



Site Audit Report Overarching Remedial Action Plan, Barangaroo

Prepared for:
Barangaroo Delivery Authority

Prepared by:
ENVIRON Australia Pty Ltd

Date:
June 2010

Project Number:
A121191

Audit Number:
GN 439A

2 June 2010

Our Ref: A121191

Barangaroo Delivery Authority
Attn: Brian ten Brinke
Level 3, Foreshore House
66 Harrington Street
The Rocks NSW 2000

Dear Brian

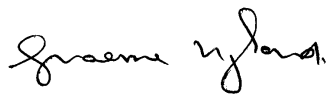
Re: Site Audit Report – Overarching Remedial Action Plan, Barangaroo

I have pleasure in submitting the Site Audit Report for the subject site. The Site Audit Statement, produced in accordance with the NSW Contaminated Land Management Act 1997 follows this letter. The Audit was commissioned by Barangaroo Delivery Authority to assess the suitability of the overarching Remedial Action Plan for the site known as Barangaroo.

The Audit was initiated to comply with a requirement by the Director General, application number MP10_0026 dated 23 March 2010.

Thank you for giving me the opportunity to conduct this Audit. Please call me on 9954 8100 if you have any questions.

Yours faithfully,
ENVIRON Australia Pty Ltd



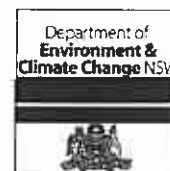
Graeme Nyland
EPA Accredited Site Auditor 9808

/ DECCW

/ City of Sydney – statement only

NSW Site Auditor Scheme

SITE AUDIT STATEMENT



A site audit statement summarises the findings of a site audit. For full details of the site auditor's findings, evaluations and conclusions, refer to the associated site audit report.

This form was approved under the Contaminated Land Management Act 1997 on 26 March 2009. For more information about completing this form, go to Part IV.

PART I: Site audit identification

Site audit statement no. GN 439A

This site audit is a **statutory audit/non-statutory audit*** within the meaning of the *Contaminated Land Management Act 1997*.

Site auditor details (as accredited under the *Contaminated Land Management Act 1997*)

Name: Graeme Nyland **Company:** ENVIRON Australia Pty Ltd

Address: Level 3, 100 Pacific Highway (PO Box 560)

North Sydney NSW

Postcode: 2060

Phone: 02 9954 8100

Fax: 02 9954 8150

Site details

Address: Barangaroo, Berths 3-8, Hickson Road, Millers Point, NSW

Postcode: 2000

Property description (*attach a list if several properties are included in the site audit*)

Lots 1, 3, 4, 5 and 6 DP 876514, and part of Hickson Road adjacent to 30-38 Hickson Road

Local Government Area: Sydney

Area of site (e.g. hectares): 22.6 ha approximately

Current zoning: B4 Mixed Use and RE1 Public Recreation

To the best of my knowledge, the site ~~is/is not~~* the subject of a declaration, order, agreement or notice under the *Contaminated Land Management Act 1997* or the *Environmentally Hazardous Chemicals Act 1985*.

Declaration/Order/Agreement/Proposal/Notice* no(s):

Declaration Number 21122, Area Number 3221 (part of site)

*** Strike out as appropriate**

Site audit commissioned by

Name: Brian ten Brinke

Company: Barangaroo Delivery Authority

Address: Level 3, Foreshore House, 66 Harrington St, The Rocks, NSW

Postcode: 2000

Phone: 9255 1725

Fax: 9271 5114

Name and phone number of contact person (if different from above)

Sonja Shand: Phone 02 9255 1707

Purpose of site audit

☐ ~~A. To determine land use suitability (please specify intended use(s))~~

.....

OR

☐ ~~B(i) To determine the nature and extent of contamination, and/or~~

☒ B(ii) To determine the appropriateness of an **investigation/remedial action/management plan***, and/or

☐ ~~B(iii) To determine if the land can be made suitable for a particular use or uses by implementation of a specified remedial action plan/management plan* (please specify intended use(s))~~

.....

Information sources for site audit

Consultancy(ies) which conducted the site investigation(s) and/or remediation

- Jeffery & Katauskas Pty Ltd
- Environmental Resources Management Australia Pty Ltd
- Coffey Environments Pty Ltd

Title(s) of report(s) reviewed:

- 'Overarching Remedial Action Plan for The Barangaroo Project Site, Sydney', dated 1 June 2010, ERM, Report 0114385RP01Final, Environmental Resources Management Australia Pty Ltd (ERM).

Other information reviewed (including previous site audit reports and statements relating to the site)

- 'Report to Sydney Harbour Foreshore Authority on Geotechnical Investigation for Proposed Redevelopment of Wharves 3-8 at Hickson Road, Darling Harbour East, NSW' dated 21 August 2006, by Jeffery and Katauskas Pty Ltd (J&K)
- 'Land at Millers Point, Ownership and Usage' dated 1 June 2007, by Rosemary Broomham

*** Strike out as appropriate**

- 'Environmental Site Assessment, East Darling Harbour, Sydney, NSW' dated 21 June 2007, by ERM
- 'Preliminary Environmental Investigation at Hickson Road' dated May 2008 by Coffey Environments Pty Ltd (Coffey)
- 'Additional Investigation Works at Barangaroo, Hickson Road, Millers Point, NSW' dated July 2008, by ERM.

Site audit report

Title: Site Audit Report – Overarching Remedial Action Plan, Barangaroo

Report no. GN 439A (Environ Ref: AS121191) Date: June 2010

PART II: Auditor's findings

Please complete either Section A or Section B, **not both**. (*Strike out the irrelevant section.*)

Use Section A where site investigation and/or remediation has been completed and a conclusion can be drawn on the suitability of land use(s).

Use Section B where the audit is to determine the nature and extent of contamination and/or the appropriateness of an investigation or remedial action or management plan and/or whether the site can be made suitable for a specified land use or uses subject to the successful implementation of a remedial action or management plan.

Section A

☐ I certify that, in my opinion, the site is **SUITABLE** for the following use(s) (*tick all appropriate uses and strike out those not applicable*):

- ☐ Residential, including substantial vegetable garden and poultry
- ☐ Residential, including substantial vegetable garden, excluding poultry
- ☐ Residential with accessible soil, including garden (minimal home-grown produce contributing less than 10% fruit and vegetable intake), excluding poultry
- ☐ Day care centre, preschool, primary school
- ☐ Residential with minimal opportunity for soil access, including units
- ☐ Secondary school
- ☐ Park, recreational open space, playing field
- ☐ Commercial/industrial
- ☐ Other (*please specify*)

subject to compliance with the following environmental management plan
(*insert title, date and author of plan*) in light of contamination remaining on the site:

.....
.....
.....

OR

☐ I certify that, in my opinion, the site is **NOT SUITABLE** for any use due to the risk of harm from contamination.

Overall comments

.....
.....
.....
.....

Section B

Purpose of the plan¹ which is the subject of the audit was to provide a site wide remediation action plan containing principals which could be incorporated into individual RAPs for portions of the site.

I certify that, in my opinion:

☐ ~~the nature and extent of the contamination HAS/HAS NOT* been appropriately determined~~

AND/OR

☒ ~~the investigation/remedial action plan/management plan* IS/IS NOT* appropriate for the purpose stated above~~

AND/OR

☐ ~~the site CAN BE MADE SUITABLE for the following uses (tick all appropriate uses and strike out those not applicable):~~

- ☐ ~~Residential, including substantial vegetable garden and poultry~~
- ☐ ~~Residential, including substantial vegetable garden, excluding poultry~~
- ☐ ~~Residential with accessible soil, including garden (minimal home grown produce contributing less than 10% fruit and vegetable intake), excluding poultry~~
- ☐ ~~Day care centre, preschool, primary school~~
- ☐ ~~Residential with minimal opportunity for soil access, including units~~
- ☐ ~~Secondary school~~
- ☐ ~~Park, recreational open space, playing field~~
- ☐ ~~Commercial/industrial~~
- ☐ ~~Other (please specify)~~

~~if the site is remediated/managed* in accordance with the following remedial action plan/management plan* (insert title, date and author of plan)~~

.....

.....

.....

~~subject to compliance with the following condition(s):~~

.....

.....

.....

¹ For simplicity, this statement uses the term 'plan' to refer to both plans and reports.

* Strike out as appropriate

Date _____

PART IV: Explanatory notes

To be complete, a site audit statement form must be issued with all four parts.

How to complete this form

Part I identifies the auditor, the site, the purpose of the audit and the information used by the auditor in making the site audit findings.

Part II contains the auditor's opinion of the suitability of the site for specified uses or of the appropriateness of an investigation, or remedial action or management plan which may enable a particular use. It sets out succinct and definitive information to assist decision-making about the use(s) of the site or a plan or proposal to manage or remediate the site.

The auditor is to complete either Section A or Section B of Part II, **not** both.

In **Section A** the auditor may conclude that the land is *suitable* for a specified use(s) OR *not suitable* for any beneficial use due to the risk of harm from contamination.

By certifying that the site is *suitable*, an auditor declares that, at the time of completion of the site audit, no further remediation or investigation of the site was needed to render the site fit for the specified use(s). Any **condition** imposed should be limited to implementation of an environmental management plan to help ensure the site remains safe for the specified use(s). The plan should be legally enforceable: for example a requirement of a notice under the *Contaminated Land Management Act 1997* (CLM Act) or a development consent condition issued by a planning authority. There should also be appropriate public notification of the plan, e.g. on a certificate issued under s.149 of the *Environmental Planning and Assessment Act 1979*.

Auditors may also include **comments** which are key observations in light of the audit which are not directly related to the suitability of the site for the use(s). These observations may cover aspects relating to the broader environmental context to aid decision-making in relation to the site.

In **Section B** the auditor draws conclusions on the nature and extent of contamination, and/or suitability of plans relating to the investigation, remediation or management of the land, and/or whether land can be made suitable for a particular land use or uses upon implementation of a remedial action or management plan.

By certifying that a site *can be made suitable* for a use or uses if remediated or managed in accordance with a specified plan, the auditor declares that, at the time the audit was completed, there was sufficient information satisfying guidelines made or approved under the CLM Act to determine that implementation of the plan was feasible and would enable the specified use(s) of the site in the future.

For a site that *can be made suitable*, any **conditions** specified by the auditor in Section B should be limited to minor modifications or additions to the specified plan. However, if the auditor considers that further audits of the site (e.g. to validate remediation) are required, the auditor must note this as a condition in the site audit statement.

Auditors may also include **comments** which are observations in light of the audit which provide a more complete understanding of the environmental context to aid decision-making in relation to the site.

In **Part III** the auditor certifies his/her standing as an accredited auditor under the CLM Act and makes other relevant declarations.

Where to send completed forms

In addition to furnishing a copy of the audit statement to the person(s) who commissioned the site audit, statutory site audit statements must be sent to:

Department of Environment and Conservation (NSW)
Contaminated Sites Section
PO Box A290, SYDNEY SOUTH NSW 1232
Fax: (02) 9995 5930

AND

the **local council** for the land which is the subject of the audit.

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List of Abbreviations

AHD	Australian Height Datum
ALS	Australian Laboratory Services
ANZECC	Australian and New Zealand Environment and Conservation Council
BaP	Benzo(a)pyrene
BGL	below ground level
BTEX	Benzene, Toluene, Ethylbenzene & Xylenes (Monocyclic Aromatic Hydrocarbons)
CN	Cyanide (total or free)
CT	Certificate of Title
DP	Deposited Plan
DQO	Data Quality Objectives
EPA	Environment Protection Authority (NSW)
ESA	Environmental Site Assessment report
EQC	Environmental Quality Criteria
ha	Hectare
km	Kilometres
LOR	Limit of Reporting
m	Metres
MAH	Monocyclic Aromatic Hydrocarbons
Mercury	Inorganic mercury unless noted otherwise
Metals	As: Arsenic, Cd: Cadmium, Cr: Chromium, Cu: Copper, Fe: Iron, Ni: Nickel, Pb: Lead, Zn: Zinc, Hg: Mercury, Se: Selenium
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Litre
m BGL	Metres below ground level
µg/L	Micrograms per Litre
NATA	National Association of Testing Authorities
NC	Not Calculated
ND	Not Detected
NEHF	National Environmental Health Forum
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
n	Number of Samples
OCP	Organochlorine Pesticides
OH&S	Occupational Health & Safety
OPP	Organophosphorus Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PID	Photoionisation Detector
PQL	Practical Quantitation Limit
pH	a measure of acidity, hydrogen ion activity
QA/QC	Quality Assurance/Quality Control
RAP	Remediation Action Plan
RPD	Relative Percent Difference
RWP	Remediation Work Plan
SEPP	State Environmental Planning Policy
SILs	Soil Investigation Levels
SVOCs	Semi Volatile Organic Compounds
TPHs	Total Petroleum Hydrocarbons
UCL	Upper Confidence Limit
VENM	virgin excavated natural material
VOCs	Volatile Organic Compounds
-	On tables is "not calculated", "no criteria" or "not applicable"

1 Introduction

A site contamination audit has been conducted in relation to the site known as Barangaroo at Millers Point, NSW.

The Audit was conducted to provide an independent review by an EPA Accredited Auditor of the suitability and appropriateness of a remedial action plan i.e. a "Site Audit" as defined in Section 4 (1) (b) (v) of the *NSW Contaminated Land Management Act 1997* (the CLM Act).

Details of the audit are:

Requested by: Brian ten Brinke on behalf of Barangaroo Delivery Authority (BDA)

Request/Commencement Date: 14 May 2010

Auditor: Graeme Nyland

Accreditation No.: 9808

The scope of the audit included:

- Review of the following report:
 - Overarching Remedial Action Plan for The Barangaroo Project Site, Sydney", dated 1 June 2010, Environmental Resources Management Australia Pty Ltd (ERM), Report 0114385RP01Final (the RAP)
- A site visit by the Auditor, 28 May 2010
- Discussions with BDA.

Barangaroo is a large site to be developed in stages and for a variety of uses. Separate remedial action plans are to be prepared for each development stage. Also, part of the site has been declared by NSW EPA to be a Remediation Site, which will also be the subject of a separate remedial action plan. As it is envisaged that remediation in different areas of the site will be linked, for example by re use of material from one part of the site in another, an overarching RAP has been prepared to identify strategies and remedial options for remediation of the whole site.

There have been a number of investigations over all or part of the site, which are summarised in the RAP. The reports which have been provided to the Auditor and briefly reviewed in preparation of this Site Audit Report are:

- 'Report to Sydney Harbour Foreshore Authority on Geotechnical Investigation for Proposed Redevelopment of Wharves 3-8 at Hickson Road, Darling Harbour East, NSW' dated 21 August 2006, by Jeffery and Katauskas Pty Ltd (J&K)
- 'Land at Millers Point, Ownership and Usage' dated 1 June 2007, by Rosemary Broomham

- 'Environmental Site Assessment, East Darling Harbour, Sydney, NSW' dated 21 June 2007, by Environmental Resources Management Australia Pty Ltd (ERM)
- 'Preliminary Environmental Investigation at Hickson Road' dated May 2008 by Coffey Environments Pty Ltd (Coffey)
- 'Additional Investigation Works at Barangaroo, Hickson Road, Millers Point, NSW' dated July 2008, by ERM.

More recently, further data gap investigations have been conducted by AECOM, and some draft reports have been provided to the Auditor.

2 Site Details

2.1 Location

The site locality is shown on Attachment 1, Appendix A.

The site for the purpose of the RAP and the Audit is:

Street address:	Barangaroo, Berths 3-8, Hickson Road
Identifier:	Lots 1, 3, 4, 5 and 6 DP 876514, and part of Hickson Road adjacent to 30-38 Hickson Road
Local Government:	City of Sydney
Owner:	Barangaroo Delivery Authority (except Lot 4, which contains the Port Control Tower currently owned by Sydney Ports, and Hickson Road)
Site Area:	approximately 22.6 ha.

The Barangaroo Project Site (see Attachment 2, Appendix A) includes several areas of roadway on Sussex Street, Hickson road and Towns Place not covered by the RAP.

2.2 Zoning

ERM advised the current zoning of the site is defined in Schedule 3 of the State Environmental Planning Policy (SEPP) (Major Development) 2005 as Zone B4 Mixed Use and Zone RE1 Public Recreation. Figure 3 of the RAP shows the Mixed Use zone along Hickson Road on the eastern side of the site and the Public Recreation zone on the western side adjoining Darling Harbour and at the northern end.

2.3 Adjacent Uses

The site is located in harbour-side location within an area of mixed residential and commercial use. Adjacent land uses are as follows:

North: Sydney Harbour

East: Commercial and some residential properties on eastern side of Hickson Road and beyond. A sandstone cut face marks part of the site boundary in the north east. The Port Control Tower adjoins the sandstone cut

South: King Street Wharf commercial/residential area

West: Darling Harbour

2.4 Site Condition

Based on information presented in the various reports and observations made during a site visit, the current site features are:

- The site is flat, at an elevation a few metres above Darling Harbour water level
- The site is covered by hard surfacing including concrete and bitumen with only a few structures and large light towers. Former large warehouses that were previously on the site have been demolished
- Wharf 8 Overseas Passenger Terminal, including a large warehouse style building and cruise ship loading dock is on the southern portion of the site. There are landscaped garden strips on the eastern and southern boundaries and the main driveway to Wharf 8 Terminal
- There is a disused brick amenities building and electrical substation in the southeast of the site near Hickson Road
- There are several security gate houses on the eastern side of the site
- There is a sewage pumping station in the north of the site
- Construction has commenced on a new temporary passenger terminal in the central northern part of the site.

2.5 Proposed Development

The site is to be redeveloped by BDA for future uses which include commercial, residential, open space and public thoroughfare. Details of specific developments are the subject of current and future development applications. It is likely that some developments will include excavations for basement car parking, and that excavated material may be able to be re-used as fill on other portions on the site, particularly those to be landscaped for use as public open space.

Parts of the proposed development fall within 'residential with minimal access to soil', 'commercial/ industrial use', and 'recreational open space' exposure scenarios. There will also be coves off Darling Harbour.

3 Site History

ERM provided a site history based on aerial photographs, site photographs, title deed searches and previous environmental investigations. This is summarised in Table 3.1.

Table 3.1: Site History	
Date	Activity
Pre 1939	The original shoreline ran approximately along the western edge of Hickson Road
1839-1921	Gasworks operated by The Australian Gas Light Company on part of the site and what is now Hickson Road. This part of the site is the declared Remediation Site. Remainder of site commercial and wharf use during this period.
1922-1925	Demolition of gas works infrastructure. Site used for workshops and storage warehouses.
1925-1936	Ship berthing and associated activities. Part of site became Hickson Road (1925).
1936-1951	Commercial leases.
1951-1972	Land reclaimed from harbour with fill from unknown source. Finger wharves demolished 1961-1968. New sea walls and new longshore wharfs constructed. Filling undertaken behind (east of) sea walls. Majority of Barangaroo filled with the exception of Southern Cove. Site used for various port related activities.
1972-2007	Commercial and port related activities continued. Southern Cove filled in late 1980s/ early 1990s. Overseas passenger terminal built 1999.
2007-present	Majority of site vacated, warehouses demolished and site cleared. Wharf 8 Overseas Passenger Terminal still operating.

The summary indicates that the south eastern part of the site including the area now occupied by part of Hickson Road was used as a gasworks up until approximately 90 years ago. Structures included tar pits, gas holders and purifier beds. The remainder of the site has been used for wharf/ port related activities since the 1800s. In the Auditor's opinion, the site history provides an adequate indication of past activities, with the primary potential for contamination from site use being from its use as a gasworks. The locations of the gasworks structures appear reasonably well known. Other site uses included workshops, vehicle maintenance and diesel fuel storage, which have potential for more localised contamination.

The major uncertainty in the site history appears to be the sequence and source of filling activity. Uncontrolled or undocumented fill was used in various stages of site reclamation. It does not appear that any sections of the site were filled during the gasworks operation, therefore, the use of gasworks waste in bulk filling seems unlikely, although potential remains for contaminated filling from other sources to have been used.

4 Contaminants Of Concern

The RAP does not specifically discuss contaminants of concern, but discusses contaminants found in previous investigations. Based on the various investigations, the contaminants of concern and potentially contaminating activities are tabulated in Table 4.1.

Table 4.1: Contaminants of Concern		
Area	Activity	Potential Contaminants
Declared remediation Area	Former gasworks, waste products, gaskets	Could include metals, TPH, BTEX, PAHs, phenols, sulphate, cyanide, ammonia, asbestos
Whole of site	Importation of fill materials to reclaim land	Unknown, could include metals, TPH, BTEX, PAHs, PCBs, OCPs, VOCs, SVOCs, asbestos
Whole of site	Demolition of buildings	Unknown, could include lead, PCBs, asbestos
Whole of site	Land reclamation	Acid sulphate soils (ASS)

The Auditor considers that the analyte list used in the investigations undertaken is generally appropriate for the site history and condition, though not all investigations included analysis for all contaminants of concern. There have been few asbestos analyses as ERM comment that asbestos would be difficult to detect with the investigation methods used. There has been limited analysis of some potential contaminants, and the metals analyte list consisted of the eight most common metal contaminants only. The RAP adequately identifies the contaminants to be considered in site development.

5 Stratigraphy and Hydrogeology

Following a review of the reports provided, a summary of the site stratigraphy and hydrogeology was compiled as follows.

5.1 Stratigraphy

The RAP provides a summary of the site geology. The most comprehensive overall investigation of subsurface conditions is J&K 2006, which presents a series of borehole summary cross sections and contours of fill depth and bedrock elevation, based on 170 boreholes spread over the whole site.

The sub-surface profile of the site is summarised in Table 5.1.

Table 5.1: Stratigraphy	
Depth (m)	Subsurface Profile
0 – 0.5	Hard surfacing, concrete or bitumen
	Road base fill under hard surfacing
0 – 19 maximum Thickness increases east to west, 3m or less near Hickson Road	Fill, mainly sandy, possibly increasing in clay content with depth. Gravelly, silty or clayey in places. Contains sandstone floaters, as well as building rubble, brick and concrete
Overlying bedrock, thickest in central west part of the site at approximately 10m. Absent in northern area where sandstone was levelled	Alluvial sediments consisting predominantly of sandy clays
Varies, from shallow (north) to over maximum depth drilled 35m	Sandstone bedrock, shallower at the eastern portions and deepest over the western portion. Weathering and fracturing decreasing with depth

Based on review of the site history (refer Section 3) the site can be broken into the following stages of filling history:

- original filling of the eastern portion for development and construction of finger wharves, largely in the 1800s
- demolition of finger wharves and filling of the majority of the site (excluding Southern Cove) first in the southern portion (1961-1968) and then in the northern portion (approximately 1968-1972)
- filling of Southern Cove in late 1980s/ early 1990s.

None of the reports reviewed were able to identify different subunits within the fill.

In the Auditor's opinion, the overall stratigraphic conditions are well known. Uncertainties include the distribution of different fill types and whether they will have any significance on contaminant distribution.

5.2 Hydrogeology

Groundwater at the site is shallow, generally within 2-3m BGL, and is subject to tidal fluctuations indicating a high degree of connectivity between groundwater at the site and the adjoining waters of Darling Harbour. The amplitude of tidal fluctuations decreases towards Hickson Road.

Wells subject to hydraulic conductivity testing were observed to recover almost instantaneously, reflecting the sand and gravel nature of fill material, although a wide range of hydraulic conductivity can be expected depending on the local fill type. As groundwater is shallow, service trenches may also provide more permeable flow paths.

Groundwater quality was saline, approaching seawater composition. The overall groundwater flow direction is to the west towards Darling Harbour, but the flow regime will be impacted by tidal influence and hydraulic conductivity variability in the fill. ERM also suggest that flow directions could be influenced by dewatering in basements on Hickson Road.

In the Auditor's opinion, hydrogeological conditions are reasonably well known allowing for local variations, with overall flow towards Darling Harbour and migration of contaminants influenced by tidal action.

6 Quality Assurance and Quality Control

6.1 Investigations

The Auditor has briefly reviewed the overall quality of the investigation data by review of the information presented in the investigation reports. Sources for the data summarised in the RAP were:

- ERM (2007): investigations over the whole site at over 150 locations, 25 completed as monitoring wells. Some cored into bedrock, with rock core logs reported in J&K (2006)
- ERM (2008): additional 55 boreholes, 13 converted to monitoring wells. Thirteen cored into rock. Located over whole site but mainly in areas inaccessible during earlier investigation
- Coffey (2008): investigations on Hickson Road, including within the Remediation Site. Fifteen boreholes, some cored into rock, with five bores converted to monitoring wells.

This review was conducted to assess whether the data provides a sound basis for preparation of the Overarching RAP. It is anticipated that data sets relevant to each development area, including data obtained in proposed data gap investigations, will be reviewed in detail as part of audits of separate RAPs for each development area. Data requirements will vary depending on the actual remediation to be conducted in each area.

The Auditor's assessment follows in Tables 6.1 and 6.2.

Table 6.1: QA/QC – Sampling and Analysis Methodology Assessment

Sampling and Analysis Plan and Sampling Methodology	Auditor Comments
Sampling Pattern and Density	Soil: The total number of investigation locations, 220, is comparable with the minimum recommended in Table A of EPA (1995) <i>Sampling Design Guidelines</i>. Investigations comprised relatively low density sampling to support a design competition and identify any further work needed to complete the development approval rather than full characterisation of the site. Of the ERM boreholes over the whole site, approximately 135 were on a grid pattern and the rest targeted, mainly towards the Remediation Area. Investigation locations were restricted by the presence of some buildings, as well as operational constraints of the various businesses on the site. The highest density investigations were in the Remediation Area and at the far north of the site. Lowest densities were: • In the southern end of the site, within the Wharf 8 building, where some locations are spaced over 60m apart • In the central northern area, where locations are spaced up to 80m apart • Along the western site boundary (shore), where few locations are spaced within 30m of the site boundary.

Table 6.1: QA/QC – Sampling and Analysis Methodology Assessment

Sampling and Analysis Plan and Sampling Methodology	Auditor Comments
	Groundwater monitoring wells were mainly installed - along the downgradient, western side of the site, typically located 30-40m from the western site boundary. ERM attempted to place some wells as close as possible to the harbour. - within and downgradient of the Remediation area. A few wells were also installed on the upgradient eastern boundary.
Sample depths	Samples were collected from a range of depths within fill, but typically only 2-3 samples per bore were analysed. Samples were generally selected for analysis based on field indications (visual, olfactory, PID) and not related to fill type so it is not clear whether all fill layers and types were analysed. Some samples were obtained from alluvial soils. Sandstone bedrock was cored in a number of locations, but few samples were analysed.
Drilling method	Most bores were advanced to about 1.5m using hand methods, then continued with solid stem auger. Due to difficult drilling conditions (obstructions, caving), some bores were continued with rotary mud methods. ERM (2008) advanced some bores to up to 12m using a 75mm geoprobe. Coring into rock was with a NMLC diamond core barrel.
Well construction	All wells were constructed with 50mm PVC, 0.4mm slotted screens and bentonite seals. ERM (2007) wells typically screened the upper to middle sections of the fill. Screen lengths typically range from 3.5-7m. Coffey wells were screened across fill, with screen lengths from 0.7m to 9.5m long. ERM (2008) wells used a variety of screen lengths and mainly screened fill but some targeted either alluvial soil or bedrock. ERM wells were developed with submersible pumps and Coffey wells with bailers.
Sample Collection Method	Soil: Samples were obtained from augers, SPT split spoon and geoprobe. Samples from augers were used for logging and field screening. Nearly all samples for laboratory analysis were semi undisturbed samples obtained from SPT, geoprobe or core. Groundwater: Purging was by low flow methods. ERM sampled using low flow methods and Coffey used bailers
Decontamination	Downhole sampling equipment was decontaminated or dedicated, and new nitrile gloves were used in handling samples.
Field screening	Field screening for volatiles was undertaken using a PID. PID

Table 6.1: QA/QC – Sampling and Analysis Methodology Assessment

Sampling and Analysis Plan and Sampling Methodology	Auditor Comments
	readings are recorded on borelogs. Calibration certificates were provided.
Sampling Logs	Borehole logs are provided within the reports, indicating sample depth, PID readings and lithology. Soil logs generally provide adequate detail, though there were some constraints due to recovery. Coffey rock logs are detailed but ERMs provide limited detail of weathering and fracturing. All logs record indications of contamination such as odours and staining. Groundwater field sampling records were provided.

Table 6.2: QA/QC – Field and Lab Quality Assurance and Quality Control

Field and Lab QA/QC	Auditor Comments
Field quality control samples	Field quality control samples including trip blanks, trip spikes, rinsate blanks, field intra-laboratory and inter-laboratory duplicates were undertaken.
Field quality control results	All reports include adequate data quality assessments. Minor QA/QC non conformances were reported.
NATA registered laboratory and NATA endorsed methods	Laboratories used were: ALS, Labmark and SGS. Laboratory certificates were NATA stamped.
Analytical methods	Analytical methods were included in the laboratory test certificates.
Practical Quantitation Limits (PQLs)	PQLs were less than the threshold criteria for the contaminants of concern except for some groundwater analytes. Some PQLs were raised because of salinity or interference by other contaminants.
Laboratory quality control samples	Laboratory quality control samples including laboratory control samples, matrix spikes, surrogate spikes, blanks, internal standards and duplicates were undertaken.
Laboratory quality control results	No major quality control deficiencies were noted.

Although the Auditor has not undertaken a full QA/QC assessment of all data, the Auditor is able to conclude that:

- Investigation locations and sample depths are likely to be representative of the overall site conditions. Though conditions may vary locally, it is considered that the major issues affecting remediation would have been identified by the investigations conducted. As many samples were selected for analysis based on field indications of contamination, results are likely to be biased towards “worst case”

- The laboratories provided sufficient information to conclude that data is of sufficient precision, and field and laboratory quality control measures were sufficient to be confident that most of the data is likely to be accurate
- The data is generally complete and usable. The data set is large enough that minor departures from data quality objectives would not greatly impact the conclusions from the assessments
- Although different consultants, different staff and different laboratories were used, data appears to be sufficiently comparable for each sampling and analytical event.

The Auditor therefore concludes that the data is suitable as a basis for RAP preparation.

6.2 Proposed Remediation

The RAP includes a discussion of data quality objectives .It does not provide details of quality control measures to be applied during remediation. It requires:

- data to be used in risk assessments to be assessed for quality in accordance with NEPM (1999) *Schedule B(3)- Guidelines on Laboratory Analysis of Potentially Contaminated Soils*.
- Development of sampling, analysis and quality plans for validation programs, to be incorporated into specific Remediation Work Plans (RWPs).

7 Environmental Quality Criteria

The RAP envisages that remediation and management will be based on quantitative human health and environmental risk assessment. Site Specific Target Criteria (SSTC) will be developed and incorporated into RWPs.

Default assessment criteria are listed in the RAP based on EPA-endorsed guidelines for different exposure scenarios which may be applicable to different areas of the site. Given the proximity to Darling Harbour, groundwater data has been assessed in reference to ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* for marine waters. Trigger values (TVs) provided are concentrations that, if exceeded, indicate a potential environmental problem and 'trigger' further investigation. The marine 95% level of protection has been selected as most appropriate. The above criteria are included in Appendix B.

The Auditor considers that risk based remediation criteria are appropriate, and should consider:

- protection of Darling Harbour from seepage of contaminants off the site after development, which must consider the impact of long term tidal flushing from residual contamination that remains on the site after development.
- suitability for the specific land uses based on possible exposure pathways.

The RAP does not provide a validation process for material to be re-used within the project site or imported to the site. A validation process will need to be included in the RAP or RWP for each area.

8 Soil Analytical Results

The data set of soil analytical results includes over 500 primary samples, although not all samples were analysed for all the contaminants of concern listed in Section 4. The RAP presents maximum concentrations of contaminants detected in relation to four areas of the site, which are then discussed in the RAP in terms of remedial options for each area (see Section 10). All ERM (2007, 2008) data is used in the summary in Table 8.1 below.

The results have been compared to the screening values (generally Soil Investigation Levels) which change for different areas of the site. The Auditor has not attempted to analyse data for each area as the areas considered by ERM will not correspond to development areas. Data sets for each development area will need to be considered in their respective RAPs/ RWP. Also, additional data is being collected to address data gaps as applicable to each area prior to preparation of RAPs. Table 8.1 includes samples from fill, the majority of the samples, as well as a few samples from natural alluvial soil and bedrock. These will also need to be considered in individual RAPs. Table 8.1 provides an indication of the relative importance of each contaminant based on the number of exceedances of the screening values. Attachment 3 presents an indication of the distribution of the soil impacts exceeding screening values.

Table 8.1: Soil Analytical Results – Summary Table (mg/kg)				
Analyte	n	Detections	Maximum	n > screening value
Asbestos	39	1		1
Arsenic	517	100	77	0
Cadmium	517	12	2	0
Total Chromium	517	510	141	0
Copper	517	378	1480	0
Lead	521	487	13800	11
Nickel	517	364	164	0
Zinc	517	458	4770	0
Mercury (inorganic)	516	211	8	0
Sulphate	272	259	31500	28
Total Cyanide	270	51	575	0
Speciated Phenols	192	1	1.1	
PCBs	116	2	0.74	
OCP /OPP	16	0		0
TPH (C ₆ -C ₉)	439	38	1140	19
TPH (C ₁₀ -C ₃₆)	439	107	147200	59

Table 8.1: Soil Analytical Results – Summary Table (mg/kg)				
Analyte	n	Detections	Maximum	n > screening value
Benzene	410	34	140	25
Toluene	410	38	232	3
Ethyl benzene	410	29	63	1
Xylene	410	37	345	16
Total PAHs	376	234	20934	77
Benzo(a)Pyrene	376	187	652	88

n number of samples

EQC Environmental Quality Criteria

In considering the soil analytical data, the Auditor notes:

- The most detections of high concentrations of contaminants were recorded within the Remediation Area and at the northern end of the site near former Warehouse 3
- The most common contaminants are PAHs. These are mainly within the former gasworks (Remediation Area) as expected, and free phase tar was noted in and around the former gasworks structures. There were also detections, mainly at lower concentrations, over the remainder of the site
- While there is a high proportion of samples with elevated PAH concentrations near former Warehouse 3, the concentrations were generally much lower than at the former gasworks site
- Most of the high concentrations of TPH recorded were associated with PAHs
- Nearly all detections of volatiles (TPH C6-C9, BTEX) were within or close to and probably associated with the former gasworks area
- Lead is the main metal contaminant, but there were relatively few high concentrations of lead recorded. Most were with or near high PAH concentrations
- While there were a few elevated concentrations of other metals, mainly copper, mercury and zinc, there does not appear to be any indications of major metal contamination in soil (although some metals exceed groundwater trigger values)
- While most high concentrations recorded were from samples from the upper 5m, there were more samples analysed from the upper 5m, and sufficient high concentrations were detected lower in the fill to indicate that contamination is associated with the full depth of fill
- There were some indications of organic contamination in natural alluvial soils and bedrock, mainly in the gasworks area.

In the Auditor's opinion, soil contamination at the site has been sufficiently characterised for the purpose of preparing a RAP.

9 Groundwater Analytical Results

Groundwater samples were collected by ERM from 25 wells in 2008, including wells that had been installed and sampled in 2007. Groundwater was analysed for the contaminants of concern, though not all samples were analysed for all analytes. The RAP presents a table of the maximum concentration of each contaminant detected in groundwater.

In review of the results, the Auditor notes:

- Free tar, PAHs and TPH were recorded in many wells in the former gasworks area
- Much lower concentrations were recorded outside the former gasworks area including downgradient
- Dissolved metals especially zinc and copper were recorded in many wells across the site. While some may be associated with metals within fill (see Section 8), concentrations are relatively low.

The RAP (Section 10) envisages source removal but no active groundwater remediation. However this will need to be confirmed by the results of risk assessments to be completed.

10 Remediation Action Plan

The RAP divides the site into four areas for the purpose of remediation. The areas are shown on Attachment 2. These areas do not correspond to development areas, but provide a logical approach to site remediation that can be adapted when future landuses are finalised. The Areas are:

- Area 1 – Portion of the Site within the Remediation Site zoned for commercial/residential use
- Area 2 – Portion of the Site outside the Remediation Site zoned for commercial/residential use
- Area 3 – Portion of the Site within the Remediation Site occupied by Hickson Road
- Area 4 – Portion of the Site outside the Remediation Site zoned for open space use.

The remediation goal is to both address the significant contamination on the Remediation Site and to render the site suitable for the proposed development. Table 10.1 lists the extent of remediation required and options presented for each area.

Table 10.1: Remediation Requirements and Options Discussed		
Description	Extent of Remediation Required	Options Discussed
Area 1	As a declared Remediation Site, all of Area 1 will require remediation. Remediation will need to extend into the bedrock where significant contamination is present	Do nothing – considered but eliminated Ex-situ on-site treatment – considered suitable for material to be excavated for development purposes, viability of different types of treatment plants to be established In-situ on-site treatment – considered possibly viable for material that does not require excavation for development purposes, requires proving Excavation, off-site treatment and reinstatement – considered less desirable than on-site treatment Off-site disposal – hazardous wastes would require pre-treatment, otherwise viable but less desirable than on-site treatment. May be required for some material that cannot be used on-site for earthworks balance or technical (tar) reasons On-site management – not desirable, would constrain development and require long term monitoring
Area 2 (Land to be developed outside of Remediation Site)	Known contamination impacts are not significant enough to warrant regulation by EPA. Suitability for proposed commercial/ residential use is still to be verified by risk assessment, and may require	Options include those for Area 1. Material excavated for basements could be reused in other parts of the project site. RAP states that in-situ treatment would not be practical but may be suitable for any contaminated material beneath basement level

Table 10.1: Remediation Requirements and Options Discussed

Description	Extent of Remediation Required	Options Discussed
	further validation	
Area 3 (Hickson Road)	Within the declared Remediation Site, all of Area 3 will require remediation. Remediation will need to extend into the bedrock where significant contamination is present around former gasworks structures	Options include those for Area 1, but major excavation in Hickson Road is not desirable, therefore in-situ methods are preferred
Area 4 (Open space)	Known contamination impacts are not significant enough to warrant regulation by EPA. Suitability for proposed open space use is still to be verified by risk assessment, and may require further validation	Options include those for Area 1. In-situ treatment complicated by proximity to harbour. Excavation and reuse in Area 4 possible especially for shallow soil. Management more viable than other areas because of lesser amount of contamination and absence of basements.
Groundwater	On-site treatment during dewatering of excavations, and possibly ongoing	Monitoring required to determine whether ongoing treatment or monitored natural attenuation (MNA) is required

The Auditor has assessed the RAP by comparison with the checklist included in EPA (1997) *Guidelines for Consultants Reporting on Contaminated Sites*, as detailed in Table 10.1 below.

Table 10.2: Evaluation of Remedial Action Plan

Element	Remedial Action Plan	Auditor Comments
Remedial Objectives	Initially address significant contamination on the Remediation Site, then make all of the site suitable for the proposed redevelopment	This goal is considered appropriate. Aim is to also remove sources of groundwater contamination. Proposed open space areas may also require remediation to prevent off-site migration of contamination in groundwater
Discussion of the extent of remediation required.	As discussed in Table 10.1	Groundwater remediation not envisaged in the RAP. This will need to be confirmed by risk assessment
Remedial Options	As listed in Table 10.1	General options adequately identified
Selected Preferred Option	Areas 1 and 3: does not provide preferred option because selection of strategy for the Remediation Site is subject to the VMP process after further assessment and trials. Area 2: excavation and ex-situ on-site treatment and reuse in other	Considered appropriate in principle, noting that risk assessment and probably further investigations are required to establish remediation extent, and further trials are required for treatment technologies

Table 10.2: Evaluation of Remedial Action Plan

Element	Remedial Action Plan	Auditor Comments
	areas of project site. May be supplemented by off-site disposal or other methods where excavation is not required for development purposes. Area 4: on-site management. May be supplemented by excavation in areas as determined by risk assessment	
Rationale	Options justified in terms of financial, environmental and social costs	Rationale considered reasonable
Proposed Validation Testing	Notes that validation methodologies need to be included in RWPs	Detailed validation plans required, including for material to be reused within the project site
Interim Site Management Plan (before remediation)	Not discussed	Not required for contamination under current site condition
Site Management Plan (operation phase) including stormwater, soil, noise, dust, odour	Notes that preparation of development environmental management plans is required, and lists aspects that need to be included. Particularly notes potential for odours during excavation and possible requirement for excavation within negative pressure enclosure.	Level of detail considered appropriate for overarching RAP
Occupation health and safety	Notes that a Health and Safety Plan is required to be developed. RAP included information on contaminants to be considered	Level of detail considered appropriate for overarching RAP
Contingency Plan if Selected Remedial Strategy Fails	Outlines some unexpected conditions that could feasibly occur, and processes for managing them	Level of detail considered appropriate for overarching RAP
Contingency Plans to Respond to site Incidents. Site Management Plan for the Operation Phase.	Not discussed	Should be in individual area RAPs/RWPs
Remediation Schedule	Not provided, but notes that remediation of the gasworks structures beneath Hickson Road should be completed simultaneously with the development area	Voluntary Management Proposal for Remediation Site including Performance Schedule appended to RAP
Licence and Approvals	Work is to be conducted in accordance with approvals obtained under Part 3A of the Environmental Planning and Assessment Act. The RAP notes that other licences	Needs to be included in individual area RAPs/RWPs

Table 10.2: Evaluation of Remedial Action Plan		
Element	Remedial Action Plan	Auditor Comments
	and approvals may be required, such as an Environmental Protection Licence	
Community Relations	Notes need for Community Consultation Plan to notify all stakeholders	
Staged Progress Reporting	Envisages Site Audit Statements after validation of each area.	
Long term environmental management plan	May be required to control risks from residual contamination and define ongoing monitoring requirements	May be appropriate if no ongoing risk and contingency in place for groundwater monitoring

The Auditor considers that the RAP provides an adequate basis for development of RAPs/ RWPs for individual areas of the site. It generally establishes the principle of on-site treatment and reuse when practical.

11 Contamination Migration Potential

It is likely that contaminant migration into Darling Harbour has occurred. Given the time that has passed since the closure of the gasworks and of filling the site, and the significant decrease in contaminant concentrations measured in groundwater wells downgradient of the former gasworks, the extent of ongoing migration is uncertain. The risk from possible ongoing long term flushing of contaminants will need to be established by a risk assessment, and remediation standards established.

12 Compliance with Regulatory Guidelines And Directions

Guidelines currently approved by the EPA under section 105 of the NSW *Contaminated Land Management Act 1997* are listed in Appendix C. The Auditor has used these guidelines.

Director General's Requirement No 3 for Application Number MP10-0026 covering remediation and land forming works, and Requirement No 5 for Application Numbers MP10-0022 and MP10-0023 require that a site wide Remediation Action Plan be prepared. The Overarching Remedial Action Plan that is the subject of this audit was prepared to fulfil that requirement. In the Auditor's opinion:

- The investigations to date have been generally conducted in accordance with SEPP 55 Planning Guidelines
- The investigations have been generally reported in accordance with the EPA (1997) *Guidelines for Consultants Reporting on Contaminated Sites*.

Detailed Remediation Action Works Plan(s) are also required for relevant section(s) of the site, and will be prepared progressively. Those plans are required to be audited by an EPA accredited site auditor.

13 Conclusions and Recommendations

This Site Audit Report has been prepared to determine the appropriateness of a plan of remediation.

The plan of remediation, entitled:

“Overarching Remedial Action Plan for The Barangaroo Project Site, Sydney”, dated 1 June 2010, Environmental Resources Management Australia Pty Ltd, Report 0114385RP01Final

was prepared to satisfy a Director General's requirement for a site wide remediation action plan to be prepared for the Barangaroo project site.

The Auditor concludes that the Plan has fulfilled the requirement.

The Auditor notes that specific remediation action plans and more detailed remediation work plans will be prepared for each individual portion of the site. The principles incorporated into the overarching RAP which should be incorporated into each individual RAP include:

- Establishment of appropriate remediation end points applicable to both human health and the environment by a risk assessment that considers future landuse and potential long term impacts to Darling Harbour
- Establishment of a lateral and vertical extent of remediation that will address the remediation end points. This may require additional delineation investigations
- Development of technical details for the remediation methods proposed that support that the selected method(s) are technically feasible with a low chance of failure
- Sustainable remediation, by reuse of material within the Barangaroo project area where possible
- Documentation of a methodical and rigorous process for validation of the results of remediation.

14 Other Relevant Information

This Audit was conducted on the behalf of Barangaroo Delivery Authority for the purpose of providing an independent review by an EPA Accredited Auditor of the suitability and appropriateness of a remedial action plan i.e. a "Site Audit" as defined in Section 4 (1) (b) (v) of the CLM Act.

This summary report may not be suitable for other uses. ERM and Coffey included limitations in their report. The audit must also be subject to those limitations. The Auditor has prepared this document in good faith, but is unable to provide certification outside of areas over which he had some control or is reasonably able to check.

The Auditor has relied on the documents referenced in Section 1 of the Site Audit Report in preparing his opinion. If the Auditor is unable to rely on any of those documents, the conclusions of the audit could change.

It is not possible in a Site Audit Report to present all data which could be of interest to all readers of this report. Readers are referred to the referenced reports for further data. Users of this document should satisfy themselves concerning its application to, and where necessary seek expert advice in respect to, their situation.

Appendix A: Attachments

Attachment 1: Site Location

Attachment 2: Site Layout and Remedial Areas

Attachment 3: Soil Impacts

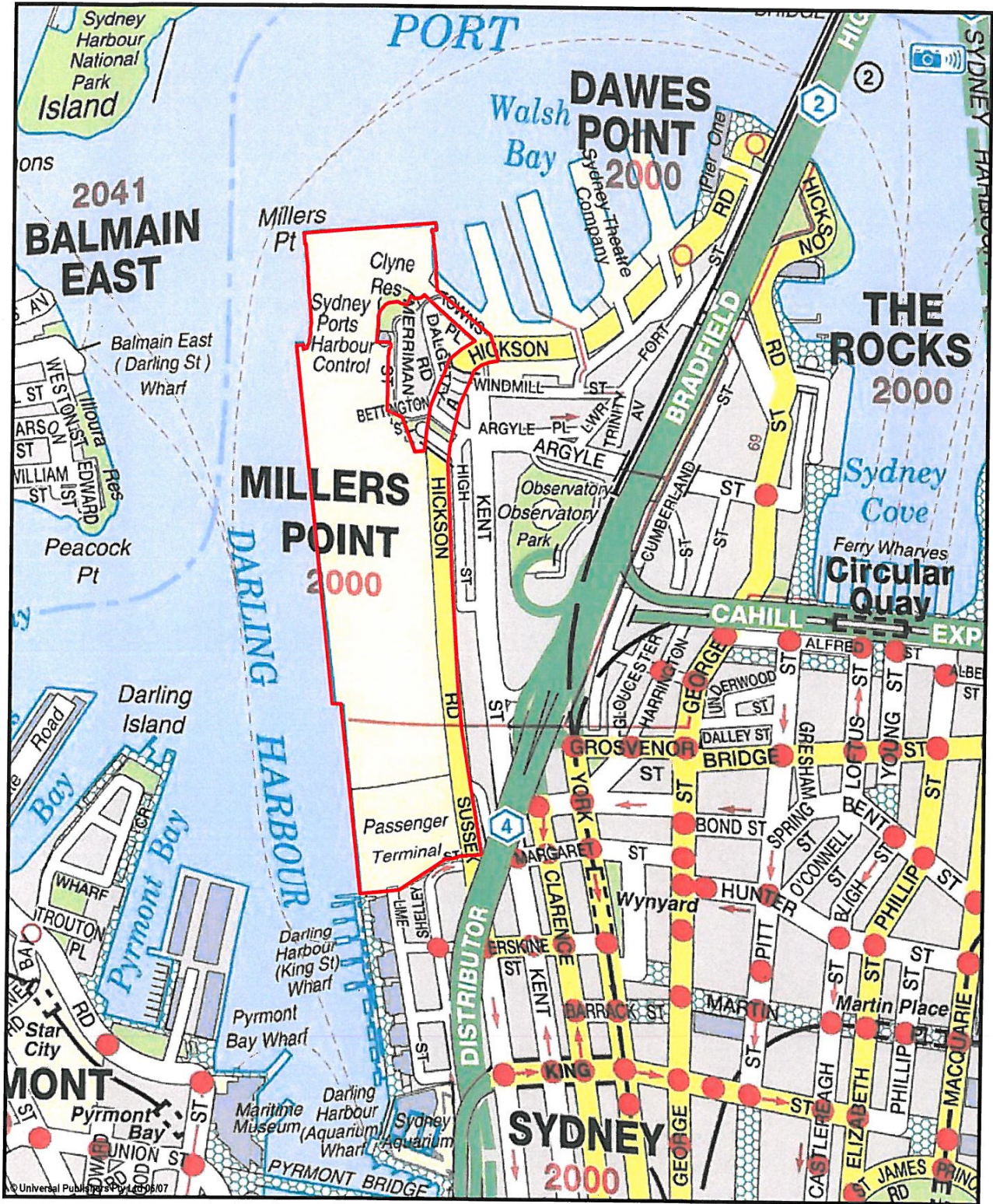


Figure 1
Site Location

Legend

 Site Location

Client:	Barangaroo Delivery Authority
Project:	Barangaroo Overarching RAP

Drawing No: 0114385s_RAP_GIS002_R0.mxd

Date: 06/04/2010 Drawing size: A4

Drawn by: JF Reviewed by: PL

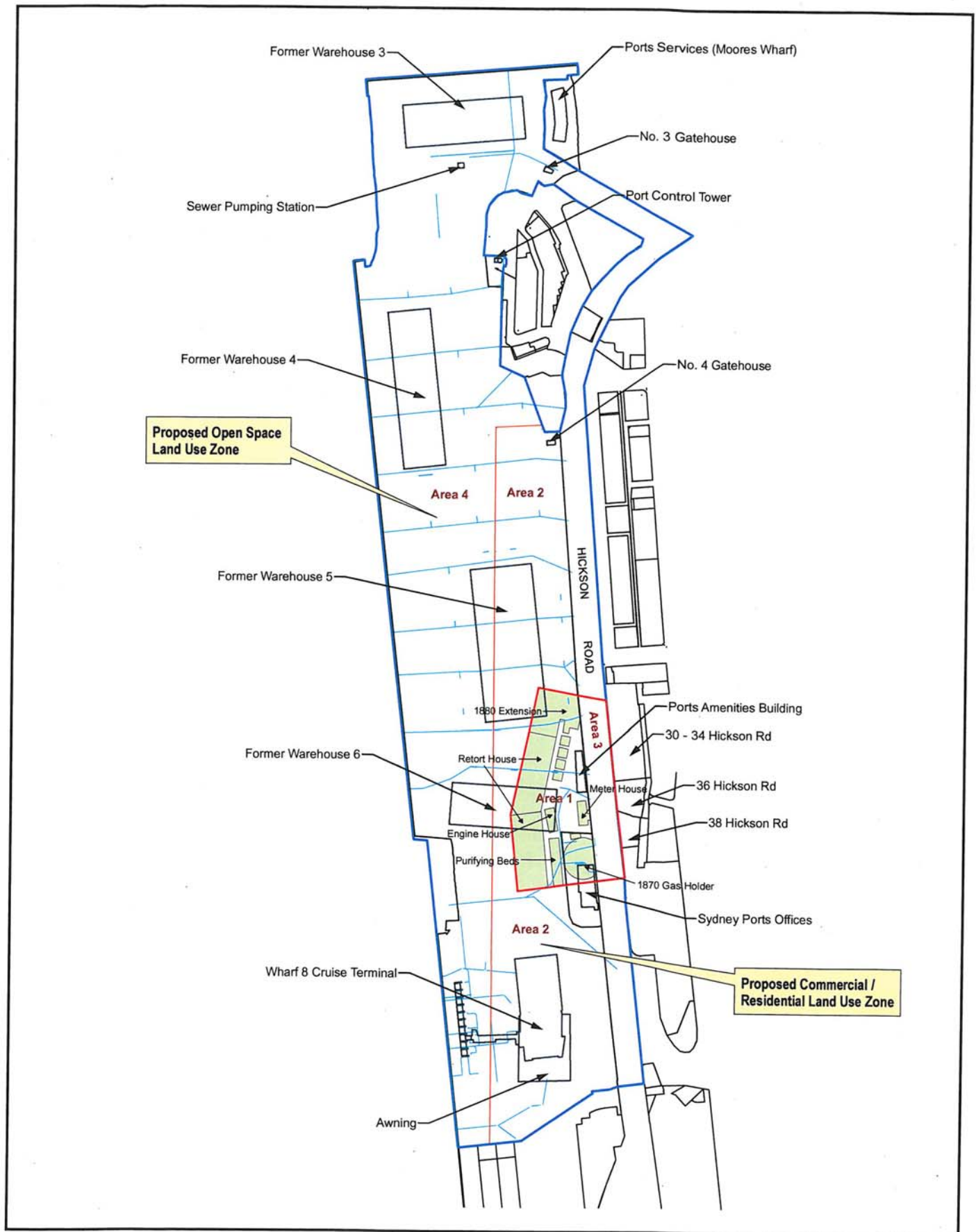
Projection: GDA 1994 MGA Zone 56

Scale: Refer to Scale Bar

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

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- Legend**
- Remediation Site
 - Lot Boundaries
 - Existing or Former Site Features
 - Approximate Boundary of Landuse Zones
 - Site Drainage
 - Approximate Location of Former Gasworks Structures
 - Barangaroo Project Site

Client: Barangaroo Delivery Authority
 Project: Barangaroo Overarching RAP
 Drawing No: 0114385a_RAP_GIS001_R0.mxd
 Date: 31/03/2010 Drawing size: A3
 Drawn by: JF Reviewed by: PL
 Projection: GDA 1994 MGA Zone 56
 Scale: Refer to Scale Bar

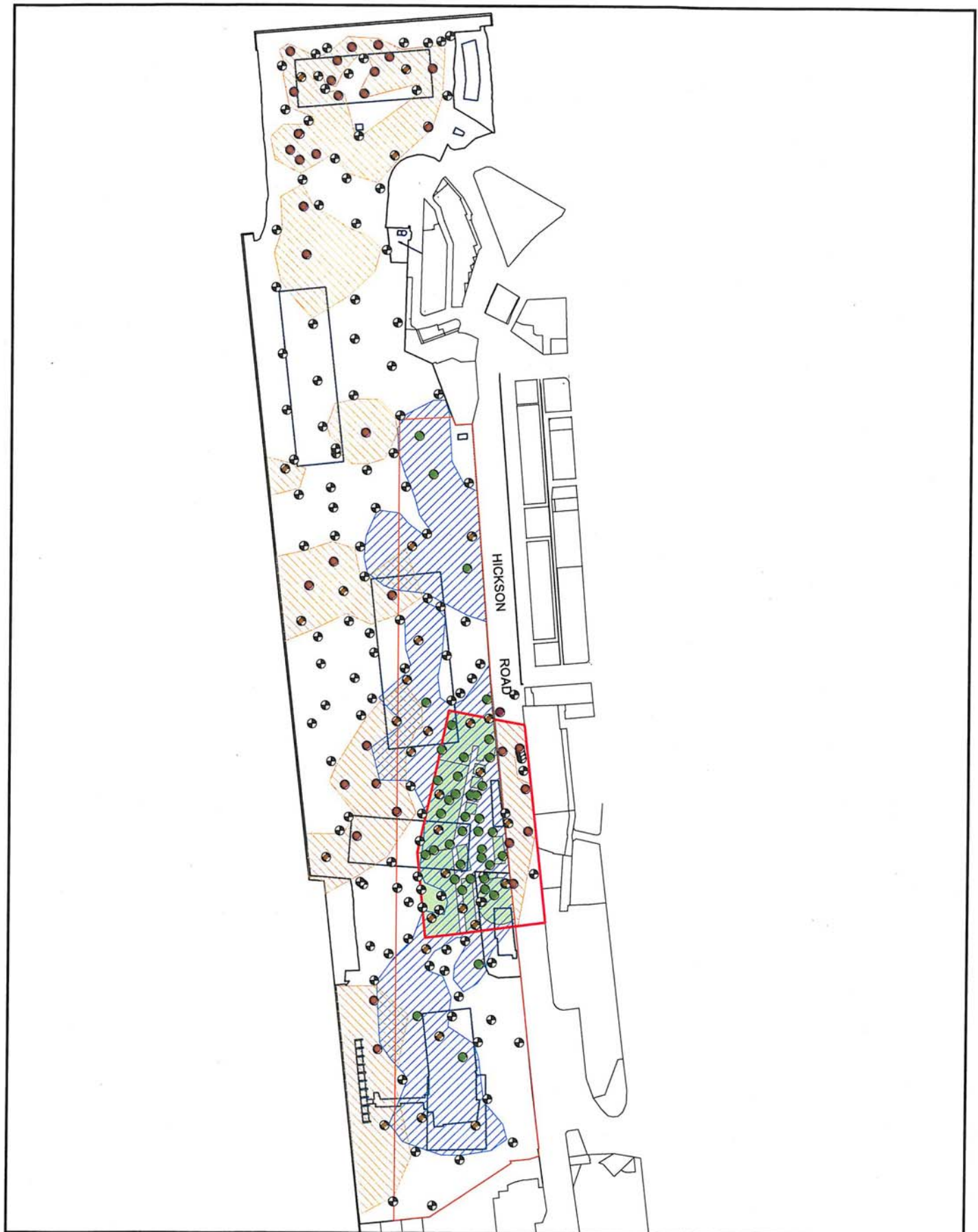
0 40 80 120m

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Figure 2
Site Layout Plan

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Legend

- Remediation Site
- Approximate Location of Former Gasworks Structures
- Approximate Extent of Soils Exceeding Comm/Residential Screening Values
- Approximate Extent of Soils Exceeding Open Space Screening Values
- Approximate Boundary of Landuse Zones
- Existing or Former Site Features
- Lot Boundaries

- ▲ Exceeds EPA 94 Criteria
- Exceeds HIL 'E'
- Exceeds HIL 'D' and / or 'F'
- ⊕ Borehole Locations

Client: Barangaroo Delivery Authority
 Project: Barangaroo Overarching RAP
 Drawing No: 0114385s_RAP_GIS006_R0.mxd
 Date: 15/04/2010 Drawing size: A3
 Drawn by: JF Reviewed by: PL
 Projection: GDA 1994 MGA Zone 56
 Scale: Refer to Scale Bar

0 25 50 75m

Map and figures contained within this document may be based on third party data. May not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

Figure 7
Approximate Extent of Soil Impacts Exceeding Screening Values

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Appendix B: Soil and Groundwater Criteria

Soil investigation levels for urban development sites

Department of Environment and Conservation NSW (April 2006)

Substance	Health-based investigation levels ¹ (mg/kg)				Provisional phytotoxicity-based investigation levels ² (mg/kg)
	Residential with gardens and accessible soil (home-grown produce contributing < 10% fruit and vegetable intake; no poultry), including children's day-care centres, preschools, primary schools, townhouses, villas (NEHF A) ³	Residential with minimal access to soil including high-rise apartments and flats (NEHF D)	Parks, recreational open space, playing fields including secondary schools (NEHF E)	Commercial or industrial (NEHF F)	
	Column 1	Column 2	Column 3	Column 4	Column 5
Metals and metaloids					
Arsenic (total)	100	400	200	500	20
Beryllium	20	80	40	100	—
Cadmium	20	80	40	100	3
Chromium (III) ⁴	12%	48%	24%	60%	400
Chromium (VI)	100	400	200	500	1
Cobalt	100	400	200	500	—
Copper	1,000	4,000	2,000	5,000	100
Lead	300	1,200	600	1,500	600
Manganese	1,500	6,000	3,000	7,500	500
Methyl mercury	10	40	20	50	—
Mercury (inorganic)	15	60	30	75	1 ⁵
Nickel	600	2,400	600	3,000	60
Zinc	7,000	28,000	14,000	35,000	200
Organics					
Aldrin + dieldrin	10	40	20	50	—
Chlordane	50	200	100	250	—
DDT + DDD + DDE	200	800	400	1,000	—
Heptachlor	10	40	20	50	—
PAHs (total)	20	80	40	100	—
Benzo(a)pyrene	1	4	2	5	—
Phenol ⁶	8,500	34,000	17,000	42,500	—
PCBs (total)	10	40	20	50	—
Petroleum hydrocarbon components⁷					
> C16–C35 (aromatics)	90	360	180	450	—
> C16–C35	5,600	22,400	11,200	28,000	—
> C35 (aliphatics)	56,000	224,000	112,000	280,000	—
Other					
Boron	3,000	12,000	6,000	15,000	— ⁸
Cyanides (complex)	500	2,000	1,000	2,500	—

Soil investigation levels for urban development sites

Department of Environment and Conservation NSW (April 2006)

Substance	Health-based investigation levels ¹ (mg/kg)				Provisional phytotoxicity-based investigation levels ² (mg/kg)
	Residential with gardens and accessible soil (home-grown produce contributing < 10% fruit and vegetable intake; no poultry), including children's day-care centres, preschools, primary schools, townhouses, villas (NEHF A) ³	Residential with minimal access to soil including high-rise apartments and flats (NEHF D)	Parks, recreational open space, playing fields including secondary schools (NEHF E)	Commercial or industrial (NEHF F)	
	Column 1	Column 2	Column 3	Column 4	Column 5
Cyanides (free)	250	1,000	500	1,250	—

- 1 The limitations of health-based soil investigation levels are discussed in Schedule B(1) Guidelines on the Investigation Levels for Soil and Groundwater and Schedule B(7a) Guidelines on Health-based Investigation Levels, *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPC 1999)
- 2 The provisional phytotoxicity-based investigation levels proposed in this document are single number criteria. Their use has significant limitations because phytotoxicity depends on soil and species parameters in ways that are not fully understood. They are intended for use as a screening guide and may be assumed to apply to sandy loam soils or soils of a closely similar texture for pH 6–8.
- 3 National Environmental Health Forum (NEHF) is now known as enHealth.
- 4 Soil discolouration may occur at these concentrations.
- 5 Total mercury
- 6 Odours may occur at these concentrations.
- 7 The carbon number is an 'equivalent carbon number' based on a method that standardises according to boiling point. It is a method used by some analytical laboratories to report carbon numbers for chemicals evaluated on a boiling point GC column.
- 8 Boron is phytotoxic at low concentrations. A provisional phytotoxicity-based investigation level is not yet available.

Notes:

This table is adapted from Table 5-A in Schedule B(1): Guidelines on Investigation Levels for Soil and Groundwater to the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC 1999).

Soil investigation levels (SILs) may not be appropriate for the protection of ground water and surface water. They also do not apply to land being, or proposed to be, used for agricultural purposes. (Consult NSW Agriculture and NSW Health for the appropriate criteria for agricultural land.)

SILs do not take into account all environmental concerns (for example, the potential effects on wildlife). Where relevant, these would require further consideration.

Impacts of contaminants on building structures should also be considered.

For assessment of hydrocarbon contamination for residential land use, refer to the Guidelines for Assessing Service Station Sites (EPA 1994).

Threshold Concentration for Sensitive Land Use – Soils Guidelines for Assessing Service Station Site (NSW EPA 1994)	
Contaminant	Threshold Concentration (mg/kg)
TPH (C ₆ -C ₉)	65
TPH (C ₁₀ -C ₃₆)	1,000
Benzene	1
Toluene	1.4
Ethylbenzene	3.1
Xylenes (total)	14

Trigger Values (TV) for Screening Marine Water Quality Data (µg/L) for Slightly to Moderately Disturbed Ecosystems (ANZECC 2000)

Contaminant	Threshold Concentration (µg/L))	Guideline Source
Metals and Metalloids		
Arsenic – As (III/V)	2.3/4.5	Low reliability trigger values (95% level of protection) from Volume 2 of ANZECC (2000)
Cadmium – Cd	0.7	ANZECC (2000) 99% protection level due to potential for bio-accumulation or acute toxicity to particular species.
Mercury – Hg	0.1	
Nickel – Ni	7	ANZECC (2000) 99% protection level due to potential for toxicity to particular species.
Manganese	80	Low reliability trigger values (derived from the mollusc figure) from Volume 2 of ANZECC (2000)
Chromium – Cr (III/VI)	27.4/4.4	ANZECC (2000) 95% protection levels.
Copper – Cu	1.3	
Cobalt	1	
Lead – Pb	4.4	
Zinc – Zn	15	
Aromatic Hydrocarbons		
Benzene	500	Low reliability trigger values (95% level of protection) from Volume 2 of ANZECC (2000)
Toluene	180	
Ethylbenzene	5	
o-xylene	350	
m-xylene	75	
p-xylene	200	
Polycyclic Aromatic Hydrocarbons		
Naphthalene	50	ANZECC (2000) 99% protection level due to potential for bio-accumulation or acute toxicity to particular species.
Anthracene	0.01	Low reliability trigger values from Volume 2 of ANZECC (2000)
Phenanthrene	0.6	
Fluroanthene	1	ANZECC (2000) 99% protection level due to potential for bio-accumulation or acute toxicity to particular species.
Benzo (a) pyrene	0.1	
Chlorinated Alkanes		
Tetrachloroethene - PCE	70	Low reliability trigger values (95% level of protection) from Volume 2 of ANZECC (2000)
1,1,2 Trichloroethene- TCE	330	
1,1,2 Trichloroethene- 1,1,2-TCE	330	
Vinyl chloride (chloroethene)	100	
1,1,1 Trichloroethane – 1,1,1-TCA (111-TCE)	270	
1,1 Dichloroethene	700	
1,1 Dichloroethane	250	
1,2 Dichloroethane	1900	
1,1,2 - Trichloroethane	1900	Moderate reliability trigger values (95% level of protection) from Volume 2 of ANZECC (2000)
Chloroform	370	Low reliability trigger values (95% level of protection) from Volume 2 of ANZECC (2000)
Non-Metallic Inorganics		
Ammonia Total – NH ₃ (at pH of 8)	910	ANZECC (2000) 95% protection levels.

Trigger Values (TV) for Screening Marine Water Quality Data (µg/L) for Slightly to Moderately Disturbed Ecosystems (ANZECC 2000)		
Contaminant	Threshold Concentration (µg/L)	Guideline Source
Cyanide (Free or unionised HCN)	4	

While the low reliability figures should not be used as default guidelines they will be useful for indicating the quality of groundwater migrating off-site.

Appendix C: EPA Approved Guidelines

Guidelines made or approved by the EPA under section 105 of the Contaminated Land Management Act 1997

(as of 3 July 2009)

Guidelines made by the EPA

- *Contaminated Sites: Guidelines for Assessing Service Station Sites*, December 1994 - [servicestnsites.pdf](#), 1.3Mb
- *Contaminated Sites: Guidelines for the vertical mixing of soil on former broad-acre agricultural land*, January 1995 - [vertmix.pdf](#), 149kb
- *Contaminated Sites: Sampling Design Guidelines*, September 1995
- *Contaminated Sites: Guidelines for Assessing Banana Plantation Sites*, October 1997 - [bananaplantsite.pdf](#), 586 kb
- *Guidelines for Consultants Reporting on Contaminated Sites* (97104consultantsglines.pdf; 209 KB), September 2000
- *Contaminated Sites: Guidelines for Assessing Former Orchards and Market Gardens*, June 2005 - [orchardgdlne05195.pdf](#), 172 kb
- *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme (2nd edition)*, April 2006 - [auditorglines06121.pdf](#), 510kb
- *Guidelines for the Assessment and Management of Groundwater Contamination*, March 2007 - [groundwaterguidelines07144.pdf](#) 604 kb
- *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*, June 2009 - [09438gldutycontclma.pdf](#), 1 Mb

Note: All references in the EPA's contaminated sites guidelines to the Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC, November 1992) are replaced as of 6 September 2001 by references to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, October 2000), subject to the same terms.

Guidelines approved by the EPA

ANZECC publications

- *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*, published by Australian and New Zealand Environment and Conservation Council (ANZECC) and the National Health and Medical Research Council (NHMRC), January 1992
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Paper No 4, October 2000

EnHealth publications (formerly National Environmental Health Forum monographs)

- *Composite Sampling*, by Lock, W. H., *National Environmental Health Forum Monographs, Soil Series No.3*, 1996, SA Health Commission, Adelaide
- *Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards*, Department of Health and Ageing and EnHealth Council, Commonwealth of Australia, June 2002

National Environment Protection Council publications

- National Environment Protection (Assessment of Site Contamination) Measure 1999

The Measure consists of a policy framework for the assessment of site contamination, Schedule A (Recommended General Process for the Assessment of Site Contamination) and Schedule B (Guidelines). Schedule B guidelines include:

- B(1) Guideline on Investigation Levels for Soil and Groundwater
- B(2) Guideline on Data Collection, Sample Design and Reporting
- B(3) Guideline on Laboratory Analysis of Potentially Contaminated Soils
- B(4) Guideline on Health Risk Assessment Methodology
- B(5) Guideline on Ecological Risk Assessment
- B(6) Guideline on Risk Based Assessment of Groundwater Contamination
- B(7a) Guideline on Health-Based Investigation Levels
- B(7b) Guideline on Exposure Scenarios and Exposure Settings
- B(8) Guideline on Community Consultation and Risk Communication
- B(9) Guideline on Protection of Health and the Environment During the Assessment of Site Contamination
- B(10) Guideline on Competencies & Acceptance of Environmental Auditors and Related Professionals

Other documents

- Guidelines for the Assessment and Clean Up of Cattle Tick Dip Sites for Residential Purposes, NSW Agriculture and CMPS&F Environmental, February 1996
- *Australian Drinking Water Guidelines*, NHMRC & Natural Resource Management Ministerial Council of Australia and New Zealand, 2004