the peak pollutant-generating activity for the remainder of the works to be undertaken under the Concept Plan.

6.1 Modelling Predictions

The maximum results predicted at any sensitive receptor assessed are provided in **Table 24** for the worst case and likely emissions scenarios. The results represent the 100th percentile concentrations for NO_2, PM_{10} and TSP; the 99.9th percentile concentrations for benzene, ethylbenzene, toluene, xylenes, naphthalene and phenol; and the 99th percentile concentrations for odour in accordance with DEC (2005a). The concentrations presented for NO_2, PM_{10} and TSP represent cumulative concentrations as required by the EPA for these criteria pollutants, i.e. these numbers represent the contribution from the proposed operations added to the ambient concentrations. 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 ambient pollutant concentrations for each hour of the modelling period were matched to the hourly/24 hourly modelling predictions.

The EPA does not have a criterion for total VOCs. In order to assess this group of pollutants, the 99.9th percentile VOC concentration from all sensitive receptors assessed (6.3 $\mu g/m^3$) was added to the predicted 99.9th percentile benzene concentration (2.5 $\mu g/m^3$) and compared to the benzene criterion to provide a very conservative assessment. This resulted in a maximum predicted concentration of 8.8 $\mu g/m^3$, which is lower than the benzene criterion (29 $\mu g/m^3$).

Table 24 Dispersion Modelling Results

Pollutant	Averaging Period	Units	Maximum Predicted Pollutant Concentrations		Criteria
			Scenario 1	Scenario 2	
NO_2	1 hour	$\mu g/m^3$	**377***	**250.6***	246
	Annual	$\mu g/m^3$	62* (20.7)	53.2 (20.7)	62
PM_{10}	24 hour	$\mu g/m^3$	**142***	**141***	50
	Annual	$\mu g/m^3$	29.9* (17.4)	28.5* (17.4)	30
TSP	Annual	$\mu g/m^3$	55* (35.5)	54.5* (35.5)	90
VOCs	1 hour	$\mu g/m^3$	8.8#	8.8#	29^
Benzene	1 hour	$\mu g/m^3$	2.5	2.5	29
Ethylbenzene	1 hour	$\mu g/m^3$	0.27	0.27	8,000
Toluene	1 hour	$\mu g/m^3$	1.55	1.55	360
Xylenes	1 hour	$\mu g/m^3$	0.58	0.58	190
Naphthalene	1 hour	$\mu g/m^3$	17.2	17.2	440
Phenol	1 hour	$\mu g/m^3$	0.22	0.22	20
Odour	1 hour	OU	0.02	0.02	2

* Barangaroo South cumulative concentration
# Represents total VOCs plus benzene (99.9th percentile) but excluding naphthalene
^ The EPA does not have a criterion for total VOCS; as such, the benzene criterion was used as described in the text.
Concentrations in parentheses represent the ambient pollutant concentrations from **Table 5**. These are not provided for 1 hour NO_2 and 24 hour PM_{10} due to the nature of the contemporaneous assessment.
NRT = Nose response time Exceedences denoted in **bold type**

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The EPA criteria for air toxics apply at and beyond the boundary of the facility. The concentrations reported above represent the highest 99.9th percentile concentrations for any sensitive receptor assessed, including those located on the boundary and those beyond it.

As shown, exceedences of the EPA criteria for 1 hour NO_2 and 24 hour PM_{10} were predicted to occur for both scenarios when the proposed works were assessed cumulatively. The predicted maximum annual NO_2 concentration was on the criterion level. Further discussion is provided in the following sections. The numbers of exceedences at each sensitive receptor for Scenario 1 are shown in **Appendix D**.

6.1.1 Particulates

The concrete batching plant was considered to be the likely cause of the predicted exceedences of the 24 hour PM_{10} criterion (AECOM, 2014). Emissions from this activity are expected to be manageable through operational practices and reactive management strategies such as real time particulate monitoring (which is currently successfully being used on the site to minimise particulate impacts). It should be noted that the Block 4 remediation works have received development approval.

As indicated in **Section 5.6**, concurrent works occurring at Barangaroo Central and Headland Park at the time of the Block 4 land forming and remediation are likely to emit particulates. The receptors assessed in JBS (2012) were matched to the receptors in the current assessment, and added to the AECOM (2014) predictions to determine cumulative particulate concentrations, which are shown in **Table 25**. The maximum predicted concentrations from each of the work areas (Barangaroo South (Scenario 1), Barangaroo Central and Headland Park) are presented, representing the worst case potential concentrations.

Table 25 Cumulative Particulate Concentrations (μg/m^3) – Barangaroo South, Barangaroo Central and Headland Park

Source	24 Hour PM_{10}			Annual PM_{10}			Annual TSP		
	R6	R19	R29	R6	R19	R29	R6	R19	R29
Barangaroo South Works	31.1	**63.5**	14.9	5.0	8.3	2.4	6.8	9.2	2.7
Barangaroo Central and Headland Park	3.6	49.0	**61.2**	0.5	13.1	16.0	1.0	26.2	33.2
Ambient concentration	43.1			17.4			35.5		
Total pollutant level	**78**	**156**	**119**	23	**39**	**36**	43	71	71
Criteria	***50***			***30***			***90***		

All concentrations presented in μg/m^3
The JBS receptors were matched to AECOM receptors as closely as possible. The closest matches were as follows: AECOM R6 matched JBS receptor 3; R19 matched JBS receptors 1 and 2 – the maximum values (receptor 2) were used here to be conservative; R29 matched JBS receptor7.

As shown, the concurrent works across the Barangaroo site have the potential to result in a number of exceedences of the PM_{10} criteria, with potentially very high hourly concentrations experienced on occasion. No exceedences of annual TSP were predicted. As explained in AECOM (2014), however, these estimates are expected to be very conservative and unlikely to occur in practice. Regardless, the results clearly demonstrate that appropriate management and mitigation of emissions is required for all works associated with the Barangaroo site.

Lend Lease has implemented an extensive reactive air quality management plan for the current Blocks 1 - 3 excavation works being undertaken on site, which is described in **Section 8**. The objective of this plan is to enable the ongoing monitoring of emissions and potential impacts and, where exceedences occur, enable the relevant emission sources to be proactively managed. Due to the generally conservative nature of dispersion modelling, extension of the existing monitoring and reactive management plan to incorporate additional monitoring sites located close to the proposed remediation works is expected to be a viable method for addressing the predicted exceedences of PM_{10}.

6.1.2 Nitrogen Dioxide

Exceedences of the 1 hour NO_2 criterion were predicted to occur at 21 of the 104 sensitive receptor locations assessed for Scenario 1, and at two of the modelled receptors for Scenario 2 in AECOM (2014). The difference in predicted exceedences between the two scenarios was directly related to the differences in the expected cumulative construction activities assessed. As many of the pollutant emitting activities associated with the construction of C4, C5, R8 and R9 buildings, particularly vehicle movements, are expected to be completed by the time Block 4 remediation commences, the NO_2 concentrations are expected to be more realistically predicted by Scenario 2 rather than Scenario 1, which broadly lumps all worst case emissions into one scenario.

The highest number of exceedences were predicted to occur for Scenario 1 at the southern end of the site[1] at R_19, which is a commercial building (26 exceedences), and at R_23, which is situated on a public walkway (25 exceedences) – due to the nature of these receptors, individuals are not expected to be affected on multiple occasions. A chart showing the times of the exceedences and the number of affected receptor locations is shown in **Figure 6**. Exceedences were predicted to occur for 65 hours of the year (0.7 % of the modelled hours).

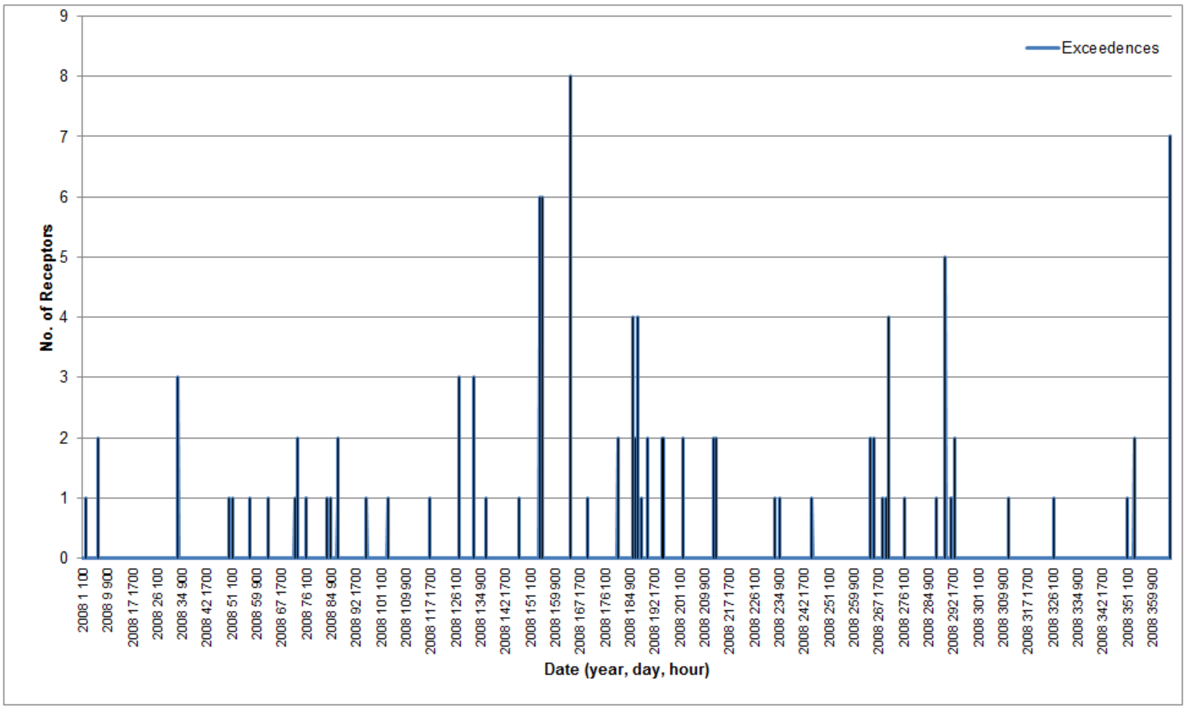

Figure 6 Predicted Numbers of Exceedences of the 1 Hour NO_2 Criterion

A sensitivity analysis was undertaken in AECOM (2014) to further investigate the predicted exceedences in NO_2 concentrations. The analysis suggested that the exceedences of 1 hour NO_2 were likely to be due to a combination of conservative emission factors and the assumption that the plant were operating on buildings C3, C4 and C5 concurrently when the operations of Block 4 were underway. Conservatism built into the modelling methodology included:

- Placing major sources of NO_X on the site boundary for the modelling, including mobile plant equipment such as concrete trucks;
- Assuming all mobile construction equipment will operate continuously within the construction hours of 7am to 6 pm; and
- Assuming forklifts will be diesel powered, when they will likely be dual powered and are expected to primarily operate on LPG.

These 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 (as demonstrated by the results of Scenario 2). On this basis, monitoring of the NO_2 during the works was not considered necessary.

[1] Refer to **Appendix C** for the location and description of sensitive receivers and **Appendix D** for the number of predicted exceedences at each receptor.

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6.1.3 Metals

Predicted concentrations of metals from AECOM (2014) are shown in **Table 26**. The EPA criteria for metals relate to the 99.9th percentile for assessments that use site specific data, such as AECOM (2014). As such, the concentrations of metals were estimated based on a1 hour TSP concentration of 369 µg/m^3 (the maximum 99.9th percentile of any sensitive receptor assessed from Scenario 1). No exceedences were predicted.

Table 26 Predicted Pollutant Concentrations - Metals

Pollutant	Estimated Concentrations (99.9th percentile) (µg/m^3)	Criteria (99.9th percentile) (µg/m^3)
Arsenic	0.001	0.1
Benzo[α]pyrene	0.007	0.4
Beryllium	0.0002	0.004
Cadmium	0.0002	0.018
Chromium (III+VI)	0.0074	0.09
Copper	0.018	18
Cyanide	0.007	90
Lead	0.074	0.5
Manganese	0.074	18
Mercury	0.0001	0.18
Nickel	0.004	0.18
Zinc	0.037	18

6.2 Odour Mitigation Capture Efficiency Sensitivity Analysis

A sensitivity analysis was reported in AECOM (2014) to determine how different odour removal efficiencies of the filtration equipment to be employed for the OCSs might affect the modelling results. The analysis indicated that reduction efficiencies between 99.8% and 90 % effectiveness would result in odour concentrations lower than the criterion (2 OU) at all assessed sensitive receptor locations. As reduction efficiencies between 98 and 99% are considered the norm for the activated charcoal scrubbers proposed to be used for the remediation works, the ability of the facility to operate within the criteria at an efficiency of 90 % provides a good margin of safety for the project.

6.3 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 AECOM (2014). The numbers used were based on information available at the time of preparation of that report, and may change to reflect the detailed design of the remediation activities.

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7.0 Comparison of Proposed Concept Plan with Approved Concept Plan

The air quality impacts associated with the approved Concept Plan were assessed in AECOM (2012). For that assessment, dispersion modelling was undertaken for the following sources:

- The construction of the R8 and R9 Buildings;
- Construction of sections of buildings C3, C4 and C5; and
- Operation of an on-site concrete batching plant.

In contrast, AECOM (2014) assessed all of the sources listed above as well as the Block 4 remediation works and the operation of an on-site water treatment plant. The AQIA for the approved Concept Plan (AECOM, 2012) did not consider the remediation works and, as such, did not assess air toxics or metals. As such, only particulate and NO_2 predictions of the 2012 and 2014 concept plans can be compared. The maximum modelling predictions of those pollutants from both assessments are compared in **Table 27**. The data represent the project contributions added to ambient pollutant concentrations (i.e. cumulative concentrations), but do not include works outside the Barangaroo South area (i.e. Headland Park etc.).

Table 27 Comparison of Approved Concept Plan with Proposed Concept Plan – Cumulative NO_2 and Particulate Concentrations.

Pollutant	Approved Concept Plan (AECOM, 2012)	Proposed Concept Plan (AECOM, 2014)	
		S1	S2
1 hour NO_2	417.2	377.0	250.6
Annual NO_2	62.8	62.0	53.2
24 hour PM_{10}	110.5	142.0	141.0
Annual PM_{10}	29.5	29.9	28.5
Annual TSP	50.3	55.0	54.5

As shown, the 1 hour NO_2 concentrations for the approved 2012 Concept Plan were higher than those expected for the peak activity emissions for the proposed 2014 Concept Plan. This is attributed to a different assessment methodology between the two assessments, specifically the inclusion of cranes in the AECOM (2012) modelling. These sources were removed from subsequent assessments as they are now expected to be electrically powered rather than diesel powered. The annual NO_2 concentrations predicted by both assessments were quite similar.

For 24 hour PM_{10}, the proposed 2014 Concept Plan is expected to result in higher concentrations, primarily due to the operation of the concrete batching plant. Annual PM_{10} concentrations, however, were essentially unchanged between the two assessments. The TSP concentrations were also similar between the two assessments, but slightly higher for the proposed Concept Plan.

As a comparison with past Concept Plan modifications (2010) and their associated impacts, the pollutant concentrations predicted for the MOD 4 (bulk excavation activities) assessment also exceeded the EPA criteria for 24 hour PM_{10} (151 $\mu g/m^3$), annual PM_{10} (44.5 $\mu g/m^3$) and 1 hour NO_2 (2,229 $\mu g/m^3$); the predicted pollutant concentrations for that assessment (AECOM, 2010) were much higher than those predicted for MOD 7 or the Block 4 remediation works.

Monitoring undertaken during the basement excavation works, however, indicated that actual pollutant concentrations were much lower than the modelling predictions. Lend Lease has monitored levels of PM_{10} at three locations within the site since February 2012. As shown in **Figure 7**, the PM_{10} rolling annual average has remained below the EPA criterion of 30 $\mu g/m^3$ throughout the monitoring period, including when the bulk excavation works associated with MOD 4 were being undertaken. While occasional exceedences of the 24 hour criterion have been recorded on the site (refer to **Figure 8** for data recorded between 2012 and 2013), the scale and number of exceedences are well below those predicted by the dispersion modelling. The monitoring and mitigation works implemented by Lend Lease are, therefore, considered to be effective at minimising air emissions associated with the on-site activities.

In summary, there are some differences in the predicted pollutant concentrations for the approved and proposed Concept Plans. It should be noted, however, that the results presented in this report (from AECOM, 2014)

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represent the peak emissions expected for any remaining activity to be undertaken under the Concept Plan. It should also be noted that the developments assessed in AECOM (2010), AECOM (2012) and AECOM (2014) were approved with the predicted pollutant concentrations.

The modification to the Concept Plan would result in an extended construction timetable, due to staging changes, and construction works undertaken over a larger area, but the scale of the development and its associated air emissions will not change compared to the approved MOD 4 Concept Plan. The cumulative impacts occurring during the proposed modifications would be expected to be lower than those occurring during the future peak activity period and lower than those that occurred during the basement excavation works. Furthermore, all emissions associated with the Concept Plan are expected to be adequately managed by the existing management and monitoring system implemented on the site, which will continue as required for the duration of the Concept Plan works.

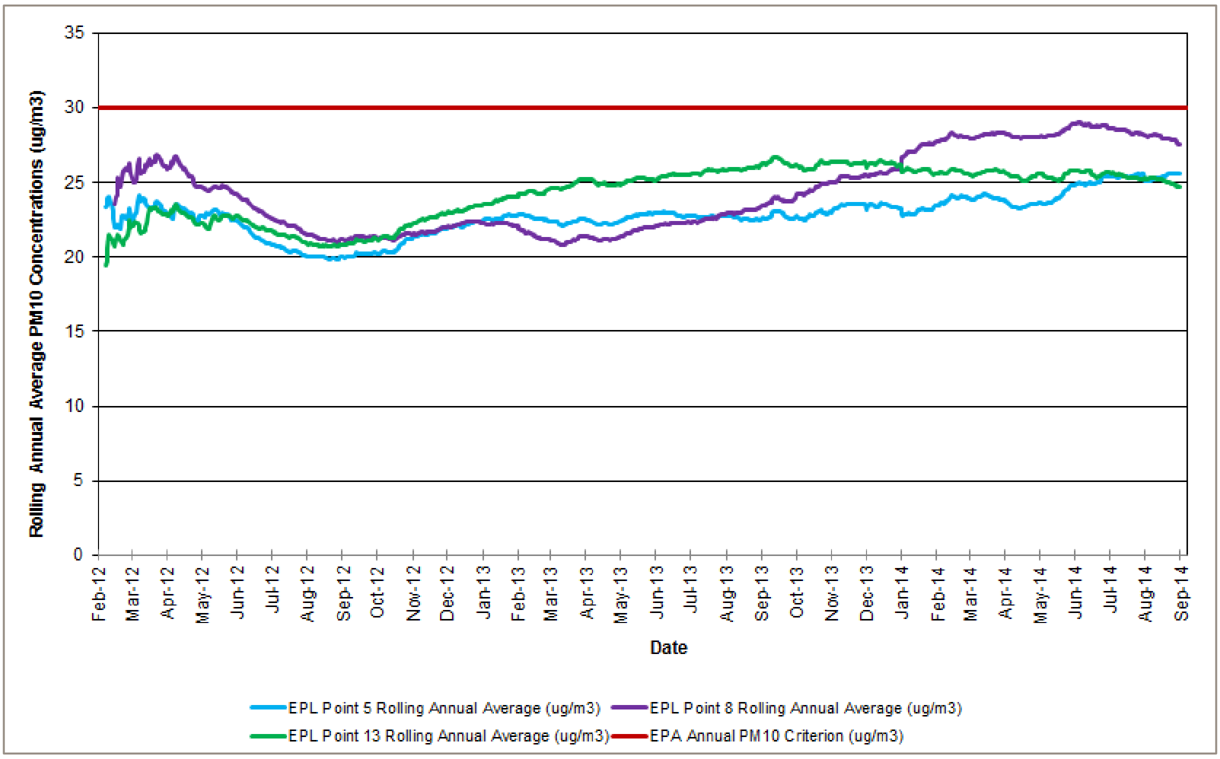

Figure 7 **PM_{10} Annual Rolling Average – Barangaroo Monitoring Data: 2012 – 2014**

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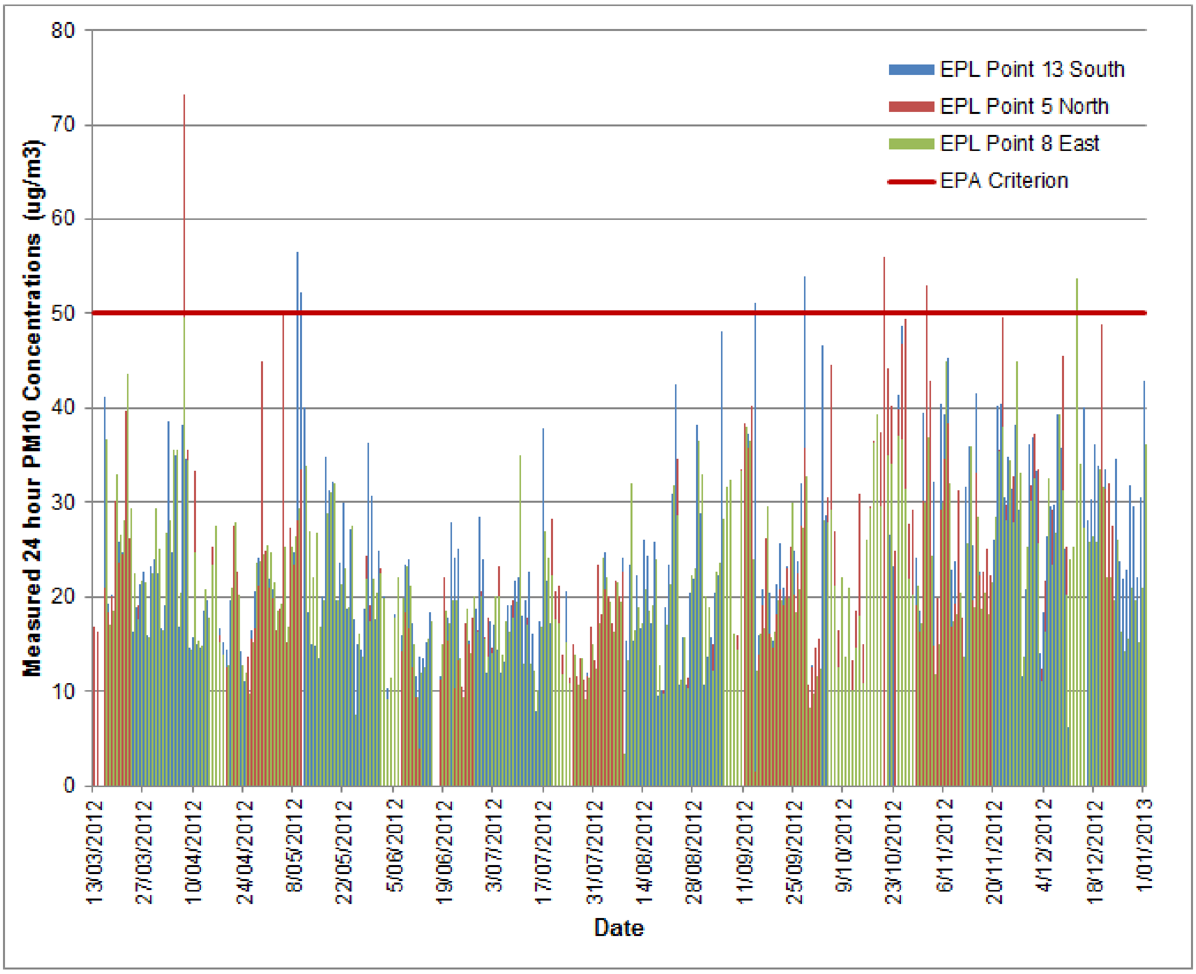

Figure 8 **PM_{10} 24 Hour Average – Barangaroo Monitoring Data: 2012 – 2013**

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8.0 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.

8.1 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:

- Mains power will be used where available and suitable.
- The dust, VOC and meteorological monitoring program will be continued as per **Section 8.3**.
- 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.
- All excavation, materials handling and ex-situ treatment (excluding retention wall works) will be undertaken within the sealed OCSs, which will be maintained under negative pressure.
- A minimum of two granular activated carbon (GAC) filters will be installed in series for each emission stack in the OCSs 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 odour control structures 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 a minimum of 60 metres from Hickson Road as assumed in the modelling.
- If off-site treatment is undertaken, all trucks transporting the spoil will be sealed, and receivers of the spoil will be appropriately licensed to receive the material.
- Alternate odour control measures will be used during retention wall works, such as covering exposed soil or using odour suppressants and foam.
- The OCSs will be maintained to their design specifications. Regular checking and maintenance of OCS filtration systems will be undertaken.
- Site speed limits will be implemented.
- Generator emissions will be vented through the OCS stacks.
- Exposed areas will be minimised as much as practical.
- 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.
- Exposed surfaces and roads will be watered as required.

An Air Quality and Odour Management Sub-Plan would be prepared to include mitigation measures from this AQIA, and that it would include an Air Quality Monitoring Plan. 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.

8.2 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 works should stop at this stage until the measured pollutant levels are below the action level to avoid an exceedence of the pollutant criterion.

The reactive management procedure for PM_{10} is provided in **Table 28**.

Table 28 Reactive Management Procedure – PM_{10}

Reactive Management Procedure				
Trigger Stage	Averaging Period	Trigger Value (µg/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		

The reactive management procedure for total VOCs is provided in **Table 29**.

Table 29 Reactive Management Procedure – Total VOCs

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Reactive Management Procedure – Total VOCs				
Trigger Stage	**Averaging Period**	**Trigger Value ($\mu g/m^3$)**	**Primary Responsibility**	**Action Required**
1 Investigate	1 hour	0.8	Environment Manager	Environmental Manager to undertake review of possible VOC sources operating during the average period. Identify possible measures for these activities, action if deemed necessary.
	3 hour	0.5		
2 Action	1 hour	8.3		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. If VOCs deemed to be coming from excavation area, speciation using a Summa canister will be undertaken. Complete Lend Lease Environmental Response Form

This plan would continue to be implemented throughout the course of the works proposed under this modification where appropriate.

8.3 Air Quality Monitoring Program

Ambient air quality monitoring around the Barangaroo site has been undertaken by AECOM since October 2011 in accordance with the Air Quality Management 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, 2005a);
- AS/NZS 3580.9.3:2003 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 3580.1.1:2007 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 30** and **Figure 9**.

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Table 30 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 AS3580.9.3 – 2003	During basement bulk excavation*
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 AS3580.9.6 - 2003	Throughout construction
Heavy Metals	HVAS	24 hours every 6 days	EPL points 5, 8, 13	***	AM-15 AS3580.9.3 – 2003	During basement bulk excavation*
PAH (speciated)	HVAS	24 hours every 6 days	EPL points 5, 8, 13		AM-15 AS3580.9.3 – 2003	During basement bulk excavation*
VOC (speciated)	Summa	As needed	As needed	***	USEPA TO-15	During basement bulk excavation
VOC (total)	RaeGuard, or alternate equipment	Continuous	EPL points 5, 8, 13	NA	NA	Throughout construction
Odour	Field Olfactometer	Morning, followed by afternoon if odour exceeds trigger level	Odour locations 1 to 6	NA	NA	During basement bulk excavation*
NO_2	Chemilumine-scent NO_X monitor.	Continuous, if required	Near a receptor where NO_2 levels exceed criteria	246 µg/m^3 one hour average	AM 3580.5.1-1993	If works reflect cumulative impacts
Met station	-	Continuous	EPL point 5	Site complies with *Approved Methods*	AM-1 to 4 USEPA (2000) EPA 454/R-99-005	Throughout construction

* 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 (2005a)

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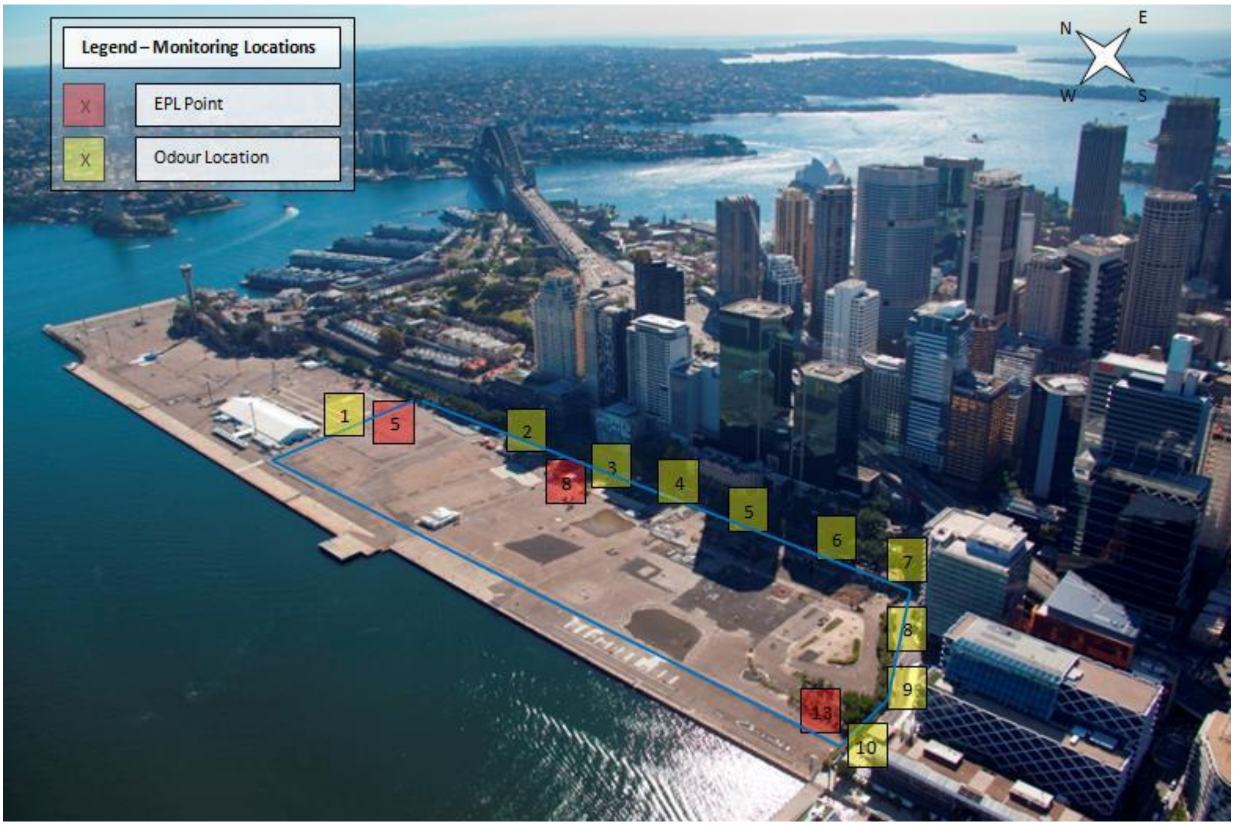

Figure 9 Approximate Existing Barangaroo South Monitoring Locations

The OCS monitoring plan would be expected to 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, 2005b). Suggested concentration limits and sampling frequencies are provided in **Table 31**; the final nature of the sampling program would be determined by the EPA and specified in the EPL.

Table 31 Suggested Monitoring Frequency and Concentration Limits for OCSs

Pollutant	100th Percentile Concentration Limit	Monitoring Frequency
NO_X	N/A	Post-commissioning followed by sampling every alternate month
Total particulates	20 mg/Nm^3	
VOCs as n-propane equivalent	20 mg/Nm^3	
PAHs	N/A	

9.0 Conclusion

AECOM undertook an air quality impact assessment to assess the potential impacts associated with the modifications to Concept Plan (MP06_0162). Following review of the proposed modification and current staging information for the Barangaroo development, the activities associated with early phase of the Block 4 remediation and excavation works were considered to represent the peak pollutant-generating activities on site for works yet to be undertaken under the Concept Plan. The modelling results from the assessment conducted for Block 4 (AECOM, 2014) were, therefore, used in this assessment to represent the likely worst-case emissions and pollutant concentrations associated with the remainder of works to be undertaken for the Concept Plan.

AECOM (2014) assessed the following activities:

- Stage 1B Basement (Block 4) remediation and excavation remediation activities;
- Construction works associated with commercial and residential buildings C3, C4, C5, R8 and R9;
- Operation of the on-site concrete batching plant; and
- Operation of the on-site water treatment plant.

It should be noted that the modifications proposed under this modification application (that is the H1 Hotel and Residential Towers R4A, R4B and R5) would be constructed after the worse-case construction peak. The modifications proposed under MOD 8 would not influence the predicted construction peak considered within this assessment (i.e. Block 4 excavation and remediation), and would be expected to result in lower levels of air emissions than would occur during the peak construction peak. As such, the air quality impacts associated with these works would be expected to be less than those assessed in this report.

Dispersion modelling using the CALPUFF model was conducted for AECOM (2014) for the following pollutants:

- NO_2;
- Particulates (TSP and PM_{10});
- Heavy metals (attached to TSP);
- VOCs, including BTEX;
- PAHs; and
- Odour.

Two scenarios were assessed in AECOM (2014), which represented the worst-case potential concurrent activities (i.e. all the activities listed above) and a more realistic scenario, where emissions associated with C4, C5, R8 and R9 were excluded. No exceedences of the EPA impact assessment criteria for TSP, metals, VOCs, PAHs or odour were predicted at any sensitive receptor location for either scenario. Exceedences of 1 hour NO_2 and 24 hour PM_{10} were predicted for a number of sensitive receptors for the worst-case activity scenario with a greatly reduced number of exceedences predicted for NO_2 for the more realistic scenario.

Exceedences of PM_{10} were predicted to occur for both scenarios, which were attributed to the operation of the concrete batching plant. The cumulative contribution of works across the Barangaroo site (including Headland Park and Barangaroo Central) may also result in elevated concentrations and additional exceedences if the works are not appropriately managed. Exceedences of 1 hour NO_2 were also predicted for both scenarios, which were considered to be the result of overconservative assumptions made regarding the plant and equipment to be used within the building construction works. The predicted maximum pollutant concentrations were, however, all lower than those predicted for the basement excavation works as assessed for MOD 4 (AECOM, 2010) and were similar to those predicted for MOD 7 (AECOM, 2012).

The modification to the Concept Plan may result in a longer construction period and a greater construction extent (in GFA terms) than is currently approved. The cumulative impacts occurring during the additional works contemplated by the Concept Plan, as proposed to be modified, however, would be expected to be lower than those occurring during the near-future peak activity period. Furthermore, all emissions associated with the Concept Plan are expected to be adequately managed by the existing management, contingency and monitoring measures implemented at the Barangaroo South site, which will continue as required for the duration of the works contemplated by the Concept Plan.

Lend Lease currently 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 many months, and will continue to operate throughout the duration of the Concept Plan works. Lend Lease uses its existing air quality monitoring network and its operational procedures for the concrete batching plant to ensure the site emissions are mitigated to an appropriate level and that adverse impacts (i.e. exceedences of ambient air quality criteria) do not occur 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. These management and monitoring systems would continue to be implemented throughout the works associated with the Concept Plan. As such, adverse effects on local air quality are not expected to occur as a result of the proposed modifications to the Concept Plan.

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Appendix A

Pollutants of Interest

D R A F T

Appendix A Pollutants of Interest

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 oxides of nitrogen (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. Furthermore, if the particles contain toxic materials (such as lead, cadmium, zinc) or live organisms (such as bacteria or fungi), toxic effects or infection can occur from the inhalation of the dust.

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 these 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, D R A F T

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.

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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.

Polycyclic Aromatic Hydrocarbons (PAHs)

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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. Naphthalene is another key PAH. Excessive non-life-threatening exposure may cause cataracts in the eyes, while ingestion can cause abdominal cramps, nausea, vomiting, diarrhoea in young infants. It is considered a possible carcinogenic to humans and carcinogenic in animals.

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 may include BTEX and PAHs, notably ethylbenzene, xylenes and naphthalene.

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Appendix B

Climate Averages

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Appendix B Climate Averages

Average Climate Data – Observatory Hill and Fort Denison, 1859 – 2010 (May)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average temperature													
Maximum (^{0}C)	25.9	25.8	24.7	22.4	19.4	16.9	16.3	17.8	20	22.1	23.6	25.2	21.7
Minimum (^{0}C)	18.7	18.8	17.5	14.7	11.5	9.3	8	8.9	11.1	13.5	15.6	17.5	13.8
Average wind speed													
9 am (km/h)	8.6	8.2	7.9	8.8	10.5	11.9	13.1	13.3	12.4	12.2	11	9.8	10.6
3 pm (km/h)	17.9	16.8	15.2	13.8	12.7	13.6	15.3	17.6	18.3	19.1	19.4	19.5	16.6
Average relative humidity													
9 am (%)	71	74	74	72	73	74	71	66	62	61	66	67	69
3 pm (%)	62	64	62	59	57	57	51	49	51	56	58	59	57
Rainfall													
Mean rainfall (mm)	101.5	118.7	128.9	125.8	120.7	130.6	97.3	81.2	69.1	77.6	83.1	77.8	1212

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Appendix C

Sensitive Receptor Details

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Appendix C Sensitive Receptor Details

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

Sensitive Receptors

Receptor ID	Coordinates		Base Elevation (m)	Flagpole Height (m)	Description
	X (m)	Y (m)			
R1	333778	6251503	6	0	
R2	333796	6251496	8	18	
R3	333789	6251492	6	0	
R4	333795	6251466	6	0	
R5	333793	6251456	6	0	
R6	333823	6251475	10	25	
R7	333822	6251462	7	25	
R8	333800	6251439	7	0	
R9	333828	6251447	8	48	
R10	333825	6251435	8	50	
R11	333803	6251418	8	0	
R12	333805	6251400	9	0	
R13	333812	6251361	6	8	
R14	333809	6251339	6	12	
R15	333813	6251327	7	15	
R16	333792	6251319	6	0	
R17	333788	6251299	6	35	
R18	333769	6251306	6	35	
R19	333757	6251310	6	0	
R20	333775	6251289	6	40	
R21	333756	6251293	6	48	
R22	333738	6251286	6	40	
R23	333724	6251285	6	0	
R24	333714	6251272	6	10	
R25	333706	6251245	6	15	
R26	333695	6251260	6	10	
R27	333674	6251251	6	12	
R28	333664	6251260	6	0	
R29	333643	6251251	5	15	
R30	333616	6251255	6	0	
R31	333632	6251884	5	0	
R32	333773	6251948	14	0	Preschool

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Receptor ID	Coordinates		Base Elevation (m)	Flagpole Height (m)	Description
	X (m)	Y (m)			
R33	333776	6251873	16	0	
R34	333812	6251839	26	0	
R35	333785	6251805	23	0	
R36	333777	6251775	23	0	
R37	333776	6251718	7	0	
R38	333776	6251718	7	30	
R39	333821	6251706	22	0	
R40	333821	6251706	22	20	
R41	333821	6251706	22	40	
R42	333821	6251706	22	60	
R43	333798	6251640	10	0	
R44	333798	6251640	10	20	
R45	333785	6251606	8	0	
R46	333785	6251606	8	20	
R47	333785	6251606	8	30	
R48	333816	6251631	21	0	
R49	333816	6251631	21	20	
R50	333816	6251631	21	40	
R51	333816	6251631	21	60	
R52	333793	6251504	7	0	
R53	333793	6251504	7	20	
R54	333822	6251500	13	20	
R55	333822	6251500	13	40	
R56	333822	6251500	13	60	
R57	333822	6251500	13	80	
R58	333702	6251273	6	0	
R59	333792.4	6251514.59	6	0	
R60	333791.69	6251521.36	7	0	
R61	333790.93	6251528.11	6	0	
R62	333789.85	6251534.56	6	0	
R63	333789.09	6251541.3	7	0	
R64	333816.87	6251535.93	16	0	Stamford on Kent
R65	333816.74	6251535.93	16	20	Stamford on Kent
R66	333816.74	6251535.93	16	40	Stamford on Kent
R67	333818.5	6251519.83	13	60	Stamford on Kent
R68	333794.74	6251551.06	12	0	

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Receptor ID	Coordinates		Base Elevation (m)	Flagpole Height (m)	Description
	X (m)	Y (m)			
R69	333795.15	6251564.05	13	0	
R70	333794.14	6251578.06	14	0	
R71	333793.73	6251592.87	7	0	
R72	333785	6251606.07	7	10	38 Hickson Rd
R73	333785	6251606.48	7	30	38 Hickson Rd
R74	333785.2	6251606.07	7	50	38 Hickson Rd
R75	333780.33	6251635.3	6	0	38 Hickson Rd
R76	333780.13	6251635.3	6	20	38 Hickson Rd
R77	333780.13	6251635.3	6	40	38 Hickson Rd
R78	333779.32	6251662.1	6	0	
R79	333786.36	6251665.79	6	20	30 The Bond
R80	333786.36	6251665.79	6	40	30 The Bond
R81	333780.84	6251675.8	6	30	30 The Bond
R82	333780.84	6251675.8	6	10	30 The Bond
R83	333773.59	6251763.63	22	0	
R84	333769.62	6251783.99	22	0	
R85	333768.24	6251795.73	22	0	
R86	333774.56	6251839.7	19	0	
R87	333773.42	6251748.79	12	0	
R88	333768.02	6251897.49	14	0	
R89	333765.67	6251925.99	13	0	
R90	333795.74	6251907.43	23	10	Observatory Hotel
R91	333804.11	6251816.69	24	20	Observatory Hotel
R92	333754.16	6251850.42	8	0	
R93	333751.28	6251893.57	6	0	
R94	333747.88	6251934.1	6	0	
R95	333743.96	6251975.16	6	0	
R96	333740.82	6252009.94	6	0	
R97	333762.53	6251978.29	15	0	
R98	333762	6251962.6	14	10	Preschool
R99	333764.62	6251934.89	15	0	Preschool
R100	333755.73	6252057.27	19	0	
R101	333736.64	6252053.61	6	0	

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Appendix D

Exceedence Data - 1 hour NO2 and 24 Hour PM10

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Appendix D Exceedence Data - 1 hour NO2 and 24 Huor PM10

Receptor ID	Number of Exceedences	
	1 Hour NO_2	24 Hour PM_{10}
R1	0	17
R2	1	5
R3	0	14
R4	0	13
R5	1	10
R6	3	1
R7	0	0
R8	0	11
R9	2	0
R10	0	0
R11	0	10
R12	2	9
R13	2	19
R14	2	0
R15	0	0
R16	0	1
R17	2	0
R18	0	0
R19	0	8
R20	3	0
R21	0	0
R22	0	0
R23	0	6
R24	0	1
R25	0	0
R26	0	0
R27	0	0
R28	0	0

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Receptor ID	Number of Exceedences	
	1 Hour NO_2	24 Hour PM_{10}
R29	0	0
R30	0	0
R31	0	1
R32	0	0
R33	0	1
R34	0	1
R35	0	2
R36	0	3
R37	0	3
R38	0	0
R39	0	3
R40	0	0
R41	0	0
R42	0	0
R43	0	9
R44	0	1
R45	0	13
R46	0	4
R47	0	2
R48	0	8
R49	0	1
R50	0	0
R51	0	0
R52	0	14
R53	0	5
R54	0	2
R55	0	0
R56	0	0
R57	0	0

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Receptor ID	Number of Exceedences	
	1 Hour NO_2	24 Hour PM_{10}
R58	0	1
R59	0	16
R60	0	17
R61	0	18
R62	0	22
R63	0	22
R64	0	11
R65	0	2
R66	0	0
R67	0	0
R68	0	17
R69	0	15
R70	0	15
R71	0	13
R72	0	10
R73	0	2
R74	0	0
R75	0	11
R76	0	2
R77	0	0
R78	0	7
R79	0	1
R80	0	0
R81	0	0
R82	0	2
R83	0	3
R84	0	3
R85	0	3
R86	0	2

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Receptor ID	Number of Exceedences	
	1 Hour NO_2	24 Hour PM_{10}
R87	0	3
R88	0	0
R89	0	0
R90	0	0
R91	0	0
R92	0	2
R93	0	0
R94	0	0
R95	0	0
R96	0	0
R97	0	0
R98	0	0
R99	0	0
R100	0	0
R101	0	0