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30 January 2013

SKM Report 300113
EN02224

Dear Sir

Technical Review of AECOM (25 October 2012) HHERA for the *Declared Area* and Adjacent Land, Barangaroo, Hickson Road, Sydney

1. Introduction

This letter provides a technical review of a revised Human Health and Ecological Risk Assessment (HHERA) for the *Declared Area* that was documented in a report prepared by AECOM dated 25 October 2012[1]. The HHERA provided an assessment of the risk to human health and the environment for the *Declared Area* and adjacent land in its current form.

This current form is public recreational open space where the ground surface is to remain sealed by concrete and asphalt pavement[2]. For this land use, the AECOM HHERA considered a wide range of potential receptors and exposure pathways. For each potential receptor and exposure pathway, the health risks posed by soil contamination, groundwater contamination and ground vapours were assessed.

This review has focused on the following three issues:

1. Whether the conceptual site model adopted by the AECOM HHERA provides a proper representation of site-related information regarding contamination sources, receptors and exposure pathways between those sources and receptors;
2. Whether the AECOM HHERA meets the relevant standards for the preparation of an environmental risk assessment; and
3. Whether the AECOM HHERA meets the relevant standards for the preparation of a human health risk assessment.

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[1] AECOM (25 October 2012) "*Human Health and Ecological Risk Assessment, VMP Remediation Works Area (Addressing the NSW EPA Remediation Site Declaration 21122, Millers Point)*", Document No: 60153531 VMP RPT049

[2] Sections 1.1, 1.2, 2.2 & 5.3 in AECOM HHERA

A summary of my review is provided in **Section 2**, with my detailed answers to these three questions provided in **Sections 3** to **5**, respectively.

In this review, I have defined the relevant standards as being those specified in guidelines prepared and/or endorsed by the NSW EPA under Section 105 of the NSW Contaminated Land Management (CLM) Act 1997 and by other Australian State and Federal Government agencies where NSW EPA guidelines are not available. This review is not a comprehensive audit of the HHERA, since its focus has been to only target issues that have been critical to its outcome. This technical review follows three earlier reviews prepared by SKM dated 10 May 2012[3], 16 August 2012[4] and 31 August 2012[5].

In my review, I have relied on the accuracy of the field and laboratory data reported by AECOM and have assumed the data in their reports are correct. If any of the data are found to be invalid then I may need to reassess the data and check if the errors are significant and may affect the conclusions made herein.

I am a Certified Practicing Engineer (CPEng) and the SKM Practice Leader for Contaminated Land Management in Sydney. I have a first class honours degree and a doctorate in civil engineering from The University of Sydney. I am an environmental and civil engineer with over 35 years professional experience specialising in the investigation, assessment, remediation and management of contaminated sites, environmental audits and waste management in Australia, South-east Asia and Europe. I have been responsible for the investigation and remediation of many of the largest contaminated sites in Australia, particularly gasworks sites, and have been a technical adviser to NSW Government agencies on key projects (eg. BHPB Hunter Sediment Remediation Project, BHPB Steel River Remediation Project, Homebush Bay Dioxin Remediation Project). I am an accredited EPA Site Auditor in most Australian States and have completed over 200 site audits in NSW. For the past three years I have also been a guest lecturer in the School of Environment at the University of Technology Sydney. Further details of my qualifications are provided in a curriculum vitae in **Appendix G** of this report.

I have prepared this report in accordance with the "*Expert witness code of conduct*" given in Schedule 7 of the Uniform Civil Procedure Rules 2005, which I have read and understood.

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[3] SKM (10 May 2012) "*Preliminary Technical Review of AECOM Contamination Reports for the Declared Area and Adjacent Land, Barangaroo, Hickson Road, Sydney*"

[4] SKM (16 August 2012) "*SKM Reply to AECOM (23 July 2012) Comments, AECOM HHERA for the Declared Area and Adjacent Land, Barangaroo, Hickson Road, Sydney (65 pages)*"

[5] SKM (31 August 2012) "*Technical Review of AECOM (16 August 2012) HHERA for the Declared Area and Adjacent Land, Barangaroo, Hickson Road, Sydney (28 pages)*"

2. Summary Opinion

2.1 Issue #1 - Conceptual Site Model

A conceptual site model (CSM) is defined as a representation of site-related information regarding contamination sources, receptors and exposure pathways between those sources and receptors[6]. The development of a CSM is an essential part of all risk assessments and provides the framework for identifying how the site became contaminated and how potential receptors may be exposed to contamination either in the present or in the future.

The NSW EPA advise[7] that a conceptual site model should establish the relationships between the sources of contamination and release mechanisms, the nature and extent of the contamination, the dominant fate and transport characteristics of contaminants, and potential receptors and exposure pathways.

In my opinion, the CSM used by the AECOM HHERA contains deficiencies that do not meet NSW EPA standards have caused incorrect conclusions and recommendations to be made by their study. These deficiencies in turn would prevent the development of a remediation strategy that would best meet the Ecologically Sustainable Development principles specified in Section 9 of the CLM Act.

These deficiencies include, but may not be limited to:

a) **Contaminant sources**:

  i. The AECOM HHERA concluded[8] that asbestos containing material was not widespread within fill materials at the *Declared Area* and did not need to be considered further by the risk assessment. However, the available investigation data indicate there is an unacceptable risk of asbestos contamination in the fill layer, which could pose an unacceptable risk to future maintenance workers if appropriate work practices were not followed. This meant that the AECOM HHERA is incomplete since it did not properly account for all types of contaminating substances that influence the remediation approach required for the *Declared Area*. In my opinion, the health risks posed by asbestos contamination can best be managed by remediating the site using a capping strategy that incorporates the use of a site management plan.

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[6] Section 4.1, NEPC (April 2011) Draft NEPM Schedule B2 "*Guideline on Site Characterisation*"

[7] Section 2.3, NSW DEC (March 2007) "*Guidelines for the Assessment and Management of Groundwater Contamination*"

[8] Section 4.2.1, AECOM HHERA

ii. The AECOM CSM did not include past and present sewerage pump stations constructed within or near the *Declared Area* as contaminant sources. These additional sources could have influenced the nature, extent and migration of contamination at the *Declared Area* and into Darling Harbour.

b) **Release mechanisms:** The AECOM CSM shows that the main sources of contamination at the former gasworks site are the tarry liquids that remain at the base of the former tar tanks and gasholders. However, the AECOM CSM and other parts of the AECOM HHERA did not assess and describe the dominant release mechanism for contaminants from these sources, particularly in relation to how these tarry wastes are impacting groundwater within the fill layer, which migrates westwards towards Darling Harbour. This is a significant deficiency because these tarry wastes have the highest contaminant concentrations of all materials at the *Declared Area* and govern the outcome of the risk assessment. An understanding of this release mechanism could in turn influence the selection and design of the preferred remediation strategy.

c) **Extent of Contamination:** The investigation data show that the nature and extent of groundwater contamination at the *Declared Area* varies significantly both horizontally and vertically. However, the AECOM CSM did not account for the variation in groundwater contamination with depth, with the AECOM human health risk assessment using the maximum concentrations measured at any depth. This is despite the critical exposure scenario involving an unprotected maintenance worker being exposed to groundwater to a maximum depth of 2.0 m bgl. The investigation data show that the maximum groundwater contaminant levels were measured at depths below 2.0 m.

d) **Potential receptors**:

i. The AECOM HHERA considered there were only two potential human receptors of contamination that remained at the *Declared Area*, these being recreational users and unprotected maintenance workers who work in a 2.0 m deep trench. However, a 10 m deep sewerage pump station (SPS1129) is located within the *Declared Area*. The remnants of another older pump station (SPS59) also exist adjacent to the eastern side of the *Declared Area*. This sewerage pump station was constructed in 1922 within an existing excavation that remained following the removal of an AGL gasholder and close to a buried tar tank that remain in Hickson Road within the *Declared Area*. This pump station continues to provide storage capacity as part of the new pump station system. It was relevant for the AECOM HHERA to assess the health risks to a maintenance worker accessing Sydney Water pump stations SPS1129 and SPS59, which extend to depths of 8 – 10 m bgl

ii. The property at 38 Hickson Road is located adjacent to and to the south-east of the *Declared Area* and was redeveloped for high-rise residential land use in 2002 –

2004. However, the AECOM CSM did not assess the health risks to residents and maintenance workers at this property from contamination migrating from the *Declared Area*. This meant that the AECOM HHERA is incomplete.

iii. The closest ecological receptor to the *Declared Area* is the marine ecosystem in Darling Harbour, which is located 90 – 150 m from the western boundary of the *Declared Area*. However, the AECOM CSM specified the closest ecological receptor as being micro-organisms present in a groundwater dependent ecosystem located between the western boundary of the *Declared Area* and Darling Harbour. This caused the AECOM HHERA to conclude that contamination migrating from the *Declared Area* is causing an unacceptable risk to the environment, which is incorrect. The AECOM approach is not considered to be credible since:

  - No GDE is presently being or could in the future be impacted by contamination remaining at the *Declared Area*;
  - The AECOM report misrepresented the ESD principles specified in Section 9 of the CLM Act;
  - Two other ecological risks assessments prepared by AECOM for the redevelopment of the Baranagroo site correctly state that the marine ecology in Darling Harbour represents the nearest environmental receptor to the site. None of these risk assessments mention the need to protect a GDE now or into the future or even mentioned the term "*groundwater dependent ecosystem*". These reports were also reviewed on several occasions by the NSW EPA and Site Auditor prior to being issued in a final approved version; and
  - Other investigation and assessment reports have been prepared by AECOM for the Baranagroo site, which correctly state that the marine ecology in Darling Harbour represents the nearest environmental receptor to the site. None of these reports mention the need to protect a GDE now or into the future or even mentioned the term "*groundwater dependent ecosystem*"

e) **Contamination Migration Pathways:** Activities undertaken after AGL vacated the site in 1921 are likely to have exacerbated the spread of contamination across the *Declared Area*, which were not included in the AECOM CSM. This includes the excavation and construction of service trenches associated with the redeveloped of the site and surrounding land. This omission is significant because the AECOM HHERA and other AECOM reports found that the risks to human receptors at the *Declared Area* and the marine ecology in Darling Harbour are most influenced by contaminant levels in shallow groundwater in the fill layer.

2.2 Ecological Risk Assessment

In my opinion, the AECOM HHERA does not meet the relevant standards for the preparation of an ecological risk assessment, which have caused incorrect conclusions and recommendations to be made by their study. These deficiencies in turn would prevent the development of a remediation strategy capable of best meeting the Ecologically Sustainable Development principles specified in Section 9 of the CLM Act.

These deficiencies include, but may not be limited to:

a) The AECOM risk assessment incorrectly concluded that groundwater flowing from the *Declared Area* is part of a Groundwater Dependent Ecosystem and the protection of this ecosystem determines whether groundwater migrating from the *Declared Area* has an acceptable quality;

b) The point of compliance adopted by AECOM for groundwater to meet the Marine Water Quality Criteria (MWQC) was not reasonable having regard to the location of the closest receptor, which is the seawall along the eastern side of Darling Harbour;

c) The assessment of environmental risks was based on groundwater data collected from wells located across the *Declared Area*, irrespective of where the well was located relative to the closest ecological receptor. This resulted in AECOM concluding that contamination within the *Declared Area* poses an unacceptable risk to the environment. This conclusion is incorrect because all investigations have found that groundwater at the point of discharge along the Darling Harbour seawall meets the MWQC;

d) No assessment was made of the extent of groundwater contamination migrating from the *Declared Area* and whether the groundwater quality meets the MWQC at the point of discharge into Darling Harbour. This meant that the AECOM HHERA was incapable of providing a reasonable for basis for assessing environmental risks posed by contaminated groundwater migrating from the *Declared Area*; and

e) The risk assessment did not follow the principles of ecologically sustainable development, as described in Section 9 of the Contaminated Land Management Act. In my opinion, the investigation data show there is no threat of serious or irreversible environmental damage at or adjacent to the *Declared Area.*

My assessment of the available data indicates that a groundwater plume extends from the *Declared Area* in a westerly direction towards Darling Harbour. Contaminant concentrations within the plume decrease with distance from the *Declared Area*, becoming non-detectible to very low and below the MWQC at a distance of at least 23 m from the point of discharge. The investigation data support the conclusion that groundwater migrating from the *Declared Area* does not pose an unacceptable risk to the aquatic ecosystem in Darling Harbour.

My conclusion is consistent with conclusions made in an affidavit of Chris Jewell dated 10 January 2011, which was prepared for a matter in the Land and Environment Court of New South Wales case number 40965 of 2010. Mr Jewell is a hydrogeologist who was retained by the BDA and Lend Lease to provide a report on contamination at the Barangaroo site. The relevant conclusions made by Mr Jewell are:

- Paragraph 48: "*In my opinion, the level of contamination outside of the gasworks area is comparable to that found in fill materials and in other areas around Darling Harbour*, *for example, in the Walsh Bay and Darling Island redevelopment.*"
- Paragraph 52: "*Only low concentrations of gasworks contaminants were detected in groundwater in the fill deposits west (downgradient) of the former gasworks. This finding was attributed to the effect of strong tidal flushing.*"
- Paragraph 69: "*As previously indicated, high dissolved-phase concentrations of monocyclic and polycyclic hydrocarbons were measured by ERM in groundwater obtained from fill materials, natural clayey sand (estuarine deposits) and sandstone within the gasworks area itself, but only low concentrations of gasworks contaminants were detected in groundwater in the fill deposits west (downgradient) of the former gasworks. This finding was attributed by ERM to the effect of strong tidal flushing.*"
- Paragraph 137: "*As indicated in Section 4 of this report, groundwater in the fill materials beneath the Remediation Site is contaminated, but contamination does not extend downgradient of the site, probably because tidal flushing of the fill materials has been effective in diluting contaminant concentrations. Contamination of fill-hosted groundwater by gas-works wastes has not been detected in the areas covered by the relevant project approvals. The exception is one monitoring well in the north-east corner of the basement car park area.*"

A fate and transport assessment provided in this report also concludes that contaminant concentrations at the point of discharge into Darling Harbour, caused by groundwater migrating from the *Declared Area*, will not increase but should further decrease with time for the case where the *Declared Area* and adjacent land remain in its current form. This means that it is not reasonably foreseeable for a groundwater plume containing higher contaminant concentrations than presently measured to migrate from the *Declared Area* to Darling Harbour.

2.3 Human Health Risk Assessment

In my opinion, the AECOM HHERA does not meet the relevant standards for the preparation of a human health risk assessment, which have caused incorrect conclusions and recommendations to be made by their study. These deficiencies in turn would prevent the development of a remediation strategy capable of best meeting the Ecologically Sustainable Development principles specified in Section 9 of the CLM Act.

These deficiencies in the AECOM HHERA include, but may not be limited to:

a) The report does not acknowledge that the NSW State Government has used the *Declared Area* for many years as a public area without their being any concerns regarding human health;

b) Human health risks were assessed for an unprotected maintenance worker undertaking short term intrusive work in a 2m deep trench. Such an exposure scenario is inappropriate;

c) Incorrect TPH concentrations were used in the analysis, which caused the short-term health risks to be unreasonably exaggerated;

d) An inappropriate soil-to-skin adherence factor was used, which caused short and long-term health risks to be exaggerated 7.89 times;

e) An inappropriate dermal slope factor was used for benzo(a)pyrene, which caused the long term risks from dermal PAH exposure to be exaggerated 107 times;

f) Risks from contaminated groundwater entering a 2 m deep trench were based on deeper samples collected from groundwater that was not capable of entering a 2 m deep trench;

g) The health risks posed by asbestos contamination in the fill were not considered despite there being an unacceptable risk of asbestos contamination at the Declared Area from activities undertaken post-1921 after AGL vacated the site;

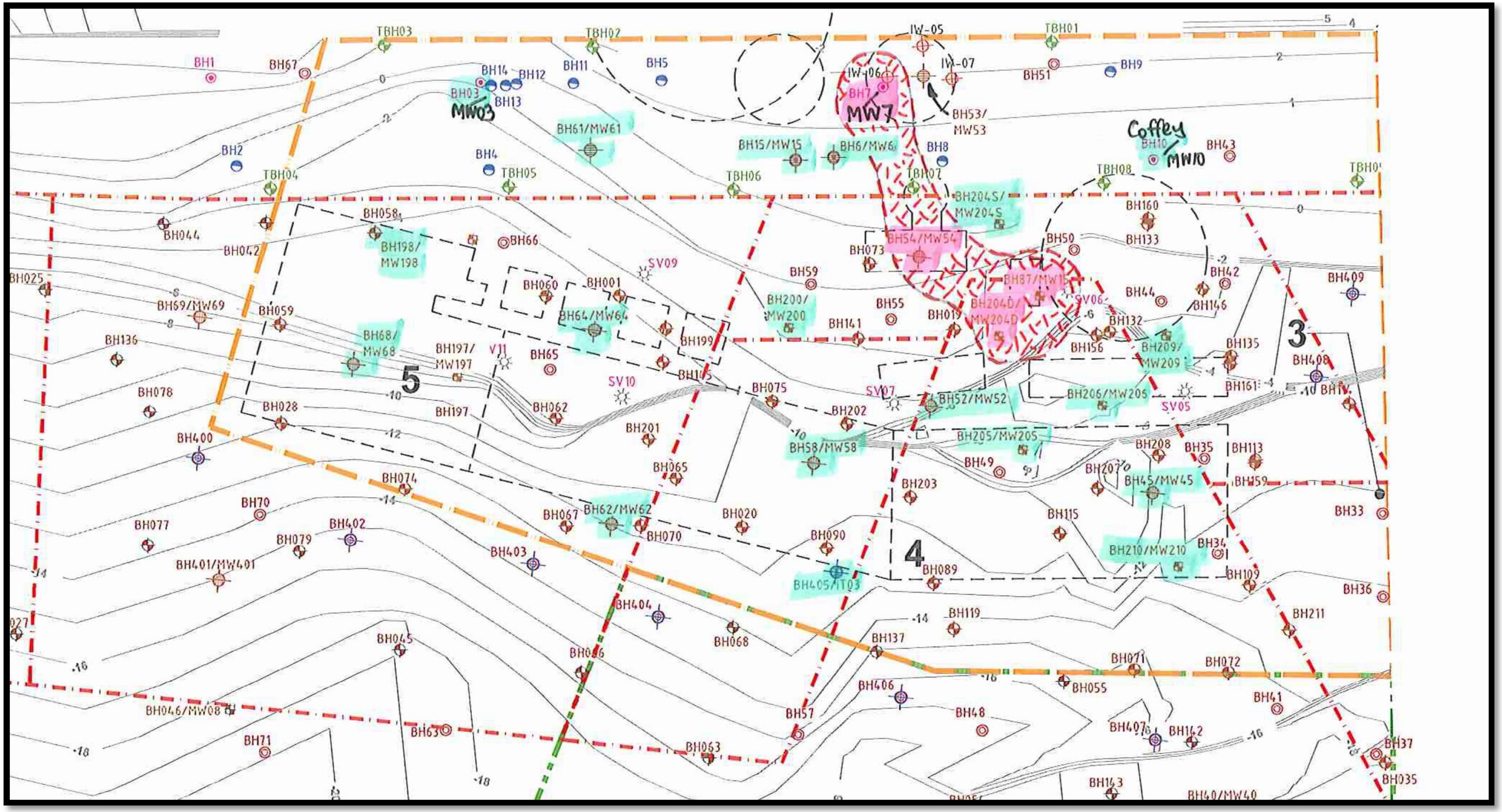
h) No reasonable analysis was provided of the extent to which soils and groundwater at the *Declared Area* represent an unacceptable risk to human health; and

i) The risk assessment did not follow the principles of ecologically sustainable development, as described in Section 9 of the Contaminated Land Management Act. In my opinion, the investigation data show there is no threat of serious or irreversible environmental damage at or adjacent to the *Declared Area*.

The deficiencies in the AECOM health risk assessment were addressed by a risk assessment undertaken by the author. For the case where the land use of the *Declared Area* is to remain unchanged, the main findings of the SKM risk assessment are:

- No soil at the *Declared Area* poses an unacceptable health risk;
- No groundwater at the *Declared Area* poses an unacceptable long-term health risk;
- Groundwater across practically the whole of the *Declared Area* (95%) does not pose an unacceptable short-term health risk; and
- Groundwater poses an unacceptable short-term health risk to an unprotected maintenance worker in a small localised part of the *Declared Area* (5%), with the estimated extent of this area shown in **Figure 2-1**. The area is located at/near buried tar tanks, gasholders, and an abandoned sewerage pump station SPS59.

- **Figure 2-1 Estimated Extent of Shallow Groundwater Exceeding Short-term Risk Target Criteria**



In my opinion, the available investigation data together with the results of the SKM risk assessment show there is no potential user of the *Declared Area* that would be exposed to an unacceptable health risk, there is no "*lack of full scientific certainty*" that should affect the assessment of health risks, and the precautionary principle has been addressed.

3. Detailed Response – Conceptual Site Model

3.1 Overview of AECOM CSM

The main elements of the CSM adopted by the AECOM HHERA were shown in AECOM Figure F6 and discussed in various sections of their report[9]. A copy of this diagram is provided in **Figure 3-1.**

The sources of contamination were specified as:

- Tar/gasworks waste located in gasworks infrastructure that remains buried at the *Declared Area* (eg tar tanks, gasholder annuli); and
- Tar/gasworks waste that had been used in the port reclamation works across and to the west of the Declared Area
- Importation of fill materials for the port reclamation activities;
- Demolition of former buildings potentially containing hazardous building materials;
- Fill from reclamation work in Darling Harbour.

The potential receptors were specified as:

- Members of the general public undertaking recreational activities (ie "*recreational receptors*");
- Maintenance workers undertaking excavation work (ie "*intrusive maintenance worker*"); &
- Ecological receptors located in Darling Harbour.

The contaminant migration pathways identified as being relevant were:

- Volatilisation of vapours from soil and groundwater to outdoor/indoor air and within trenches / excavations;
- Seepage of groundwater into trenches / excavations; and
- Groundwater migration.

In my opinion, the CSM presented in the AECOM HHERA contained deficiencies that have caused major errors in the conclusions and recommendations made by their study. The following subsections describe the deficiencies concerning how the AECOM CSM assessed and/or modelled contaminant sources (**Section 3.2**), contaminant release mechanisms (**Section 3.3**), the extent of contamination (**Section 3.4**), potential receptors (**Section 3.5**), and contaminant migration pathways (**Section 3.6**).

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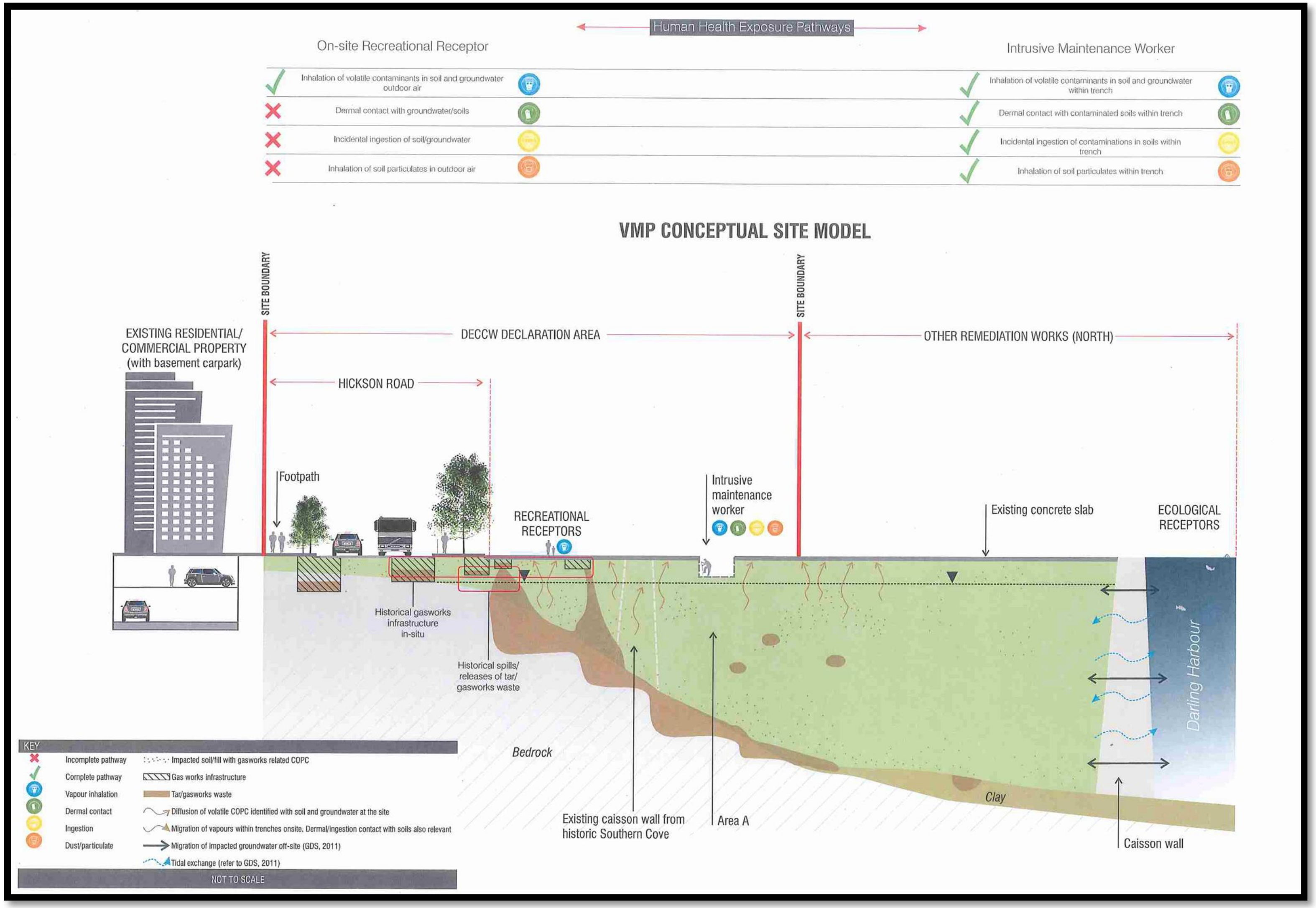
[9] Sections 4.1, 5.1, 5.3, 8.1 and 8.3, AECOM HHERA

- **Figure 3-1 AECOM CSM for the Declared Area** [Source: AECOM Figure F6]



3.2 Contaminant Sources

3.2.1 Asbestos Contamination

Australian risk assessment guidelines advise that all chemicals of potential concern need to be fully considered in a quantitative health risk assessment[10].

The AECOM HHERA identified asbestos as a contaminant of concern at the "*Declared Area*" and adjacent land[11]. However, the AECOM report did not assess the risks posed by asbestos to human health even though the report identified asbestos as a chemical of potential concern and advised that "*the Remedial Action Plan (RAP) should include consideration of mitigation measures for the appropriate management of asbestos that may be potentially encountered during the remediation works*".[12] The reasons given by AECOM for this exclusion were that:

- "*… the majority of the Declared Area is covered in hardstand (ie capped) and therefore the potential for exposure to asbestos present on the Site during normal activities is considered to be minimal*"[13]; and
- The HHERA only considered the chemicals specified in the NSW EPA Declaration Notice that was issued on 6 May 2009[14]. This omission means that the AECOM HHERA is incomplete and its conclusions and recommendations did not consider all COPCs.

In my opinion, the health risks posed by asbestos contamination should have been included in the AECOM HHERA because:

- The AECOM HHERA[15] correctly identified that asbestos contamination may have been introduced to the site following closure of the gasworks by the importation of fill materials for reclamation purposes and the demolition of former buildings containing asbestos[16, 17];

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[10] Section 2.1.1, enHealth (2012) "*Environmental Health Risk Assessment Guidelines for Assessing Human Health Risks from Environmental Hazards*"; Section 4, NEPC (1999) "*Schedule B(4) Guideline on Health Risk Assessment Methodology*"; Section 3.1, NEPC (April 2011) Draft "*Schedule B4 Guideline on Site Specific Health Risk Assessments*"

[11] Table 8 in Section 4.1, AECOM HHERA

[12] Executive Summary and Section 10.2, AECOM HHERA

[13] Section 4.2.1, AECOM HHERA

[14] Executive summary and Sections 1.3, 4.1, 4.3, 5.1, 8.1.1, AECOM HHERA

[15] Table 8 in Section 4.1, AECOM HHERA

[16] Table 8 in the AECOM HHERA also indicated that asbestos was a contaminant of concern from the former gasworks activities that occurred at the Declared Area prior to 1921. This is an incorrect statement because asbestos was not widely used for industrial applications in Australia prior to 1900 when the last development phase of the Hickson Road gasworks occurred (Broomham, 1 June 2007), and no asbestos waste was found by SKM at a similar gasworks in Sydney (the Abbotsford Gasworks), which ceased operations in around 1900 and was remediated a few years ago.

[17] Broomham R (1 June 2007) "*Land at Millers Point Ownership and Usage*". 66 pages

- The NSW EPA Declaration Notice was qualified in that it stated it was targeting gasworks waste, which did not include asbestos [**DOCUMENT 1**];
- The AECOM assessment identified a maintenance worker undertaking trenching activities as having unacceptable health risk[18]. Such a worker would be at risk of being exposed to asbestos fibres and such risks would need to be assessed by a HHERA; and
- The investigation data indicate a high likelihood of asbestos / UMF[19] contamination being present in building demolition rubble within the fill material. An analysis of these data is provided in **Appendix A**.

The implications of this deficiency are that:

- The AECOM HHERA is incomplete since it did not properly account for all types of contaminating substances that influence the remediation approach required for the *Declared Area*; and
- Fill containing building demolition rubble at the *Declared Area* should be regarded as containing asbestos and either managed on-site in a capped area that incorporates the use of a site management plan, or disposed offsite as *Asbestos Waste* at a suitably licensed landfill.

3.2.2 Additional Contaminant Sources – Sydney Water Pump Station SPS59

Documentation provided by Sydney Water[20] and URS[21] indicate that sewerage pump station SPS59 was constructed by Sydney Water in 1922 soon after AGL had vacated the former gasworks site. The pump station was located in an existing excavation that remained following the removal of an AGL gasholder and close to a buried tar tank that remains in Hickson Road (**Figure 3-2**).

Additional details of sewerage pump station SPS59 include:

- The pump station was a deep underground structure that extended to a depth of 8 m;
- A drainage trench was constructed around the station;
- The station was upgraded in 1980 with new pumping equipment and pipework;
- An inspection conducted in August 2002 found black tar liquid in all areas of the pump station with a strong tar-like odour;

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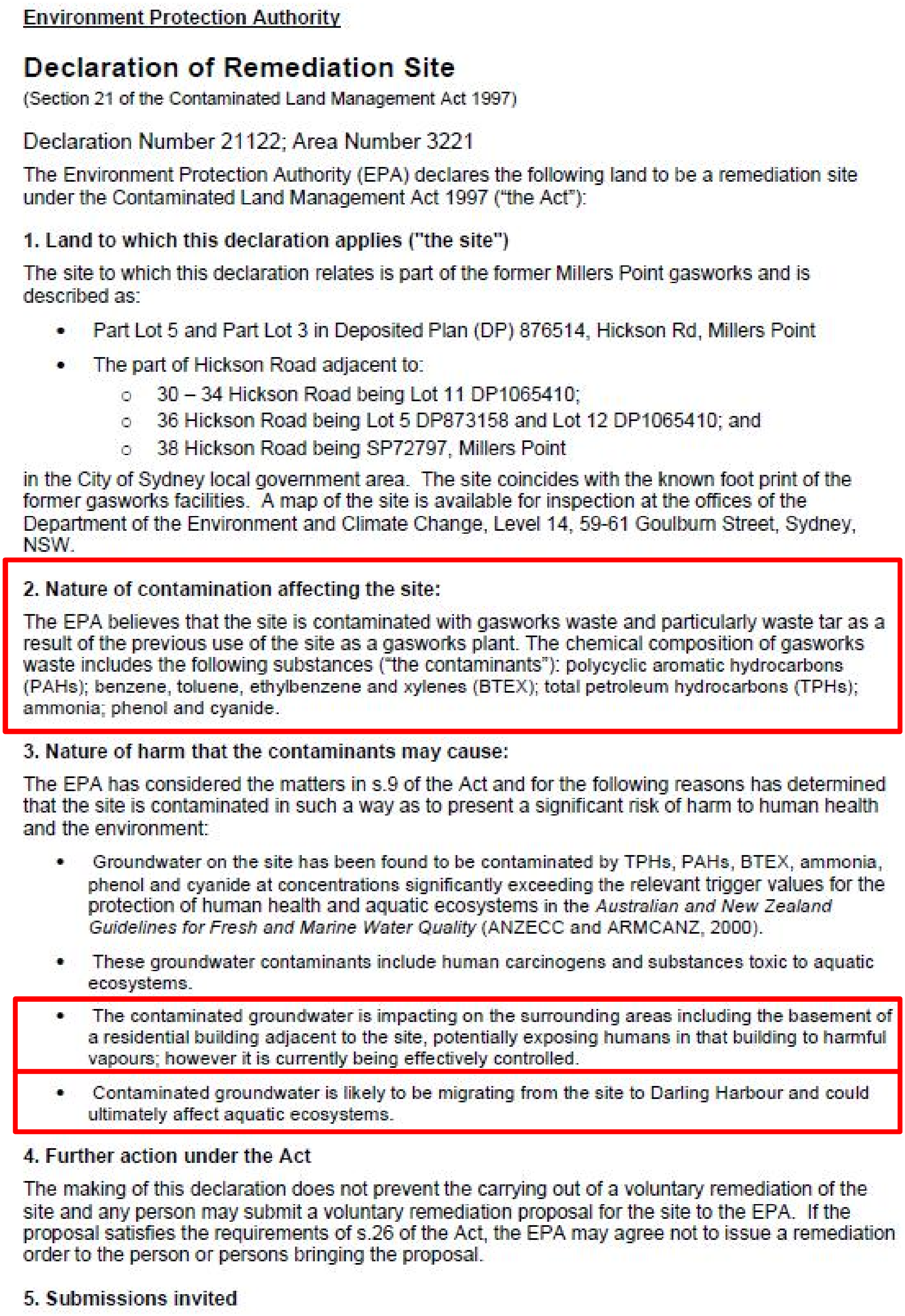
[18] Executive summary, Sections 5.4.2.2 & 10.1, AECOM HHERA

[19] UMF = Unidentified Mineral Fibre

[20] Sydney Water (14 November 2002) "*SewerFix Pumping Stations Program Concept Design Report, SP1129 – Hickson Road, Sydney*", Document No. SP1129, revision D, 8 pages; Sydney Water (2003) "*Review of Environmental Factors (REF), SP1129 Hickson Road, Sydney*"

[21] URS Letter dated 10 July 2003 in Appendix B2, URS (9 October 2003) "*Remediation Validation Report, 36 Hickson Road, Millers Point, NSW*". Prepared for Bovis Lend Lease

DOCUMENT (1) – NSW EPA Declaration Notice 6 May 2009 – page 1



Environment Protection Authority

Declaration of Remediation Site

(Section 21 of the Contaminated Land Management Act 1997)

Declaration Number 21122; Area Number 3221

The Environment Protection Authority (EPA) declares the following land to be a remediation site under the Contaminated Land Management Act 1997 ("the Act"):

1. Land to which this declaration applies ("the site")

The site to which this declaration relates is part of the former Millers Point gasworks and is described as:

- Part Lot 5 and Part Lot 3 in Deposited Plan (DP) 876514, Hickson Rd, Millers Point
- The part of Hickson Road adjacent to:
  - 30 – 34 Hickson Road being Lot 11 DP1065410;
  - 36 Hickson Road being Lot 5 DP873158 and Lot 12 DP1065410; and
  - 38 Hickson Road being SP72797, Millers Point

in the City of Sydney local government area. The site coincides with the known foot print of the former gasworks facilities. A map of the site is available for inspection at the offices of the Department of the Environment and Climate Change, Level 14, 59-61 Goulburn Street, Sydney, NSW.

2. Nature of contamination affecting the site:

The EPA believes that the site is contaminated with gasworks waste and particularly waste tar as a result of the previous use of the site as a gasworks plant. The chemical composition of gasworks waste includes the following substances ("the contaminants"): polycyclic aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene and xylenes (BTEX); total petroleum hydrocarbons (TPHs); ammonia; phenol and cyanide.

3. Nature of harm that the contaminants may cause:

The EPA has considered the matters in s.9 of the Act and for the following reasons has determined that the site is contaminated in such a way as to present a significant risk of harm to human health and the environment:

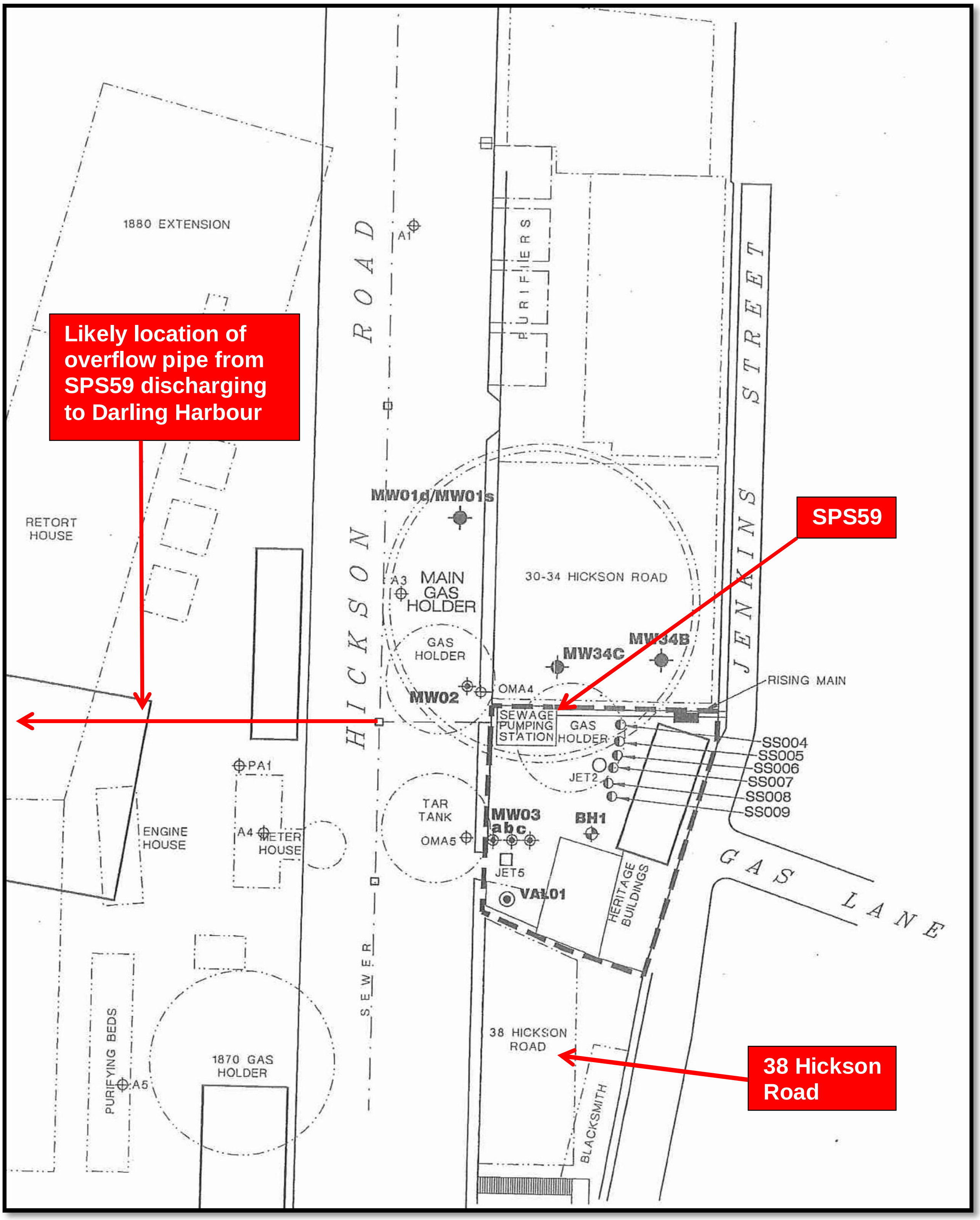
- Groundwater on the site has been found to be contaminated by TPHs, PAHs, BTEX, ammonia, phenol and cyanide at concentrations significantly exceeding the relevant trigger values for the protection of human health and aquatic ecosystems in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000).
- These groundwater contaminants include human carcinogens and substances toxic to aquatic ecosystems.
- The contaminated groundwater is impacting on the surrounding areas including the basement of a residential building adjacent to the site, potentially exposing humans in that building to harmful vapours; however it is currently being effectively controlled.
- Contaminated groundwater is likely to be migrating from the site to Darling Harbour and could ultimately affect aquatic ecosystems.

4. Further action under the Act

The making of this declaration does not prevent the carrying out of a voluntary remediation of the site and any person may submit a voluntary remediation proposal for the site to the EPA. If the proposal satisfies the requirements of s.26 of the Act, the EPA may agree not to issue a remediation order to the person or persons bringing the proposal.

5. Submissions invited

- **Figure 3-2 Location & Arrangement of Sewerage Pump Station SPS59 (Pre-2003)**


Likely location of overflow pipe from SPS59 discharging to Darling Harbour

SPS59

38 Hickson Road

Source: Figure 3, URS (9 October 2003)

- Water samples collected from the inlet pipe and the wet wells were impacted by TPH and PAHs, with the elevated concentration considered most likely to be due to the presence of tar in the wells and the inlet pipe;
- The pump station was designed to allow sewerage effluent to overflow in wet weather and/or when there was an equipment breakdown. This is indicated by the current NSW EPA Environment Protection Licence for the Bondi Sewage Treatment System[22], which allows:
  - Directed overflows from sewage pumping stations to waterways in dry weather if the station is being operated and maintained in a proper and efficient manner (Condition L1.3) provided the total number of dry weather overflows reaching waterways from the system does not exceed 19 in each 12 month period (Condition L7.4);
  - Directed overflows to waterways during periods of wet weather (Condition L7.2); and
  - In the event of an overflow or bypass that harms or is likely to harm the environment, Sydney Water must use all practicable measures to minimise the impact of the overflow or bypass on the environment and public health (Condition O3.1).

  The emergency relief line from SPS59 would have allowed sewage and tarry wastes to be discharged to Darling Harbour through a pipe connected to the stormwater system. The likely location of this emergency relief line is shown in **Figure 3-2**;
- Overflows from the pump station and discharges to Darling Harbour were subject to a POEO license issued by the NSW EPA. The licence allowed a specified number of dry weather overflows to occur per year together with overflows during wet weather[23]; and
- The pump station was decommissioned and abandoned sometime between 2003 and 2004.

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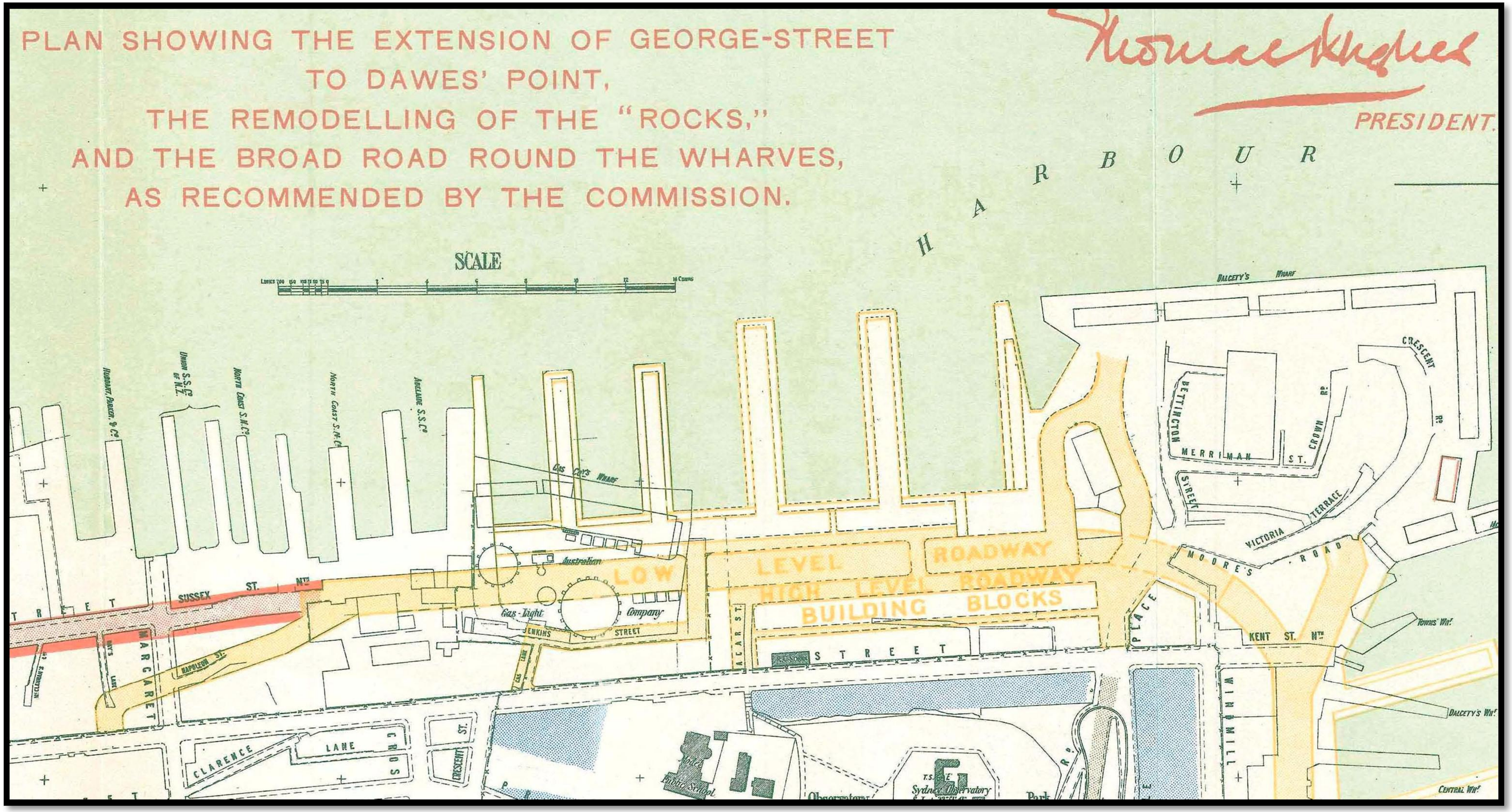
[22] NSW EPA (28 June 2012) Environmental Protection Licence No: 1688 for the Bondi Sewage Treatment System (first issued 25 May 2000)

[23] The current POEO licence is numbered 1688 and was first issued on 25 May 2000. The licence covers all parts of the Bondi Sewerage Scheme.

- **Figure 3-3 Plan of Old Gasworks Site and Proposed Port Works** [Source: Royal Commission (1909)]



The AECOM CSM did not include sewerage pump station SPS59 as an additional source of tar/gasworks and sewage waste that would have contaminated the soils, sediments and groundwater in the *Declared Area* and Darling Harbour. Overflows from the pump station would have contaminated the *Declared Area* between 1922 and the 1970's when the outlet for the emergency relief line would have been located at the shoreline as it then existed, which is now within the *Declared Area* (**Figure 3-3**[24]). Evidence for this contamination source includes:

- The inspection conducted by URS found tarry waste and gasworks odours to be present in the pump station;
- The pump station was located inside a former gasholder and close to a tar tank; and
- The pump station was designed to overflow in wet weather and/or when there was an equipment breakdown.

Darling Harbour would have been contaminated from these overflows throughout the entire period of operation of SPS59 (1922 – 2004).

3.2.3 Additional Contaminant Sources – Sydney Water Pump Station SPS1129

SPS59 was replaced by a new pump station SPS1129 constructed by Sydney Water in 2004. The new pump station is located within the *Declared Area* to the west of Hickson Road, as shown in **Figure 3-4**[25].

Sydney Water documents[26] advise that "*the existing emergency relief system shall be retained or modified if required*" and the new pump station has a 2 hour storage capacity[27]. This information suggests that overflows from the new pump station may continue to be discharged to Darling Harbour using the same or a modified emergency relief system formerly used by SPS59.

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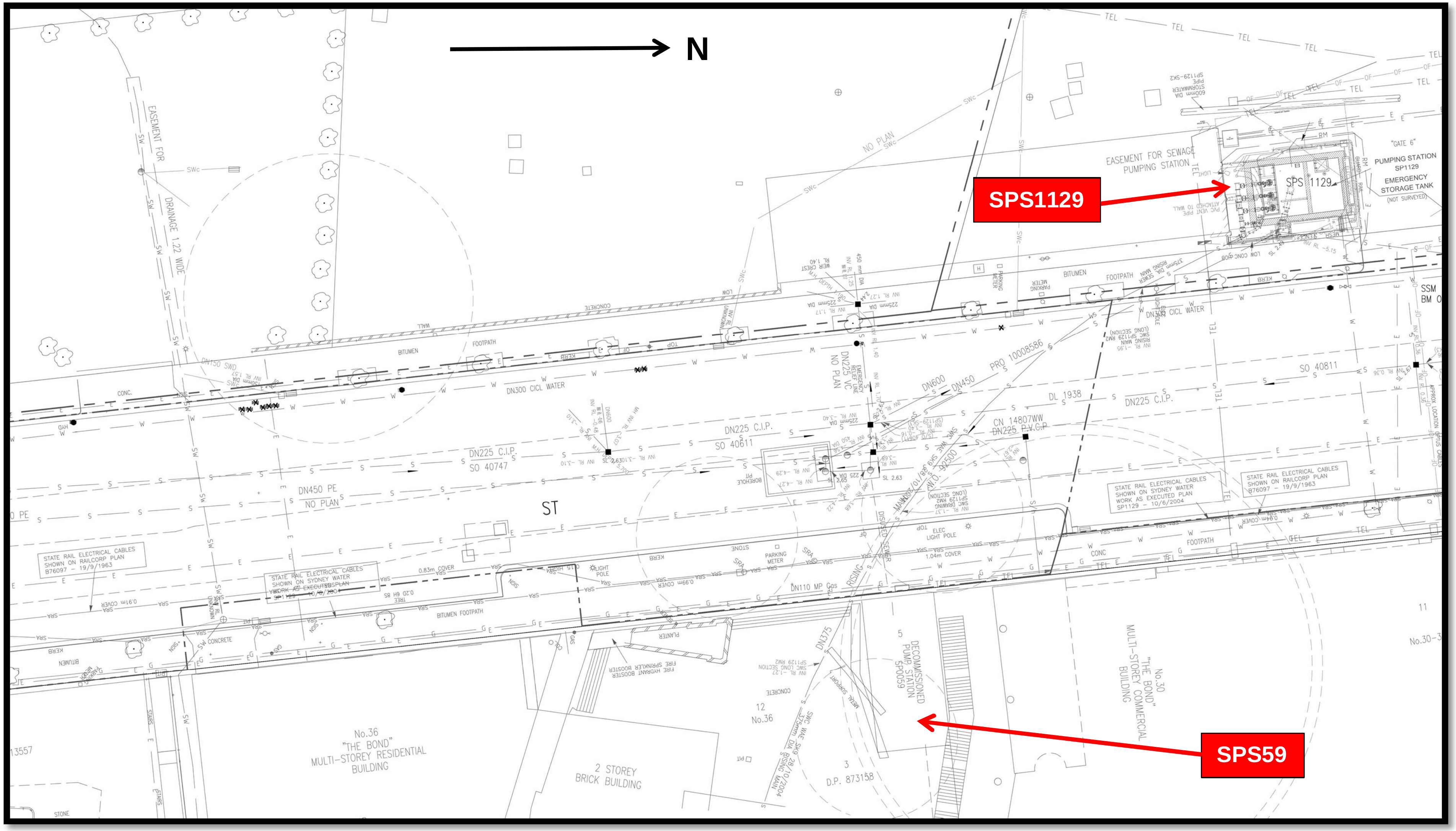
[24] Royal Commission (1909) "*Royal Commission for the Improvement of the City of Sydney and its Suburbs*". (Sourced from the City of Sydney website)

[25] Sydney Water (2 May 2011) Drawing "*City of Sydney Sewerage Drains to SPS1129 B.O.O.S via Kent St Submain*". Sheet 1 of 4

[26] Section F, Sydney Water (June 2002) "*Concept Design Brief, Bondi Sewerage System SP0059 – Hickson Road, Sydney*", 6 pages

[27] Section 4, Sydney Water (14 November 2002) "*Concept Design Report, SP1129 – Hickson Road, Sydney*", 8 pages

- **Figure 3-4 Location of SPS1129 and SPS59** [Source: Sydney Water 2011 drawing]



The AECOM CSM did not include sewerage pump station SPS1129, which is located within the *Declared Area*, as an additional source of contamination to Darling Harbour. Overflows from the pump station would have contaminated Darling Harbour after it commenced operation in 2004. These overflows would include tarry wastes collected by a groundwater collection system at 38 Hickson Road, which discharges its effluent to sewer under a Sydney Water licence (**Appendix C-2**).

3.3 Release Mechanisms

The AECOM CSM shows that the main sources of contamination at the former gasworks site are the tarry liquids that remain at the base of the former tar tanks and gasholders. The investigation data combined with my knowledge of historic gasworks operations support this feature of their model.

However, the AECOM CSM and other parts of the AECOM HHERA did not assess and describe the dominant release mechanism for contaminants from these sources, particularly in relation to how these tarry wastes are impacting groundwater within the fill layer, which migrates westwards towards Darling Harbour. The only reference to this issue made by the AECOM HHERA was a comment on the CSM figure that mentioned the presence of "*historic spills / releases of tar / gasworks waste*" in AECOM Figure F6 (**Figure 3-1**).

In my opinion, this is a significant deficiency in the AECOM HHERA because these tarry wastes have the highest contaminant concentrations of all materials at the *Declared Area* and govern the outcome of the risk assessment.

Knowledge of this release mechanism would inform the HHERA on:

- The presence and significance of variations in contaminant levels with depth;
- The source of the light hydrocarbon layer[28] that floats on the top of the water table at and near the buried gasworks structures;
- How these tarry wastes are impacting shallow groundwater within the fill layer; and
- How these tarry wastes influence the migration of contamination across the *Declared Area*.

Knowledge of these matters could in turn influence the selection and design of the preferred remediation strategy.

In my opinion, it is likely that the primary cause of the light hydrocarbon layer that floats on the top of the water table was the flooding of these underground structures, which was caused when the gasworks was demolished and filled over. Furthermore, the majority of contamination being

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[28] Also referred to as light non-aqueous phase liquids (LNAPL)

released from within these underground structures is due to groundwater flowing out from the top of these buried structures. My reasons for these conclusions include:

- These underground structures were designed to store fluids, water in the case of gasholders and tar in the case of tar tanks (**Figure 3-5**)[29]. This involved siting these structures at locations within the *Declared Area* where bedrock was shallow so that most of the underground portion could be excavated into solid rock. Brickwork and/or concrete walls would have been constructed to extend the sides of these structures from bedrock to ground level;
- These underground structures would have been built with edges raised above ground level (as it existed at the time the gasworks operated) and with covers (in the case of tar tanks), in order to prevent surface water flowing into these underground storage structures;
- After AGL vacated the site in 1921, the gasworks was reported to have been demolished by the Sydney Harbour Trust[30]. It is likely that tarry wastes that were being stored in above ground structures at the site were dumped into these underground structures prior to being buried and filled over by demolition waste. The investigation data indicate that the tops of these structures were not sealed prior to being buried, with some of the infrastructure constructed after 1921 actually being located within excavations that had formed some of the former gasworks structures (eg SPS59). The manner in which the former gasworks site was redeveloped meant that shallow groundwater was now able to flow into these underground structures, mix with the tarry waste, and flow out to re-join the groundwater system flowing through the fill layer;
- The sandstone bedrock has a much lower permeability compared to the overlying fill layer; and
- AECOM studies found that a very efficient hydraulic connection exists between the fill aquifer and Darling Harbour whereas groundwater discharge via the sandstone bedrock is not considered to be significant[31].

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[29] Newbigging T (1913) "*Handbook for Gas Engineers and Managers*", 8th Edition, Walter King London (sourced from Wikipedia at http://en.wikipedia.org/wiki/History_of_manufactured_gas

[30] Page 38, Broomham R (1 June 2007) "*Land at Millers Point, Ownership and Usage*"

[31] Section 6.0, AECOM (3 November 2010) "*Groundwater Discharge Study (GDS), Stage 1 Barangaroo Development*"; Section 3.5, AECOM (9 March 2012) "*Supplementary Data Gap Investigation, VMP Area, Hickson Road, Millers Point, NSW*"

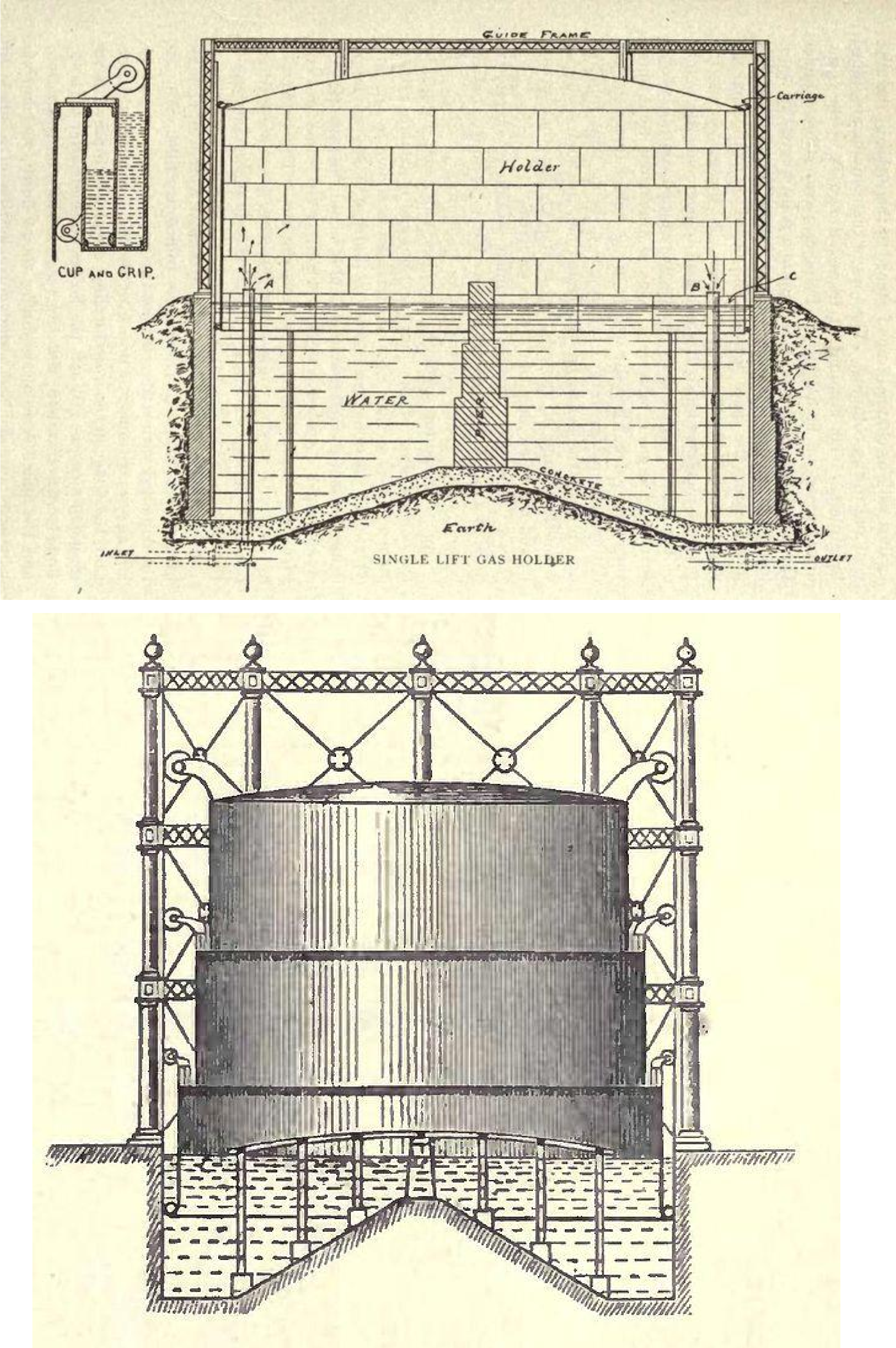

Figure 3-5 Single Lift & Telescoping Gasholder Designs

3.4 Extent of Contamination

The investigation data show that the nature and extent of groundwater contamination at the *Declared Area* varies significantly both horizontally and vertically. However, the AECOM CSM did not account for the variation in groundwater contamination with depth, with the AECOM human health risk assessment using the maximum concentrations measured at any depth. This is despite the critical exposure scenario involving an unprotected maintenance worker being exposed to groundwater to a maximum depth of 2.0 m bgl.

The investigation data show that the maximum groundwater contaminant levels were measured at depths below 2.0 m, with the maximum PAH and TPH concentrations measured in sandstone bedrock in a well screened at a depth of 15.0 – 19.5 m bgl.

This deficiency in the AECOM HHERA has caused major errors in the conclusions and recommendations made by their study. An assessment of the significance of these errors is provided in **Section 5.5**.

3.5 Potential Receptors

3.5.1 Maintenance Workers Accessing Sewerage Pump Stations

The AECOM HHERA considered there were only two potential human receptors of contamination that remained at the *Declared Area*, these being recreational users and unprotected maintenance workers who work in a 2.0 m deep trench. However, Sydney Water documents [32,33] indicate that a 10 m deep sewerage pump station was constructed within the *Declared Area* in 2004 (**Figure 3-4**). The pump station is numbered SPS1129 and continues to operate. The AECOM HHERA did not assess the risks to maintenance workers who are required to enter this pump station.

The remnants of another older pump station (SPS59) also exist adjacent to the eastern side of the *Declared Area* (**Figure 3-2**). Documentation provided by Sydney Water[34] and URS[35] indicate that this sewerage pump station was constructed by Sydney Water in 1922 soon after AGL had vacated the former gasworks site. The pump station was located in an existing

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[32] Section F, Sydney Water (June 2002) "*Concept Design Brief, Bondi Sewerage System SP0059 – Hickson Road, Sydney*", 6 pages

[33] Section 4, Sydney Water (14 November 2002) "*Concept Design Report, SP1129 – Hickson Road, Sydney*", 8 pages; Sydney Water (2003) "*Review of Environmental Factors (REF), SP1129 Hickson Road, Sydney*"

[34] Sydney Water (14 November 2002) "*SewerFix Pumping Stations Program Concept Design Report, SP1129 – Hickson Road, Sydney*". Sydney Water (2003) "*Review of Environmental Factors (REF), SP1129 Hickson Road, Sydney*"

[35] URS Letter dated 10 July 2003 in Appendix B2, URS (9 October 2003) "*Remediation Validation Report, 36 Hickson Road, Millers Point, NSW*". Prepared for Bovis Lend Lease

excavation that remained following the removal of an AGL gasholder and close to a buried tar tank that remain in Hickson Road within the *Declared Area*. The station consists of a machinery dry well and two adjacent wet wells and was upgraded in 1980. URS found tarry liquids in all areas of the pump station when inspected in August 2002. This pump station continues to provide storage capacity as part of the new pump station system.

In my opinion, it was relevant for the AECOM HHERA to assess the health risks to a maintenance worker accessing Sydney Water pump stations SPS1129 and SPS59, which extend to depths of 8 – 10 m bgl.

3.5.2 Residents at 38 Hickson Road

The property at 38 Hickson Road is located adjacent to and to the south-east of the *Declared Area* with its north-western corner some 7 m from a tar tank that remains buried in Hickson Road (**Figure 3-2**). The property has a history of commercial/industrial land use and was redeveloped for high-rise residential land use in 2002 – 2004.

The development included the construction of a multi-level basement carpark, which involved an 11 m deep excavation below Hickson Road to an elevation of -8.4 m AHD[36]. The basement structure was not waterproofed (ie “tanked”), but allowed groundwater and soil vapours to seep through the bedrock. The basement walls were constructed away from the bedrock using blockwork, with a drain constructed between the blockwall and the bedrock to collect groundwater for treatment.

Sometime after the URS issued their remediation and validation report in 2003 and residents started to occupy the building, the NSW EPA declared the property as a Significant Risk of Harm (SRoH) site under the provisions of the Contaminated Land Management (CLM) Act 1997. Further remediation and monitoring work is understood to have been undertaken by the owners Delmo Pty Ltd.

The reason for the Declaration was that contaminated groundwater was entering the basement, causing objectionable odours and potentially harmful vapours. The NSW EPA subsequently withdrew their SRoH declaration and replaced it with the current Declaration Notice on 6 May 2009. The present Declaration Notice states that “*The contaminated groundwater is impacting on the surrounding areas including the basement of a residential building adjacent to the site, potentially exposing humans in that building to harmful vapours; however it is currently being effectively controlled.*” [**DOCUMENT 1**]

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[36] URS (25 June 2003) “*Validation Report, 38 Hickson Road, Millers Point, NSW*”. Prepared for Bovis Lend Lease

However, the AECOM CSM did not assess the health risks to residents and maintenance workers at 38 Hickson Road from contamination migrating from the *Declared Area*. This meant that the AECOM HHERA was incomplete.

3.5.3 Groundwater Dependant Ecosystems

The most recent definition of a Groundwater Dependent Ecosystem (GDE) made by NSW Government authorities is provided in the NSW Office of Water (May 2012) document "*Risk assessment guidelines for groundwater dependent ecosystems, Volume 1 – The conceptual framework*". The definition is:

> "*Ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater*".

This definition is similar to the one given in the Department of Land & Water Conservation (April 2002) "*The NSW State Groundwater Dependent Ecosystems Policy*", which is referred to in the NSW EPA (March 2007) "*Guidelines for the Assessment and Management of Groundwater Contamination*".[37]

The NSW Office of Water document[38] also advises that:

> "*GDEs include a broad range of environments from highly specialised species and ecosystems that possess unique biotic and abiotic characteristics that 'separate' them from other ecosystems that do not rely on groundwater to survive to more general terrestrial and aquatic ecosystems that have an opportunistic dependence on groundwater or rely on it during times of drought.*"

The DLWC document[39] also advises that four types of ecosystems are recognised in NSW based mainly on vegetation. These are terrestrial vegetation (where shallow groundwater supported forests and woodlands), base flow in streams (where river flow is maintained largely by groundwater), aquifer and cave ecosystems, and wetlands.

Groundwater at or to the west of the *Declared Area* is not a GDE with the closest ecological receptor to the *Declared Area* being the marine ecosystem in Darling Harbour, which is located 90 – 150 m from the western boundary of the *Declared Area* (**Figure 3-6**). The point of compliance is the location at the site where the groundwater quality should not exceed the Marine Water Quality Criteria (MWQC). For groundwater migrating from the *Declared Area*, this point of compliance should be the seawall that runs along the eastern side of Darling Harbour, since this is the point where the marine ecosystem in Darling Harbour is closest to groundwater migrating from the *Declared Area*. This location also corresponds to the point of discharge (**Figure 3-6**).

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[37] Section 1.3.3 in NSW EPA (March 2007)
[38] Section 2.1 in NSW Office of Water (May 2012)
[39] Sections 2.1 & 2.3 in DLWC (April 2002)

- **Figure 3-6 Site Plan provided in NSW EPA Declaration** Source: NSW EPA (6 May 2009) Declaration

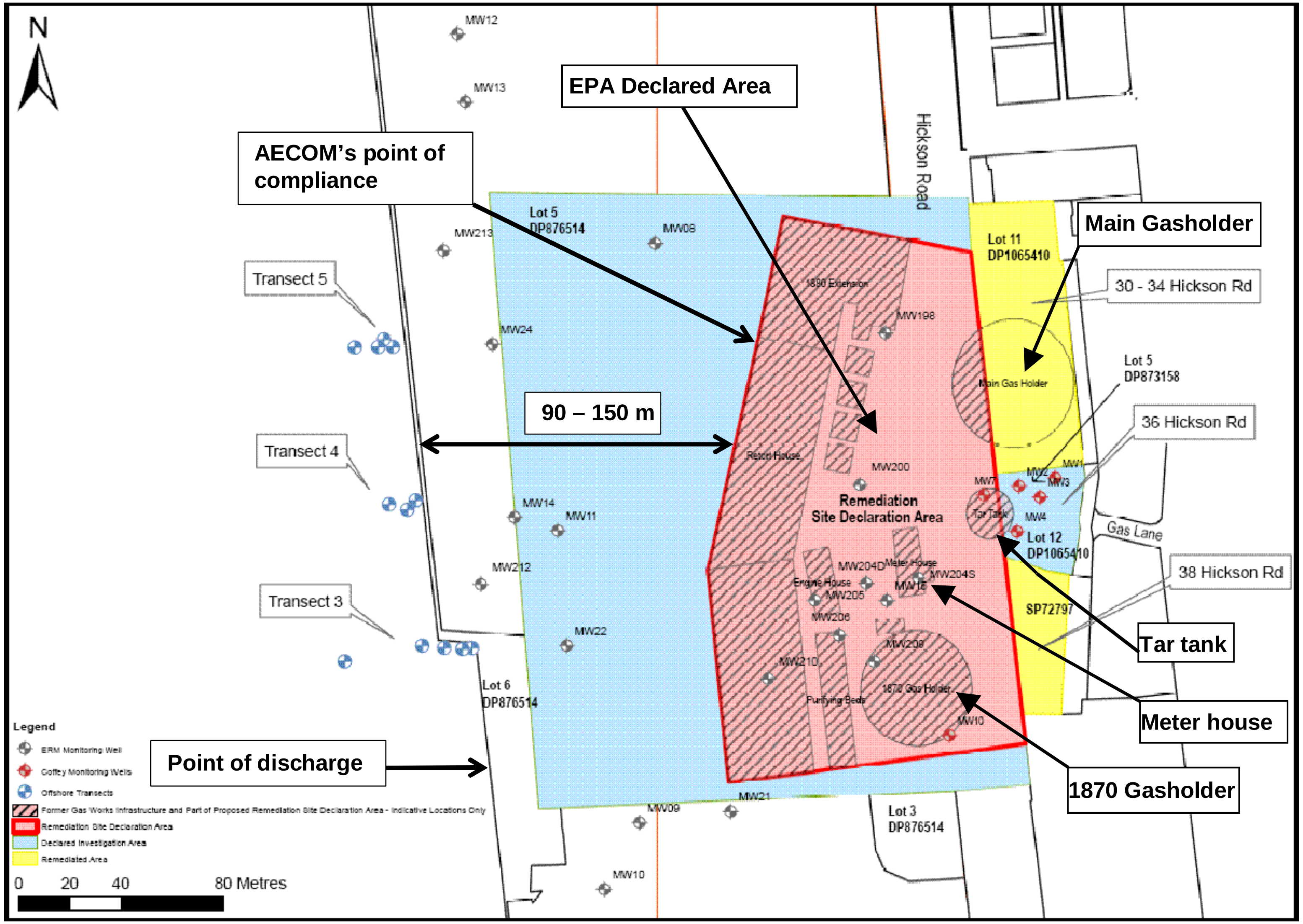

Figure F6 in the AECOM HHERA also identifies the marine ecosystem in Darling Harbour as the closest ecological receptor to the Declared Area (**Figure 3-1**). However, the AECOM report considered there are micro-organisms present in groundwater between the western boundary of the *Declared Area* and Darling Harbour that are part of a GDE and which need to be protected[40, 41, ,42, 43].

AECOM justified the need to consider a GDE as the most critical ecological receptor because, even though they had no knowledge of whether a GDE was present at the site

> "*The precautionary principle has been applied, in consultation with the NSW EPA, in the absence of scientific data to confirm the presence of groundwater dependant ecological systems and their novel fauna. According to the precautionary principle irrespective of whether there are groundwater ecosystems present at the Site currently or not, the level of protection is required to be the highest that is practicably achievable based on the protection of the potential for such ecosystems to occur in the future.*"[44]

The incorporation of a GDE as the most critical ecological receptor resulted in the AECOM HHERA to conclude that contamination migrating from the *Declared Area* is causing an unacceptable risk to the environment, which is incorrect.

In my opinion, the AECOM approach of basing the ecological risk assessment for the *Declared Area* on the need to protect a GDE now or into the future is not considered to be credible. This is because:

- No GDE is presently being or could in the future be impacted by contamination remaining at the *Declared Area*;

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[40] "*The Contaminated Land Management (CLM) Act (1997), section 9, which requires adoption of the precautionary principle where the lack of scientific certainty is not a reason for postponing measures. With respect to the Site, this relates to the protection of groundwater dependent ecosystems down hydraulic gradient of the Site …*" [Executive Summary & Section 8.1, AECOM HHERA]

[41] "*The ecological risk assessment (ERA) comprised of the following key steps: … Assessment of whether (or not) the concentrations of CoPC within the Site and at the down hydraulic gradient Site boundary represent a risk to groundwater dependant ecosystems*" [Executive Summary, Sections 1.5 & 8.1, AECOM HHERA]

[42] "*… the NSW EPA has directed that the point of compliance for the assessment of ecological risk is at the down hydraulic gradient Site boundary, in order to be protective of such groundwater dependent ecosystems.*" [Section 8.2.2.1, AECOM HHERA]

[43] "*the assessment of ecological risk is based on whether groundwater concentrations within the Site and at the Site boundary exceed the MWQC … in order to protect groundwater dependant ecosystems which may be present down hydraulic gradient of the Site boundary currently or in the future.*" [Section 8.6.3, AECOM HHERA]

[44] Table 7 in Section 3.4, AECOM HHERA

- The AECOM report misrepresented the ESD principles specified in Section 9 of the CLM Act;
- Two other ecological risks assessments have been prepared by AECOM for the redevelopment of the central and southern areas of the Baranagroo site[45], which includes the *Declared Area* (**Figure 3-7[46]**). These reports correctly state that the marine ecology in Darling Harbour represents the nearest environmental receptor to the site[47]. None of these risk assessments mention the need to protect a GDE now or into the future or even mentioned the term "*groundwater dependent ecosystem*". These reports were also reviewed on several occasions by the NSW EPA and Site Auditor prior to being issued in a final approved version[48]; and
- Other investigation and assessment reports have been prepared by AECOM for the Barangaroo site[49], which correctly state that the marine ecology in Darling Harbour represents the nearest environmental receptor to the site[50]. None of these reports mention the need to protect a GDE now or into the future or even mentioned the term "*groundwater dependent ecosystem*".

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[45] These additional HHERAs comprise: AECOM (9 June 2011) "*Human Health and Ecological Risk Assessment, Declaration Site (Development Works) Remediation Works Area – Barangaroo*"; and, AECOM (4 July 2011) "*Human Health and Ecological Risk Assessment Addendum, Other Remediation Works (South) Area, Barangaroo*".

[46] Figure F2, AECOM (9 June 2011) HHERA

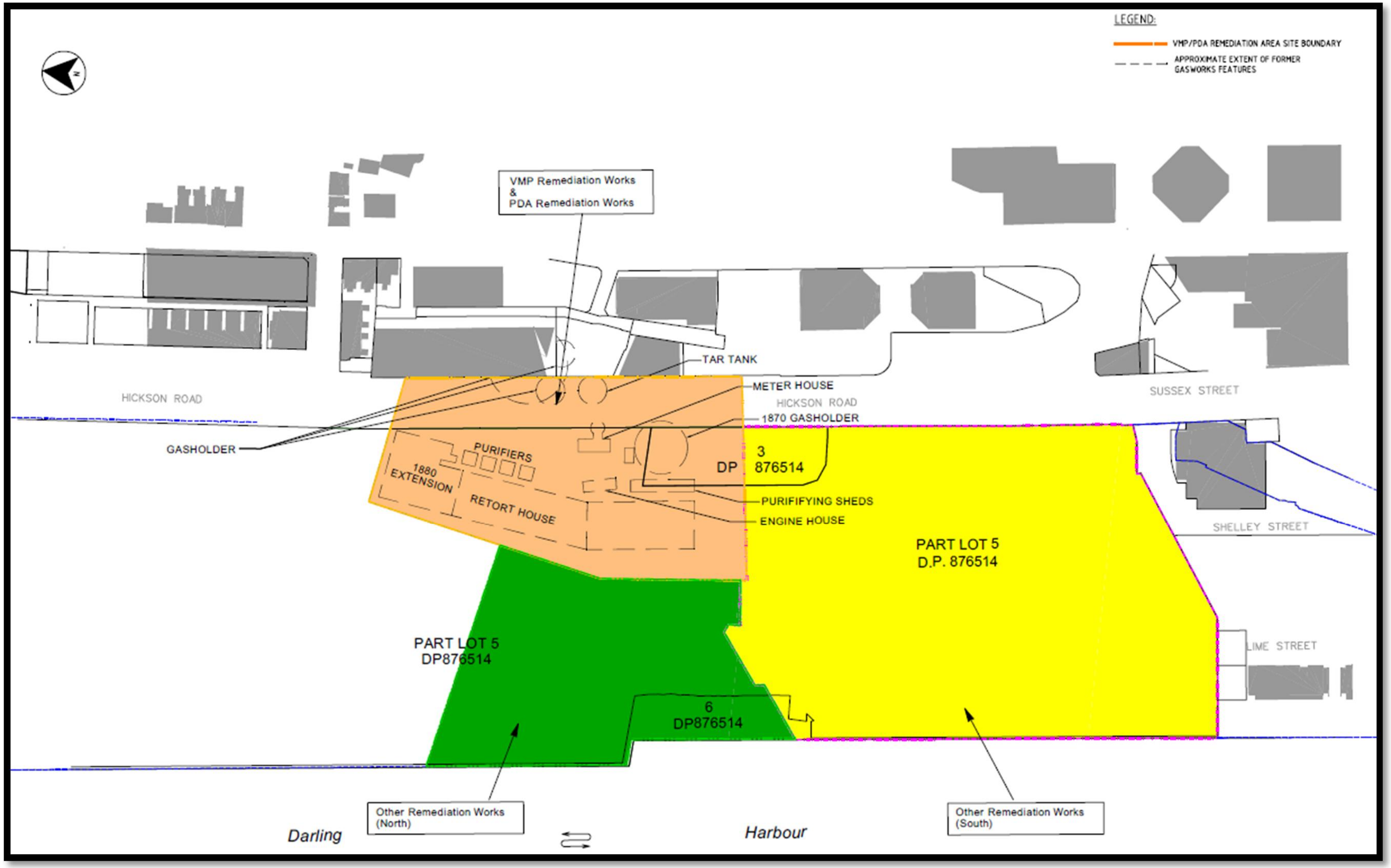
[47] Executive Summary, Section 7.1.2, 7.1.3 & 7.4, AECOM (9 June 2011) HHERA; Sections 5.2.2, 5.2.3 & 5.7.3.1, AECOM (4 July 2011) HHERA

[48] The 9 June 2011 report was reviewed by the NSW EPA and Site Auditor on three occasions from 12 April 2011 prior to being issued as an approved final document. The 4 July 2011 report was reviewed by the NSW EPA and/or Site Auditor on three occasions from 18 April 2011 prior to being issued as an approved final document.

[49] These additional reports comprise: AECOM (27 May 2010) "*Data Gap Investigation, Other Remediation Works (South) Area, Hickson Road, Millers Point, NSW*"; AECOM (23 September 2010) "*Data Gap Investigation, EPA Declaration Area (Parts of Barangaroo Site and Hickson Road), Millers Point, NSW*"; AECOM (20 October 2010) "*Data Gap Investigation, Other Remediation Works North, Hickson Road, Millers Point, NSW*"; AECOM (9 March 2012) "*Supplementary Data Gap Investigation, VMP Area, Hickson Road, Millers Point, NSW*".

[50] Sections 5.6 & 12.0, AECOM (27 May 2010); Sections 5.6 & 12.0, AECOM (23 September 2010); Section 5.6.1, AECOM (20 October 2010); Sections 5.6 & 9.3, AECOM (9 March 2012)

- **Figure 3-7 Areas of the Barangaroo Development Site Covered by Other AECOM HHERA’s**



More detailed information regarding my conclusions is provided in the following dot points:

- Groundwater at and down-gradient of the *Declared Area* is not part of an ecosystem that supports terrestrial vegetation, base flow in streams, aquifer and cave ecosystems, or wetlands, which are features of a GDE specified by the DLWC;
- Groundwater at and down-gradient of the *Declared Area* has been part of a commercial / industrial site for more than 170 years where groundwater has been intercepted, isolated and removed by underground structures, basements and foundations;
- Groundwater at and down-gradient of the *Declared Area* is now part of an inner-city development site where groundwater will be removed or isolated when basements and foundations for the Barangaroo development are constructed. Some of this groundwater will also be removed when excavations are undertaken for the construction of Southern Cove;
- It is unreasonable to assume that a GDE is likely to occur at the site in the future, given the site's location in the centre of the Sydney CBD adjacent to a maritime waterway;
- Nowhere does Section 9 of the CLM Act state that "*the level of protection is required to be the highest that is practicably achievable based on the protection of the potential for such ecosystems to occur in the future*", as reported by AECOM[51]. Section 9(3)(a) of the Act states that "*the precautionary principle – namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:*
    - *(i) Careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and*
    - (ii) *An assessment of the risk-weighted consequences of various options*"
- Schedule 4 of the NSW "*Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*" does not include the "*Declared Area*" or adjacent land as containing a high priority GDE. The closest high priority GDE to the site is the Botany Wetlands that are located on the northern shore of Botany Bay;
- The Australian National Atlas of Groundwater Dependent Ecosystems is prepared by the Australian Government's Bureau of Meteorology and is provided online at the website http://www.bom.gov.au/water/groundwater/gde/index.shtml. The website advises that "*The National Atlas of Groundwater Dependent Ecosystems (GDE Atlas) presents the current knowledge of GDEs across Australia, and shows known GDEs as well as ecosystems that potentially use groundwater. The GDE Atlas is a tool to assist the consideration of ecosystem groundwater requirements in natural resource management,*

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[51] Table 7 in Section 3.4, AECOM HHERA

including water planning and environmental impact assessment". The database was accessed by SKM on 29/11/12 and it showed that is no GDE at or near the *Declared Area*, Darling Harbour or the Sydney CBD. A copy of the output from the atlas is provided in **Figure 3-8**;

- The NSW EPA (9 May 2009) "*Declaration of Remediation Site*" lists the only ecosystem at risk from contamination as being the aquatic ecosystem in Darling Harbour. No mention is made of the presence of a GDE. [**DOCUMENT 1];**
- The Water Quality Objectives (WQOs) developed by the NSW EPA for Sydney Harbour and the Parramatta River do not list the presence or need to protect a GDE[52]. The main WQO of relevance to groundwater flowing from the "*Declared Area*" is the need to protect aquatic ecosystems within Darling Harbour. [**DOCUMENT 2**];
- In the WQO guidance for Sydney Harbour, the NSW EPA also advises that the recommended criteria for chemical contaminants are listed as being the default trigger values provided in the ANZECC 2000 Guidelines. The NSW EPA states that "*the default trigger values provided in ANZECC 2000 Guidelines are essentially conservative and precautionary. If they are not exceeded, a very low risk of environmental damage can be assumed. If they are exceeded, further investigation is "triggered" for the pollutant concerned*". [**DOCUMENT 2**];
- Groundwater at the *Declared Area* and adjacent land does not support any terrestrial habitat. This is because the groundwater is not part of a freshwater aquifer that has a beneficial reuse potential, it does not support terrestrial vegetation and it does not discharge into a freshwater stream, wetland, estuarine foreshore environment or underground karst system. The land is currently sealed by concrete and bitumen pavement[53];
- Groundwater at the *Declared Area* and adjacent land does not support the aquatic environment in Darling Harbour. This is because the aquatic environment in Darling Harbour is dependent on the aquatic environment in Sydney Harbour. Groundwater flowing from the *Declared Area* towards Darling Harbour does not contain any unique micro-organisms that are part of the food chain for the marine environment in Darling Harbour;

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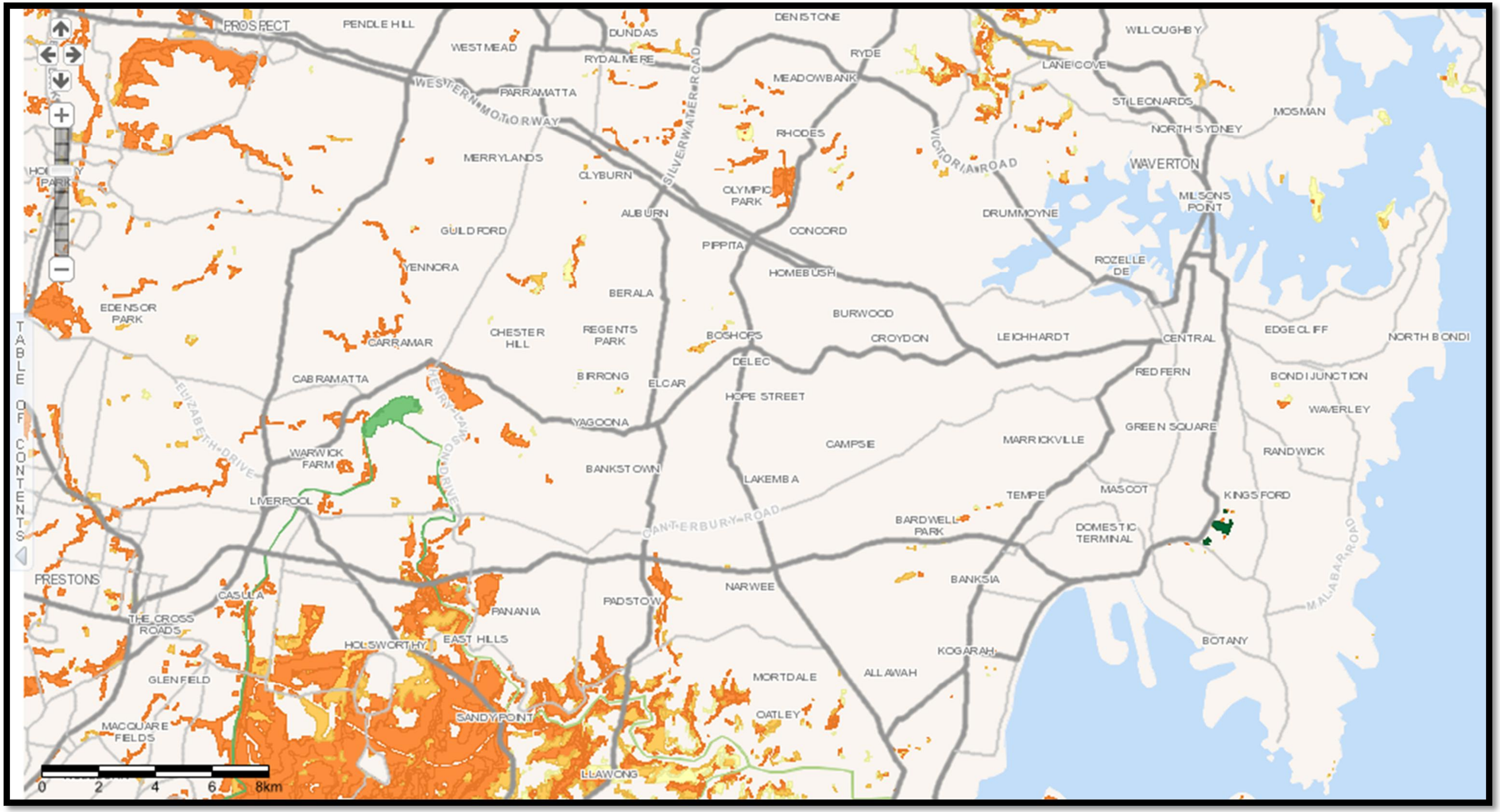
[52] http://www.environment.nsw.gov.au/ieo/SydneyHarbour/report-03.htm#P307_25850

[53] Similar conclusions were made in Section 8.2.1 of the AECOM (16 August 2012) HHERA

- **Figure 3-8 Output from Australian National Atlas of Groundwater Dependent Ecosystems for the Sydney Area (29/11/12)**



- Groundwater at the *Declared Area* and adjacent land has no significant influence on the benthic organisms that live in the sediments in Darling Harbour. This is because studies have shown that practically all groundwater flowing from the *Declared Area* towards Darling Harbour occurs in the fill layer that was formed by port reclamation work in the 1970's. The amount of groundwater flowing from the *Declared Area* under the seawall and up through the sediment layer in Darling Harbour is not considered to be significant. This is because of the much lower permeability of the natural soil and sandstone bedrock that underlies the thick and more permeable fill layer[54] and because the seawall is permeable, as shown by the results of the AECOM (November 2010) "*Groundwater Discharge Study, Stage 1 Barangaroo Development*". This outcome is also shown by the AECOM CSM in **Figure 3-1**; and
- Some seawater does flow inland from the seawall towards the *Declared Area* during a rising tide. The extent of this seawater intrusion is often referred to as a tidal prism. Studies by AECOM have shown that the tidal exchange prism extends a distance of 10 m to the east of the seawall[55], as shown by a copy of the AECOM drawing provided in **Figure 3-9**. The AECOM HHERA showed that none of the wells located within a distance of 10 m of the seawall have measured groundwater concentrations exceeding the MWQC. This means groundwater migrating from the *Declared Area* poses a low risk to micro-organisms present in seawater that flows inland of the seawall during a rising tide.

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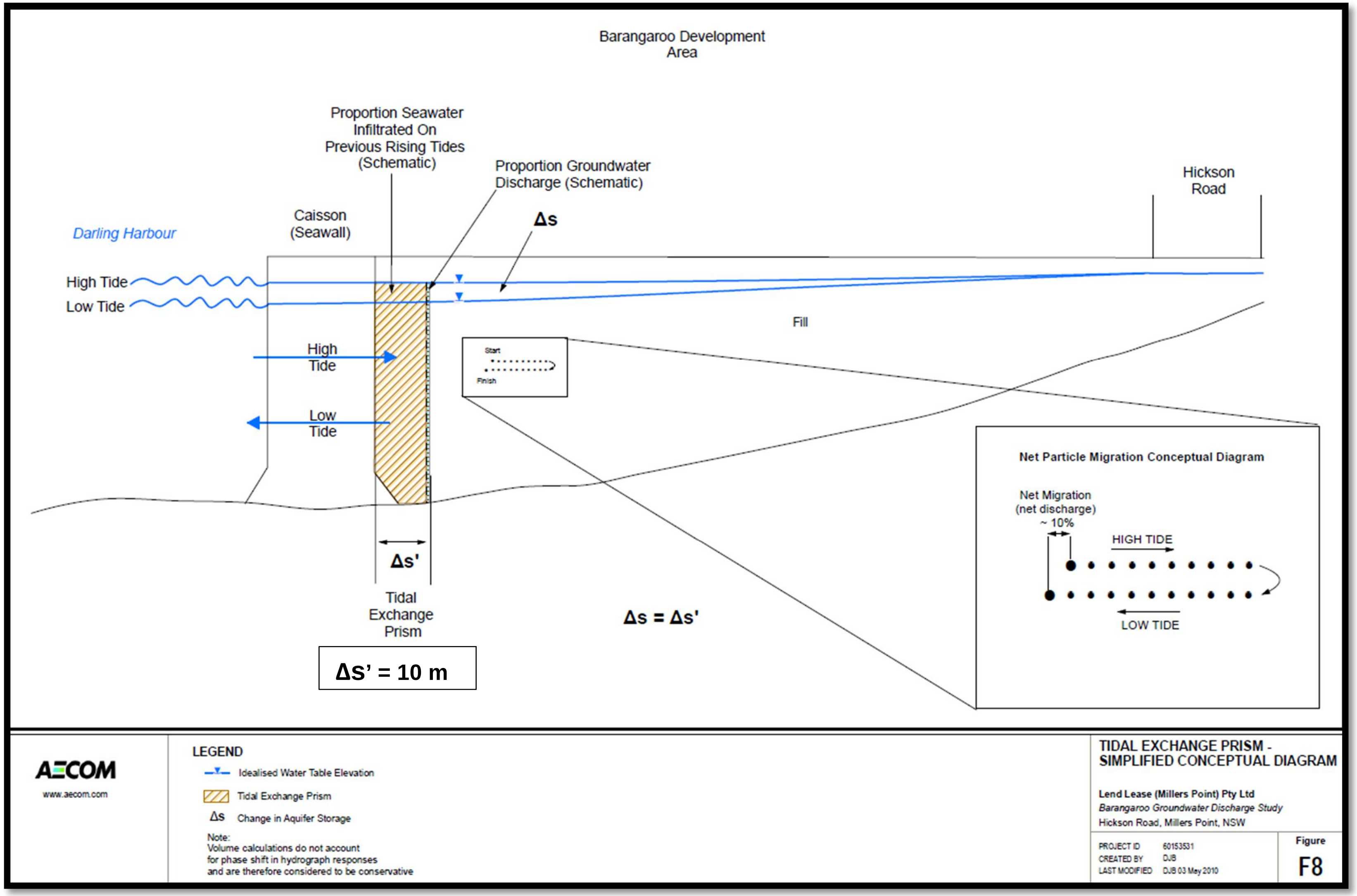
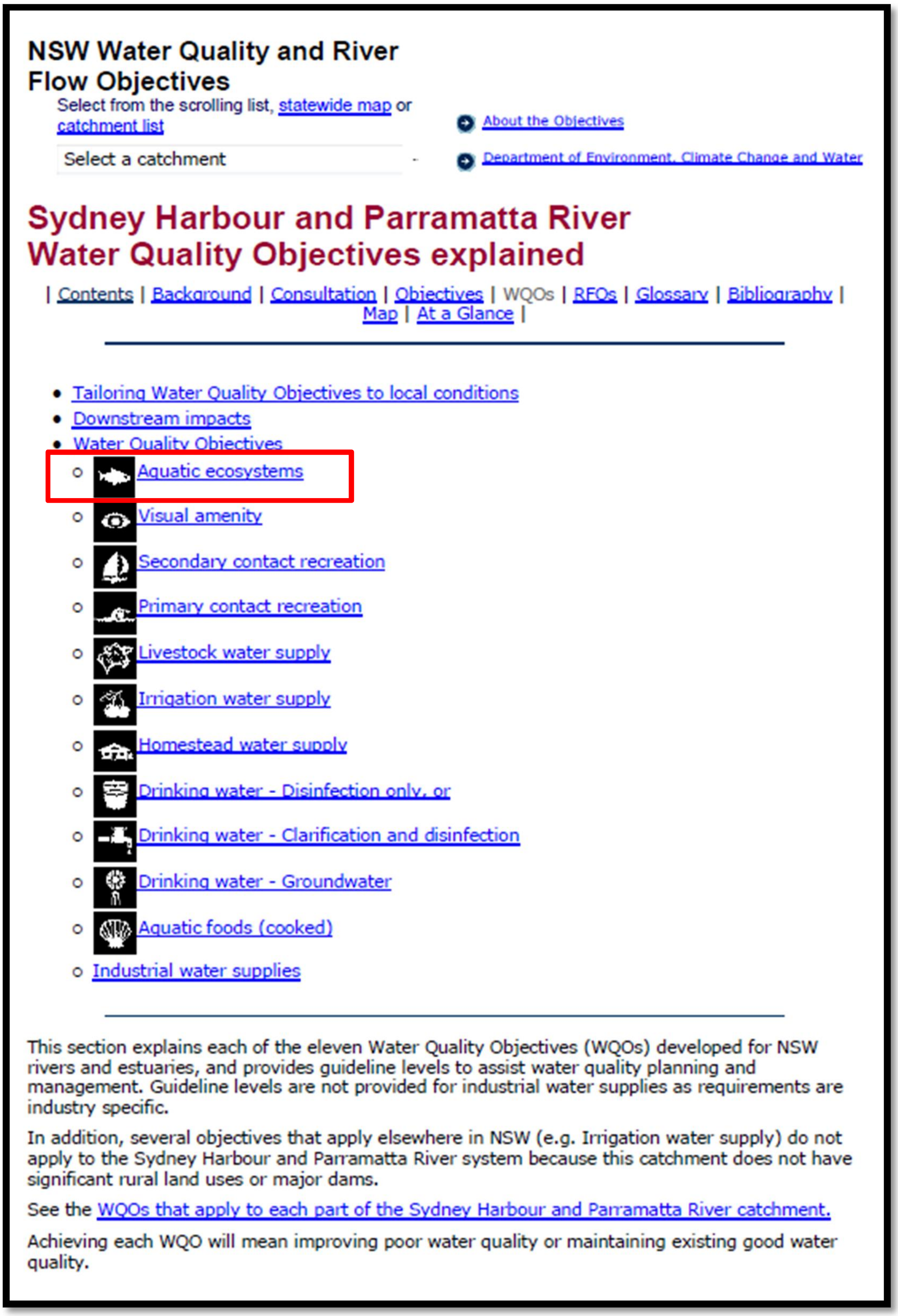
[54] Refer Section 6.0, AECOM (3 November 2010) "*Groundwater Discharge Study (GDS), Stage 1 Barangaroo Development*"

[55] Section 5.3.1, AECOM (3 November 2010) GDS and Section 7.3.2, AECOM (21 March 2012) draft HHERA

- **Figure 3-9 Tidal Prism West of “*Declared Area*”** [Source: Figure F8, AECOM (3 Nov. 2010)]



DOCUMENT (2) – Extract from NSW EPA "*Sydney Harbour and Parramatta River Water Quality Objectives explained*" (Page 1 of 4)



NSW Water Quality and River Flow Objectives

Select from the scrolling list, statewide map or catchment list

Select a catchment

About the Objectives

Department of Environment, Climate Change and Water

Sydney Harbour and Parramatta River Water Quality Objectives explained

| Contents | Background | Consultation | Objectives | WQOs | RFOs | Glossary | Bibliography | Map | At a Glance |

- Tailoring Water Quality Objectives to local conditions
- Downstream impacts
- Water Quality Objectives
  - Aquatic ecosystems
  - Visual amenity
  - Secondary contact recreation
  - Primary contact recreation
  - Livestock water supply
  - Irrigation water supply
  - Homestead water supply
  - Drinking water - Disinfection only, or
  - Drinking water - Clarification and disinfection
  - Drinking water - Groundwater
  - Aquatic foods (cooked)
  - Industrial water supplies

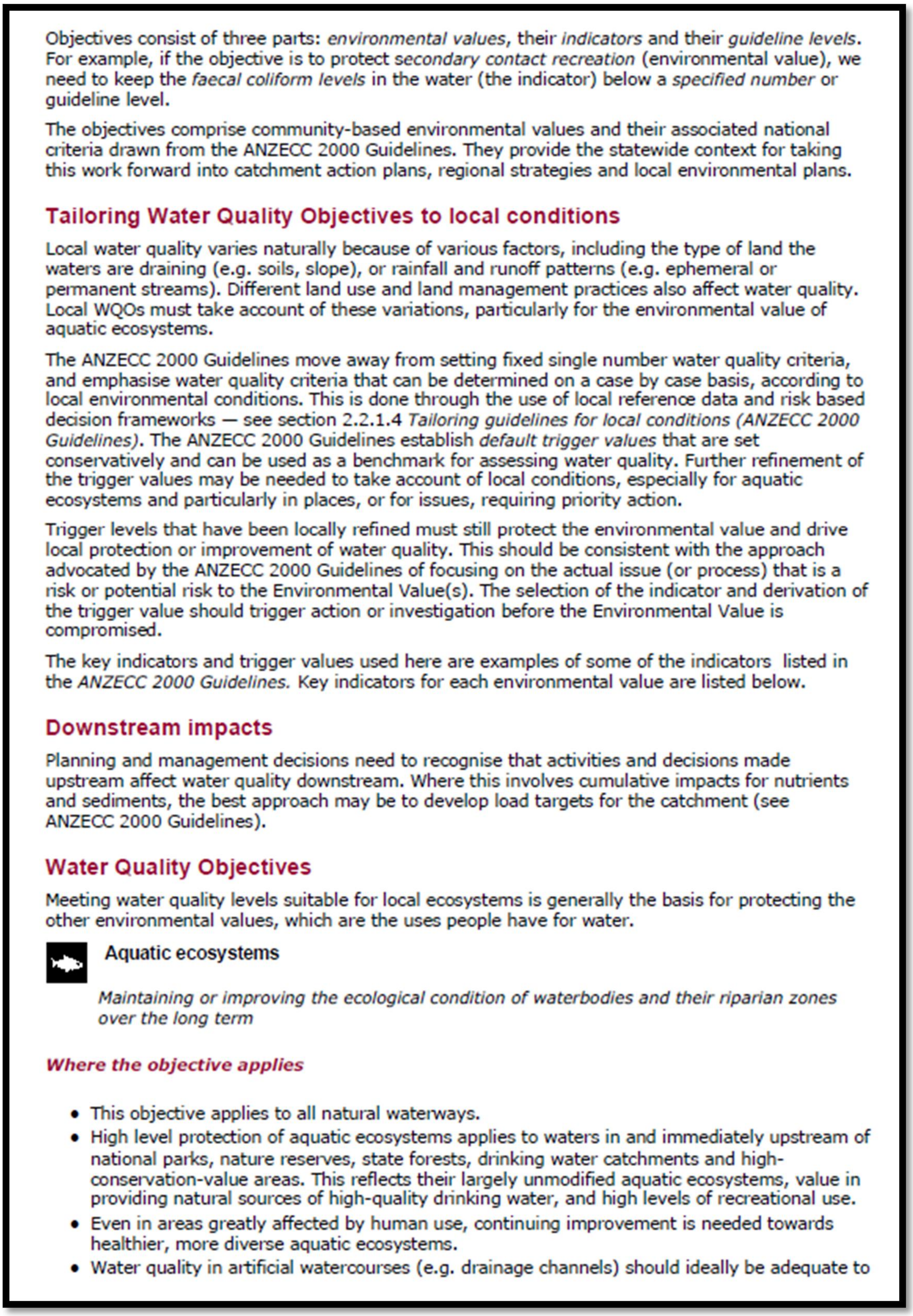
This section explains each of the eleven Water Quality Objectives (WQOs) developed for NSW rivers and estuaries, and provides guideline levels to assist water quality planning and management. Guideline levels are not provided for industrial water supplies as requirements are industry specific.

In addition, several objectives that apply elsewhere in NSW (e.g. Irrigation water supply) do not apply to the Sydney Harbour and Parramatta River system because this catchment does not have significant rural land uses or major dams.

See the WQOs that apply to each part of the Sydney Harbour and Parramatta River catchment.

Achieving each WQO will mean improving poor water quality or maintaining existing good water quality.

DOCUMENT (2) – cont'd (Page 2 of 4)



Objectives consist of three parts: *environmental values*, their *indicators* and their *guideline levels*. For example, if the objective is to protect *secondary contact recreation* (environmental value), we need to keep the *faecal coliform levels* in the water (the indicator) below a *specified number* or guideline level.

The objectives comprise community-based environmental values and their associated national criteria drawn from the ANZECC 2000 Guidelines. They provide the statewide context for taking this work forward into catchment action plans, regional strategies and local environmental plans.

Tailoring Water Quality Objectives to local conditions

Local water quality varies naturally because of various factors, including the type of land the waters are draining (e.g. soils, slope), or rainfall and runoff patterns (e.g. ephemeral or permanent streams). Different land use and land management practices also affect water quality. Local WQOs must take account of these variations, particularly for the environmental value of aquatic ecosystems.

The ANZECC 2000 Guidelines move away from setting fixed single number water quality criteria, and emphasise water quality criteria that can be determined on a case by case basis, according to local environmental conditions. This is done through the use of local reference data and risk based decision frameworks — see section 2.2.1.4 *Tailoring guidelines for local conditions (ANZECC 2000 Guidelines)*. The ANZECC 2000 Guidelines establish *default trigger values* that are set conservatively and can be used as a benchmark for assessing water quality. Further refinement of the trigger values may be needed to take account of local conditions, especially for aquatic ecosystems and particularly in places, or for issues, requiring priority action.

Trigger levels that have been locally refined must still protect the environmental value and drive local protection or improvement of water quality. This should be consistent with the approach advocated by the ANZECC 2000 Guidelines of focusing on the actual issue (or process) that is a risk or potential risk to the Environmental Value(s). The selection of the indicator and derivation of the trigger value should trigger action or investigation before the Environmental Value is compromised.

The key indicators and trigger values used here are examples of some of the indicators listed in the *ANZECC 2000 Guidelines.* Key indicators for each environmental value are listed below.

Downstream impacts

Planning and management decisions need to recognise that activities and decisions made upstream affect water quality downstream. Where this involves cumulative impacts for nutrients and sediments, the best approach may be to develop load targets for the catchment (see ANZECC 2000 Guidelines).

Water Quality Objectives

Meeting water quality levels suitable for local ecosystems is generally the basis for protecting the other environmental values, which are the uses people have for water.

Aquatic ecosystems

Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term

Where the objective applies

- This objective applies to all natural waterways.
- High level protection of aquatic ecosystems applies to waters in and immediately upstream of national parks, nature reserves, state forests, drinking water catchments and high-conservation-value areas. This reflects their largely unmodified aquatic ecosystems, value in providing natural sources of high-quality drinking water, and high levels of recreational use.
- Even in areas greatly affected by human use, continuing improvement is needed towards healthier, more diverse aquatic ecosystems.
- Water quality in artificial watercourses (e.g. drainage channels) should ideally be adequate to

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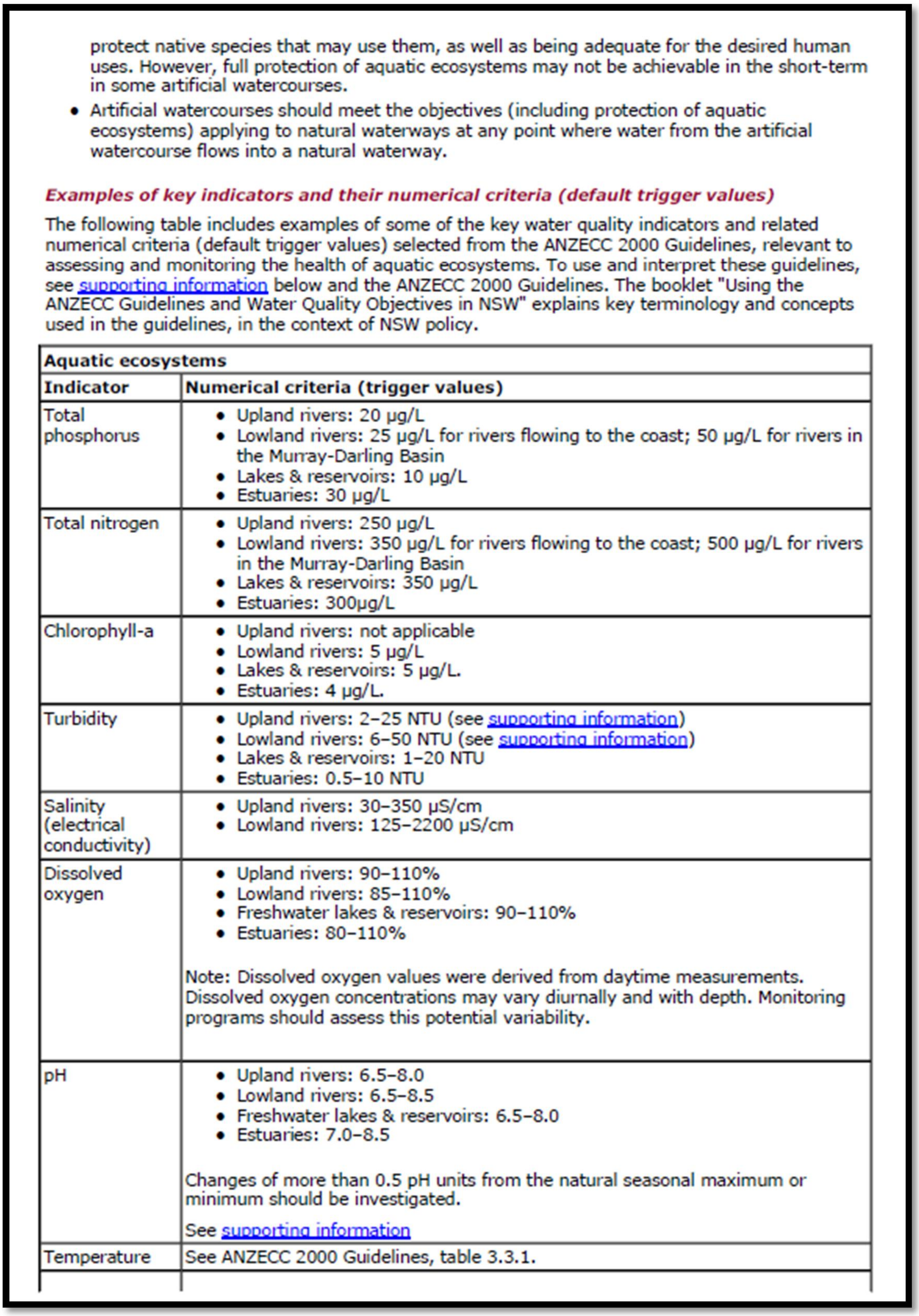

protect native species that may use them, as well as being adequate for the desired human uses. However, full protection of aquatic ecosystems may not be achievable in the short-term in some artificial watercourses.

- Artificial watercourses should meet the objectives (including protection of aquatic ecosystems) applying to natural waterways at any point where water from the artificial watercourse flows into a natural waterway.

Examples of key indicators and their numerical criteria (default trigger values)

The following table includes examples of some of the key water quality indicators and related numerical criteria (default trigger values) selected from the ANZECC 2000 Guidelines, relevant to assessing and monitoring the health of aquatic ecosystems. To use and interpret these guidelines, see supporting information below and the ANZECC 2000 Guidelines. The booklet "Using the ANZECC Guidelines and Water Quality Objectives in NSW" explains key terminology and concepts used in the guidelines, in the context of NSW policy.

Aquatic ecosystems	
Indicator	**Numerical criteria (trigger values)**
Total phosphorus	• Upland rivers: 20 µg/L • Lowland rivers: 25 µg/L for rivers flowing to the coast; 50 µg/L for rivers in the Murray-Darling Basin • Lakes & reservoirs: 10 µg/L • Estuaries: 30 µg/L
Total nitrogen	• Upland rivers: 250 µg/L • Lowland rivers: 350 µg/L for rivers flowing to the coast; 500 µg/L for rivers in the Murray-Darling Basin • Lakes & reservoirs: 350 µg/L • Estuaries: 300µg/L
Chlorophyll-a	• Upland rivers: not applicable • Lowland rivers: 5 µg/L • Lakes & reservoirs: 5 µg/L. • Estuaries: 4 µg/L.
Turbidity	• Upland rivers: 2–25 NTU (see supporting information) • Lowland rivers: 6–50 NTU (see supporting information) • Lakes & reservoirs: 1–20 NTU • Estuaries: 0.5–10 NTU
Salinity (electrical conductivity)	• Upland rivers: 30–350 µS/cm • Lowland rivers: 125–2200 µS/cm
Dissolved oxygen	• Upland rivers: 90–110% • Lowland rivers: 85–110% • Freshwater lakes & reservoirs: 90–110% • Estuaries: 80–110% Note: Dissolved oxygen values were derived from daytime measurements. Dissolved oxygen concentrations may vary diurnally and with depth. Monitoring programs should assess this potential variability.
pH	• Upland rivers: 6.5–8.0 • Lowland rivers: 6.5–8.5 • Freshwater lakes & reservoirs: 6.5–8.0 • Estuaries: 7.0–8.5 Changes of more than 0.5 pH units from the natural seasonal maximum or minimum should be investigated. See supporting information
Temperature	See ANZECC 2000 Guidelines, table 3.3.1.

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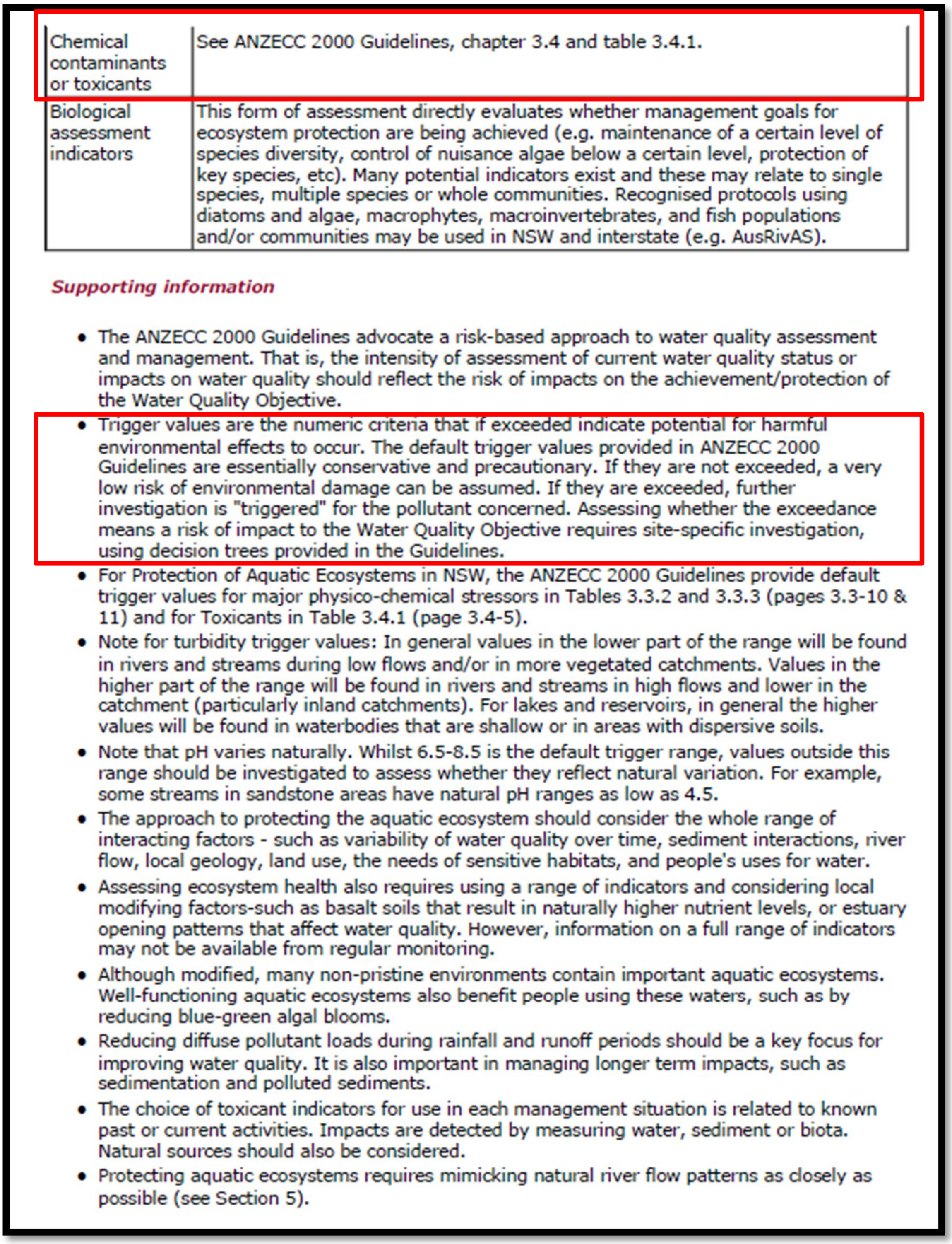

Chemical contaminants or toxicants	See ANZECC 2000 Guidelines, chapter 3.4 and table 3.4.1.
Biological assessment indicators	This form of assessment directly evaluates whether management goals for ecosystem protection are being achieved (e.g. maintenance of a certain level of species diversity, control of nuisance algae below a certain level, protection of key species, etc). Many potential indicators exist and these may relate to single species, multiple species or whole communities. Recognised protocols using diatoms and algae, macrophytes, macroinvertebrates, and fish populations and/or communities may be used in NSW and interstate (e.g. AusRivAS).

Supporting information

- The ANZECC 2000 Guidelines advocate a risk-based approach to water quality assessment and management. That is, the intensity of assessment of current water quality status or impacts on water quality should reflect the risk of impacts on the achievement/protection of the Water Quality Objective.
- Trigger values are the numeric criteria that if exceeded indicate potential for harmful environmental effects to occur. The default trigger values provided in ANZECC 2000 Guidelines are essentially conservative and precautionary. If they are not exceeded, a very low risk of environmental damage can be assumed. If they are exceeded, further investigation is "triggered" for the pollutant concerned. Assessing whether the exceedance means a risk of impact to the Water Quality Objective requires site-specific investigation, using decision trees provided in the Guidelines.
- For Protection of Aquatic Ecosystems in NSW, the ANZECC 2000 Guidelines provide default trigger values for major physico-chemical stressors in Tables 3.3.2 and 3.3.3 (pages 3.3-10 & 11) and for Toxicants in Table 3.4.1 (page 3.4-5).
- Note for turbidity trigger values: In general values in the lower part of the range will be found in rivers and streams during low flows and/or in more vegetated catchments. Values in the higher part of the range will be found in rivers and streams in high flows and lower in the catchment (particularly inland catchments). For lakes and reservoirs, in general the higher values will be found in waterbodies that are shallow or in areas with dispersive soils.
- Note that pH varies naturally. Whilst 6.5-8.5 is the default trigger range, values outside this range should be investigated to assess whether they reflect natural variation. For example, some streams in sandstone areas have natural pH ranges as low as 4.5.
- The approach to protecting the aquatic ecosystem should consider the whole range of interacting factors - such as variability of water quality over time, sediment interactions, river flow, local geology, land use, the needs of sensitive habitats, and people's uses for water.
- Assessing ecosystem health also requires using a range of indicators and considering local modifying factors-such as basalt soils that result in naturally higher nutrient levels, or estuary opening patterns that affect water quality. However, information on a full range of indicators may not be available from regular monitoring.
- Although modified, many non-pristine environments contain important aquatic ecosystems. Well-functioning aquatic ecosystems also benefit people using these waters, such as by reducing blue-green algal blooms.
- Reducing diffuse pollutant loads during rainfall and runoff periods should be a key focus for improving water quality. It is also important in managing longer term impacts, such as sedimentation and polluted sediments.
- The choice of toxicant indicators for use in each management situation is related to known past or current activities. Impacts are detected by measuring water, sediment or biota. Natural sources should also be considered.
- Protecting aquatic ecosystems requires mimicking natural river flow patterns as closely as possible (see Section 5).

3.6 Contaminant Migration Pathways

Activities undertaken after AGL vacated the site in 1921 are likely to have exacerbated the spread of contamination across the *Declared Area*, which were not included in the AECOM CSM. This includes the excavation and construction of service trenches associated with the redeveloped of the site and surrounding land.

Some of these service trenches are reported to have been excavated into the sandstone bedrock and backfilled with fill. In a 2003 report, URS concluded[56] that "*they are likely to provide a higher permeability conduit for the preferential flow of groundwater within the area and off-site, potentially towards Darling Harbour. It is these preferential conduit zones which may also facilitate the migration of contaminated groundwater, contained within the gasholder pits to off site locations (beneath Hickson Road, the Miller Point Wharf and Darling Harbour.*"

A Sydney Water plan[57] of the area (**Figure 3-4**) shows that a large number of buried services have been constructed within the three main underground gasworks structures located in the Declared Area. These buried services and their number include:

- Main Gasholder – Sewerage pump station (1), sewer mains (4), water main (1), electricity cables (3), gas main (1), telephone line (1);
- Tar Tank – Borehole pit for sewer main construction (1), sewer manhole (1), sewer main (1), electricity cables (3), gas main (1); and
- 1870 Gasholder – Water main (1), electricity cables (2), stormwater main (1).

The AECOM CSM did not include the influence of existing service trenches constructed post 1921 on the spread of contamination across the *Declared Area*. The AECOM HHERA justified this omission on the following basis[58]:

> "*It is noted that, in the opinion of AECOM, the current database and conceptual site model indicate that the shallow subsurface trenches are unlikely to act as preferential pathways for contaminant migration as the contamination is present at depths below the likely depth of the service trenches*".

This omission is an error in the AECOM HHERA because:

- Sydney Water documents[59] indicate that the former sewerage pump station SPS59 (located adjacent to the *Declared Area*) is 8 m deep, with pipelines / tunnels at a depth of 2 m. The

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[56] Section 3.2, URS (10 July 2003)

[57] Sydney Water (2 May 2011) Drawing "*City of Sydney Sewerage Drains to SPS1129 B.O.O.S via Kent St Submain*". Sheet 1 of 4

[58] Section 2.8, AECOM HHERA

newly constructed pump station SPS1129 (located within the *Declared Area*) is even deeper, with the inside floor of the tank at a depth of 10.03 m and the invert of the inlet pipe at a depth of 7.73 m;

- Other AECOM reports recognised the influence of service trenches constructed post 1921 on the spread of contamination across the *Declared Area*[60]; and
- Reports prepared by many other investigators recognised the influence of service trenches constructed post 1921 on the spread of contamination across the *Declared Area*[61].

This omission in the AECOM CSM is significant because the AECOM HHERA[62] and other AECOM reports[63] found that the risks to human receptors at the *Declared Area* and the marine ecology in Darling Harbour are most influenced by contaminant levels in shallow groundwater in the fill layer.

4. Detailed Response - Review of AECOM Environmental Risk Assessment

4.1 Groundwater Dependant Ecosystems

The AECOM HHERA considered there are micro-organisms present in groundwater between the western boundary of the *Declared Area* and Darling Harbour that are part of a GDE and which need to be protected. The incorporation of a GDE as the most critical ecological receptor resulted in the AECOM HHERA incorrectly concluding that contamination migrating from the *Declared Area* is causing an unacceptable risk to the environment, with the reasons for my views given in **Section 3.3.2**.

4.2 Point of Compliance

The point of compliance is the location at a site where the groundwater quality needs to meet the water quality criteria adopted for the project so that no further action is required.

The most reasonable point of compliance for assessing ecological risks posed by contaminated groundwater migrating from the *Declared Area* is the seawall along the eastern side of Darling

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[59] Sydney Water (14 November 2002) "*Concept Design Report, SP1129, SewerFix Pumping Stations Program*"; Sydney Water (2003) "*Review of Environmental Factors (REF), SP1129 Hickson Road, Sydney*"

[60] Section 5.5, AECOM (27 May 2010); Section 5.5, AECOM (23 September 2010); Section 2.8, AECOM (4 July 2011)

[61] Section 3.2, URS (10 July 2003); Section 4.5, ERM (21 June 2007)

[62] Executive Summary and Section 10.1, AECOM HHERA

[63] Sections 11.2 and 11.3, AECOM (23 September 2010); Executive summary & Section 11.3, AECOM (20 October 2010); Executive summary and Sections 5.3, 5.5 & 6.0, AECOM (3 November 2010); Section 5.7.1.1, AECOM (4 July 2011); Sections 3.5 & 11.3, AECOM (9 March 2012)

Harbour. This is because the nearest environmental receptor to the *Declared Area* is the marine ecosystem in Darling Harbour.

My conclusion agrees with two earlier ecological risks assessments prepared by AECOM in 2011 for the redevelopment of the Baranagroo site, together with other investigation and assessment reports, as previously discussed in **Section 3.3.2**. These reports also state that the marine ecology in Darling Harbour represents the nearest environmental receptor to the site. None of these reports mention the need to protect a GDE now or into the future or even mentioned the term "*groundwater dependent ecosystem*".

Nevertheless, the AECOM HHERA adopted the point of compliance as the western (down-hydraulic gradient) boundary of the *Declared Area* in order to protect GDEs[64]. This resulted in the AECOM HHERA concluding that contamination migrating from the *Declared Area* is causing an unacceptable risk to the environment. This is an unreasonable conclusion because all investigations have found that groundwater at the point of discharge along the Darling Harbour seawall meets the marine water quality criteria, as discussed in the following section.

4.3 Selection of Groundwater Well Locations

Groundwater quality across and adjacent to the *Declared Area* has been extensively investigated by numerous consultants since the early 1990's. These investigations have involved the drilling of boreholes and the construction and monitoring of a large number of groundwater wells screened at various depths. The locations of these wells are shown in Figure F3 from the AECOM HHERA, with a copy provided in **Figure 4-1**.

The AECOM HHERA assessed environmental risks based on groundwater data collected from all wells located across the *Declared Area*, irrespective of where the well was located relative to the closest ecological receptor. This meant that groundwater data from wells located in a buried tar tank or gasholders along the eastern side of the *Declared Area* were used to assess potential environmental impacts to the closest ecological receptor, this being the marine ecology in Darling Harbour located to the west of the *Declared Area*. AECOM justified their approach because they considered there were uncertainties regarding whether existing groundwater monitoring results are representative of groundwater leaving the western boundary of the *Declared Area*[65].

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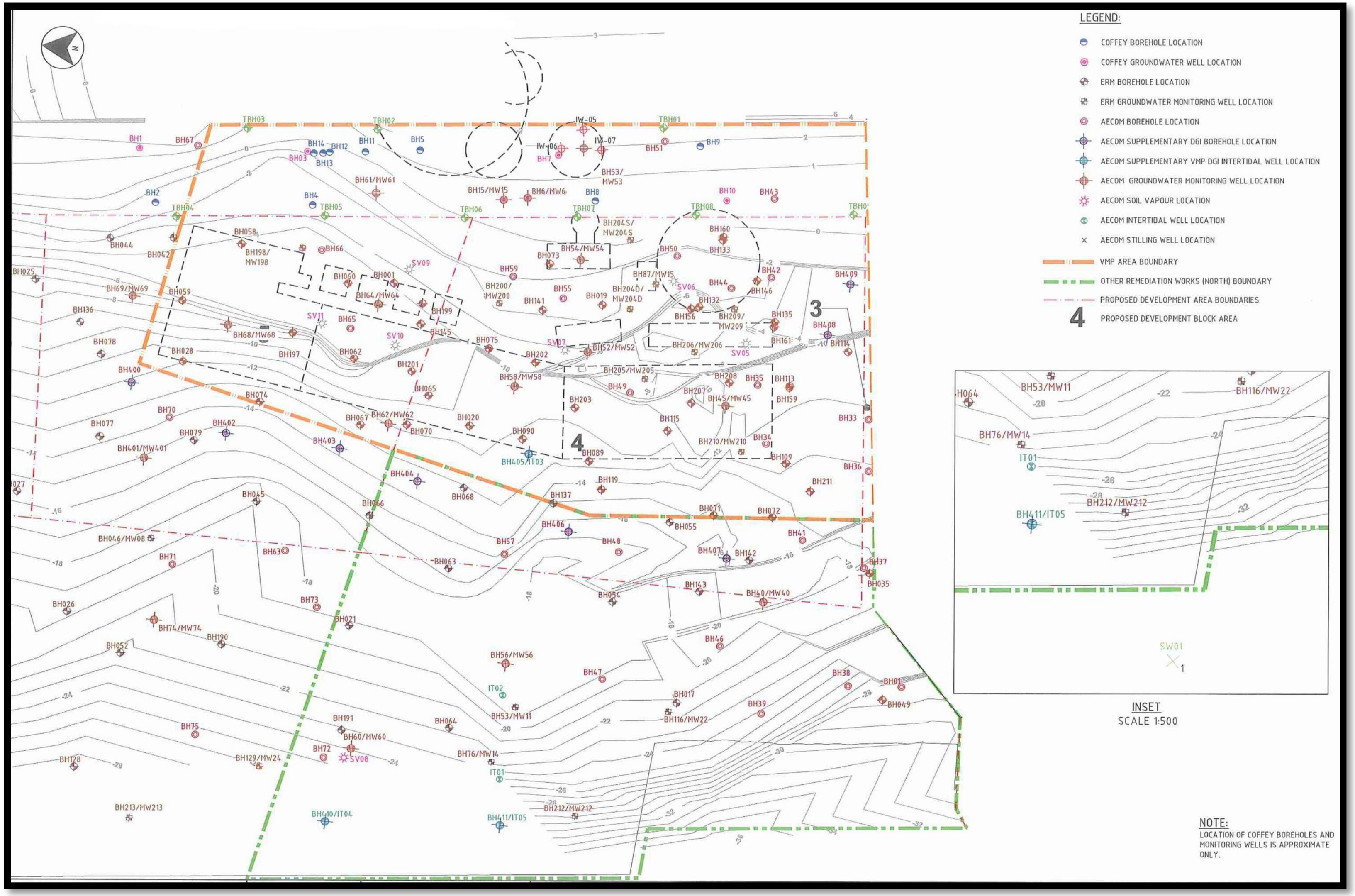
[64] Executive summary and Sections 1.4.2, 8.1, 8.2.2.1, AECOM HHERA

[65] Section 8.1, AECOM HHERA

- **Figure 4-1 Investigation Locations at Declared Area** [Source: Figure F3, AECOM (9 October 2012)]



In my opinion, the AECOM approach is incorrect because:

- The quality of groundwater at and down-gradient of the *Declared Area* has been extensively investigated by numerous consultants since the early 1990's and reviewed by the NSW EPA and Site Auditor. Similar conclusions were reached by the AECOM HHERA[66] and investigation reports prepared by AECOM[67], which have also been reviewed by the NSW EPA and Site Auditor;
- The spatial coverage of groundwater investigation is considered to be sufficient to characterise the nature and extent of groundwater contamination within and down-gradient of the *Declared Area*. Similar conclusions were reached by the AECOM HHERA[68];
- The point of compliance should be the Darling Harbour seawall rather than the western boundary of the *Declared Area* (**Section 4.2**), since this is the point of discharge and the closest environmental receptor is the marine ecology in Darling Harbour (**Sections 3.3.2** & **4.1**);
- An extensive amount of groundwater data is available from wells located near the Darling Harbour seawall. These data have allowed the extent of groundwater contamination to be defined (**Section 4.4)**; and
- The available data indicate that groundwater at the point of discharge along the Darling Harbour seawall is not contaminated at concentrations exceeding the marine water quality criteria (**Section 4.4)**.

The approach adopted by AECOM resulted in their HHERA concluding that contamination with the *Declared Area* poses an unacceptable risk to the environment[69]. This is an incorrect conclusion because all investigations have found that groundwater at the point of discharge along the Darling Harbour seawall meets the marine water quality criteria, as discussed in the following section.

4.4 Contaminant Concentrations at Closest Ecological Receptor

The AECOM HHERA did not assess the extent of groundwater contamination migrating from the *Declared Area* and whether the groundwater quality meets the marine water quality criteria (MWQC) at the point of discharge into Darling Harbour where the closest ecological receptor is located. This meant that the AECOM HHERA was incapable of providing a reasonable for basis for assessing environmental risks posed by contaminated groundwater migrating from the

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[66] Section 3.2, AECOM HHERA

[67] AECOM (23 September 2010), AECOM (9 March 2012)

[68] Section 3.3, AECOM HHERA

[69] Executive summary, Sections 8.6.3 & 10.1, AECOM HHERA

Declared Area. These deficiencies in the AECOM HHERA have been addressed by the following assessment.

Groundwater concentrations in the land west of the *Declared Area* have been obtained by numerous investigations conducted between 2007 and 2012. A summary of the laboratory data for groundwater samples taken from wells screened only in the fill aquifer between the *Declared Area* and Darling Harbour is provided in **Appendix B**.

These results show that a groundwater plume extends from the *Declared Area* in a westerly direction towards Darling Harbour. Contaminant concentrations within the plume decrease with distance from the *Declared Area*, becoming non-detectible to very low and below the MWQC at a distance of at least 23 m from the point of discharge.

The contaminant concentrations and size of this groundwater plume are likely to be less than that defined by the laboratory test results, which means that the distance of the front edge of the plume from the point of discharge is likely to be more than 23 m. The evidence supporting this conclusion includes:

- Most of the groundwater samples taken from the wells west of the *Declared Area* and tested by the laboratories were unfiltered. In unfiltered samples, contaminants can be present as either dissolved in the water or attached to suspended solids. Environmental risks are governed by the dissolved contaminants, since the suspended solids are much less bioavailable and may be generated by the sampling process. Of the 14 locations west of the *Declared Area* where groundwater was sampled, filtered samples were collected from only 3 (or 21 %) locations. This means that the groundwater contaminant concentrations measured at the majority of locations would have been exaggerated;
- The groundwater sampling process can significantly increase the amount of suspended solids in a sample, which in turn can lead to the contaminant concentrations being exaggerated if unfiltered samples are tested and/or because contaminants absorbed onto the soils may go into solution in the groundwater. Low flow sampling techniques are preferred to high flow techniques because they reduce the amount of suspended solids generated by the sampling process. Of the 14 locations west of the *Declared Area* where groundwater was sampled, low flow sampling techniques were used at only 6 (or 29 %) of the locations. This means that the groundwater contaminant concentrations measured at the majority of locations would have been exaggerated;
- The AECOM (9 March 2012) investigation report[70] documented the results of an assessment into differences in contaminant concentrations between filtered and unfiltered groundwater samples. The results showed that filtered samples had much lower PAH and

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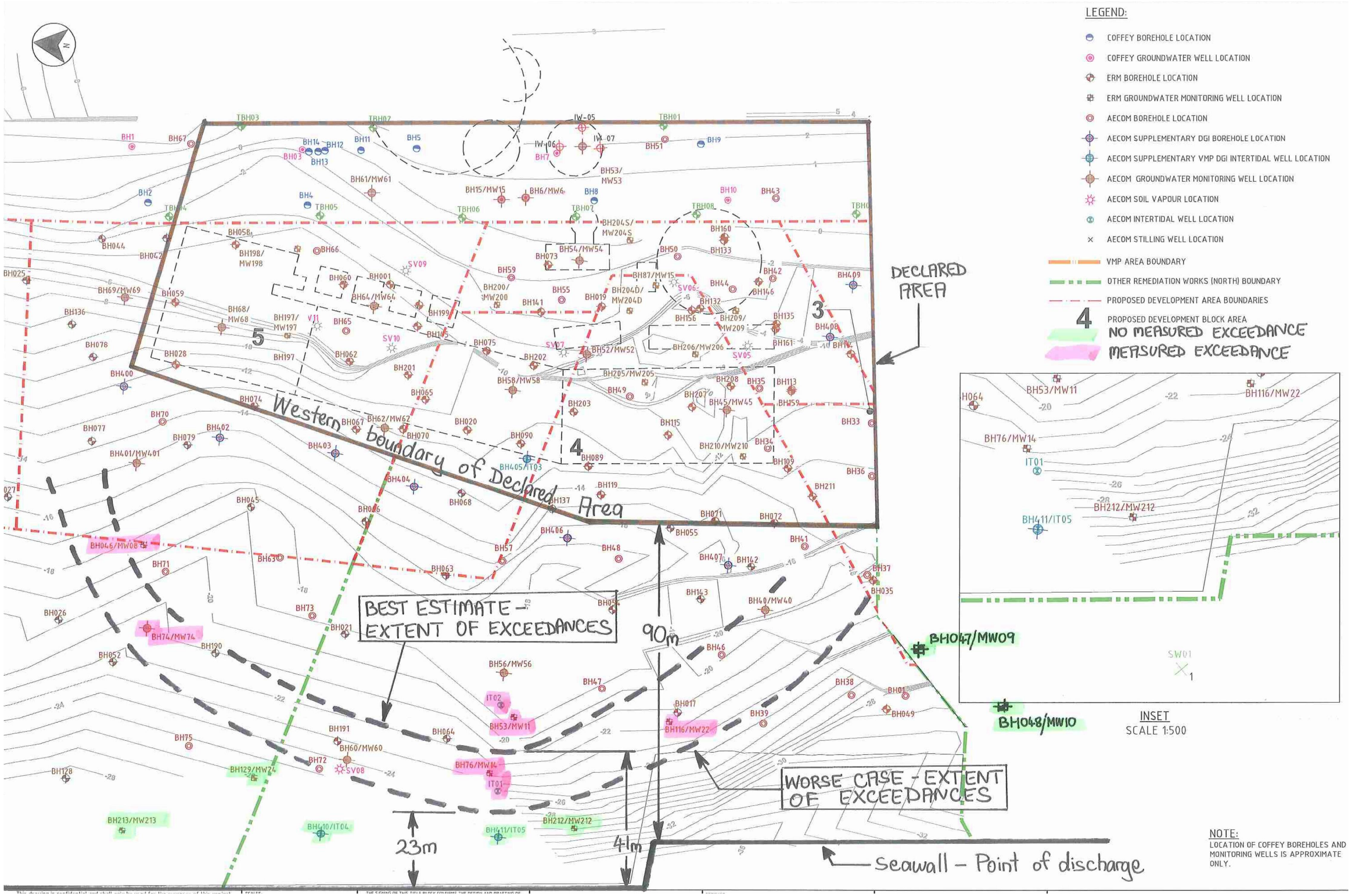
[70] AECOM (9 March 2012) "*Supplementary Data Gap Investigation, VMP Area, Hickson Road, Millers Point, NSW*"

TPH concentrations compared to unfiltered samples. This was particularly the case for unfiltered samples where high molecular weight PAHs were measured, since these substances have a very low solubility and their presence in the laboratory result is a clear indication of contaminated suspended solids. This means that the groundwater contaminant concentrations measured at the majority of locations would have been exaggerated;

- The presence of contamination caused when fill material was dumped at the site during the 1970’s port reclamation work. An example of such material is shown by the AECOM borehole log for IT1, which shows the presence of coke fragments between 5.0 and 6.0 m and possibly to 15.5 m bgl. No drill cuttings or samples were obtained from 6.0 – 15.5 m, so there is a risk of other contaminated material having been dumped with the fill placed west of the *Declared Area*. The presence of contaminated material dumped with the fill could lead to contamination of groundwater not associated with the *Declared Area*. This issue is significant due to the low MWQC values and the extensive use of high flow and unfiltered sampling techniques;
- The laboratory results could have exaggerated TPH concentrations since a silica gel clean-up procedure was not performed to remove naturally occurring organic material and other types of substances that cause false positive results to be obtained. This issue is significant given the potential for the fill used in the port reclamation work to contain natural organic material and because of past and present sewerage discharges from sewerage pump stations located within and near the *Declared Area*; and
- There was the potential for cyanide to have been incorrectly detected by laboratory tests (ie. false positive), due to sulfide interference. This interference can be minimised by placing the groundwater sample in a pre-treatment bottle containing lead acetate, which reacts with sulphide to form an insoluble lead sulfide precipitate. However, none of the investigations appear to have used this technique.

A plot of the worse-case groundwater plume on the western side of the “*Declared Area*” is provided in **Figure 4-2**. The drawing also shows a best-estimate plume shape, which seeks to account for the over-estimated groundwater concentrations provided by the laboratory test data. The leading edge of the best-estimate plume is estimated to meet the MWQC at a distance of 41m from the point of discharge.

- **Figure 4-2 Extent of Groundwater Plume from Declared Area**



In my opinion, the investigation data support the conclusion that groundwater migrating from the *Declared Area* does not pose an unacceptable risk to the aquatic ecosystem in Darling Harbour. This is because:

- The available data on groundwater quality at and down-gradient of the *Declared Area* is of an acceptable quality and suitable for use in an environmental risk assessment for the reasons previously given in **Section 4.3**;
- The MWQC were based on conservative and precautionary criteria largely obtained from the ANZECC (2000) water quality guidelines. This is stated by the NSW EPA in their document that explains the water quality objectives for Sydney Harbour and the Parramatta River, which includes Darling Harbour (**DOCUMENT 2**). In their document, the NSW EPA states that *"Trigger values are the numeric criteria that if exceeded indicate potential for harmful environmental effects to occur. The default trigger values provided in ANZECC 2000 Guidelines are essentially conservative and precautionary. If they are not exceeded, a very low risk of environmental damage can be assumed. If they are exceeded, further investigation is "triggered" for the pollutant concerned. Assessing whether the exceedance means a risk of impact to the Water Quality Objective requires site-specific investigation, using decision trees provided in the Guidelines.";*
- Groundwater concentrations at the point of discharge to Darling Harbour have been found not to exceed the MWQC at all locations; and
- Groundwater concentrations at the point of discharge to Darling Harbour also do not exceed the remediation and validation criteria proposed by AECOM and approved by the NSW EPA and site auditor for the Barangaroo high-rise development project. These criteria, as recommended in other AECOM HHERAs, is that "*The median groundwater concentrations at the point of discharge to Darling Harbour should, on average, not exceed the MWQC*" for the contaminants of concern[71].

My conclusion that groundwater concentrations at the point of discharge to Darling Harbour have been found not to exceed the MWQC is consistent with the opinion expressed in an affidavit by Jackie Wright dated 10 January 2011, which was prepared for a matter in the Land and Environment Court of New South Wales case number 40965 of 2010. Ms Wright is a human health and environmental risk assessor who was retained by the BDA and Lend Lease to provide a report on contamination risks at the Barangaroo site. Paragraph 16(a) of the affidavit states that "*No PAHs have been detected in groundwater close to the harbour; therefore at present these contaminants are not discharging to the harbour*".

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[71] Executive summary & Section 10.2, AECOM (9 June 2011) HHERA; Executive summary & Section 8.2, AECOM (4 July 2011) HHERA

4.5 Fate and Transport

The NSW EPA requires[72] that "*Any detailed (eg quantitative) assessment of risks posed by groundwater contamination requires a thorough understanding of all relevant aspects. Of particular importance are aspects relating to … the fate and transport of contaminants in groundwater...*".

Similar recommendations are made in the NEPC (1999) guidelines[73]. The CLM Act[74] and other NSW EPA guidelines[75] also require risk assessments to determine the foreseeable movement of contaminants through groundwater by means of fate and transport assessment.

The AECOM risk assessment did not assess the fate and transport of contaminated groundwater from the *Declared Area* to the point of discharge into Darling Harbour where the closest ecological receptor is located. This is despite earlier AECOM reports advising that such an analysis would be done as part of the HHERA[76]. It appears that the AECOM HHERA did not include a fate and transport analysis for groundwater because it assumed that a groundwater dependent ecosystem could exist between the *Declared Area* and Darling Harbour and that the point of compliance is the western boundary of the *Declared Area*.

I consider that a groundwater dependent ecosystem does not exist between the *Declared Area* and Darling Harbour and that the point of compliance should be the point of discharge into Darling Harbour for the reasons given in **Sections 4.1** and **4.2**. Consequently, it is important that in my review, the fate and transport of groundwater contamination from the *Declared Area* to Darling Harbour be assessed

As previously mentioned in **Section 4.4**, the investigation data support the conclusion that groundwater migrating from the *Declared Area* does not pose an unacceptable risk to the aquatic ecosystem in Darling Harbour.

In my opinion, the investigation data also support the conclusion that contaminant concentrations at the point of discharge into Darling Harbour, caused by groundwater migrating

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[72] Section 2.3.2, NSW DEC (March 2007) "*Guidelines for the Assessment of Groundwater Contamination*"

[73] Section 3.2, NEPC (1999) "*Schedule B(6) Guidance on Risk Based Assessment of Groundwater Contamination*"

[74] Paragraph 12(2), CLM Act 1997

[75] Section 2.3.6, NSW DECC (June 2009) "*Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*"

[76] Sections 12.1, 12.2 & 13.0, AECOM (23 September 2010) "*Data Gap Investigation, EPA Declared Area (Parts of Barangaroo Site and Hickson Road), Millers Point, NSW*"

from the *Declared Area*, will not increase but should further decrease with time for the case where the *Declared Area* and adjacent land remain in its current form. This is because:

- Groundwater concentrations at the point of discharge to Darling Harbour have been found not to exceed the MWQC at all locations, as previously mentioned in **Section 4.4**;
- The amount of gasworks contamination that remains at sources within the *Declared Area* is finite since town gas production ceased at the *Declared Area* nearly 100 years ago;
- The amount of gasworks contamination that remains at sources within the *Declared Area* has gradually decreased over the years due to the natural attenuation processes. These processes include biodegradation, which AECOM studies[77] have concluded to be actively occurring at the *Declared Area*;
- The amount of contamination migrating from the *Declared Area* through the marine sediment layer into Darling Harbour is negligible[78];
- The amount of contamination migrating from the *Declared Area* through the Hawkesbury Sandstone layer into Darling Harbour is negligible[79];
- The greatest amount of contamination migrating from the *Declared Area* to Darling Harbour is occurring through the fill layer[80];
- Contamination assessments undertaken for the *Declared Area* indicate that it takes only 7 to 455 days for groundwater at the western edge of the *Declared Area* to migrate the 90 – 150m to Darling Harbour. Given that the fill was placed by reclamation work undertaken in the 1970’s, groundwater would have been travelled from the *Declared Area* into Darling Harbour less than 1.5 years after the completion of the reclamation work. This means that it is not reasonably foreseeable for a groundwater plume containing higher contaminant concentrations than presently measured to migrate from the *Declared Area* to Darling Harbour.

The time estimates for groundwater to migrate from the western edge of the *Declared Area* to Darling Harbour are based on the results of assessments made by AECOM. The highest groundwater velocity was provided in the AECOM HHERA[81], which adopted a groundwater seepage velocity into a trench of 13 m/day.

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[77] Sections 10.5.2 & 11.2, AECOM (23 September 2010); Sections 10.5.2 & 11.2, AECOM (20 October 2010)

[78] Sections 5.3.2, 5.5 & 6.0, AECOM (3 November 2010) “*Groundwater Discharge Study, Stage 1 Barangaroo Development*”

[79] Sections 5.3, 5.5 & 6.0, AECOM (3 November 2010)

[80] Sections 5.3 & 6.0, AECOM (3 November 2010)

[81] Table 19 in Section 5.3.6.6, AECOM HHERA

The lowest groundwater velocity derived from data provided in the AECOM (November 2010) groundwater discharge study. The study[82] estimated that a volume of 50 m^3 of water flowed through the fill behind the seawall per day for each linear metre of seawall and that 10 – 20 % of this volume is groundwater. For a 15 m high tidal prism, this gives a groundwater flow velocity through the fill layer of 0.33 – 0.67 m/day.

4.6 Ecologically Sustainable Development

The AECOM HHERA does not meet the relevant standards for preparation of an environmental risk assessment because it did not follow the principles of ecologically sustainable development, as described in Section 9 of the Contaminated Land Management (CLM) Act (**DOCUMENT 3**). This is because:

- The investigations undertaken between 2007 and 2012 show there is no threat of serious or irreversible environmental damage at or adjacent to the *Declared Area*;
- There is no "*lack of full scientific certainty*" that should affect the assessment of risks to the environment at or adjacent to the *Declared Area*; and
- The precautionary principle has been addressed because the investigations show there is no threat of serious or irreversible environmental damage. Consequently, all other principles of ecologically sustainable development have also been met.

In my opinion, the investigations undertaken between 2007 and 2012 show there is no threat of serious or irreversible environmental damage at or adjacent to the *Declared Area* because:

- There are no terrestrial habitats at the *Declared Area* or adjacent land that need to be protected, since these areas have been extensively developed for commercial/industrial purposes for over 170 years. Furthermore, the land is currently sealed by concrete and bitumen pavement[83];
- Groundwater at or flowing from the *Declared Area* is not part of a GDE (**Section 3.3.2**);
- The only significant environmental receptor for groundwater migrating from the *Declared Area* is the aquatic ecosystem in Darling Harbour. The point of discharge for groundwater migrating from the "*Declared Area*" towards Darling Harbour is the seawall along the western property boundary (**Section 4.2**);
- All the investigations undertaken between 2007 and 2012 show there is no threat of serious or irreversible environmental damage to the aquatic ecosystem in Darling Harbour because the quality of groundwater migrating into Darling Harbour at the point of discharge meets the MWQC (**Section 4.4**); and

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[82] Sections 5.1, 5.5 & 6.0, AECOM (3 November 2010)

[83] Similar conclusions were made in Section 8.2.1 of the AECOM (16 August 2012) HHERA

- The investigations show that natural attenuation mechanisms will continue to reduce the migration potential of contaminants from the *Declared Area* to Darling Harbour and the risk to environmental receptors[84].

In my opinion, there is no "*lack of full scientific certainty*" that should affect the assessment of risks to the environment at or surrounding the *Declared Area* because:

- The *Declared Area* and adjacent land have been extensively investigated between 2006 and 2012, as shown by the large number of boreholes and groundwater monitoring wells located across the site (**Figure 4-1**) and the large number of investigation reports that have been prepared. This conclusion is supported by the comment made by Chris Jewell, who stated in his 10 January 2011 affidavit (paragraph 57) that "*intensive investigations*" have been undertaken at the site;
- There is no GDE at the *Declared Area* or adjacent land (**Sections 3.3.2** & **4.1**). Consequently, no further investigations of micro-organisms in groundwater, the receiving water in Darling Harbour or sediments in Darling Harbour are required;
- The MWQC were based on conservative and precautionary criteria largely obtained from the ANZECC (2000) water quality guidelines. The NSW EPA[85] advise that "*The default trigger values provided in ANZECC 2000 Guidelines are essentially conservative and precautionary. If they are not exceeded, a very low risk of environmental damage can be assumed. If they are exceeded, further investigation is "triggered" for the pollutant concerned. Assessing whether the exceedance means a risk of impact to the Water Quality Objective requires site-specific investigation, using decision trees provided in the Guidelines.*" **[DOCUMENT 2]**;
- The investigation data support the conclusion that groundwater migrating from the *Declared Area* does not pose an unacceptable risk to the aquatic ecosystem in Darling Harbour. This is because groundwater concentrations at the point of discharge have been found not to exceed the MWQC (**Section 4.4**);
- The contaminant concentrations and size of the groundwater plume are likely to be less than that defined by the laboratory test results because the investigations used methods that were prone to exaggerate dissolved concentrations and record false positives (**Section 4.4**); and
- Groundwater concentrations at the point of discharge to Darling Harbour do not exceed the remediation and validation criteria proposed by AECOM and approved by the NSW EPA and site auditor for the Barangaroo high-rise development project (**Section 4.4**).

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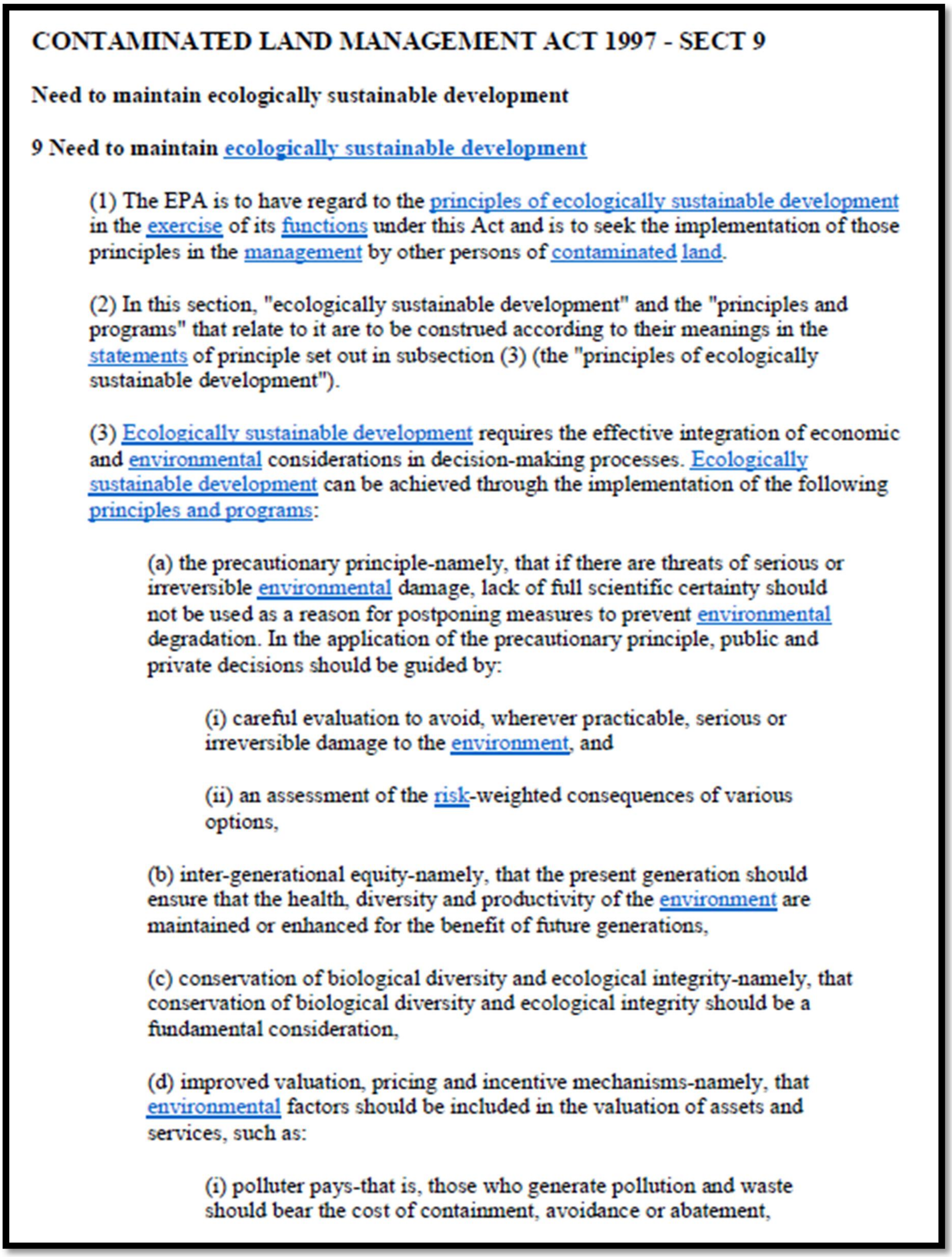
[84] Similar conclusions were made by AECOM. In Section 1.3 of their 16 August 2012 HHERA, AECOM advise that "*There are significant biodegradation processes occurring within sub-surface soils based on measured oxygen concentrations beneath the sub-surface*". In Section 11.2 of their 23 September 2010 report "*Data Gap Investigation, EPA Declaration Area (Parts of Barangaroo Site and Hickson Road), Millers Point, NSW*" AECOM state that "*The assessment of natural attenuation parameters indicate that a suitable environment for biodegradation of hydrocarbons is present at the Site, and there is evidence the degradation processes is actively occurring. Evidence of this included reduced sulphate concentrations, increased alkalinity and higher TOC concentrations in wells reporting the presence on hydrocarbon contamination*".

[85] NSW EPA "*Sydney Harbour and Parramatta River Water Quality Objectives explained*"

DOCUMENT (3) – Section 9 of the CLM Act 1997



CONTAMINATED LAND MANAGEMENT ACT 1997 - SECT 9

Need to maintain ecologically sustainable development

9 Need to maintain ecologically sustainable development

(1) The EPA is to have regard to the principles of ecologically sustainable development in the exercise of its functions under this Act and is to seek the implementation of those principles in the management by other persons of contaminated land.

(2) In this section, "ecologically sustainable development" and the "principles and programs" that relate to it are to be construed according to their meanings in the statements of principle set out in subsection (3) (the "principles of ecologically sustainable development").

(3) Ecologically sustainable development requires the effective integration of economic and environmental considerations in decision-making processes. Ecologically sustainable development can be achieved through the implementation of the following principles and programs:

(a) the precautionary principle-namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:

(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and

(ii) an assessment of the risk-weighted consequences of various options,

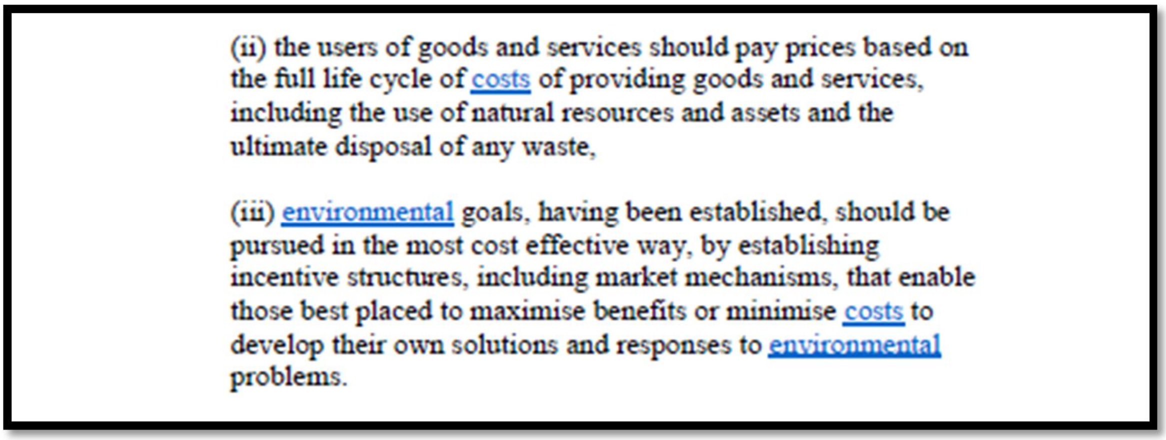
(b) inter-generational equity-namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations,

(c) conservation of biological diversity and ecological integrity-namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration,

(d) improved valuation, pricing and incentive mechanisms-namely, that environmental factors should be included in the valuation of assets and services, such as:

(i) polluter pays-that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,

DOCUMENT (3) – cont'd



(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,

(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

5. Detailed Response - Review of AECOM Human Health Risk Assessment

5.1 Exposure Scenarios

The AECOM HHERA identified two potential human receptors at the *Declared Area* for the case where the current public recreational open space land use is maintained[86]. These were:

- A recreational user of the area who walks over the concrete/asphalt pavement; and
- An unprotected maintenance worker undertaking short term intrusive work in a trench 2 m deep and 2 m long. AECOM allowed this worker to be exposed to contaminated soil located in the sides and floor of the trench, contaminated groundwater that was assumed to be present in the trench from a depth of 1.5 m to 2.0 m below ground level (bgl), and vapours generated by contaminated soil and groundwater (**Figure 5-1)**[87].

The AECOM health risk assessment determined that the recreational user is not exposed to any unacceptable health risk[88]. However, the AECOM assessment determined that the unprotected maintenance worker has the potential to be exposed to an unacceptable health risk[89].

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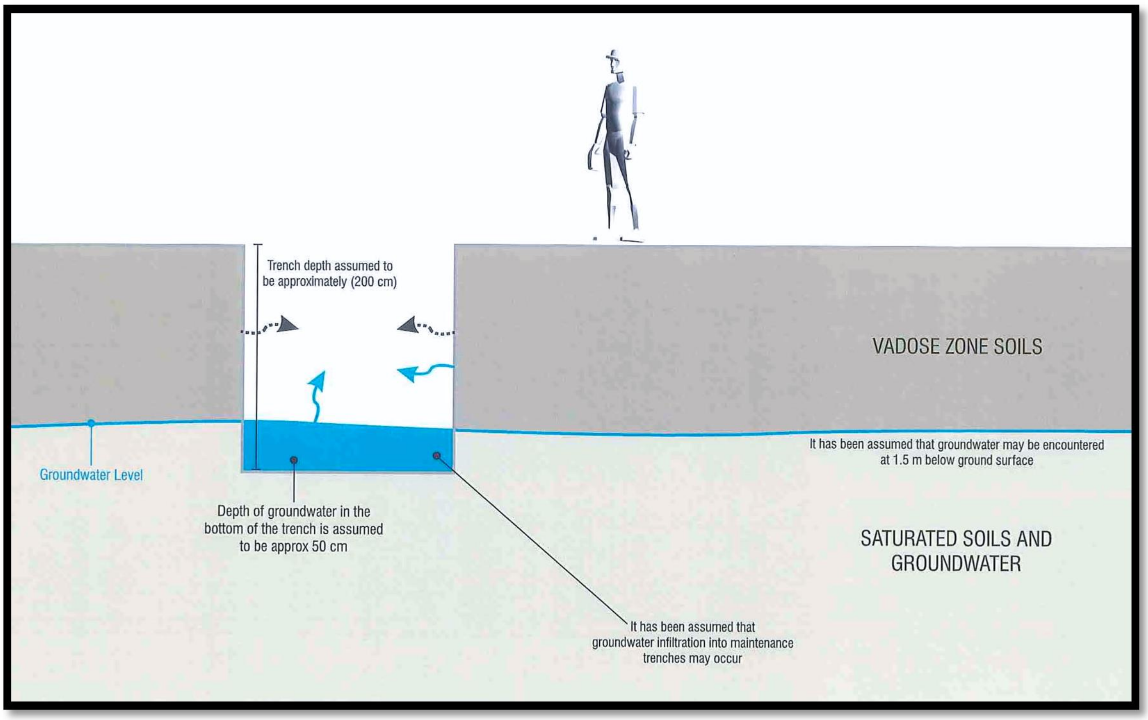
[86] Sections 5.3.4 to 5.3.6, AECOM HHERA

[87] Copy of Figure F5, AECOM HHERA

[88] Section 5.4.2.1, AECOM HHERA

[89] Executive Summary, Sections 5.4.2.2 & 10.1, AECOM HHERA

- **Figure 5-1 AECOM Conceptual Site Model for Unprotected Maintenance Worker**



The unprotected maintenance worker exposure scenario used in the AECOM HHERA is considered to be inappropriate because:

- It was unrealistic for the AECOM HHERA to assume that a maintenance worker undertaking short term intrusive work in a trench at a contaminated site would be unprotected and not wearing any personal protective equipment (PPE) capable of mitigating any health risk. This is because:
  - The use of a safe work method statement (SWMS) containing appropriate work procedures is a regulatory requirement for any maintenance and construction work that is carried out in a trench excavated to a depth greater than 1.5 m. This is stated in the Safe Work Australia (July 2012) "*Code of Practice – Excavation Work*" (**DOCUMENT 4**). The requirement for such a plan is even more important at sites with a long history of industrial land use, such as the *Declared Area*. The AECOM HHERA did not consider the ability to manage health risks to a maintenance worker undertaking trenching work by means of compliance with such protocols;

  - Australian risk assessment guidelines allow the protection offered by workers wearing protective equipment to be included in the risk assessment[90]; and
  - Maintenance workers have been undertaking trenching work on buried pipelines in the *Declared Area* for the past 90 years, with many of these buried services remaining in use. Examples of these buried services are shown in a May 2011 plan by Sydney Water, with an extract provided in **Figure 5-2**. The plan shows buried services that exist at the Declared Area include a sewerage pump station SPS1129, a sewerage collection pit, sewer mains, stormwater drains, water mains, electrical cables, gas mains and telephone cables.

- The use of this exposure scenario excluded the option of remediating the *Declared Area* using a capping strategy and managing contamination remaining under the cap by means of a long-term management plan. The exclusion of a capping strategy was inappropriate because:
  - The use of capping and a long-term management plan are recognised by the NSW Contaminated Land Management (CLM) Act 1997[91], NSW EPA guidelines and SEPP 55 guidelines to be acceptable approaches to remediate contaminated land; and
  - The City of Sydney and the NSW EPA have approved a capping / long-term management strategy for the property at 36 Hickson Road, which is located adjacent to the *Declared Area* and is contaminated with gasworks wastes (**Figure 3-6**). Tarry wastes remain in a buried tar tank on the property. This property was certified as being suitable for commercial/industrial use and as an outdoor plaza in a site audit statement dated 16 March 2004 (**Appendix F**);
  - The City of Sydney and the NSW EPA have approved the use of containment strategies for properties adjacent to the *Declared Area* where gasworks wastes, including coal tar, are present at the property boundaries. These properties are located to the east of the *Declared Area* and are numbered 30-34 and 38 Hickson Road (**Figure 3-6**). The property at 30 – 34 Hickson Road intersected the main gasholder and involved the construction of a deep basement. This property was certified as being suitable for commercial / industrial land use that included a childcare centre in a site audit statement dated 19 March 2003 (**Appendix F**). The property at 38 Hickson Road involved the construction of a deep excavation, which resulted in tarry wastes migrating into the underground carpark. This property was certified as being suitable for residential land use with minimal soil access that included a childcare centre in a site audit statement dated 20 June 2003 (**Appendix F**);

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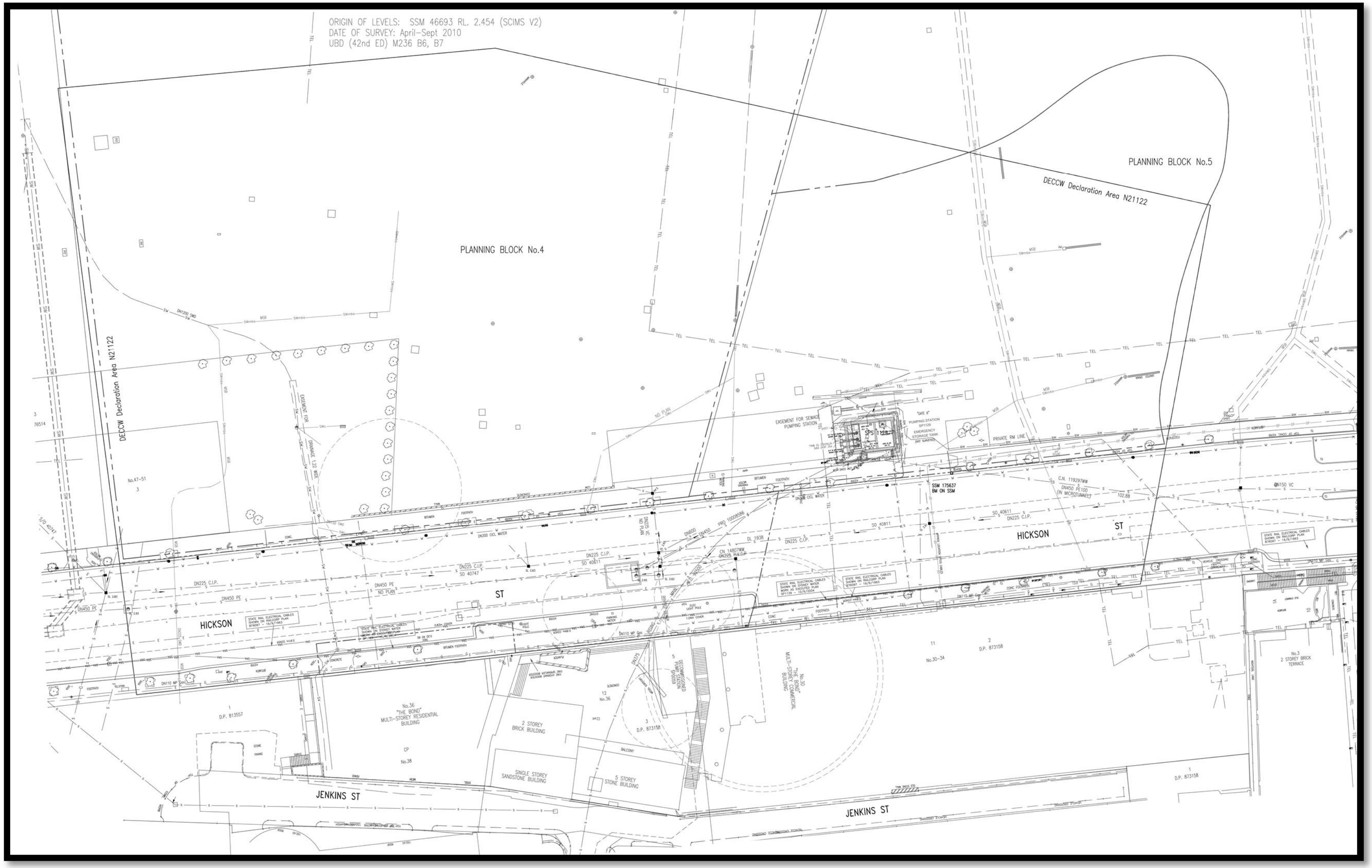
[90] Section 17.3.2, enHealth (2012) "*Environmental Health Risk Assessment Guidelines for Assessing Human Health Risks from Environmental Hazards*"; Section 4, NEPC (1999) "*Schedule B(4) Guideline on Health Risk Assessment Methodology*"; Section 3.1, NEPC (April 2011) Draft "*Schedule B4 Guideline on Site Specific Health Risk Assessments*"

[91] Refer to the definition of "remediation" in Section 4, CLM Act (1997)

- **Figure 5-2 Existing Buried Services at the Declared Area** [Source: Sydney Water X10220_MP_SWC_ASSETS 2/05/2011]



- Two other ecological risks assessments have been prepared by AECOM for the redevelopment of the central and southern areas of the Baranagroo site[92], which includes the *Declared Area* (**Figure 3-7**). The AECOM June 2011 report[93] advised that "*services within Hickson Road are expected to be generally contained within the upper 1.5 m of the soil profile above the groundwater table. As such there will be no (or limited) exposure of services to contaminated groundwater*". Similar comments were made in the AECOM July 2011 report[94]. Both these reports have been reviewed by the NSW EPA and Site Auditor on several occasions prior to being finalised. Buried services requiring maintenance are presently or could be readily relocated to a depth not greater than 1.5 m, which would avoid any significant exposure of a maintenance worker to contaminated groundwater. Such work could be incorporated into a capping remediation strategy, thereby eliminating the need for a detailed risk assessment to consider the risks to an unprotected maintenance worker; and
- Detailed health risk assessments undertaken for the properties at 36 and 38 Hickson Road concluded that a maintenance worker is unlikely to have direct contact with contaminants soils and groundwater. On account of this low likelihood of exposure, these exposure pathways were not considered to be relevant in assessing health risks to a maintenance worker undertaking trenching work at these properties. The results of these assessments have also been reviewed and accepted by the NSW EPA and a Site Auditor (**Appendix F**), who have accepted the use of a capping / containment / long term management strategy and have not required any additional remediation work to be undertaken. Reviews of risk assessments prepared for these two properties are provided in **Appendix C**.

The inappropriate use by the AECOM HHERA of an exposure scenario involving an unprotected maintenance worker had a major influence on the conclusion that was made by their study.

The use of an unprotected maintenance worker exposure scenario resulted in the AECOM HHERA to conclude that the *Declared Area* is not fit for its current land use because of unacceptable health risks, which is incorrect. The detailed risk assessment should have concluded that the *Declared Area* is fit for its current land use because:

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[92] These additional HHERAs comprise: AECOM (9 June 2011) "*Human Health and Ecological Risk Assessment, Declaration Site (Development Works) Remediation Works Area – Barangaroo*"; and, AECOM (4 July 2011) "*Human Health and Ecological Risk Assessment Addendum, Other Remediation Works (South) Area, Barangaroo*".

[93] Section 2.4.3, AECOM (9 June 2011) HHERA

[94] Section 2.4.3, AECOM (4 July 2011) HHERA

- There is no potential user of the *Declared Area* that would be exposed to an unacceptable health risk while the area remains capped and managed; and
- The NSW State Government has used the *Declared Area* for many years as a public area. For nearly 20 years it was used as an overseas passenger terminal following the EPA approving this use prior to development consent being granted[95]. Then in 2008 the area was cleared of buildings and the site was used as one of the main venues for the 23rd World Youth Day 2008. On 15 July, the event began at Barangaroo with an Opening Mass celebrated by Cardinal George Pell, the Archbishop of Sydney. On 17 July 2008, 500,000 attendees from around the world were present at Barangaroo to welcome Pope Benedict XVI (**Figure 5-3**).
- **Figure 5-3 Pope Benedict XVI Arriving at Barangaroo on 17 July 2008**

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[95] Page 6-1 in Woodard-Clyde (5 May 1993)

My conclusion that the unprotected maintenance worker is an inappropriate exposure scenario for assessing health risks at the *Declared Area* is consistent with conclusions made by other reports prepared for the Barangaroo site.

One such report was an affidavit by Jackie Wright dated 10 January 2011, which was prepared for a matter in the Land and Environment Court of New South Wales case number 40965 of 2010. Ms Wright is a human health and environmental risk assessor who was retained by the BDA and Lend Lease to provide a report on contamination risks at the Barangaroo site. The relevant conclusions made by Ms Wright are:

- Paragraphs 13 and 22: *"The existing contamination is currently present beneath concrete in an area that is not used for any purpose. Hence there is no potential for humans to come into contact with the contamination, nor is there any current potential for soil to move off-site to the aquatic environment and deposit as sediment. On this basis existing risks to human health and the environment, associated with contamination identified in soil in this area are negligible";*
- Paragraph 25: *"However it can be noted that regardless of contamination levels that may be present in groundwater there are no existing risks to human health. This is due to the existing site being inaccessible and more specifically, groundwater is inaccessible and not extracted and used for any purpose."*

Another report was prepared by AECOM dated 23 September 2010 and titled "*Data Gap Investigation, EPA Declaration Area (Parts of Barangaroo Site and Hickson Road), Millers Point, NSW*". The document indicates that it was internally reviewed by an AECOM Site Auditor (Brad Eismen) and by the Barangaroo Development's Site Auditor (Graeme Nyland) on two occasions prior to being finalised.

The report identified the human receptors at the *Declared Area* to be site workers, visitors and the general public. The report also concluded that there was no complete exposure pathway and that there was no exposure risk to the human receptors because of the presence of the concrete / asphalt cap[96]. The results of their assessment were summarised in Tables 18 and 19 of their report, with a copy provided in **DOCUMENT 4B**.

These conclusions were repeated in a followup report prepared by AECOM dated 20 October 2010 titled "*Data Gap Investigation, Other Remediation Works North, Hickson Road, Millers Point, NSW*". The document indicates that it was internally reviewed by an AECOM Site Auditor (Brad Eismen) on three occasions prior to being finalised.

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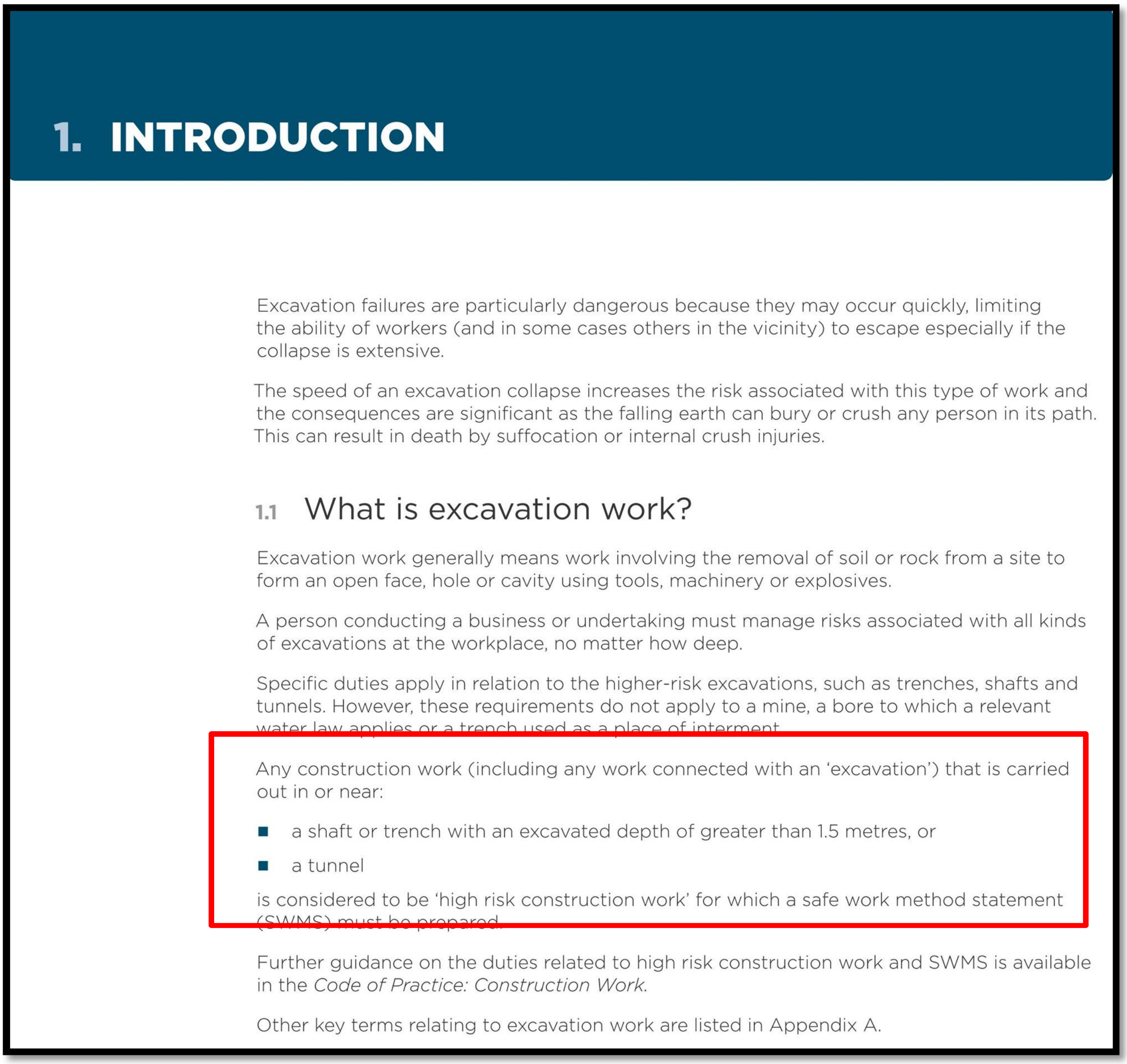
[96] Sections 12, 12.2 and Table 19, AECOM (23 September 2010)

DOCUMENT (4) – Safe Work Australia (July 2012) “Code of Practice – Excavation Work” – Section 1.1



1. INTRODUCTION

Excavation failures are particularly dangerous because they may occur quickly, limiting the ability of workers (and in some cases others in the vicinity) to escape especially if the collapse is extensive.

The speed of an excavation collapse increases the risk associated with this type of work and the consequences are significant as the falling earth can bury or crush any person in its path. This can result in death by suffocation or internal crush injuries.

1.1 What is excavation work?

Excavation work generally means work involving the removal of soil or rock from a site to form an open face, hole or cavity using tools, machinery or explosives.

A person conducting a business or undertaking must manage risks associated with all kinds of excavations at the workplace, no matter how deep.

Specific duties apply in relation to the higher-risk excavations, such as trenches, shafts and tunnels. However, these requirements do not apply to a mine, a bore to which a relevant water law applies or a trench used as a place of interment.

Any construction work (including any work connected with an ‘excavation’) that is carried out in or near:

- a shaft or trench with an excavated depth of greater than 1.5 metres, or
- a tunnel

is considered to be ‘high risk construction work’ for which a safe work method statement (SWMS) must be prepared.

Further guidance on the duties related to high risk construction work and SWMS is available in the *Code of Practice: Construction Work.*

Other key terms relating to excavation work are listed in Appendix A.

DOCUMENT (4B) – AECOM (September 201) Table 19

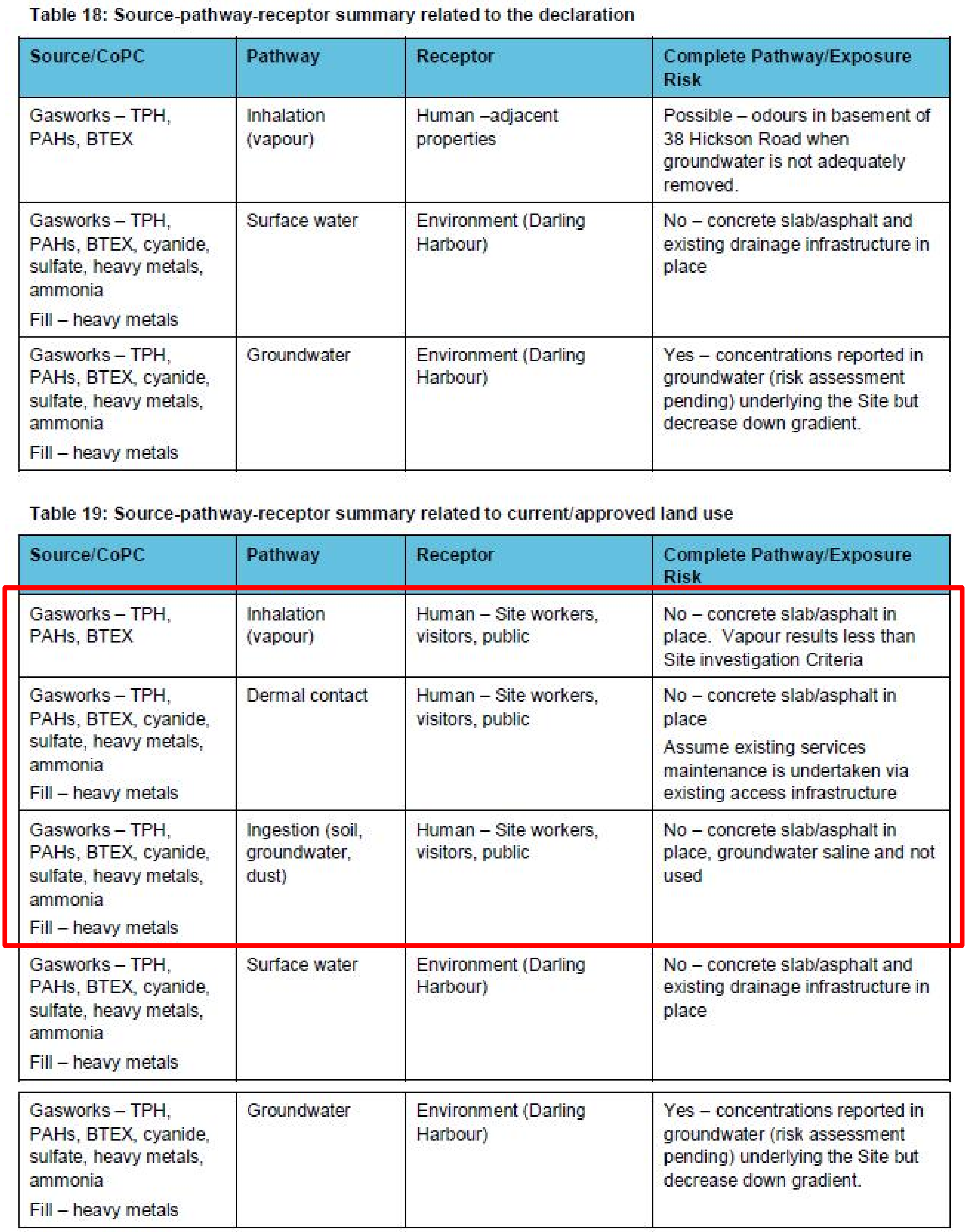


Table 18: Source-pathway-receptor summary related to the declaration

Source/CoPC	Pathway	Receptor	Complete Pathway/Exposure Risk
Gasworks – TPH, PAHs, BTEX	Inhalation (vapour)	Human –adjacent properties	Possible – odours in basement of 38 Hickson Road when groundwater is not adequately removed.
Gasworks – TPH, PAHs, BTEX, cyanide, sulfate, heavy metals, ammonia Fill – heavy metals	Surface water	Environment (Darling Harbour)	No – concrete slab/asphalt and existing drainage infrastructure in place
Gasworks – TPH, PAHs, BTEX, cyanide, sulfate, heavy metals, ammonia Fill – heavy metals	Groundwater	Environment (Darling Harbour)	Yes – concentrations reported in groundwater (risk assessment pending) underlying the Site but decrease down gradient.

Table 19: Source-pathway-receptor summary related to current/approved land use

Source/CoPC	Pathway	Receptor	Complete Pathway/Exposure Risk
Gasworks – TPH, PAHs, BTEX	Inhalation (vapour)	Human – Site workers, visitors, public	No – concrete slab/asphalt in place. Vapour results less than Site investigation Criteria
Gasworks – TPH, PAHs, BTEX, cyanide, sulfate, heavy metals, ammonia Fill – heavy metals	Dermal contact	Human – Site workers, visitors, public	No – concrete slab/asphalt in place Assume existing services maintenance is undertaken via existing access infrastructure
Gasworks – TPH, PAHs, BTEX, cyanide, sulfate, heavy metals, ammonia Fill – heavy metals	Ingestion (soil, groundwater, dust)	Human – Site workers, visitors, public	No – concrete slab/asphalt in place, groundwater saline and not used
Gasworks – TPH, PAHs, BTEX, cyanide, sulfate, heavy metals, ammonia Fill – heavy metals	Surface water	Environment (Darling Harbour)	No – concrete slab/asphalt and existing drainage infrastructure in place
Gasworks – TPH, PAHs, BTEX, cyanide, sulfate, heavy metals, ammonia Fill – heavy metals	Groundwater	Environment (Darling Harbour)	Yes – concentrations reported in groundwater (risk assessment pending) underlying the Site but decrease down gradient.

5.2 TPH Contaminant Concentrations

Total petroleum hydrocarbons (TPH) are a mixture of a large number of petroleum-based hydrocarbons that are typically divided into fractions, with the most common being C6 – C9, C10 – C14, C15 – C28 and C29 – C36. TPH concentrations can also be divided into aromatic and aliphatic compounds, and concentrations for these two components can be provided for various TPH fractions.

The AECOM risk assessment concluded that TPH was responsible for practically all the short term health risks to an unprotected maintenance worker undertaking trenching work at the *Declared Area*. For a worker exposed to contaminated soil in a trench, the AECOM analysis[97] calculated that TPH contributed to 80 % of the short-term risk, with the contribution from groundwater exposure being 89%.

However, the AECOM risk assessment used incorrect TPH concentrations, which caused the short-term risks to be unreasonably exaggerated. These errors were:

- All the investigations measured TPH concentrations in samples of soil and groundwater from the *Declared Area* in terms of the unspeciated fractions C6 – C9, C10 – C14, C15 – C28 and C29 – C36. None of the investigations measured the aliphatic and aromatic components that make up these TPH fractions. Furthermore, the main laboratory AECOM used for the TPH testing advised that they were unable to assess the aliphatic/aromatic distributions from the results of the unspeciated TPH tests[98]. However, AECOM used a risk assessment methodology based on the use of aliphatic and aromatic components of these TPH fractions without conducting any testing to determine reasonable estimates of these components;
- The AECOM risk assessment used TPH concentrations that were double those actually measured in samples collected from the *Declared Area*. This error occurred because AECOM applied the measured unspeciated concentration to both the aliphatic and aromatic components[99]; and
- The concentrations measured by the TPH test include other hydrocarbon compounds such as BTEX, PAHs and phenols, which are also potential contaminants of concern for the *Declared Area*. However, the AECOM risk assessment did not reduce the TPH concentrations used in the risk assessment to account for the presence of these other

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[97] Page 3 of 24 in Appendix C, AECOM HHERA

[98] Letter from ALS dated 28/04/11 that was provided in Appendix G, AECOM (16 August 2012) HHERA

[99] For example, the maximum TPH C10-C14 concentration in a soil sample was measured at 54,000mg/kg. AECOM applied this concentration to both the C10-C14 aliphatic compound and the C10-C14 aromatic compound, which meant that the risk assessment used a TPH C10-C14 concentration of 108,000 mg/kg [refer Table 9 and page 1 of 24 in Appendix C, AECOM (16 August 2012) HHERA]

hydrocarbons, which meant that included the contributions from BTEX, PAHs and phenols were included twice in the risk assessment.

This error has caused the AECOM HHERA to significantly exaggerate the short-term (threshold) health risks to an unprotected maintenance worker for all exposure pathways.

These deficiencies in the AECOM HHERA can be addressed using the available data by making reasonable assumptions that allow upper, lower bound and best-estimate short term risks from TPH contamination to be derived. Such an approach involves:

- Reducing the TPH concentrations used in the risk assessment by deducting the contributions made by BTEX, PAHs and phenols;
- Calculating short-term risks by assuming all TPHs are aromatic or aliphatic in order to obtain upper and lower bound risk estimates; and
- Calculating best-estimate short-term risks by assuming a 50:50 split in TPH concentrations between aliphatic and aromatic components.

SKM has used this approach to obtain more accurate and confident human health risk estimates, with the results of these calculations are presented in **Section 5.7**.

5.3 Soil-to-Skin Adherence Factor

An important parameter in the analysis of health risks from contaminated soil is the amount of soil that is estimated to adhere to a person's skin during their exposure period. This factor is referred to as the soil-to-skin adherence factor and is expressed in units of the amount of soil (in mg) per unit area of skin (in cm^2). The higher the soil-to-skin adherence factor, the greater is the amount of soil that adheres to the skin, which causes more contaminant to be adsorbed by the body and the higher the health risk.

The magnitude of the soil-to-skin adherence factor depends mainly on the soil type, the type of activity being undertaken by the person and the part of the body (eg face, arms, hands, legs, feet).

The AECOM health risk assessment adopted a soil-to-skin adherence factor for an unprotected maintenance worker of 1.5 mg/cm^2. This value is actually an error that occurred in an earlier HHERA prepared by AECOM for the Barangaroo development site and in an earlier version of their HHERA for the case where the *Declared Area* remains in its current form. This error caused the AECOM HHERA to exaggerate the health risks to an unprotected maintenance worker from dermal exposure to soil by a factor of 14 times. This error was identified by SKM in a letter dated 10 May 2012 and drawn to the attention of AECOM. However, AECOM decided to carry this error through into the most recent version of their HHERA. In a follow-up response[100], AECOM advised that they were instructed to adopt this value by the Site Auditor and the NSW EPA to ensure consistency between the AECOM HHERA for Barangaroo South and another HHERA prepared by JBS for Headland Park. Further details on this issue are provided in **Appendix D**.

In the latest version of their HHERA, AECOM stated that their reason for selecting a soil-to-skin adherence factor of 1.5 mg/cm^2 was because the value was recommended in a superseded USEPA (December 1989)[101] document. A copy of the relevant part of the document is provided at the end of this section (**DOCUMENT 5**).

In my opinion, the adoption of a soil-to-skin adherence factor of 1.5 mg/cm^2 was much too high and inappropriate for the following reasons:

- The soil-to-skin adherence value of 1.5 mg/cm^2 that was given in the USEPA (1989) guideline was for residential exposure and was not applicable to an unprotected maintenance worker undertaking trench work[102];
- The USEPA (1989) guideline is out-of-date and was superseded some 5 years later by the July 2004 version[103] and then by the USEPA "*Exposure Factors Handbook*", which was issued as an "*External Review Draft*" in July 2009[104] and then as a final document in September 2011[105]. The AECOM HHERA that was issued on 9 October 2012 should have followed the guidance that was provided in the most recent USEPA guideline issued some 13 months earlier;
- All versions of the USEPA guidelines issued after 1989 recommended that soil-to-skin adherence factors be selected on the basis of the activity that best represents the activity of the receptor together with the types of soil and body parts exposed[106]. Both the USEPA July 2009 and September 2011 guidelines provide a summary of soil-to-skin adherence factors obtained by several field studies. All values are considerably less than the value

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[100] Barangaroo Delivery Authority (23 July 2012) Letter "*Declaration 21122 – Hickson Road, Millers Point – Draft HHERA*". 23 pages

[101] Exhibit 6-15 in USEPA (December 1989) "*Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)*"

[102] Section 6.6.2 and Exhibit 6-15, USEPA (December 1989)

[103] USEPA (July 2004) "*Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment, Final*". Document No: EPA/540/R/99/005

[104] The USEPA advised that the "*External Review Draft*" had not been subject to peer and administrative review and did not constitute UUEPA policy.

[105] The USEPA advised that the document had been reviewed in accordance with USEPA policy and was approved for publication

[106] Section 7.2.2, USEPA (September 2011)

adopted in the AECOM HHERA of 1.5 mg/cm^2. A summary of these values is provided in **Table 5-1**;

- **Table 5-1 Summary of Soil-to-Skin Adherence Factors Recommended by the USEPA (Sept. 2011) for Construction / Maintenance Workers**

Activity	Geometric Mean Soil-to-Skin Adherence Factors for Body Region (mg/cm^2)				
	Hands	Arms	Legs	Faces	Feet
Construction Worker	0.24	0.098	0.066	0.029	
Utility Worker No. 1	0.32	0.20		0.10	
Utility Worker No. 2	0.27	0.30		0.10	
Equipment Operator No. 1	0.26	0.089		0.10	
Equipment Operator No. 2	0.32	0.27		0.23	

Note: The USEPA (September 2011) guideline provided the following descriptions of the conditions for the selected activities:
  - Construction worker: Mixed bare earth and concrete surfaces, dust and debris
  - Utility worker Nos. 1 & 2: Cleaning, fixing mains, excavation (backhoe and shovel)

- In their most recent guidance issued in September 2011, the USEPA recommended soil-to-skin adherence values for construction activities undertaken by construction workers, utility workers and equipment operators. These values varied from 0.066 mg/cm^2 for legs to 0.2763 mg/cm^2 for hands, with a copy of the relevant part of the guideline provided in **DOCUMENT 6**. All the soil-to-skin adherence values recommended by the USEPA for construction activities are considerably less than the value adopted in the AECOM HHERA of 1.5 mg/cm^2;
- The USEPA guidelines issued after 1989 recommended that the soil-to-skin adherence factor be weighted according to the body part exposed. The AECOM HHERA did not do this and applied their high soil-to-skin adherence factor to all exposed skin, which further inflated their calculated risks; and
- Recent guidance on appropriate soil-to-skin adherence factors has been provided by the Australian Government Department of Health and Aging in the form of a guideline issued

by enHealth[107] in 2012 titled "*Australian Exposure Factor Guide*". In Section 3.3 on "*Soil Adherence*", the guideline advised that risk assessors should use activity specific skin-to-soil adherence factors for workers, such as those derived by the USEPA. A summary of these factors was provided in Tables 3.3.4 and 3.3.5 of the enHealth guideline, with a copy provided in **DOCUMENT 7**.

In my opinion, a weighted average soil-to-skin adherence factor of 0.19 mg/cm^2 should have been used by the AECOM HHERA because:

- It is based on the latest soil-to-skin adherence factors recommended by the USEPA (September 2011) guideline for "*construction activities*", which includes utility workers. The rounded-up values for the various body areas are 0.10 mg/cm^2 for the face, 0.20mg/cm^2 for arms and 0.30 mg/cm^2 for hands (**DOCUMENT 6**);
- These values agree with the values recommended in the recently released Australian enHealth (2012) guideline (**DOCUMENT 7**); and
- The weighted average soil-to-skin adherence factor was calculated as recommended by the latest USEPA (Sept. 2011) guideline[108], based on the same surface areas used in the AECOM HHERA (head = 0.130 m^2, forearms = 0.131 m^2, hands = 0.099 m^2).

Using a soil-to-skin adherence factor of 0.19 mg/cm^2 would reduce the health risks calculated in the AECOM health risk assessment for dermal contact with soil by 7.89 times.

This error has caused the AECOM HHERA to significantly exaggerate the short and long-term health risks to an unprotected maintenance worker for the exposure pathway that involves dermal contact with soil. These deficiencies in the AECOM HHERA can be addressed by using a soil-to-skin adherence factor of 0.19 mg/cm^2 in a revised health risk assessment. SKM has used this approach to obtain more accurate and confident human health risk estimates, with the results of these calculations are presented in **Section 5.7**.

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[107] The enHealth website advised that "*This handbook is intended to provide risk assessors with sets of tabulated data on human factors that may be used as inputs to the exposure assessment component of an environmental health risk assessment.*" The address of this website is http://www.health.gov.au/internet/main/publishing.nsf/Content/health-pubhlth-publicat-environ.htm

[108] Refer Equation 7-1, USEPA (Sept. 2011)

DOCUMENT (5) - Exhibit 6-15 from USEPA (Dec. 1989) "*Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)*"

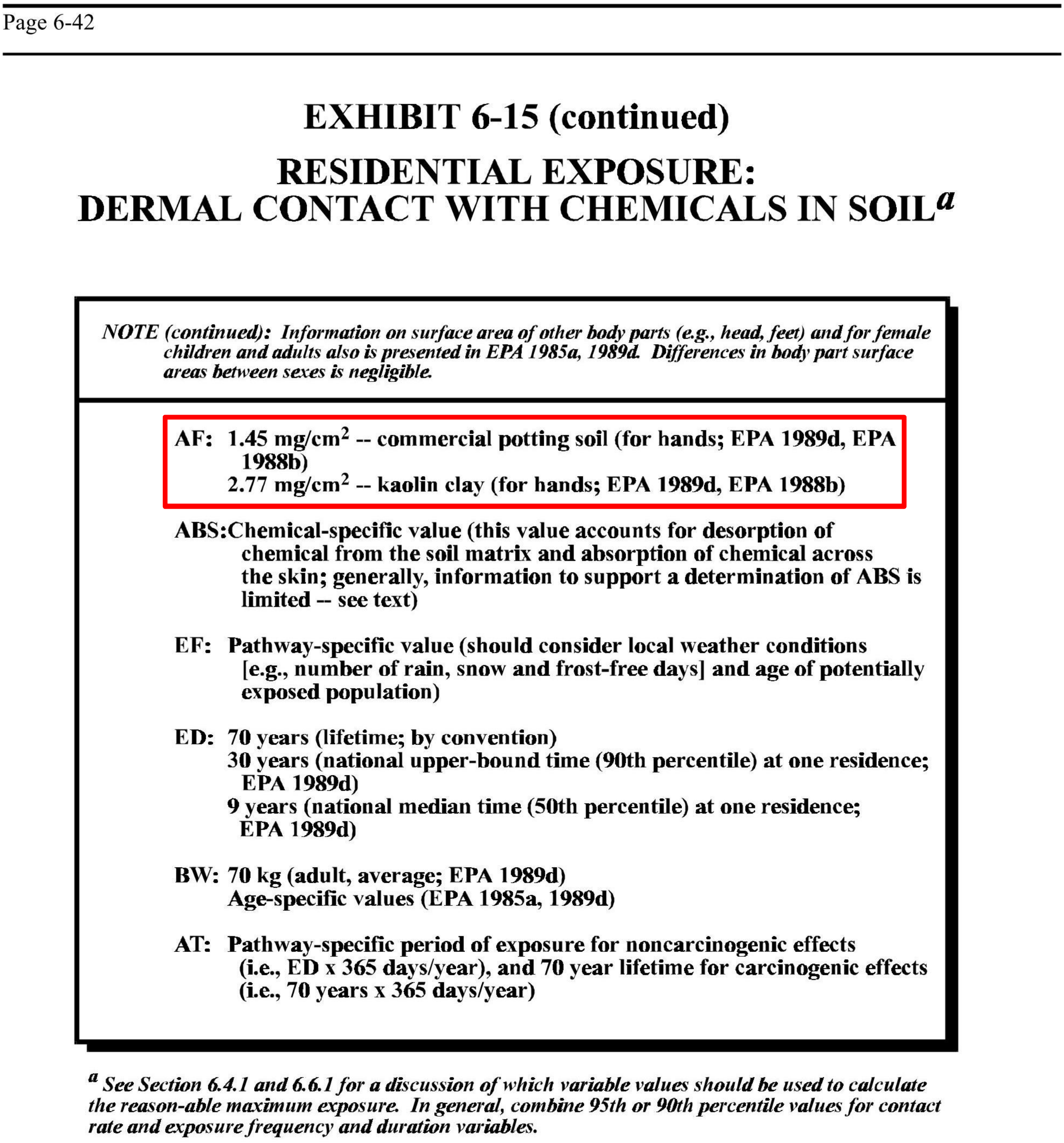


EXHIBIT 6-15 (continued)

RESIDENTIAL EXPOSURE: DERMAL CONTACT WITH CHEMICALS IN SOIL[a]

NOTE (continued): Information on surface area of other body parts (e.g., head, feet) and for female children and adults also is presented in EPA 1985a, 1989d. Differences in body part surface areas between sexes is negligible.

AF: 1.45 mg/cm^2 -- commercial potting soil (for hands; EPA 1989d, EPA 1988b)
2.77 mg/cm^2 -- kaolin clay (for hands; EPA 1989d, EPA 1988b)

ABS: Chemical-specific value (this value accounts for desorption of chemical from the soil matrix and absorption of chemical across the skin; generally, information to support a determination of ABS is limited -- see text)

EF: Pathway-specific value (should consider local weather conditions [e.g., number of rain, snow and frost-free days] and age of potentially exposed population)

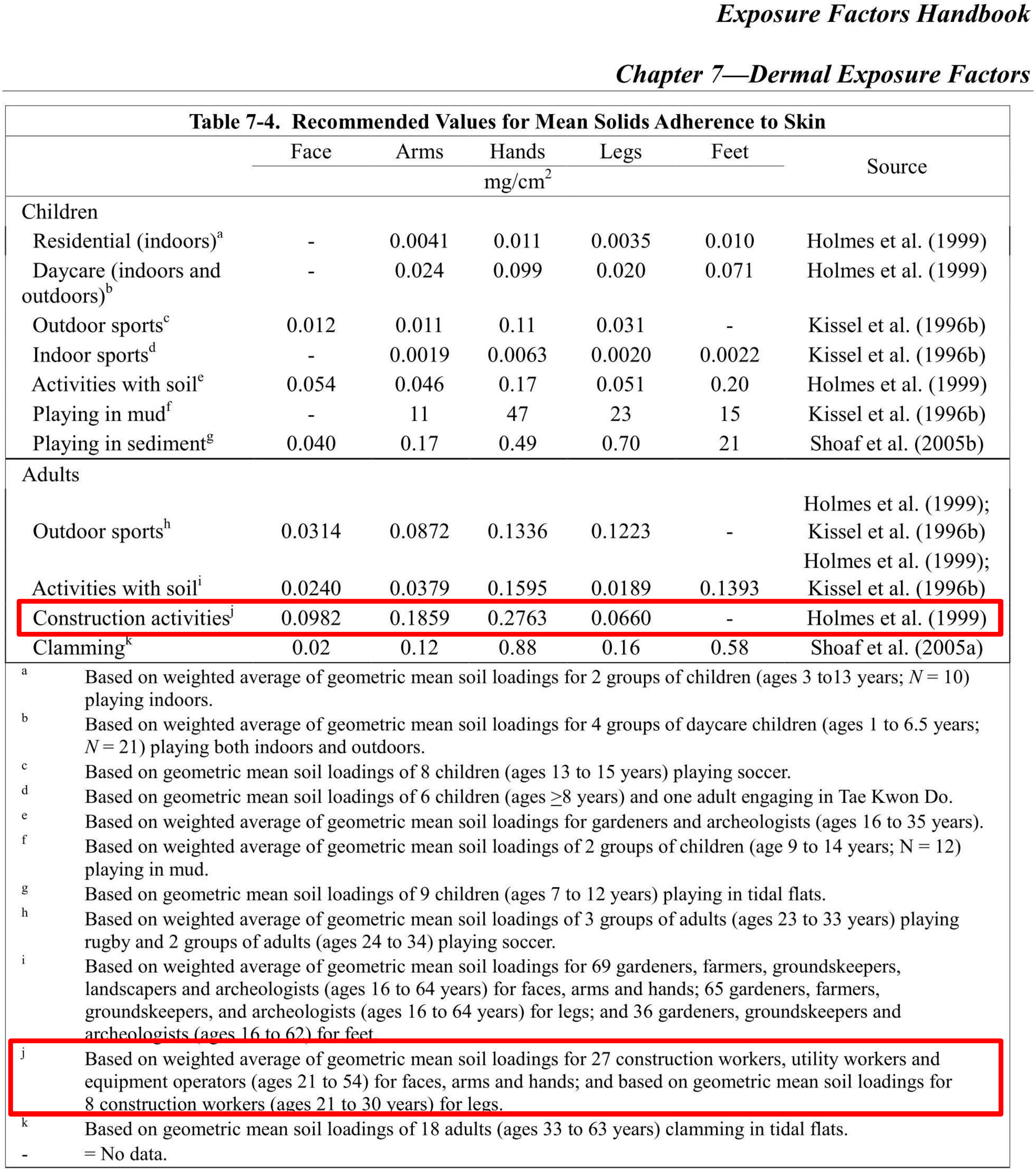
ED: 70 years (lifetime; by convention)
30 years (national upper-bound time (90th percentile) at one residence; EPA 1989d)
9 years (national median time (50th percentile) at one residence; EPA 1989d)

BW: 70 kg (adult, average; EPA 1989d)
Age-specific values (EPA 1985a, 1989d)

AT: Pathway-specific period of exposure for noncarcinogenic effects (i.e., ED x 365 days/year), and 70 year lifetime for carcinogenic effects (i.e., 70 years x 365 days/year)

[a] See Section 6.4.1 and 6.6.1 for a discussion of which variable values should be used to calculate the reason-able maximum exposure. In general, combine 95th or 90th percentile values for contact rate and exposure frequency and duration variables.

DOCUMENT (6) – Table 7-4 from USEPA (Sept. 2011) "*Exposure Factors Handbook: 2011 Edition*"



Exposure Factors Handbook

Chapter 7—Dermal Exposure Factors

Table 7-4. Recommended Values for Mean Solids Adherence to Skin

	Face	Arms	Hands	Legs	Feet	Source
			mg/cm²			
Children						
Residential (indoors)[a]	-	0.0041	0.011	0.0035	0.010	Holmes et al. (1999)
Daycare (indoors and outdoors)[b]	-	0.024	0.099	0.020	0.071	Holmes et al. (1999)
Outdoor sports[c]	0.012	0.011	0.11	0.031	-	Kissel et al. (1996b)
Indoor sports[d]	-	0.0019	0.0063	0.0020	0.0022	Kissel et al. (1996b)
Activities with soil[e]	0.054	0.046	0.17	0.051	0.20	Holmes et al. (1999)
Playing in mud[f]	-	11	47	23	15	Kissel et al. (1996b)
Playing in sediment[g]	0.040	0.17	0.49	0.70	21	Shoaf et al. (2005b)
Adults						
Outdoor sports[h]	0.0314	0.0872	0.1336	0.1223	-	Holmes et al. (1999); Kissel et al. (1996b)
Activities with soil[i]	0.0240	0.0379	0.1595	0.0189	0.1393	Holmes et al. (1999); Kissel et al. (1996b)
Construction activities[j]	0.0982	0.1859	0.2763	0.0660	-	Holmes et al. (1999)
Clamming[k]	0.02	0.12	0.88	0.16	0.58	Shoaf et al. (2005a)

[a] Based on weighted average of geometric mean soil loadings for 2 groups of children (ages 3 to13 years; *N* = 10) playing indoors.

[b] Based on weighted average of geometric mean soil loadings for 4 groups of daycare children (ages 1 to 6.5 years; *N* = 21) playing both indoors and outdoors.

[c] Based on geometric mean soil loadings of 8 children (ages 13 to 15 years) playing soccer.

[d] Based on geometric mean soil loadings of 6 children (ages ≥8 years) and one adult engaging in Tae Kwon Do.

[e] Based on weighted average of geometric mean soil loadings for gardeners and archeologists (ages 16 to 35 years).

[f] Based on weighted average of geometric mean soil loadings of 2 groups of children (age 9 to 14 years; N = 12) playing in mud.

[g] Based on geometric mean soil loadings of 9 children (ages 7 to 12 years) playing in tidal flats.

[h] Based on weighted average of geometric mean soil loadings of 3 groups of adults (ages 23 to 33 years) playing rugby and 2 groups of adults (ages 24 to 34) playing soccer.

[i] Based on weighted average of geometric mean soil loadings for 69 gardeners, farmers, groundskeepers, landscapers and archeologists (ages 16 to 64 years) for faces, arms and hands; 65 gardeners, farmers, groundskeepers, and archeologists (ages 16 to 64 years) for legs; and 36 gardeners, groundskeepers and archeologists (ages 16 to 62) for feet.

[j] Based on weighted average of geometric mean soil loadings for 27 construction workers, utility workers and equipment operators (ages 21 to 54) for faces, arms and hands; and based on geometric mean soil loadings for 8 construction workers (ages 21 to 30 years) for legs.

[k] Based on geometric mean soil loadings of 18 adults (ages 33 to 63 years) clamming in tidal flats.

\- = No data.

DOCUMENT (7) – Extract from Section 3.3 of the enHealth (2012) "*Australian Exposure Factor Guide*"

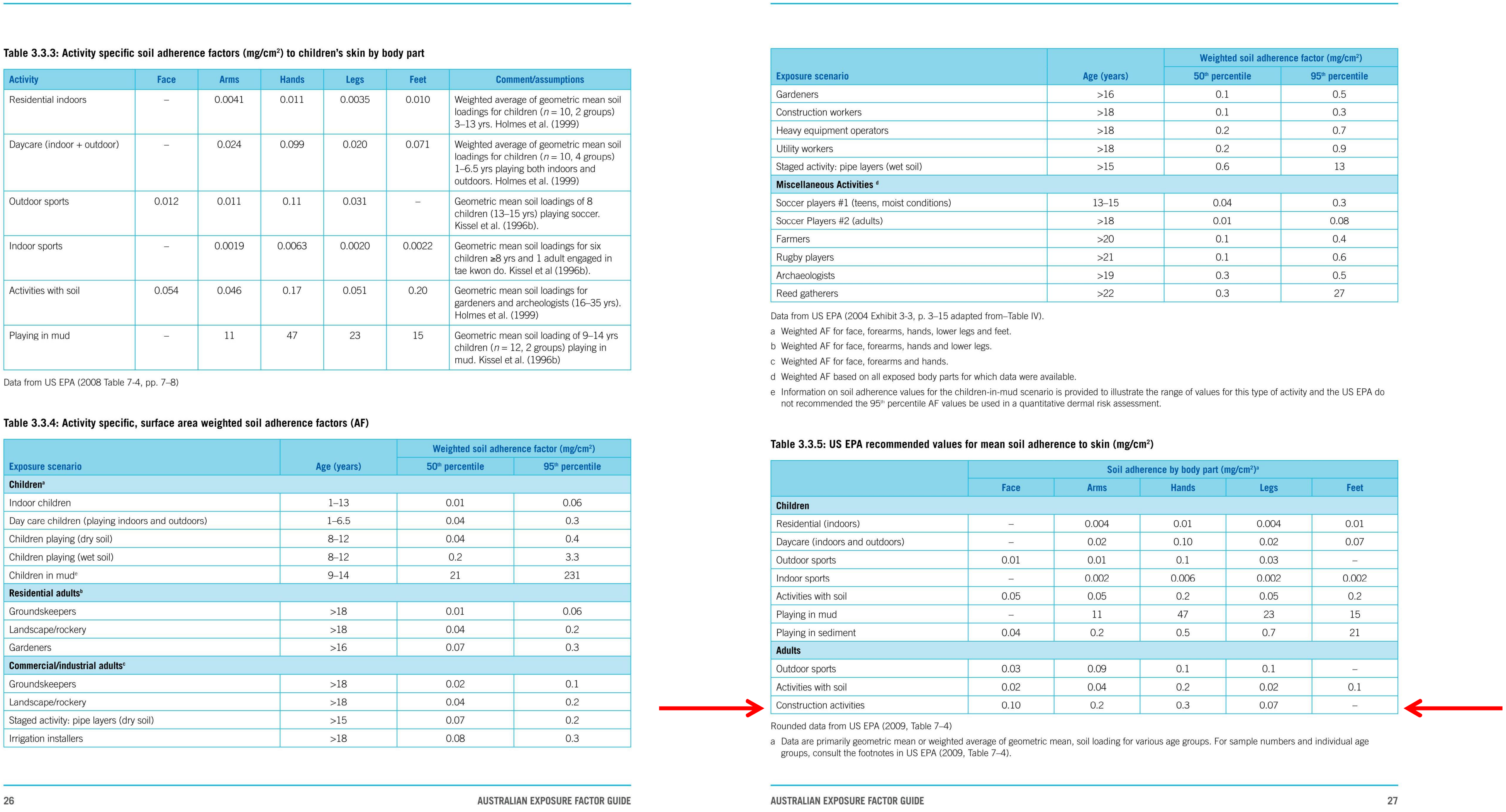


Table 3.3.3: Activity specific soil adherence factors (mg/cm^2) to children's skin by body part

Activity	Face	Arms	Hands	Legs	Feet	Comment/assumptions
Residential indoors	–	0.0041	0.011	0.0035	0.010	Weighted average of geometric mean soil loadings for children (*n* = 10, 2 groups) 3–13 yrs. Holmes et al. (1999)
Daycare (indoor + outdoor)	–	0.024	0.099	0.020	0.071	Weighted average of geometric mean soil loadings for children (*n* = 10, 4 groups) 1–6.5 yrs playing both indoors and outdoors. Holmes et al. (1999)
Outdoor sports	0.012	0.011	0.11	0.031	–	Geometric mean soil loadings of 8 children (13–15 yrs) playing soccer. Kissel et al. (1996b).
Indoor sports	–	0.0019	0.0063	0.0020	0.0022	Geometric mean soil loadings for six children ≥8 yrs and 1 adult engaged in tae kwon do. Kissel et al (1996b).
Activities with soil	0.054	0.046	0.17	0.051	0.20	Geometric mean soil loadings for gardeners and archeologists (16–35 yrs). Holmes et al. (1999)
Playing in mud	–	11	47	23	15	Geometric mean soil loading of 9–14 yrs children (*n* = 12, 2 groups) playing in mud. Kissel et al. (1996b)

Data from US EPA (2008 Table 7-4, pp. 7–8)

Table 3.3.4: Activity specific, surface area weighted soil adherence factors (AF)

Exposure scenario	Age (years)	Weighted soil adherence factor (mg/cm^2)	
		50th percentile	95th percentile
Children[a]			
Indoor children	1–13	0.01	0.06
Day care children (playing indoors and outdoors)	1–6.5	0.04	0.3
Children playing (dry soil)	8–12	0.04	0.4
Children playing (wet soil)	8–12	0.2	3.3
Children in mud[e]	9–14	21	231
Residential adults[b]			
Groundskeepers	>18	0.01	0.06
Landscape/rockery	>18	0.04	0.2
Gardeners	>16	0.07	0.3
Commercial/industrial adults[c]			
Groundskeepers	>18	0.02	0.1
Landscape/rockery	>18	0.04	0.2
Staged activity: pipe layers (dry soil)	>15	0.07	0.2
Irrigation installers	>18	0.08	0.3
Gardeners	>16	0.1	0.5
Construction workers	>18	0.1	0.3
Heavy equipment operators	>18	0.2	0.7
Utility workers	>18	0.2	0.9
Staged activity: pipe layers (wet soil)	>15	0.6	13
Miscellaneous Activities [d]			
Soccer players #1 (teens, moist conditions)	13–15	0.04	0.3
Soccer Players #2 (adults)	>18	0.01	0.08
Farmers	>20	0.1	0.4
Rugby players	>21	0.1	0.6
Archaeologists	>19	0.3	0.5
Reed gatherers	>22	0.3	27

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Data from US EPA (2004 Exhibit 3-3, p. 3–15 adapted from–Table IV).

a Weighted AF for face, forearms, hands, lower legs and feet.

b Weighted AF for face, forearms, hands and lower legs.

c Weighted AF for face, forearms and hands.

d Weighted AF based on all exposed body parts for which data were available.

e Information on soil adherence values for the children-in-mud scenario is provided to illustrate the range of values for this type of activity and the US EPA do not recommended the 95th percentile AF values be used in a quantitative dermal risk assessment.

Table 3.3.5: US EPA recommended values for mean soil adherence to skin (mg/cm^2)

	Soil adherence by body part (mg/cm^2)[a]				
	Face	Arms	Hands	Legs	Feet
Children					
Residential (indoors)	–	0.004	0.01	0.004	0.01
Daycare (indoors and outdoors)	–	0.02	0.10	0.02	0.07
Outdoor sports	0.01	0.01	0.1	0.03	–
Indoor sports	–	0.002	0.006	0.002	0.002
Activities with soil	0.05	0.05	0.2	0.05	0.2
Playing in mud	–	11	47	23	15
Playing in sediment	0.04	0.2	0.5	0.7	21
Adults					
Outdoor sports	0.03	0.09	0.1	0.1	–
Activities with soil	0.02	0.04	0.2	0.02	0.1
Construction activities	0.10	0.2	0.3	0.07	–

Rounded data from US EPA (2009, Table 7–4)

a Data are primarily geometric mean or weighted average of geometric mean, soil loading for various age groups. For sample numbers and individual age groups, consult the footnotes in US EPA (2009, Table 7–4).

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5.4 Long Term Dermal Toxicity of PAHs

The long term (non-threshold) toxicity of chemicals is typically expressed in a risk assessment by a parameter referred to as a cancer slope factor[109].

The AECOM HHERA correctly identified that carcinogenic PAHs and benzene are the only contaminants of concern (excluding asbestos) that could pose a long term health risk to an unprotected maintenance worker undertaking trench work at the *Declared Area*. The toxicity of carcinogenic PAHs is controlled by benzo(a)pyrene, since benzo(a)pyrene is the most toxic carcinogenic PAH compound. Furthermore, the toxicity of the other carcinogenic PAHs is determined by applying a toxic equivalency factor (TEF) to the benzo(a)pyrene slope factor.

The NSW EPA requires[110] risk assessments to be prepared in accordance with the National Environment Protection Measure (NEPM) for the assessment of site contamination and any relevant guidelines made or approved by the NSW EPA (**DOCUMENT 8**). Site Auditors must also check that any human health risk assessment satisfies all the requirements in a checklist provided in Appendix VII of the Site Auditor guidelines (**DOCUMENT 9**).

The most recent version of the NEPM guidelines was issued in draft form in April 2011. Appendix A2 in Schedule B7 of the NEPM provided the most up-to-date peer reviewed assessment of benzo(a)pyrene slope factors, with an extract of the relevant part of the guidelines provided in **DOCUMENT 10**.

The NEPM guideline recommended that a slope factor of 0.233 $(mg/kg/day)^{-1}$ be used to define the non-threshold dermal toxicity of benzo(a)pyrene. The NEPM guideline also advised against using the slope factor of 25 $(mg/kg/day)^{-1}$ proposed in a study by Knafla et al (2006) because:

- The Canadian Council of Ministers of the Environment (CCME, 2008) and the New Zealand Ministry for the Environment (MfE, 2010) noted in a review of the study that the approach adopted by the Knafla study requires further review and consideration before being adopted;
- The Knafla approach is relatively untested;
- Greater uncertainties exist in the extrapolation of dermal data derived from animals to humans than for the oral or inhalation route;
- A conservative approach was used to quantify dermal exposures; and

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[109] The enHealth (2012) "*Australian Exposure Factor Guide*" defines a cancer slope factor as "*The plausible upper-bound estimate of the probability of a response per unit of intake of an agent over a lifetime*".

[110] Section 4.2.2 and Appendix VII of NSW DEC (April 2006) "*Guidelines for the NSW Site Auditor Scheme (2nd edition)*"

- No other international agency has currently adopted the use of the dermal slope factor proposed by the Knafla study.

Despite the advice from the most recent NEPM guideline and the NSW EPA requirement that risk assessments be prepared in accordance with the NEPM, the AECOM HHERA did not use a slope factor of 0.233 $(mg/kg/day)^{-1}$ to define the non-threshold dermal toxicity of benzo(a)pyrene and the other carcinogenic PAHs. The AECOM HHERA instead used the slope factor of 25 $(mg/kg/day)^{-1}$ that was derived by the Knafla et al (2006) study[111].

The approach adopted by the AECOM HHERA resulted in the long term risks from dermal PAH exposure to an unprotected maintenance worker to be exaggerated 107 times.

This error has caused the AECOM HHERA to significantly exaggerate the long-term health risks to an unprotected maintenance worker for exposure pathways involving dermal contact with soil or groundwater. These deficiencies in the AECOM HHERA can be addressed by using a slope factor of 0.233 $(mg/kg/day)^{-1}$ in a revised health risk assessment. SKM has used this approach to obtain more accurate and confident human health risk estimates, with the results of these calculations are presented in **Section 5.7**.

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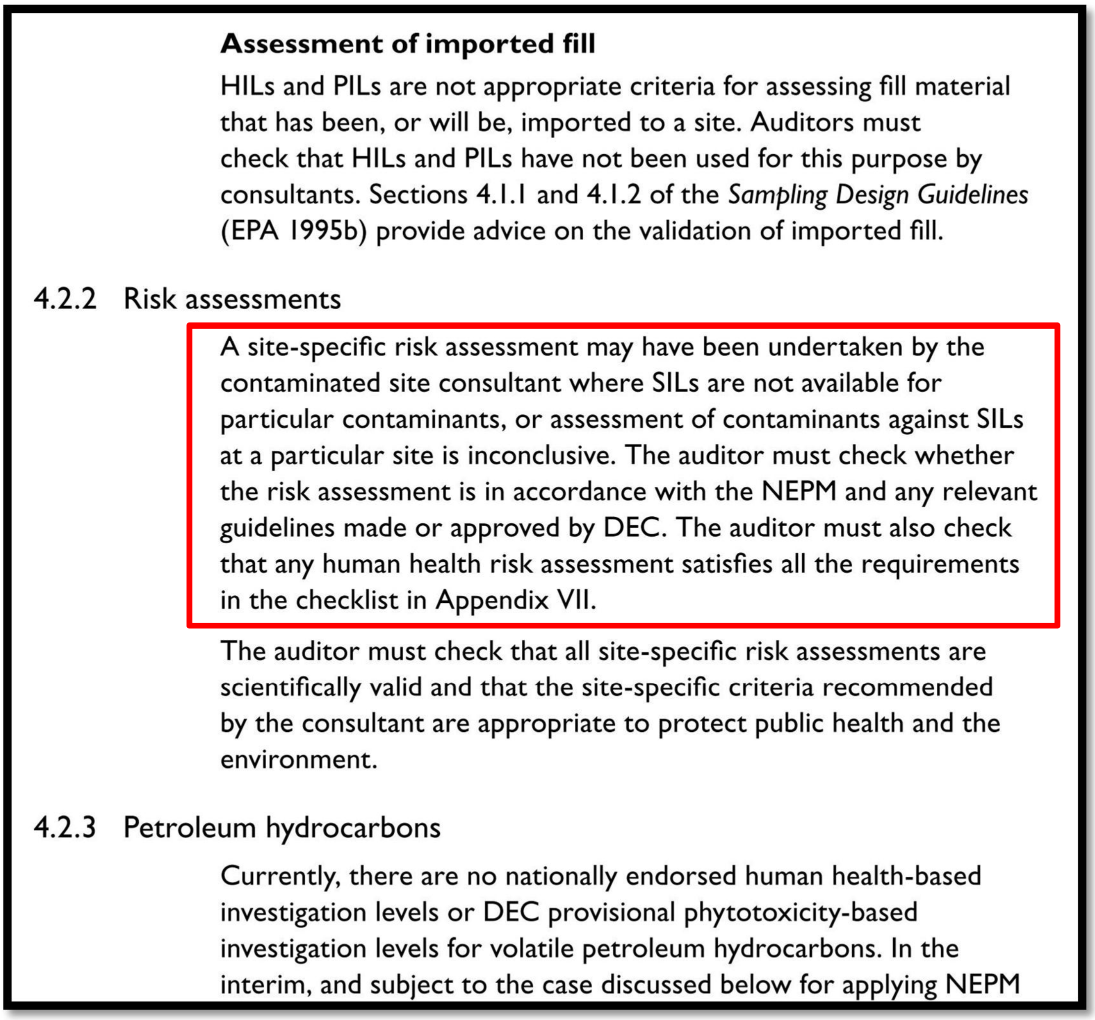
[111] Section 5.2.6, AECOM HHERA

DOCUMENT (8) – Extract from NSW EPA (2006) Site Auditor Guideline



Assessment of imported fill

HILs and PILs are not appropriate criteria for assessing fill material that has been, or will be, imported to a site. Auditors must check that HILs and PILs have not been used for this purpose by consultants. Sections 4.1.1 and 4.1.2 of the *Sampling Design Guidelines* (EPA 1995b) provide advice on the validation of imported fill.

4.2.2 Risk assessments

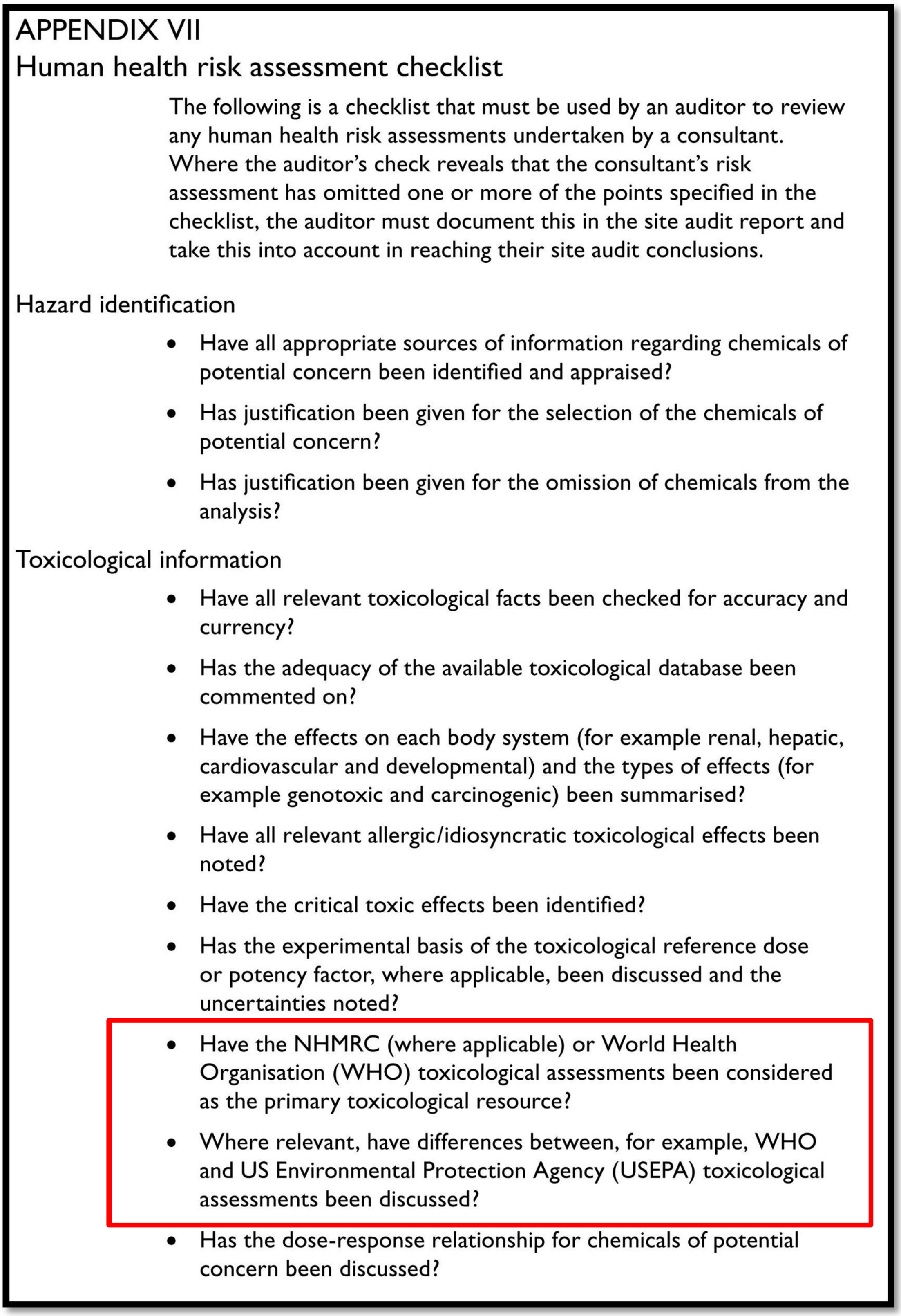
A site-specific risk assessment may have been undertaken by the contaminated site consultant where SILs are not available for particular contaminants, or assessment of contaminants against SILs at a particular site is inconclusive. The auditor must check whether the risk assessment is in accordance with the NEPM and any relevant guidelines made or approved by DEC. The auditor must also check that any human health risk assessment satisfies all the requirements in the checklist in Appendix VII.

The auditor must check that all site-specific risk assessments are scientifically valid and that the site-specific criteria recommended by the consultant are appropriate to protect public health and the environment.

4.2.3 Petroleum hydrocarbons

Currently, there are no nationally endorsed human health-based investigation levels or DEC provisional phytotoxicity-based investigation levels for volatile petroleum hydrocarbons. In the interim, and subject to the case discussed below for applying NEPM

DOCUMENT (9) – Extract from NSW EPA (2006) Site Auditor Guideline



APPENDIX VII

Human health risk assessment checklist

The following is a checklist that must be used by an auditor to review any human health risk assessments undertaken by a consultant. Where the auditor's check reveals that the consultant's risk assessment has omitted one or more of the points specified in the checklist, the auditor must document this in the site audit report and take this into account in reaching their site audit conclusions.

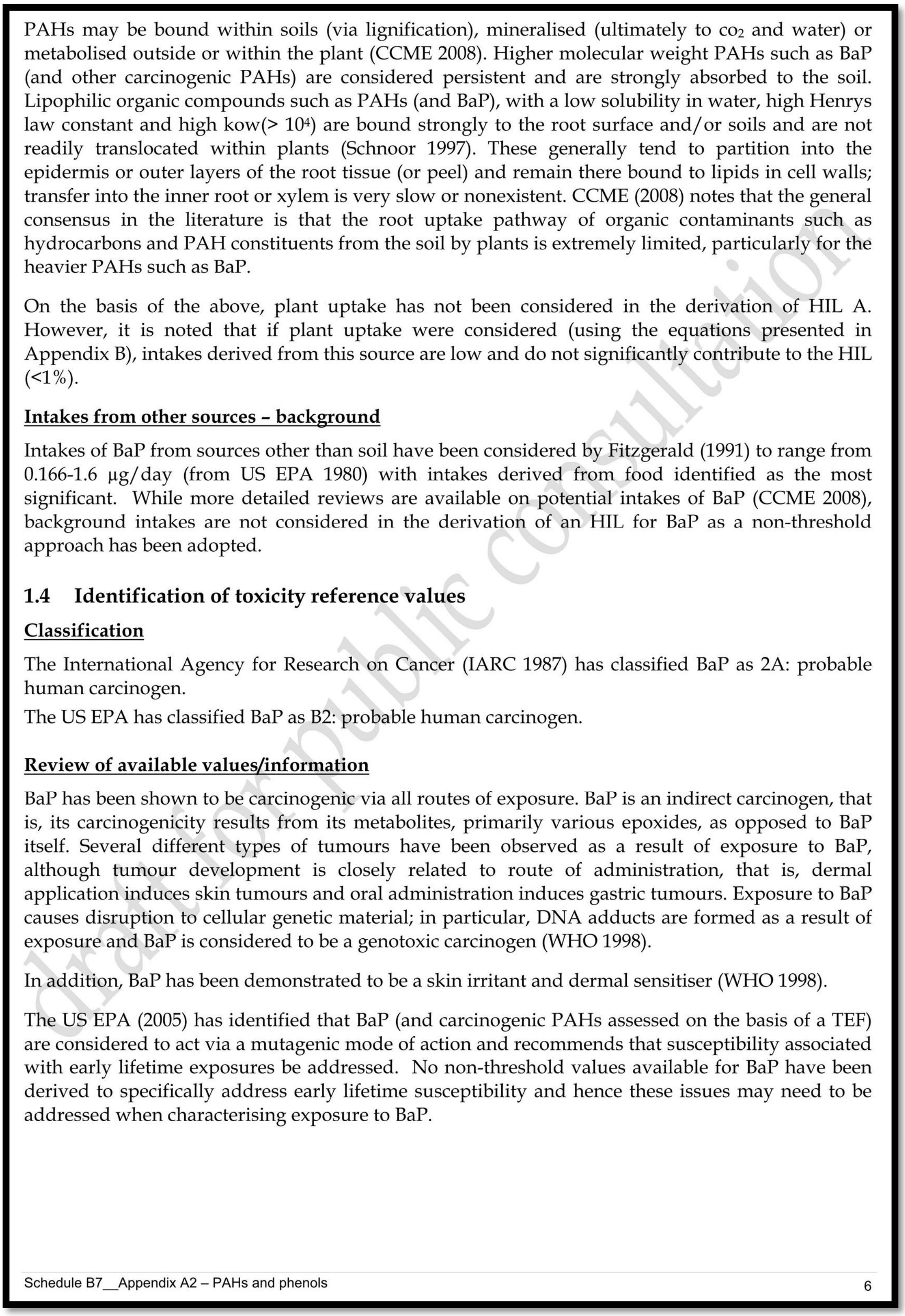
Hazard identification

- Have all appropriate sources of information regarding chemicals of potential concern been identified and appraised?
- Has justification been given for the selection of the chemicals of potential concern?
- Has justification been given for the omission of chemicals from the analysis?

Toxicological information

- Have all relevant toxicological facts been checked for accuracy and currency?
- Has the adequacy of the available toxicological database been commented on?
- Have the effects on each body system (for example renal, hepatic, cardiovascular and developmental) and the types of effects (for example genotoxic and carcinogenic) been summarised?
- Have all relevant allergic/idiosyncratic toxicological effects been noted?
- Have the critical toxic effects been identified?
- Has the experimental basis of the toxicological reference dose or potency factor, where applicable, been discussed and the uncertainties noted?
- Have the NHMRC (where applicable) or World Health Organisation (WHO) toxicological assessments been considered as the primary toxicological resource?
- Where relevant, have differences between, for example, WHO and US Environmental Protection Agency (USEPA) toxicological assessments been discussed?
- Has the dose-response relationship for chemicals of potential concern been discussed?

DOCUMENT (10) – NEPC (April 2011) Draft NEPM Schedule B7 Appendix A2



PAHs may be bound within soils (via lignification), mineralised (ultimately to co_2 and water) or metabolised outside or within the plant (CCME 2008). Higher molecular weight PAHs such as BaP (and other carcinogenic PAHs) are considered persistent and are strongly absorbed to the soil. Lipophilic organic compounds such as PAHs (and BaP), with a low solubility in water, high Henrys law constant and high kow(> 10^4) are bound strongly to the root surface and/or soils and are not readily translocated within plants (Schnoor 1997). These generally tend to partition into the epidermis or outer layers of the root tissue (or peel) and remain there bound to lipids in cell walls; transfer into the inner root or xylem is very slow or nonexistent. CCME (2008) notes that the general consensus in the literature is that the root uptake pathway of organic contaminants such as hydrocarbons and PAH constituents from the soil by plants is extremely limited, particularly for the heavier PAHs such as BaP.

On the basis of the above, plant uptake has not been considered in the derivation of HIL A. However, it is noted that if plant uptake were considered (using the equations presented in Appendix B), intakes derived from this source are low and do not significantly contribute to the HIL (<1%).

Intakes from other sources – background

Intakes of BaP from sources other than soil have been considered by Fitzgerald (1991) to range from 0.166-1.6 µg/day (from US EPA 1980) with intakes derived from food identified as the most significant. While more detailed reviews are available on potential intakes of BaP (CCME 2008), background intakes are not considered in the derivation of an HIL for BaP as a non-threshold approach has been adopted.

1.4 Identification of toxicity reference values

Classification

The International Agency for Research on Cancer (IARC 1987) has classified BaP as 2A: probable human carcinogen.

The US EPA has classified BaP as B2: probable human carcinogen.

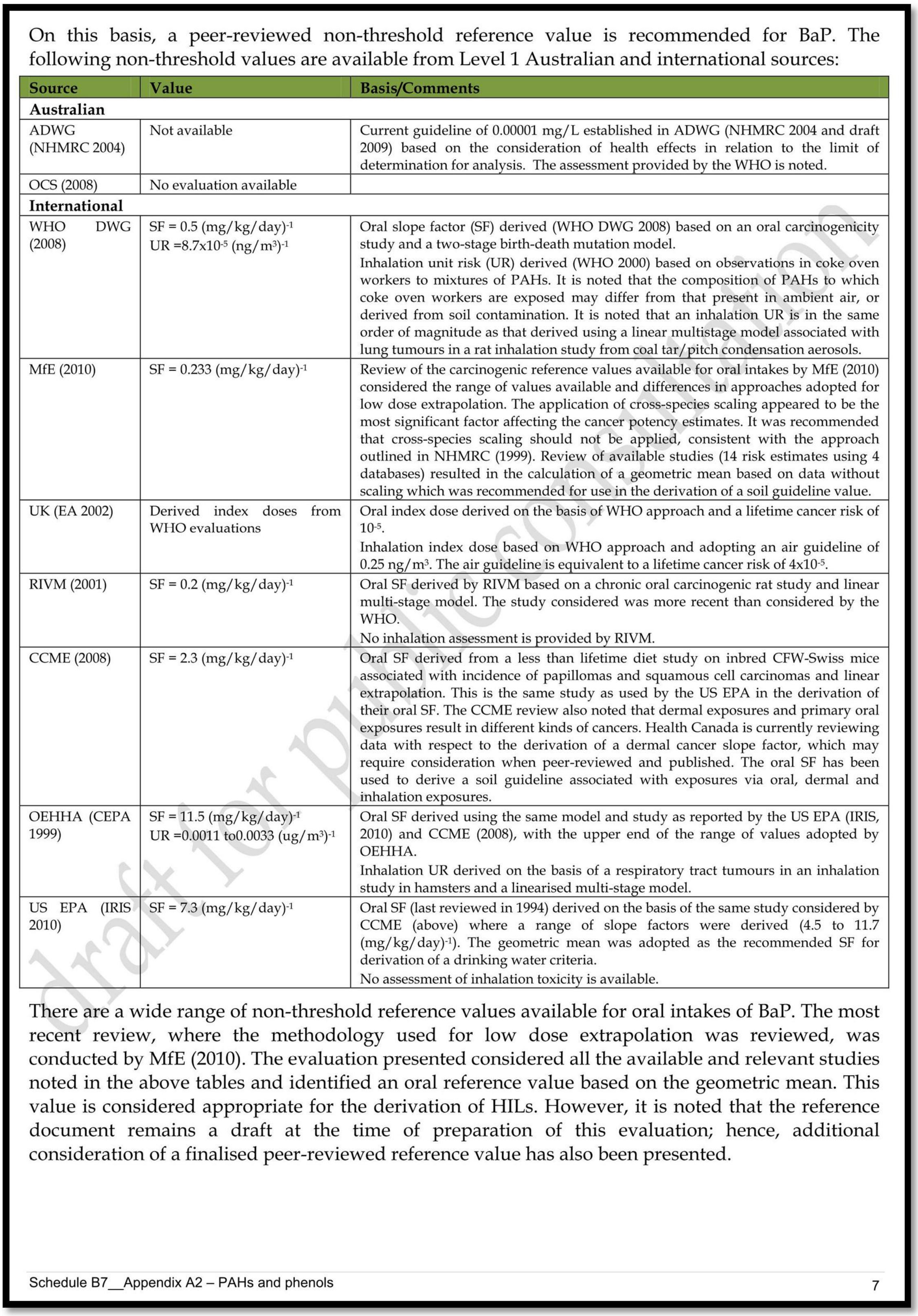
Review of available values/information

BaP has been shown to be carcinogenic via all routes of exposure. BaP is an indirect carcinogen, that is, its carcinogenicity results from its metabolites, primarily various epoxides, as opposed to BaP itself. Several different types of tumours have been observed as a result of exposure to BaP, although tumour development is closely related to route of administration, that is, dermal application induces skin tumours and oral administration induces gastric tumours. Exposure to BaP causes disruption to cellular genetic material; in particular, DNA adducts are formed as a result of exposure and BaP is considered to be a genotoxic carcinogen (WHO 1998).

In addition, BaP has been demonstrated to be a skin irritant and dermal sensitiser (WHO 1998).

The US EPA (2005) has identified that BaP (and carcinogenic PAHs assessed on the basis of a TEF) are considered to act via a mutagenic mode of action and recommends that susceptibility associated with early lifetime exposures be addressed. No non-threshold values available for BaP have been derived to specifically address early lifetime susceptibility and hence these issues may need to be addressed when characterising exposure to BaP.

DOCUMENT (10) cont'd – NEPC (April 2011) Draft NEPM Schedule B7 Appendix A2

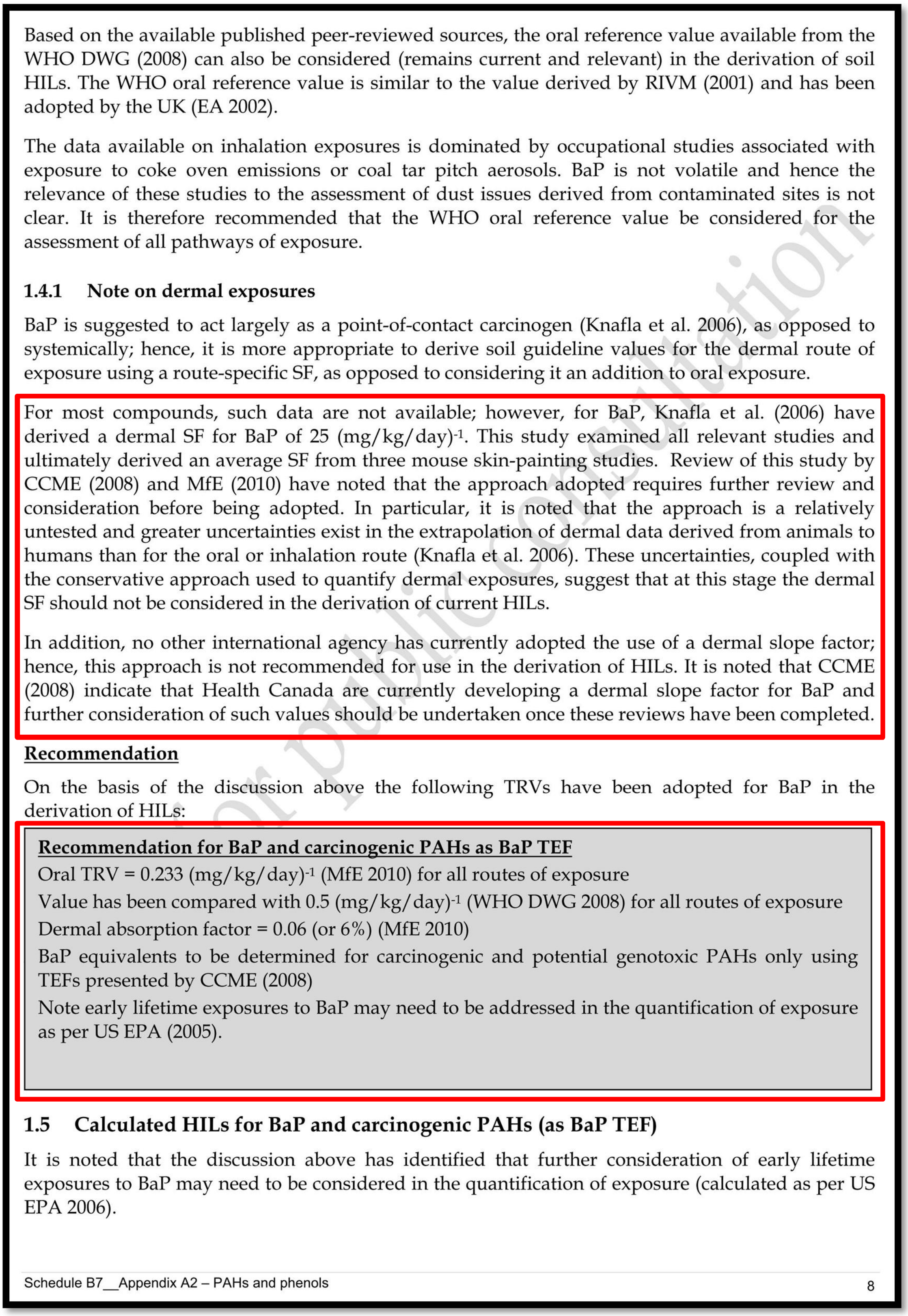


On this basis, a peer-reviewed non-threshold reference value is recommended for BaP. The following non-threshold values are available from Level 1 Australian and international sources:

Source	Value	Basis/Comments
Australian		
ADWG (NHMRC 2004)	Not available	Current guideline of 0.00001 mg/L established in ADWG (NHMRC 2004 and draft 2009) based on the consideration of health effects in relation to the limit of determination for analysis. The assessment provided by the WHO is noted.
OCS (2008)	No evaluation available	
International		
WHO DWG (2008)	SF = 0.5 (mg/kg/day)$^{-1}$ UR =8.7x10^{-5} (ng/m^{3})$^{-1}$	Oral slope factor (SF) derived (WHO DWG 2008) based on an oral carcinogenicity study and a two-stage birth-death mutation model. Inhalation unit risk (UR) derived (WHO 2000) based on observations in coke oven workers to mixtures of PAHs. It is noted that the composition of PAHs to which coke oven workers are exposed may differ from that present in ambient air, or derived from soil contamination. It is noted that an inhalation UR is in the same order of magnitude as that derived using a linear multistage model associated with lung tumours in a rat inhalation study from coal tar/pitch condensation aerosols.
MfE (2010)	SF = 0.233 (mg/kg/day)$^{-1}$	Review of the carcinogenic reference values available for oral intakes by MfE (2010) considered the range of values available and differences in approaches adopted for low dose extrapolation. The application of cross-species scaling appeared to be the most significant factor affecting the cancer potency estimates. It was recommended that cross-species scaling should not be applied, consistent with the approach outlined in NHMRC (1999). Review of available studies (14 risk estimates using 4 databases) resulted in the calculation of a geometric mean based on data without scaling which was recommended for use in the derivation of a soil guideline value.
UK (EA 2002)	Derived index doses from WHO evaluations	Oral index dose derived on the basis of WHO approach and a lifetime cancer risk of 10^{-5}. Inhalation index dose based on WHO approach and adopting an air guideline of 0.25 ng/m^{3}. The air guideline is equivalent to a lifetime cancer risk of 4x10^{-5}.
RIVM (2001)	SF = 0.2 (mg/kg/day)$^{-1}$	Oral SF derived by RIVM based on a chronic oral carcinogenic rat study and linear multi-stage model. The study considered was more recent than considered by the WHO. No inhalation assessment is provided by RIVM.
CCME (2008)	SF = 2.3 (mg/kg/day)$^{-1}$	Oral SF derived from a less than lifetime diet study on inbred CFW-Swiss mice associated with incidence of papillomas and squamous cell carcinomas and linear extrapolation. This is the same study as used by the US EPA in the derivation of their oral SF. The CCME review also noted that dermal exposures and primary oral exposures result in different kinds of cancers. Health Canada is currently reviewing data with respect to the derivation of a dermal cancer slope factor, which may require consideration when peer-reviewed and published. The oral SF has been used to derive a soil guideline associated with exposures via oral, dermal and inhalation exposures.
OEHHA (CEPA 1999)	SF = 11.5 (mg/kg/day)$^{-1}$ UR =0.0011 to0.0033 (ug/m^{3})$^{-1}$	Oral SF derived using the same model and study as reported by the US EPA (IRIS, 2010) and CCME (2008), with the upper end of the range of values adopted by OEHHA. Inhalation UR derived on the basis of a respiratory tract tumours in an inhalation study in hamsters and a linearised multi-stage model.
US EPA (IRIS 2010)	SF = 7.3 (mg/kg/day)$^{-1}$	Oral SF (last reviewed in 1994) derived on the basis of the same study considered by CCME (above) where a range of slope factors were derived (4.5 to 11.7 (mg/kg/day)$^{-1}$). The geometric mean was adopted as the recommended SF for derivation of a drinking water criteria. No assessment of inhalation toxicity is available.

There are a wide range of non-threshold reference values available for oral intakes of BaP. The most recent review, where the methodology used for low dose extrapolation was reviewed, was conducted by MfE (2010). The evaluation presented considered all the available and relevant studies noted in the above tables and identified an oral reference value based on the geometric mean. This value is considered appropriate for the derivation of HILs. However, it is noted that the reference document remains a draft at the time of preparation of this evaluation; hence, additional consideration of a finalised peer-reviewed reference value has also been presented.

DOCUMENT (10) cont'd – NEPC (April 2011) Draft NEPM Schedule B7 Appendix A2



Based on the available published peer-reviewed sources, the oral reference value available from the WHO DWG (2008) can also be considered (remains current and relevant) in the derivation of soil HILs. The WHO oral reference value is similar to the value derived by RIVM (2001) and has been adopted by the UK (EA 2002).

The data available on inhalation exposures is dominated by occupational studies associated with exposure to coke oven emissions or coal tar pitch aerosols. BaP is not volatile and hence the relevance of these studies to the assessment of dust issues derived from contaminated sites is not clear. It is therefore recommended that the WHO oral reference value be considered for the assessment of all pathways of exposure.

1.4.1 Note on dermal exposures

BaP is suggested to act largely as a point-of-contact carcinogen (Knafla et al. 2006), as opposed to systemically; hence, it is more appropriate to derive soil guideline values for the dermal route of exposure using a route-specific SF, as opposed to considering it an addition to oral exposure.

For most compounds, such data are not available; however, for BaP, Knafla et al. (2006) have derived a dermal SF for BaP of 25 $(mg/kg/day)^{-1}$. This study examined all relevant studies and ultimately derived an average SF from three mouse skin-painting studies. Review of this study by CCME (2008) and MfE (2010) have noted that the approach adopted requires further review and consideration before being adopted. In particular, it is noted that the approach is a relatively untested and greater uncertainties exist in the extrapolation of dermal data derived from animals to humans than for the oral or inhalation route (Knafla et al. 2006). These uncertainties, coupled with the conservative approach used to quantify dermal exposures, suggest that at this stage the dermal SF should not be considered in the derivation of current HILs.

In addition, no other international agency has currently adopted the use of a dermal slope factor; hence, this approach is not recommended for use in the derivation of HILs. It is noted that CCME (2008) indicate that Health Canada are currently developing a dermal slope factor for BaP and further consideration of such values should be undertaken once these reviews have been completed.

Recommendation

On the basis of the discussion above the following TRVs have been adopted for BaP in the derivation of HILs:

Recommendation for BaP and carcinogenic PAHs as BaP TEF

Oral TRV = 0.233 $(mg/kg/day)^{-1}$ (MfE 2010) for all routes of exposure

Value has been compared with 0.5 $(mg/kg/day)^{-1}$ (WHO DWG 2008) for all routes of exposure

Dermal absorption factor = 0.06 (or 6%) (MfE 2010)

BaP equivalents to be determined for carcinogenic and potential genotoxic PAHs only using TEFs presented by CCME (2008)

Note early lifetime exposures to BaP may need to be addressed in the quantification of exposure as per US EPA (2005).

1.5 Calculated HILs for BaP and carcinogenic PAHs (as BaP TEF)

It is noted that the discussion above has identified that further consideration of early lifetime exposures to BaP may need to be considered in the quantification of exposure (calculated as per US EPA 2006).

5.5 Groundwater Data

The AECOM HHERA assumed there was potential for an unprotected maintenance worker to be exposed to contaminated groundwater when working in a 2 m deep trench, with groundwater entering the trench from a depth of 1.5 m to 2.0 m bgl[112].

However, despite this exposure scenario being limited to groundwater down to a 2 m depth, the AECOM risk assessment used groundwater contamination data obtained from samples collected at all depths, which include groundwater from sandstone bedrock[113]. The AECOM report provided no justification for their approach.

The AECOM HHERA[114] assessed the health risks posed by shallow groundwater at the *Declared Area* from a total of 28 groundwater monitoring wells, which are shown in **Figure 4-1**. The investigation data indicate that groundwater quality at the *Declared Area* met the AECOM health-based acceptance criteria (SSTC[115]) at 19 of the 28 locations, while groundwater quality at 9 locations exceeded the AECOM acceptance criteria. Summaries of the water level, screened intervals and contaminant concentrations for those groundwater wells that exceeded the AECOM criteria are provided in **Table 5-2**.

The data show that:

- Most of the wells where groundwater samples exceeded the AECOM acceptance criteria should not have been used in the risk assessment because groundwater has only been measured at depths below 2.0 m or in sandstone bedrock that was screened below a depth of 2.0 m. The invalid wells that were used in the AECOM analysis are numbered BH200/MW200, BH205/MW205, BH206/MW206, MW10_Coffey and MW15_Coffey;
- Groundwater at only 4 wells has been measured at a depth of 0 – 2 m bgl and at concentrations that exceed the AECOM acceptance criteria. These wells are NH087/MW015, BH204D/MW204D, MW7_Coffey and AECOM BH54/MW54;
- The maximum TPH and naphthalene concentrations used in the AECOM health risk assessment were taken from a groundwater sample at well BH205/MW205 where the groundwater was obtained from a depth of 15.0 – 19.5 m in the sandstone bedrock;

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[112] Table 19, AECOM HHERA

[113] Table 10, Sections 5.1.2 & 5.3.3.1, AECOM HHERA

[114] Table T3, AECOM HHERA

[115] SSTC – Site-specific target criteria

- **Table 5-2 Summary of Groundwater Contaminant Concentrations at Wells Exceeding AECOM Acceptance Criteria**

					Measured Groundwater Concentrations (mg/L)								
Well	Sample Date	Depth to Groundwater (m bgl)	Screened Interval	Soil in Screened Interval	Benzene	cPAH	Fluoranthene	Naphthalene	Phenanthrene	Pyrene	TPH C_{10}-C_{14}	TPH C_{15}-C_{28}	TPH C_{29}-C_{36}
BH087 / MW015	25/07/2006	1.980	3.0 - 9.0	Fill	14.4		0.135	21.7	0.367	0.130	46.0	19.6	0.760
	14/08/2006	1.870			8.89		0.480	11.4	0.932	0.451	50.5	22.7	1.34
	15/08/2007	not recorded			7.27		0.116	3.93	0.242	0.110	48.2	23.8	2.19
	12/05/2008	2.280			4.14		<0.018	2.43	0.019	<0.018	104	15.5	0.150
	15/03/2010	1.890			13.1		0.018	7.80	0.087	0.016	41.0	14.4	0.470
BH200 / MW200	13/05/2008	1.995	4.4 - 7.4	Sandstone bedrock	12.9		<0.019	2.29	<0.019	<0.019	97.2	22.0	0.120
	16/03/2010	2.020			16.2		<0.009	7.95	0.012	<0.009	100	22.5	0.150
	28/02/2011	1.940			17.9		<0.098	5.45	<0.098	<0.098	47.4	17.2	<0.05
BH204D / MW204D	13/05/2008	1.758	1.0 - 4.0	Fill and natural clayey sand	7.7		0.767	5.92	1.39	0.732	422	75.8	9.84
	15/03/2010	1.470			nt		nt	nt	nt	nt	nt	nt	nt
BH205 / MW205	9/05/2008	3.958	15.0 - 19.5	Sandstone bedrock	27.8		<0.019	1.59	<0.019	<0.019	72.8	8.10	0.080
	16/03/2010	2.905			nt		25.2	283	74.1	27.9	1730	1520	332
BH206 / MW206	12/05/2008	2.515	7.0 - 8.0	Natural clayey sand	2.96		0.001	0.870	0.010	0.001	6.94	1.50	<0.05
	19/03/2010	not recorded			5.45		1.25	10.6	2.84	1.52	68.0	70.6	14.8
MW7_Coffey	26/03/2008	1.240	0.95 - 5.45	Fill	25.2		0.216	7.20	0.388	0.215	830	46.9	0.670
MW10_Coffey	26/03/2008	2.020	1.8 - 9.4	Fill	18.3		2.42	15.8	4.39	2.56	492	89.4	14.7
	1/05/2008	not recorded			41.0		19.2	149	33.3	16.9	654	1050	305
MW15_Coffey	1/05/2008	2.820	2.5 - 12.0	Sandstone bedrock	40.2		25.9	192	42.0	23.2	494	754	205
AECOM BH54 / MW54	19/03/2010	1.310	1.90 - 2.80	Natural sand	0.621		0.019	8.64	0.098	0.014	28.0	10.9	0.400
AECOM Groundwater SSTC - Human Health (mg/L)					3.4	1	nr	29	nr	nr	21	220	250

🟨 Groundwater below 2 m deep trench

- The maximum benzene concentration used in the AECOM health risk assessment was invalid since it was taken from a groundwater sample that is not representative of groundwater that would enter a trench between a depth of 1.5 – 2.0 m. This is because the sample was taken from well MW10_Coffey at a depth below the base of a 2.0 m deep trench; and
- The maximum groundwater concentrations that have been measured to a depth of 2.0 m bgl at the *Declared Area* are significantly less than those used in the AECOM health risk assessment. These maximum concentrations and their relative concentration to those used by AECOM are Benzene 25.2 mg/L (61 %), naphthalene 21.7 mg/L (7.7 %), TPH C10 - C14 = 422 mg/L (24 %), and TPH C15 – C28 = 75.8 mg/L (5.0 %).

In my opinion, the health risks to an unprotected maintenance worker should have been calculated using only groundwater samples collected in fill where the water table lies above the base of a 2.0 m deep trench. This is because:

- The AECOM exposure scenario limits the trench to a depth of 2.0 m;
- The worker would not be exposed to groundwater that lies below the trench floor;
- The worker would not be exposed to groundwater that is present in fractures in the sandstone bedrock that underlies the fill; and
- The locations at the *Declared Area* where the highest contaminant levels have been measured in the upper 2.0 m of soil correspond to those wells where the water table has been measured in fill at a depth no greater than 2.0 m and where the groundwater contaminant concentrations are highest and exceed the AECOM acceptance criteria[116]. This indicates that where the water table lies in fill below the base of the trench, the groundwater will not influence contaminant levels within the trench.

The available data also indicate that most of the wells that have been monitoring shallow groundwater (≤ 2 m bgl) at the *Declared Area* have measured concentrations below the AECOM acceptance criteria. Only 4 wells have measured concentrations that exceed the AECOM groundwater acceptance criteria. These wells are situated in a localised area bounded by the abandoned sewerage pump station SPS59, a buried tar tank and the buried remains of the 1870 gasholder. The extent of this shallow groundwater plume is estimated to represent 5 % of the *Declared Area* and is shown in **Figure 5-4**.

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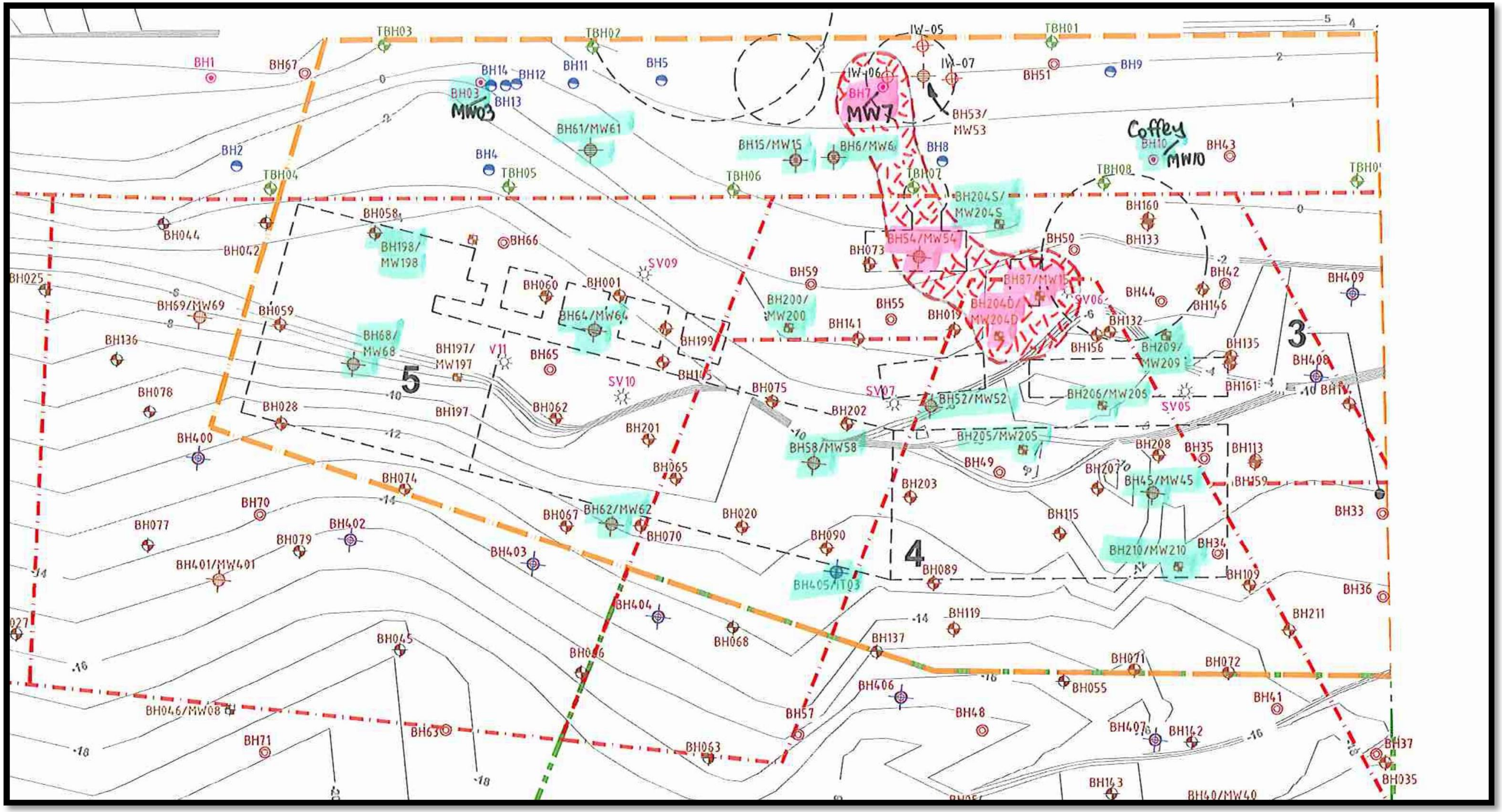
[116] This is shown by the soil contamination data summarised in AECOM Table 9. This table records that the locations where the maximum soil contamination has been measured comprise boreholes BH087/MW015 and BH204D/MW204D and AECOM BH54/MW54.

- **Figure 5-4 Estimated Extent of Shallow Groundwater Exceeding AECOM Acceptance Criteria**



5.6 Asbestos Not Considered by AECOM

The AECOM health risk assessment did not assess the risks posed by asbestos contamination in the fill to an unprotected maintenance workers undertaking trenching work at the *Declared Area*. In my opinion, the health risks posed by asbestos contamination should have been included in the AECOM HHERA for the reasons given in **Section 3.2.1**.

The implications of this deficiency are that:

- The AECOM HHERA is incomplete since it did not properly account for all types of contaminating substances that influence the remediation approach required for the *Declared Area*;
- My analysis of the investigation data indicate there is an unacceptable risk to an unprotected maintenance worker from asbestos contamination in fill at the *Declared Area* (**Section 3.2.1** and **Appendix A**); and
- Fill containing building demolition rubble at the *Declared Area* should be regarded as containing asbestos and either managed on-site in a capped area that incorporates the use of a site management plan, or disposed offsite as *Asbestos Waste* at a suitably licensed landfill.

5.7 Risk Management

The draft NEPM (April 2011) guidelines[117] advise that "*one of the key objectives of risk assessment is usually to support a decision about what to do about the contamination present on a site*" and that "*one of the key considerations in risk management is the extent to which remediation is needed in order to adequately mitigate the risk*".

The AECOM HHERA did not provide a reasonable analysis of the extent to which soils and groundwater at the *Declared Area* represent an unacceptable risk to human health. This is because:

- The maximum concentrations used in the AECOM HHERA to calculate risk estimates were not obtained at a single location but from across several locations spread across the *Declared Area*. This approach would have led to exaggerated risk estimates since no location at the *Declared Area* has been found to be contaminated at these levels;
- It is unreasonable to calculate long-term risks based on the human receptor being exposed to contamination at only one location at the *Declared Area* over their lifetime, particularly if the critical receptor is an unprotected maintenance worker working in trenches;
- The AECOM HHERA advised that the Site Specific Target Criteria derived by their risk assessment did not follow Australian guidelines[118]; and

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[117] Section 6.2, draft NEPM (April 2011) Schedule B4
[118] Section 6.2.1, AECOM HHERA

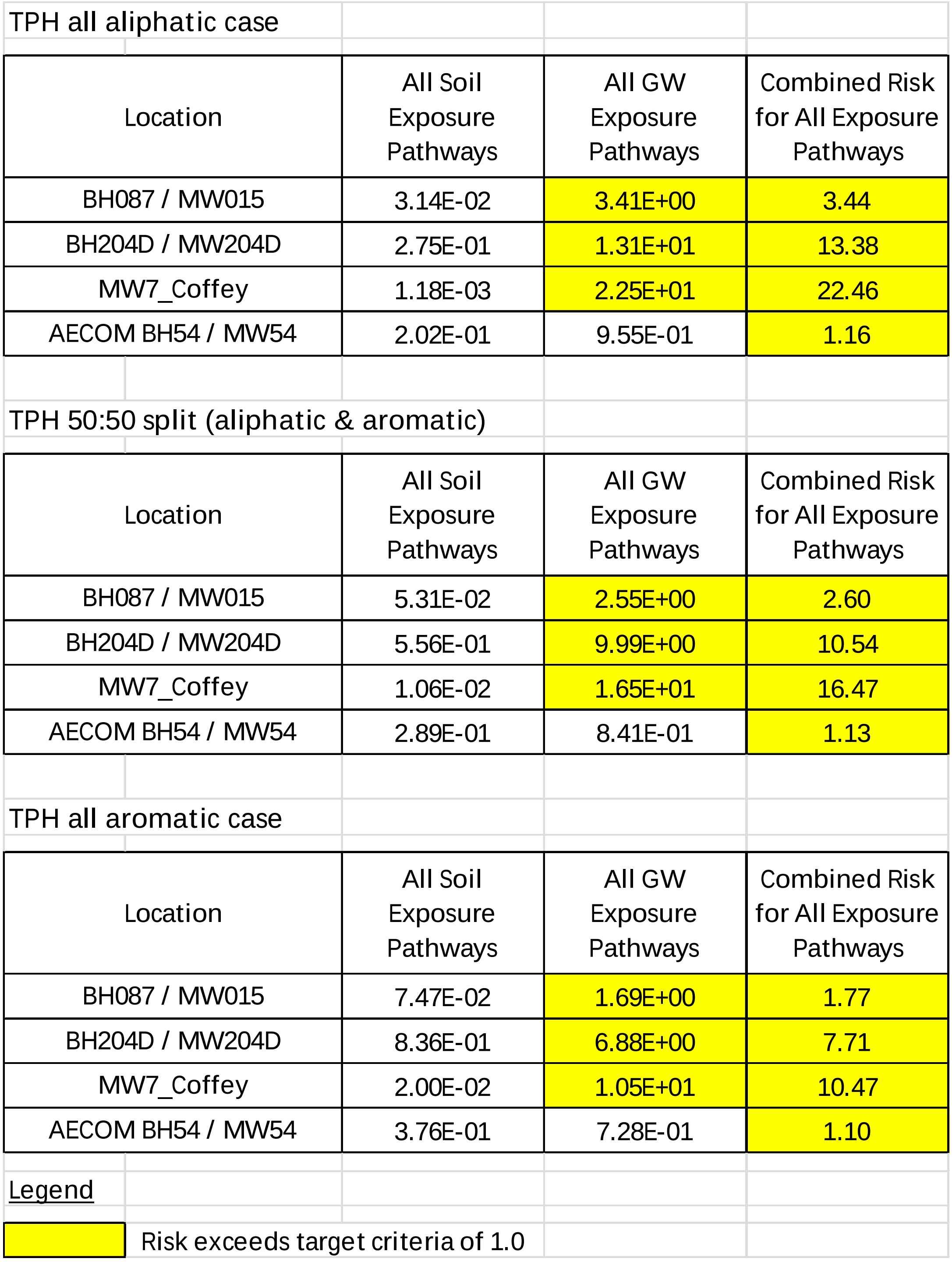
- The extent to which contamination is found to pose an unacceptable risk to human health is an important finding that will influence decisions on the type of remediation approach that best meets ecologically sustainable development principles, as specified in Section 9 of the Contaminated Land Management Act.

This deficiency in the AECOM HHERA has been addressed by this review calculating the risks to an unprotected maintenance worker at each of the many locations that have been investigated at the *Declared Area*, as shown in **Figure 4-1**. The SKM risk assessment has also addressed the deficiencies in the AECOM HHERA described in **Sections 5.2** to **5.5**. These corrections comprise:

- TPH contaminant concentrations in soil and groundwater were adjusted to better account for the split in concentrations between aliphatic and aromatic TPH and the presence of other hydrocarbons included in the TPH concentrations (eg. BTEX, PAHs and phenols), which have been separately assessed (**Section 5.2**). This correction effected the calculation of short term health risks for all exposure pathways;
- The use of a weighted average soil-to-skin adherence factor of 0.19 mg/cm^2 (**Section 5.3**). This correction effected the calculation of short and long term health risks for the exposure pathway involving dermal contact with soil;
- The use of a slope factor of 0.233 (mg/kg/day)$^{-1}$ used to define the long term dermal toxicity of benzo(a)pyrene, which also influenced the slope factor used by other carcinogenic PAHs (**Section 5.4**). This correction effected the calculation of long term health risks for all exposure pathways; and
- The calculation of the health risks at each investigation location in the *Declared Area* using the maximum contaminant concentrations measured at each location.

The analysis found that there are only 4 locations across the *Declared Area* where the health risks to an unprotected maintenance worker exceed the target criteria of 1.0 for short term (threshold) risks and 1 x 10^{-5} for long term (non-threshold) risks. These locations are BH087/MW015, BH204D/MW204D, MW7_Coffey and AECOM BH54/MW54. Summaries of the short-term and long-term health risk results are provided in **Tables 5-3** and **5-4,** respectively. More detailed summary tables are provided in **Appendix E**.

- **Table 5-3 Short-Term Health Risks at Locations where Target Criteria Exceeded**



TPH all aliphatic case

Location	All Soil Exposure Pathways	All GW Exposure Pathways	Combined Risk for All Exposure Pathways
BH087 / MW015	3.14E-02	3.41E+00	3.44
BH204D / MW204D	2.75E-01	1.31E+01	13.38
MW7_Coffey	1.18E-03	2.25E+01	22.46
AECOM BH54 / MW54	2.02E-01	9.55E-01	1.16

TPH 50:50 split (aliphatic & aromatic)

Location	All Soil Exposure Pathways	All GW Exposure Pathways	Combined Risk for All Exposure Pathways
BH087 / MW015	5.31E-02	2.55E+00	2.60
BH204D / MW204D	5.56E-01	9.99E+00	10.54
MW7_Coffey	1.06E-02	1.65E+01	16.47
AECOM BH54 / MW54	2.89E-01	8.41E-01	1.13

TPH all aromatic case

Location	All Soil Exposure Pathways	All GW Exposure Pathways	Combined Risk for All Exposure Pathways
BH087 / MW015	7.47E-02	1.69E+00	1.77
BH204D / MW204D	8.36E-01	6.88E+00	7.71
MW7_Coffey	2.00E-02	1.05E+01	10.47
AECOM BH54 / MW54	3.76E-01	7.28E-01	1.10

Legend

🟨 Risk exceeds target criteria of 1.0

- **Table 5-4 Long-Term Health Risks at Locations where Target Criteria Exceeded**

Location	All Soil Exposure Pathways	All GW Exposure Pathways	Combined Risk for All Exposure Pathways
BH087 / MW015	2.04E-07	5.97E-07	8.01E-07
BH204D / MW204D	1.67E-06	3.36E-07	2.00E-06
MW7_Coffey	7.82E-08	1.03E-06	1.11E-06
AECOM BH54 / MW54	1.50E-06	2.54E-08	1.52E-06

Legend

🟨 Risk exceeds target criteria of 1.0 x 10^{-5}

For the case where the land use of the *Declared Area* is to remain unchanged, the main findings of the SKM risk assessment are:

- No soil at the *Declared Area* poses an unacceptable health risk;
- No groundwater at the *Declared Area* poses an unacceptable long-term health risk;
- Groundwater across practically the whole of the *Declared Area* (95%) does not pose an unacceptable short-term health risk;
- Groundwater poses an unacceptable short-term health risk to an unprotected maintenance worker in a small localised part of the *Declared Area* (5%), with the estimated extent of this area shown in **Figure 5-4**. The area is located at/near buried tar tanks, gasholders, and an abandoned sewerage pump station SPS59.

The AECOM HHERA concluded that soil concentrations within the *Declared Area* represent an unacceptable health risk and recommended that the upper 2 m of soil across the *Declared Area* should be remediated[119]. The results of the SKM risk assessment demonstrate that this conclusion is incorrect for contamination that resulted from the former gasworks operation and that the recommendation is not warranted. The SKM risk assessment found that the available data support the conclusion that no gasworks-impacted soil at the *Declared Area* poses an unacceptable health risk.

However, my analysis of the investigation data indicate there is an unacceptable risk to an unprotected maintenance worker from asbestos contamination in fill at the *Declared Area* due to the results and deficiencies in the investigations conducted to-date (**Section 5.6**). In my

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[119] Executive summary & Section 10.2, AECOM HHERA

opinion, the fill containing building demolition rubble at the *Declared Area* should be regarded as containing asbestos and either managed on-site in a capped area that incorporates the use of a site management plan, or disposed offsite as *Asbestos Waste* at a suitably licensed landfill.

5.8 Ecologically Sustainable Development

The AECOM HHERA does not meet the relevant standards for preparation of a human health risk assessment because it did not follow the principles of ecologically sustainable development, as described in Section 9 of the Contaminated Land Management (CLM) Act (**DOCUMENT 3**). This is because:

- There is no potential user of the *Declared Area* that would be exposed to an unacceptable health risk while the area remains capped and managed;
- There is no "*lack of full scientific certainty*" that should affect the assessment of risks to human health at the *Declared Area*; and
- The precautionary principle has been addressed because a properly conducted risk assessment undertaken by SKM shows there is no threat of serious or irreversible health impacts from gasworks wastes (this excludes asbestos). Consequently, all other principles of ecologically sustainable development have also been met.

In my opinion, the available investigation data together with the results of a detailed health risk assessment undertaken by SKM show there is no potential user of the *Declared Area* that would be exposed to an unacceptable health risk because:

- The NSW State Government has used the *Declared Area* for many years as a public area without their being any concerns regarding human health (**Section 5.1**);
- The site would remain capped by a concrete and asphalt pavement and managed (**Section 5.1**);
- The AECOM HHERA found there was no unacceptable risk to recreational users of the site;
- It is reasonable to assume that a maintenance worker undertaking trenching work would be required to undertake their work in a safe manner and be appropriately protected (**Section 5.1**);
- SKM undertook a detailed health risk assessment in accordance with current standards;
- Even a risk assessment that considered an unprotected maintenance worker would find that no gaswork-impacted soil poses an unacceptable health risk, no groundwater poses an unacceptable long-term health risk, and groundwater across practically the whole of the *Declared Area* (95%) does not pose an unacceptable short-term health risk. In my opinion, the short-term health risks posed by groundwater at the localised hot-spot do not represent an unacceptable health risk because:

- There are likely to be few old buried services in this small area that would require maintenance in the future;
- New services could be constructed to avoid the hot-spot area; and
- New services that may need to be constructed in the area could be constructed in the dry (above the water table) at depths less than 1.5 m.

In my opinion, there is no "*lack of full scientific certainty*" that should affect the assessment of risks to human health at the *Declared Area* because:

- Of the reasons given in the previous paragraph;
- The *Declared Area* and adjacent land have been extensively investigated between 2006 and 2012, as shown by the large number of boreholes and groundwater monitoring wells located across the site (**Figure 4-1**) and the large number of investigation reports that have been prepared. This conclusion is supported by the comment made by Chris Jewell, who stated in his 10 January 2011 affidavit (paragraph 57) that "*intensive investigations*" have been undertaken at the site;
- The SKM detailed health risk assessment follows a methodology given in the latest NSW and Australian guidelines;
- Conservative estimates of contaminant concentrations have been used based on maximum concentrations measured at each investigation location; and
- Uncertainty with regard to the spilt between aliphatic and aromatic petroleum hydrocarbons has been addressed by calculating upper and lower bound solutions.

Yours sincerely

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APPENDIX A
ASSESSMENT OF ASBESTOS CONTAMINATION AT THE DECLARED AREA & SURROUNDING LAND

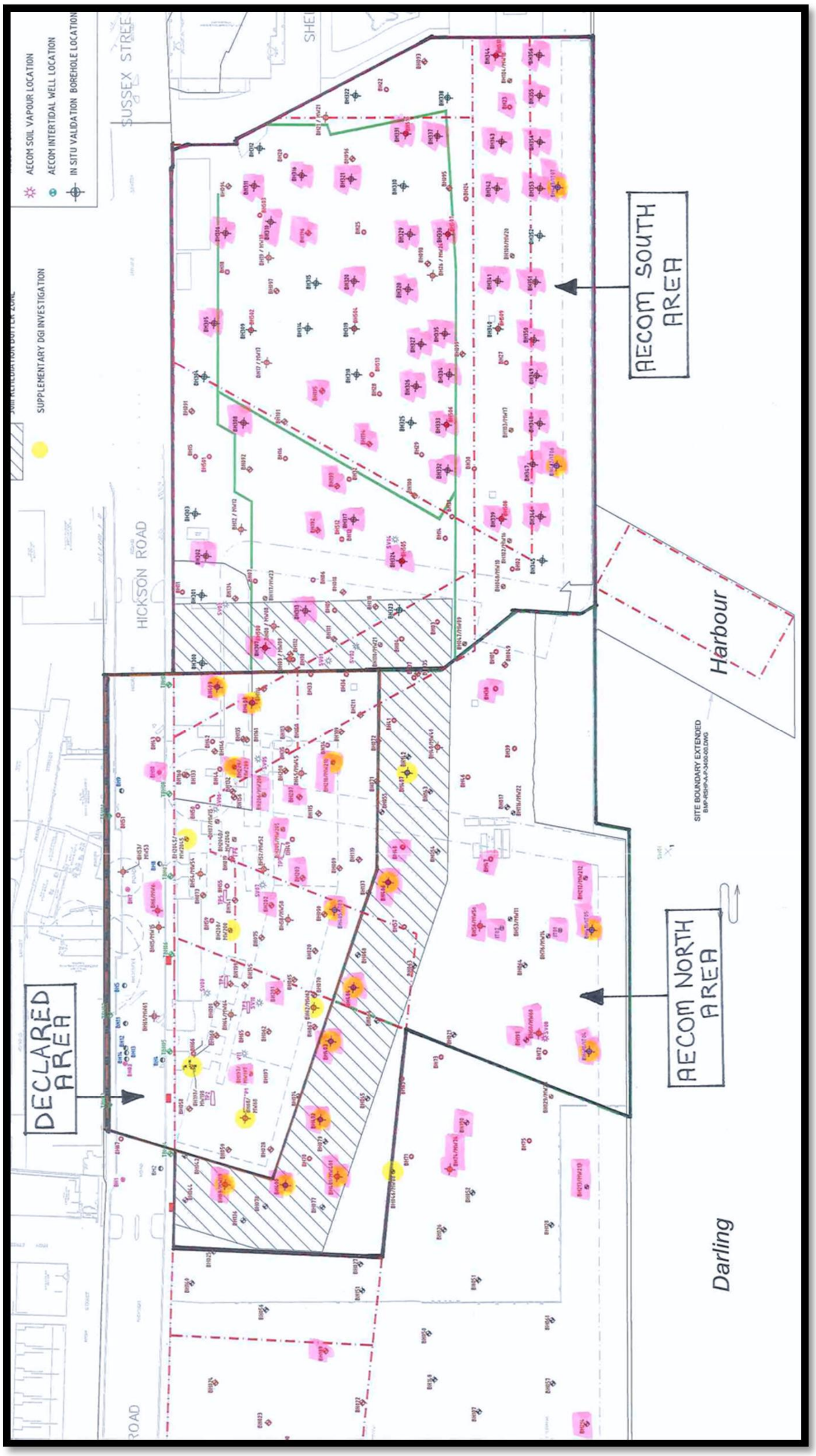
The data available to the AECOM HHERA indicate that the frequency of asbestos identification at the *Declared Area* was not low because:

- The investigation data indicate that 27 % of fill samples that contained building demolition rubble (as indicated by brick fragments) detected asbestos or UMF. This proportion increased to 33 % at the "*Declared Area*". This is a high frequency of detection, particularly for samples that were collected by drilling. A summary of these investigation data is provided in **Table A-1**;
- Most of the soil samples selected for asbestos laboratory testing did not contain building demolition rubble (such as the presence of brick fragments). This is despite the borehole logs showing large amounts of fill containing building demolition rubble is present at the Barangaroo site, as shown by the data presented in **Figure A-1**. This meant that the laboratory results obtained by the investigations were unrepresentative of much of the fill present at the site and there is a high risk that more asbestos contamination is present than indicated by the investigations;
- AECOM relied on identifying the presence of asbestos from borehole data, which is not a reliable technique for identifying the presence of asbestos fragments below the ground surface. Test pitting would have been a much better approach because the amount of soil exposed is many times greater. Very few test pits were used to assess the presence of asbestos in soils at Barangaroo; and
- Excavation work undertaken at Barangaroo south of the *Declared Area* found asbestos contamination that caused the site work to be temporarily shut down and an investigation to be undertaken by the NSW EPA [**DOCUMENTS A-1 & A-2**].

- **Table A-1 Summary of Asbestos Test Data for the Declared Area and the AECOM North and South Areas**

	Number of Soil Sample Locations				Proportion of Locations	
Area	Fill Tested for Asbestos	Brick Fragments Found in Fill	Asbestos / UMF Detected	Containing Brick Fragments & Asbestos/UMF	Brick fragments present in samples where asbestos/UMF detected	Asbestos/UMF found in Fill containing brick fragments
DA	16	6	2	2	**100%**	**33%**
AECOM North	14	10	4	4	**100%**	**40%**
AECOM South	47	14	4	2	**50%**	**14%**
Totals	77	30	10	8	**80%**	**27%**

- **Figure A-1 Borehole Locations where Fill Contains Building Demolition Rubble**



DOCUMENT (A-1) – Sydney Morning Herald 11 April 2012 Article

2 NEWS WEDNESDAY, APRIL 11, 2012 smh.com.au

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Jessica Irvine

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Barangaroo work stops as asbestos discovered

Anna Patty
STATE POLITICS

CONSTRUCTION work at the Barangaroo site in Sydney has stopped in response to the discovery of asbestos on the site which is near a childcare centre and the King Street Wharf area.

The Construction Forestry Mining and Energy Union said yesterday it had learnt there had been 13 other asbestos discoveries since the construction project began.

The CFMEU state secretary, Brian Parker, said the 150 workers on the site would not resume duties until they were satisfied all asbestos had been identified and removed.

He expected the site would be closed for the foreseeable future and said members of the public may also have been exposed to asbestos fibres. He said they could also have blown across the road to a nearby childcare centre.

Mr Parker said that despite the reports of asbestos, the construction site manager, Bovis Lend Lease, had not alerted workers about the possible health risk. He said it was likely the site would remain closed to workers for some time.

"Not one bit of training has been provided to anyone on site about the dangers of dealing with asbestos, despite the fact that management knew it had been found," he said.

"There wasn't even a safety committee established on the job.

"We will now need all 150 workers to undergo lung function tests and X-rays. We know how deadly this stuff is.

"The union is of course deeply concerned about the dangers posed to workers, but the broader community has the right to be asking questions as well.

"On a high-wind day like today there is a real chance that dust from the site could blow all the way up to King Street Wharf."

Workers will meet today at 7am to discuss their response to the asbestos findings.

Lend Lease's group head of development, David Hutton, said safety was Lend Lease's "highest priority" and any contamination at the Barangaroo South site would be remedied.

"The company has procedures in place to ensure the safety of the workforce, surrounding community and environment," Mr Hutton said.

"Sampling over the past five years showed small traces of isolated, historically buried asbestos material at the site.

"As part of our government-approved remediation action plan we have carried out further testing.

"When asbestos has been found in a small number of excavation locations we closed and quarantined those areas and brought in accredited occupational hygienists to approve, oversee and validate the removal of any asbestos in accordance with WorkCover regulations."

Mr Hutton said as part of the on-site induction process all workers were informed about the dangers of materials such as asbestos being uncovered during excavations.

"Currently we have static monitoring devices around the site, as well as personal monitoring devices, checking air quality for asbestos," he said.

"No traces of asbestos have been found in the air nor have we found any evidence of exposure risk to workers or the community."

A report commissioned by the NSW Environmental Defender's Office, by the chemical engineer Wayne Davies reported last year that it would take at least 30 years to get rid of a plume of toxic chemicals from the $6 billion Barangaroo development.

DOCUMENT (A-2) – NSW EPA 18 April 2012 Press Release

You are here: Home > About us

EPA report shows asbestos found at Barangaroo site is being appropriately managed

Media release: 18 April 2012

Following reports of potential exposure to workers and other nearby residents of airborne asbestos last week, the Environment Protection Authority (EPA) has conducted inspections of the Barangaroo construction site and today issued Lend Lease with a report about its findings.

The report states that management of asbestos on site was being appropriately handled and that on site air monitoring data, conducted for OH&S purposes, had showed no sign of asbestos fibres.

Acting Chief Environmental Regulator for the EPA, Mark Gifford, said that the purpose of the inspection was to determine whether or not Lend Lease had been compliant with EPA requirements relating to the handling and management of asbestos.

"EPA acted quickly late last week in response to reports of asbestos at the Barangaroo site, sending EPA officers on site to inspect the process, handling, movement and storage of any materials and substances that may contain traces of asbestos.

"Our officers inspected the site where small quantities of asbestos had been found last week and reported that the area had been properly fenced off, signage erected and air monitors in place.

"The asbestos was removed from the site and appropriately disposed of.

"Lend Lease is currently constructing a retention wall, piling and undertaking archaeological investigations on the Barangaroo site. The discovery of asbestos material was not completely unexpected and was covered in their remediation plan," Mr Gifford said.

"Lend Lease has been cooperative with our enquiries and investigations.

"The EPA will continue to monitor activities at the site," he said.

Contact: Liza Cassidy

Page last updated: 18 April 2012

APPENDIX B

SUMMARY OF LABORATORY TEST RESULTS 2007 - 2012 GROUNDWATER MONITORING WELLS SCREENED IN FILL LAYER BETWEEN DECLARED AREA & DARLING HARBOUR

						Low MW PAHs						High MW PAHs										
						Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)&(k) fluoranthene	Benzo(b) fluoranthene	Benzo(g,h,i) perylene	Benzo(k) fluoranthene	Chrysene	Dibenz(a,h) anthracene	Indeno(1,2,3-c,d) pyrene	Fluoranthene	Pyrene
Unit						µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
AECOM MWQC (16 August 2012)						5.8	5.8	0.1	3	70	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1	0.1
Location Code	Field ID	Sampled Date	Type	Filtered/ unfiltered	Monitoring Unit																	
BH046	MW08	16/08/2007	high flow	unfiltered	fill	4.6	2	4.9	2.9	49.5	7.4	2.6	3.1		2.2	1.6	1.6	2.2	<1	1.4	6	6.1
BH046	MW08	7/05/2008	high flow	unfiltered	fill	6.1	1.3	3.1	4.2	37.6	5.5	<1	0.6		<1	<1	<1	<1	<1	<1	2.8	2.4
BH046	MW08	16/03/2010	low flow	unfiltered	fill	2	<0.5	1	2	13	3	<0.5	<0.5	<1		<0.5		<0.5	<0.5	<0.5	1	1
BH046	MW08	28/02/2011	low flow	unfiltered	fill	2.1	<1	1.9	2.2	7.9	3.1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH046	MW08	28/02/2011	low flow	filtered	fill	0.7	0.3	0.4	<0.1	9.7	<0.1	<0.1	<0.05		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BH047	MW09	15/08/2007	high flow	unfiltered	fill	<1	<1	<1	<1	16.4	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH047	MW09	9/05/2008	high flow	unfiltered	fill	<1	<1	<1	<1	<1	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH047	MW09	15/03/2010	high flow	unfiltered	fill	<1	<1	<1	<1	<1	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH048	MW10	15/08/2007	high flow	unfiltered	fill	<1	<1	<1	<1	10.8	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH048	MW10	8/05/2008	high flow	unfiltered	fill	<1	<1	<1	<1	<1	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH048	MW10	12/03/2010	high flow	unfiltered	fill	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BH53	MW11	14/07/2006	high flow	unfiltered	fill	<1	1.5	<1	1.6	2.8	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	2.2	1.9
BH53	MW11	14/08/2007	high flow	unfiltered	fill	<1	<1	<1	<1	<1	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	1.7	2.2
BH76	MW14	14/08/2007	high flow	unfiltered	fill	<1	<1	<1	<1	<1	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH76	MW14	7/05/2008	high flow	unfiltered	fill	<1	<1	<1	<1	<1	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH76	MW14	16/03/2010	low flow	unfiltered	fill	<2	<2	<2	<2	<2	<2	<2	<2	<4		<2		<2	<2	<2	<2	<2
BH116	MW22	15/08/2007	high flow	unfiltered	fill	<1	<1	<1	<1	29.6	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH116	MW22	7/05/2008	high flow	unfiltered	fill	<1	<1	<1	<1	<1	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH116	MW22	15/03/2010	low flow	unfiltered	fill	<2	<2	<2	<2	<2	<2	<2	<2	<4		<2		<2	<2	<2	<2	<2
BH129	MW24	15/08/2007	high flow	unfiltered	fill	<1	<1	<1	<1	7.6	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH129	MW24	6/05/2008	high flow	unfiltered	fill	<1	<1	<1	<1	<1	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH129	MW24	16/03/2010	low flow	unfiltered	fill	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1		<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
BH212	MW212	5/8/2008 & 5/12/2008	high flow	unfiltered	fill	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BH213	MW213	8/05/2008	high flow	unfiltered	fill	<1	<1	<1	<1	<1	<1	<1	<0.5		<1	<1	<1	<1	<1	<1	<1	<1
BH213	MW213	16/03/2010	low flow	unfiltered	fill	<2	<2	<2	<2	<2	<2	<2	<2	<4		<2		<2	<2	<2	<2	<2
BH74	MW74	18/03/2010	low flow	unfiltered	fill	1	<0.9	1	1	4	4	1	<0.9	<2		<0.9		<0.9	<0.9	<0.9	3	3
IT1	IT1_SHALLOW	25/03/2010	high flow	unfiltered	fill	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<2		<0.9		<0.9	<0.9	<0.9	<0.9	<0.9
IT1	IT1_MID	24/03/2010	high flow	unfiltered	fill	6	10	6	11	16	20	7	7	12		3		7	<1	2	13	14
IT2	IT2_SHALLOW	24/03/2010	high flow	unfiltered	fill	1	<1	<1	<1	<1	<1	<1	<1	<2		<1		<1	<1	<1	1	<1
IT2	IT2_MID	24/03/2010	high flow	unfiltered	fill	6	2	2	5	41	10	<1	<1	<2		<1		<1	<1	<1	2	2
BH410	IT04S	19/05/2011	high flow	unfiltered	fill	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BH410	IT04S	19/05/2011	high flow	filtered	fill	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BH411	IT05S	19/05/2011	high flow	unfiltered	fill	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BH411	IT05S	19/05/2011	high flow	filtered	fill	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BH411	IT05M	19/05/2011	high flow	unfiltered	fill	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BH411	IT05M	19/05/2011	high flow	filtered	fill	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

						TPH				BTEX						Phenols	Cyanide			Ammonia	
						TPH C6 - C9	TPH C10-C14	TPH C15 - C28	TPH C29 - C36	Benzene	Ethylbenzene	Toluene	Xylene (m & p)	Xylene (o)	Total Xylenes	Phenol	WAD Cyanide	Cyanide (free)	Cyanide (Total)	Ammonia	Ammonia (as N)
					Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
					AECOM MWQC (16 August 2012)	110	40	100	50	700	80	180	75	350		400	4	4	4	4830	4830
Location Code	Field ID	Sampled Date	Type	Filtered/ unfiltered	Monitor-ing Unit																
BH046	MW08	16/08/2007	high flow	unfiltered	fill	<20	1490	8300	1660	4	3	<2	4	3	7	2.2			<4	16300	
BH046	MW08	7/05/2008	high flow	unfiltered	fill	<20	1070	4300	960	2	3	<5	2	2	4	<1			<4	12400	
BH046	MW08	16/03/2010	low flow	unfiltered	fill	20	950	3190	350	7	<2	<5	<2	2	3	<0.5	6	<4			
BH046	MW08	28/02/2011	low flow	unfiltered	fill	<20	560	2110	160	6	2	<5	2	2	4	<1	<4	<4			
BH046	MW08	28/02/2011	low flow	filtered	fill											2.3					
BH047	MW09	15/08/2007	high flow	unfiltered	fill	<20	<50	<100	<50	1	<2	<2	2	<2	3	<1			<4	<100	
BH047	MW09	9/05/2008	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<1			<4	<100	
BH047	MW09	15/03/2010	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<1	<4	<4		<100	
BH048	MW10	15/08/2007	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	2	<2	3	<1			<4	<100	
BH048	MW10	8/05/2008	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<1			<4	<15	
BH048	MW10	12/03/2010	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<1	<4	<4		<100	
BH53	MW11	14/07/2006	high flow	unfiltered	fill	<20	<50	200	<50	<1	<2	<2	<2	<2	<4						
BH53	MW11	14/08/2007	high flow	unfiltered	fill	<20	50	700	140	<1	<2	<2	<2	<2	<4	<1			<4	6050	
BH76	MW14	14/08/2007	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<2	<2	<2	<4	<1			<4	1070	
BH76	MW14	7/05/2008	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<2	<2	<2	<4	<1			9.3	144	
BH76	MW14	16/03/2010	low flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<2	6	<4			
BH116	MW22	15/08/2007	high flow	unfiltered	fill	40	280	2100	520	4	4	5	6	4	10	<1			<4	47	
BH116	MW22	7/05/2008	high flow	unfiltered	fill	30	100	200	<50	2	<2	<5	<2	<2	<4	<1			<4	1240	
BH116	MW22	15/03/2010	low flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<2					2700
BH129	MW24	15/08/2007	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<1			<4	<100	
BH129	MW24	6/05/2008	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<1			<4	138	
BH129	MW24	16/03/2010	low flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<0.5	<4	<4			
BH212	MW212	5/8/2008 & 5/12/2008	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<1			<4	<15	
BH213	MW213	8/05/2008	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<1			<4	<15	
BH213	MW213	16/03/2010	low flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<2	<4	<4			
BH74	MW74	18/03/2010	low flow	unfiltered	fill	<20	<50	280	140	<1	<2	<5	<2	<2	<4	<0.9	<4	<4			
IT1	IT1_SHALLOW	25/03/2010	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<4	<0.9	7	<4		<100	
IT1	IT1_MID	24/03/2010	high flow	unfiltered	fill	<20	100	900	450	<1	<2	<5	<2	<2	<4	<1	85	37		<100	
IT2	IT2_SHALLOW	24/03/2010	high flow	unfiltered	fill	40	<50	240	90	2	<2	20	<2	<2	<4	<1	<4	<4		<100	
IT2	IT2_MID	24/03/2010	high flow	unfiltered	fill	30	210	3580	320	3	<2	<5	<2	<2	<4	2	<4	<4		9260	
BH410	IT04S	19/05/2011	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<2	<0.1	<4	<4			<100
BH410	IT04S	19/05/2011	high flow	filtered	fill	<20	<50	<100	<50	<1	2	<5	<2	<2	<2	<0.1	<4	<4			<100
BH411	IT05S	19/05/2011	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<2	<0.1	<4	<4			<100
BH411	IT05S	19/05/2011	high flow	filtered	fill	<20	<50	<100	<50	<1	2	<5	<2	<2	<2	0.3	<4	<4			<100
BH411	IT05M	19/05/2011	high flow	unfiltered	fill	<20	<50	<100	<50	<1	<2	<5	<2	<2	<2	<0.1	<4	<4			<100
BH411	IT05M	19/05/2011	high flow	filtered	fill	<20	<50	<100	<50	<1	3	<5	<2	<2	<2	0.2	<4	<4			<100

APPENDIX C
REVIEW OF HEALTH RISK ASSESSMENTS & REMEDIATION STRATEGIES FOR PROPERTIES ADJACENT TO THE DECLARED AREA

C-1 36 Hickson Road

Part of the former gasworks site forms the property at 36 Hickson Road, which is located outside and to the east of the *Declared Area*. Several buried structures from the former gasworks operation remain in this area consisting of part of the main gasholder, another small gasholder and a tar tank. A site layout plan showing these features is provided in **Figure C-1**.

Investigations found the land to be contaminated by gaswork wastes similar to the *Declared Area*, which included the presence of liquid tar at the base of the buried structures[120]. The highest level of groundwater contamination was measured at well MW34B[121] located on the eastern side of the site (**Figure C-1**). Groundwater at this location was found to exceed the Site Specific Target Criteria (SSTC) derived by the AECOM HHERA[122], with the exceedances and criteria being:

- TPH C10 – C14 = 209 mg/L (AECOM SSTC = 21 mg/L)
- Benzene = 25.2 mg/L (AECOM SSTC = 3.4 mg/L)
- Naphthalene = 45.2 mg/L (AECOM SSTC = 29 mg/L)

A human health risk assessment was performed by the environmental consultant URS for the properties at 30 – 36 Hickson Road, with the results documented in a report dated 31 May 2002[123]. Some of the key features of the human health risk assessment were:

- Health risks were assessed for the case where it would be used as an open plaza for public access and commercial land use[124], which is similar to the current land use of the *Declared Area*;
- The methodology was based on guidelines provided by the NEPM, NSW EPA, ANZECC, NHMRC, USEPA and WHO[125];

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[120] Sections 2.6 & 3.1, URS (31 May 2002); Sections 2.5 & 2.7, URS (9 October 2003)

[121] Tables 3A – 3C, URS (9 Oct 2003)

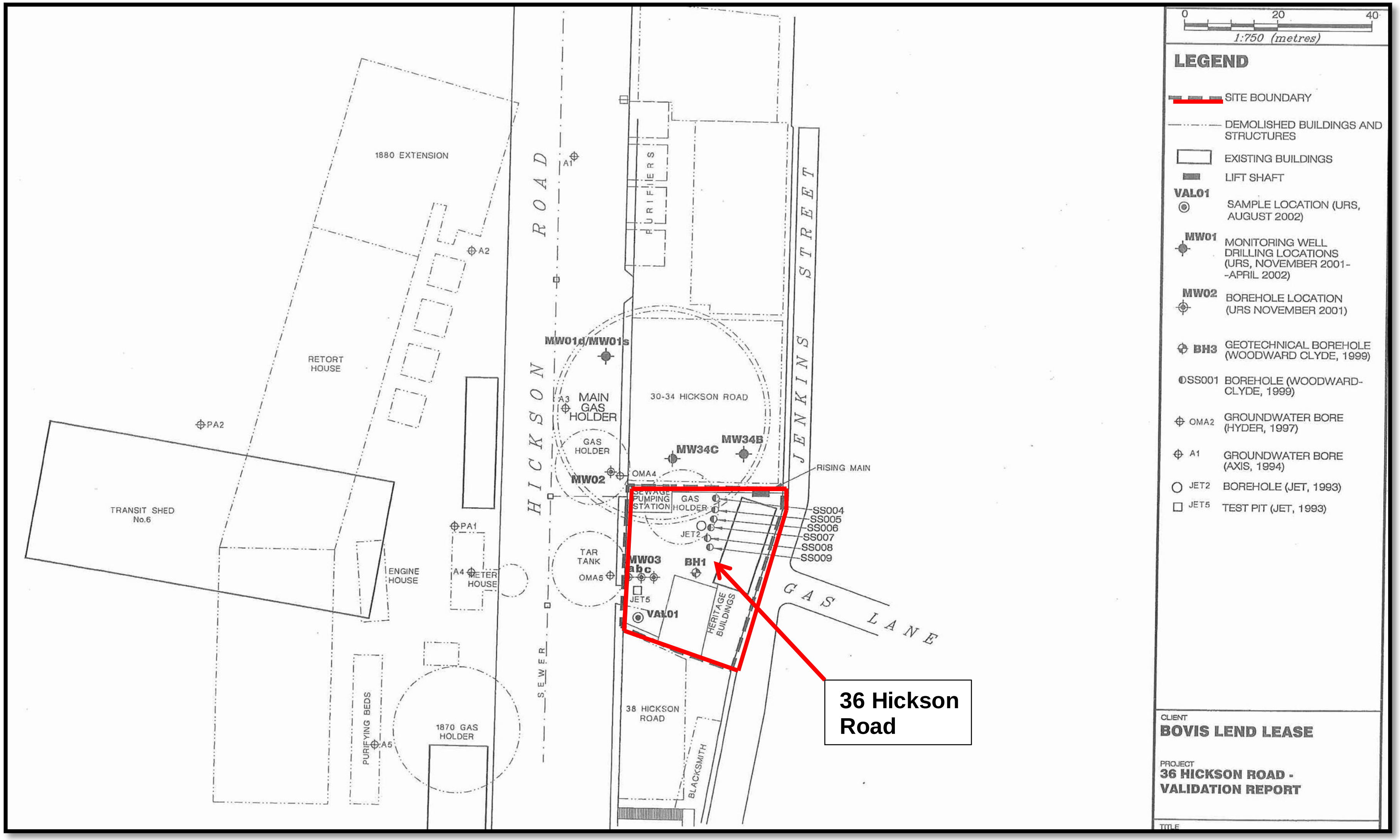
[122] Table 23, AECOM HHERA

[123] URS (31 May 2002) "*Risk Assessment, Bovis Lend Lease, Hickson Road, Millers Point*". Prepared for Bovis Lend Lease

[124] Sections 1.1 & 6, URS (31 May 2002); Sections ES5 & 2.1.4, URS (9 October 2003)

[125] Section 1.3.1, URS (31 May 2002); Section 2.8.1, URS (9 Oct. 2003)

- **Figure C-1 Site Layout Plan for 36 Hickson Road** (Source: Figure 2, URS (9 Oct. 2003))



36 Hickson Road

- Two potential human receptors were identified as having a potential to be exposed to an unacceptable health risk, these being an on-site employee and a maintenance / construction worker working in a confined space[126]. Examples of the type of work that a maintenance worker may undertake were within a trench, below the floor of the plaza development or in a lift shaft;
- The health risk assessment identified other potential human receptors at the site, these being visitors, short-term employees and off-site residents. However, URS considered the potential for exposure to these groups would be significantly less and was not considered further by the assessment;
- The health risk assessment considered there to be only one main exposure pathway of concern to an on-site employee and a maintenance / construction worker, which was the inhalation of vapours given off by buried contamination. For an on-site employee, these vapours may occur within the general work area of the outdoor plaza or partially covered areas of the plaza. For the maintenance / construction worker, these vapours may occur within trenches, lift shaft or beneath the plaza floor; and
- Risks associated with potential direct contact with the gasworks contaminants at the site were considered to be insignificant[127]. For the case of maintenance / construction workers, this was because:
  - The contamination was below the level of the proposed plaza (ie below ground level); and
  - Construction or intrusive works would be undertaken in accordance with responsibilities under the relevant Occupational Health and Safety Act, which would ensure such work would be carried out under an appropriate site health and safety plan.

The risk assessment was based on fluxhood vapour tests taken from 6 sampling points, with 5 located at the 36 Hickson Road property (S1, S2, S4, S5 & S6) and the other located near the centre of the main gasholder area[128]. These locations are shown in **Figure C-2**. The risk assessment advised that it adopted reasonable maximum exposure (RME) parameters[129].

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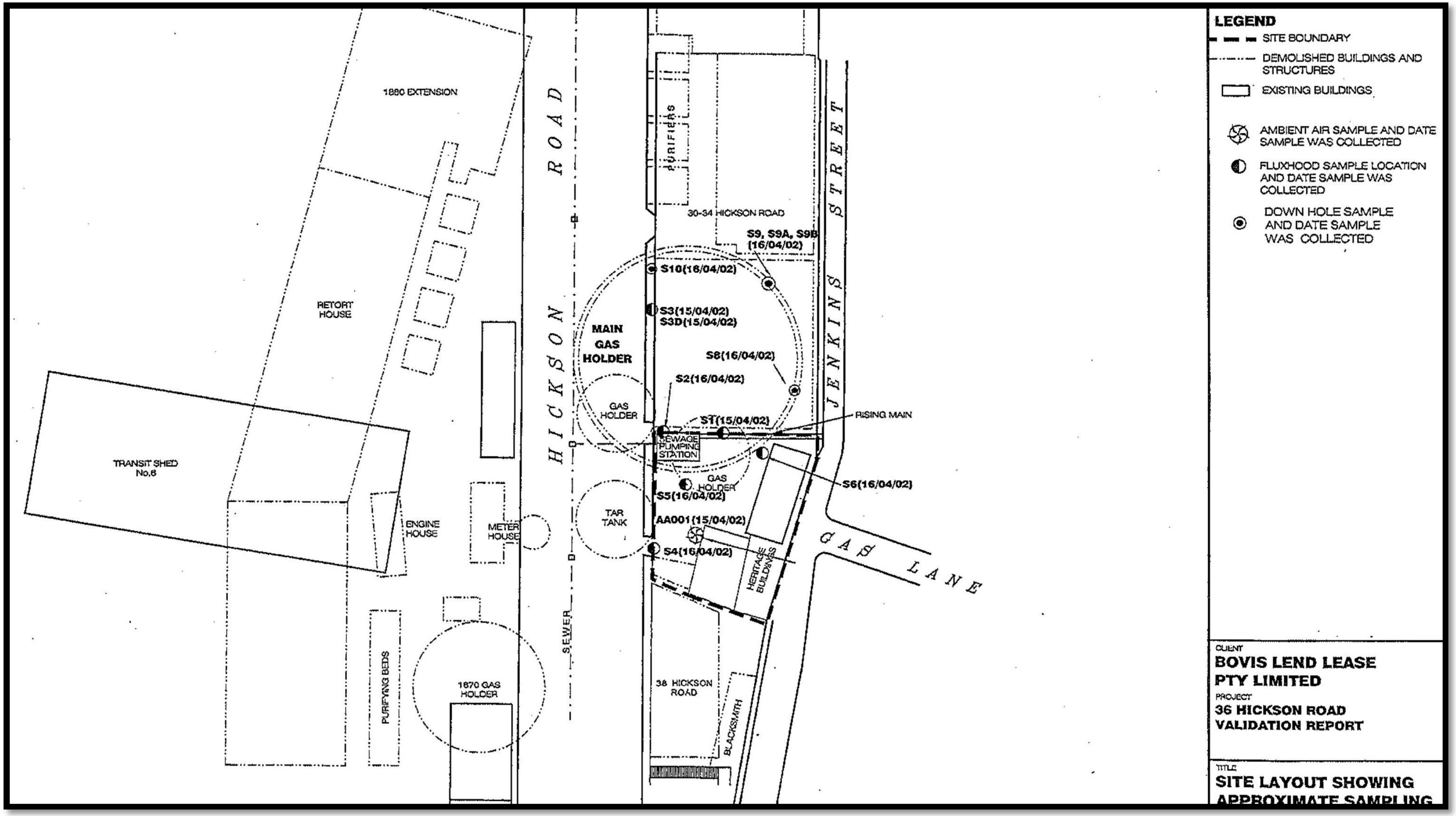
[126] Section 4.1.3, URS (31 May 2002); Section 2.8.1, URS (9 Oct 2003)

[127] Section 4.1.3, URS (31 May 2002)

[128] Section 3.2.3, URS (31 May 2002)

[129] Section 4.1.5, URS (31 May 2002)

- **Figure C-2 Location of Fluxhood Vapour Sample Locations** (Source: Figure 3, URS (9 Oct. 2003))



The results of the URS health risk assessment were summarised in URS Tables 4.3 and 4.4 (**DOCUMENT C-1**). The URS assessment found that the highest health risks were associated with the maintenance / construction worker, but the risks were calculated to be acceptable and below the acceptance criteria. The results were[130]:

- Short-term (threshold) risk = 0.22 < 1.0 (Acceptance criteria)
- Long – term (non-threshold) risk = $1.2 \times 10^{-6} < 1.0 \times 10^{-5}$ (Acceptance criteria).

The URS health risk assessment concluded[131] that, since the calculated risks were less than the acceptance criteria, it is unlikely that the contamination remaining beneath 36 Hickson Road poses a significant risk of harm to human health for the proposed open space / commercial land use. URS further concluded[132] that "*the residual contamination that would remain beneath the proposed development represented a negligible risk to human health*".

The results of the health risk assessment were used by URS to justify the adoption of a capping strategy for the remediation of 36 Hickson Road, with details of the remediation work completed at this property documented in a URS report dated 9 October 2003[133].

The URS remediation report advised[134] that for the site at 36 Hickson Road and following consideration of the NSW EPA policy regarding the hierarchy of remediation options:

- Capping the contaminated material represented the most appropriate remediation strategy;
- Capping the contaminated material would pose no risk of harm to human health;
- The potential for residual contamination at the site to adversely affect the water quality of Darling Harbour was negligible, and there was no unacceptable risk to the environment from groundwater contaminants;
- A Site Management Plan (SMP) be developed that outlines the measures that should be taken during any future intrusive and excavation works that may take place at the site. The objective of the SMP should be "*to provide a framework for the management of potentially contaminated materials that are to be retained on-site, in particular in the area of the former gas-holder annulus and former small gas-holder located in the northern part of the site, in the area of the former tar tank which encroaches onto the western boundary of the site, and in the area of the sewage pumping station. The SMP includes procedures for current and future site workers to ensure contact with the contaminated fill and/or soils*

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[130] Section 4.4.2, URS (31 May 2002)

[131] Section 6.0, URS (31 May 2002)

[132] Section ES2.5, URS (9 October 2003)

[133] URS (9 October 2003) "*Remediation and Validation Report, 36 Hickson Road, Millers Point, NSW*". Prepared for Bovis Lend Lease

[134] Sections ES3.3, ES3.3.2, ES5 & 6.0, URS (9 October 2003)

during any maintenance of the site is in accordance with strict Occupational, Health and Safety (OH&S) and environmental controls. This includes the identification of potential worker exposure pathways and methods for minimising worker's exposure to the contaminated fill and/or soils."; and

- The site is suitable for the intended commercial land use, which includes an open plaza area for public access.

The available documentation indicates that a Site Auditor and the NSW EPA reviewed and accepted the HHERA and remediation / validation reports prepared by URS for 36 Hickson Road. This is indicated by statements made by URS[135], statements made in the AECOM (16 August 2012) HHERA[136] and the NSW EPA issued a "*Notice to end significantly contaminated land declaration and management order*" for 36 Hickson Road on 24 August 2009 (**DOCUMENT C-2**). The site no longer has any NSW EPA notices.

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[135] Sections 1.2, 2.8, 5.2.1 & Appendix B1, URS (9 October 2003)

[136] Executive Summary, Sections 4.1, 5.4.4 & 10.1, AECOM HHERA

DOCUMENT (C-1) – Tables 4.3 and 4.4 from URS (31 May 2002) HHERA

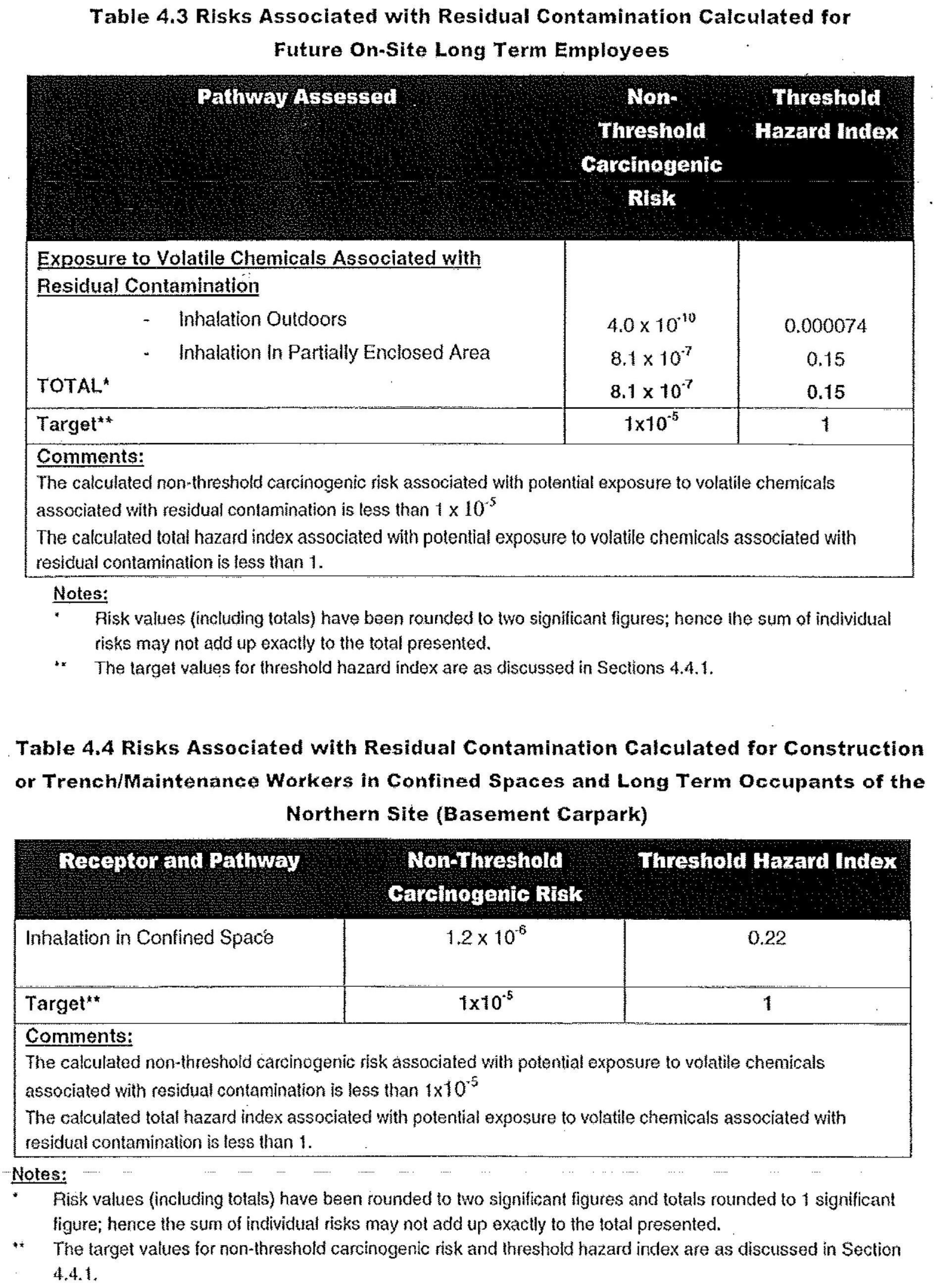


Table 4.3 Risks Associated with Residual Contamination Calculated for Future On-Site Long Term Employees

Pathway Assessed	Non-Threshold Carcinogenic Risk	Threshold Hazard Index
Exposure to Volatile Chemicals Associated with Residual Contamination		
- Inhalation Outdoors	4.0×10^{-10}	0.000074
- Inhalation In Partially Enclosed Area	8.1×10^{-7}	0.15
TOTAL*	8.1×10^{-7}	0.15
Target**	1×10^{-5}	1
Comments: The calculated non-threshold carcinogenic risk associated with potential exposure to volatile chemicals associated with residual contamination is less than 1×10^{-5} The calculated total hazard index associated with potential exposure to volatile chemicals associated with residual contamination is less than 1.		

Notes:

* Risk values (including totals) have been rounded to two significant figures; hence the sum of individual risks may not add up exactly to the total presented.

** The target values for threshold hazard index are as discussed in Sections 4.4.1.

Table 4.4 Risks Associated with Residual Contamination Calculated for Construction or Trench/Maintenance Workers in Confined Spaces and Long Term Occupants of the Northern Site (Basement Carpark)

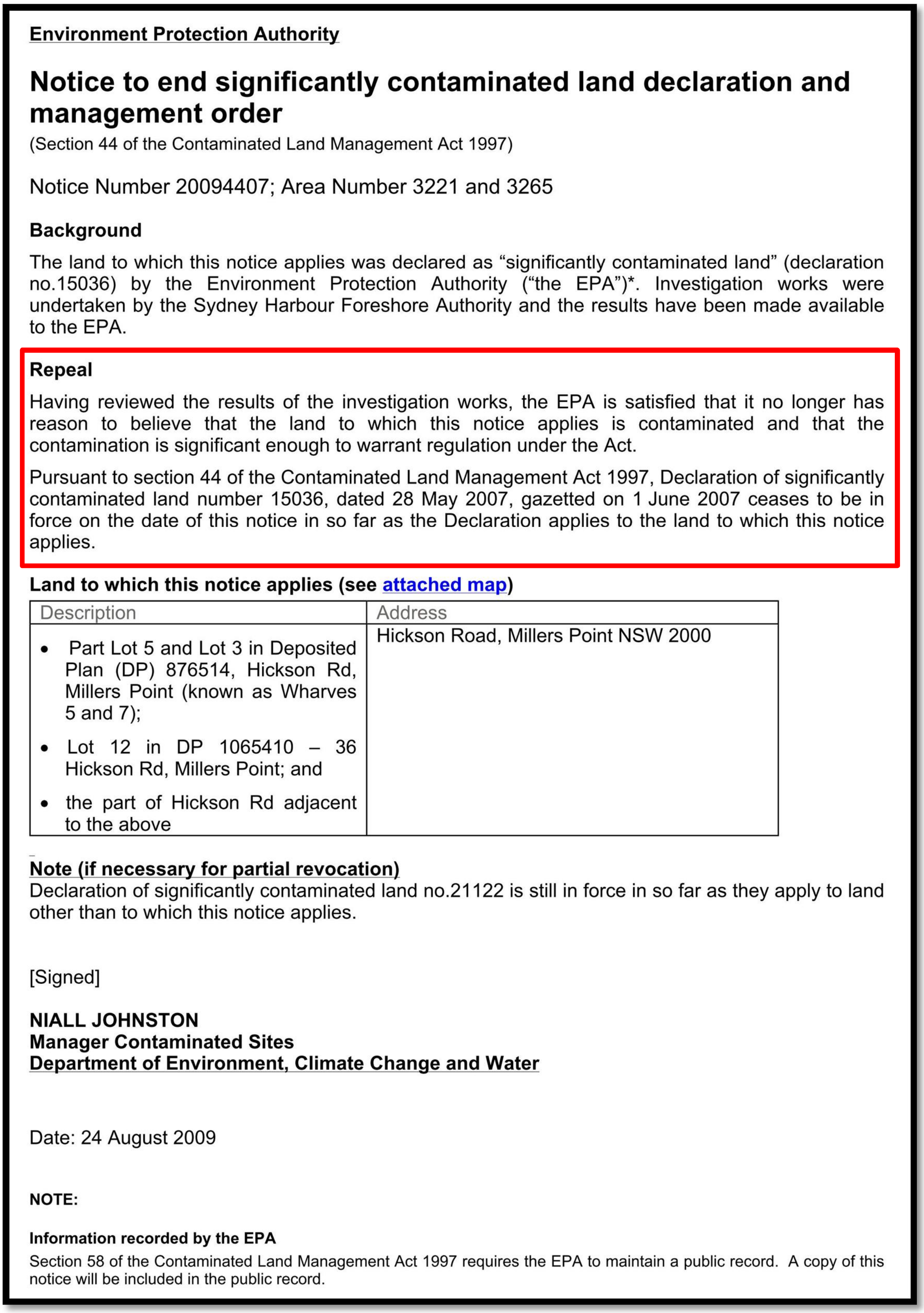
Receptor and Pathway	Non-Threshold Carcinogenic Risk	Threshold Hazard Index
Inhalation in Confined Space	1.2×10^{-6}	0.22
Target**	1×10^{-5}	1
Comments: The calculated non-threshold carcinogenic risk associated with potential exposure to volatile chemicals associated with residual contamination is less than 1×10^{-5} The calculated total hazard index associated with potential exposure to volatile chemicals associated with residual contamination is less than 1.		

Notes:

* Risk values (including totals) have been rounded to two significant figures and totals rounded to 1 significant figure; hence the sum of individual risks may not add up exactly to the total presented.

** The target values for non-threshold carcinogenic risk and threshold hazard index are as discussed in Section 4.4.1.

DOCUMENT (C-2) – NSW EPA (24 August 2009) Notice for 36 Hickson Road



Environment Protection Authority

Notice to end significantly contaminated land declaration and management order

(Section 44 of the Contaminated Land Management Act 1997)

Notice Number 20094407; Area Number 3221 and 3265

Background

The land to which this notice applies was declared as "significantly contaminated land" (declaration no.15036) by the Environment Protection Authority ("the EPA")*. Investigation works were undertaken by the Sydney Harbour Foreshore Authority and the results have been made available to the EPA.

Repeal

Having reviewed the results of the investigation works, the EPA is satisfied that it no longer has reason to believe that the land to which this notice applies is contaminated and that the contamination is significant enough to warrant regulation under the Act.

Pursuant to section 44 of the Contaminated Land Management Act 1997, Declaration of significantly contaminated land number 15036, dated 28 May 2007, gazetted on 1 June 2007 ceases to be in force on the date of this notice in so far as the Declaration applies to the land to which this notice applies.

Land to which this notice applies (see attached map)

Description	Address
• Part Lot 5 and Lot 3 in Deposited Plan (DP) 876514, Hickson Rd, Millers Point (known as Wharves 5 and 7); • Lot 12 in DP 1065410 – 36 Hickson Rd, Millers Point; and • the part of Hickson Rd adjacent to the above	Hickson Road, Millers Point NSW 2000

Note (if necessary for partial revocation)

Declaration of significantly contaminated land no.21122 is still in force in so far as they apply to land other than to which this notice applies.

[Signed]

NIALL JOHNSTON
Manager Contaminated Sites
Department of Environment, Climate Change and Water

Date: 24 August 2009

NOTE:

Information recorded by the EPA

Section 58 of the Contaminated Land Management Act 1997 requires the EPA to maintain a public record. A copy of this notice will be included in the public record.

C-2 38 Hickson Road

The property at 38 Hickson Road is located to the south-east of the *Declared Area* and close to a tar tank that remains buried in Hickson Road (**Figure 5**). Investigations found the property to have been contaminated by gaswork wastes. The contamination consisted of all fill material overlying bedrock, tar seeps and tar impacted rock along excavation walls and base[137].

The site needed to be remediated in order to make it suitable for a high-rise residential development. The development required the site to be excavated to a depth of 11 m below Hickson Road, in order to allow the construction of a 4-level basement car park. Despite the floor of the basement being located some 11 m below mean sea level, the basement was not designed as a waterproof “tanked” structure but as a free-draining structure that included a groundwater collection and treatment system and blockwork walls. Ventilation of the void space was to be provided together with access panels for maintenance of the groundwater collection system[138].

A human health risk assessment was performed by URS for the site, with the results documented in a report dated 14 April 2003[139]. Some of the key features of the health risk assessment were:

- The objective was to assess the human health risks associated with the presence of hydrocarbon impacted groundwater and associated seeps within the proposed residential development;
- The main receptors of concern were residents, visitors and workers that maintain the groundwater drainage system. There would be no maintenance workers undertaking trenching work at the site;
- The methodology was based on guidelines provided by the NEPM, ANZECC, NHMRC and USEPA[140];
- The risks to all potential receptors were assessed to be low and acceptable. Short-term (non-threshold) risks were all calculated to be less than 1, while long-term (non-threshold) risks were all calculated to be less than 1 x 10^{-5}; and
- The report recommended that all confined space work undertaken by workers maintaining the groundwater drainage system should be conducted under an appropriate OH&S plan[141].

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[137] Section ES2.4, URS (25 June 2003)

[138] Section 2.1.4, URS (25 June 2003)

[139] URS (14 April 2003) “*Supplemental Human Health Risk Assessment, 38 Hickson Road, Millers Point*”. Prepared for Bovis Lend Lease (copy provided in Appendix B, URS (25 June 2003))

[140] Section 1.2, URS (14 April 2003)

[141] Section 7, URS (14 April 2003)

Information on the remediation of the site was provided in a report prepared by URS dated 25 June 2003[142]. Some of the key features of this work were described by URS as follows[143]:

- The remediation strategy was designed and implemented by Bovis Lend Lease;
- All contaminated fill was removed from the site as part of the bulk earthworks requirements for the proposed development. Odorous and discoloured rock encountered during bulk excavations were also removed and disposed off-site;
- Following the completion of bulk excavation works, localised tar seeps encountered along the boundary walls were sealed by grout. Tar seeps encountered below the final basement level were sealed by the concrete floor slab. Tar seeps encountered in the vicinity of the groundwater collection sumps were sealed by the placement of concrete pits;
- Residual fill material and odour rock remaining in the boundary walls were sealed by shotcreting and/or by construction of a concrete blockwork wall; and
- Contaminated groundwater that continued to seep into the site was collected by a drainage system located behind the concrete blockwalls, treated by an on-site water treatment plant and disposed to sewer under a Sydney Water licence. The treatment system is designed for a flow of 1.5 L/sec (90 L/min).

The available data indicate that the remediation strategy used at 38 Hickson Road involved, among other things, the use of:

- Containment to minimise the risk of contaminated groundwater migrating onto the site;
- A long-term management plan to collect, treat and dispose contaminated groundwater; and
- An OH&S plan to ensure maintenance workers are protected.

The available documentation indicates that an accredited Site Auditor reviewed and accepted the HHERA and remediation / validation reports prepared by URS for 38 Hickson Road. This is indicated by statements made in the URS (25 June 2003) report and statements made in the AECOM HHERA[144]. The NSW EPA website also indicates that the site has no present notices issued under the CLM Act. The Declaration of Remediation Site that was issued by the NSW EPA for the *Declared Area* on 6 May 2009 mentions that "*contaminated groundwater is impacting on the surrounding areas including the basement of a residential building adjacent to the site* (presumably 38 Hickson Road), *potentially exposing humans in that building to harmful vapours; however it is currently being effectively controlled.*" (**DOCUMENT C-3**).

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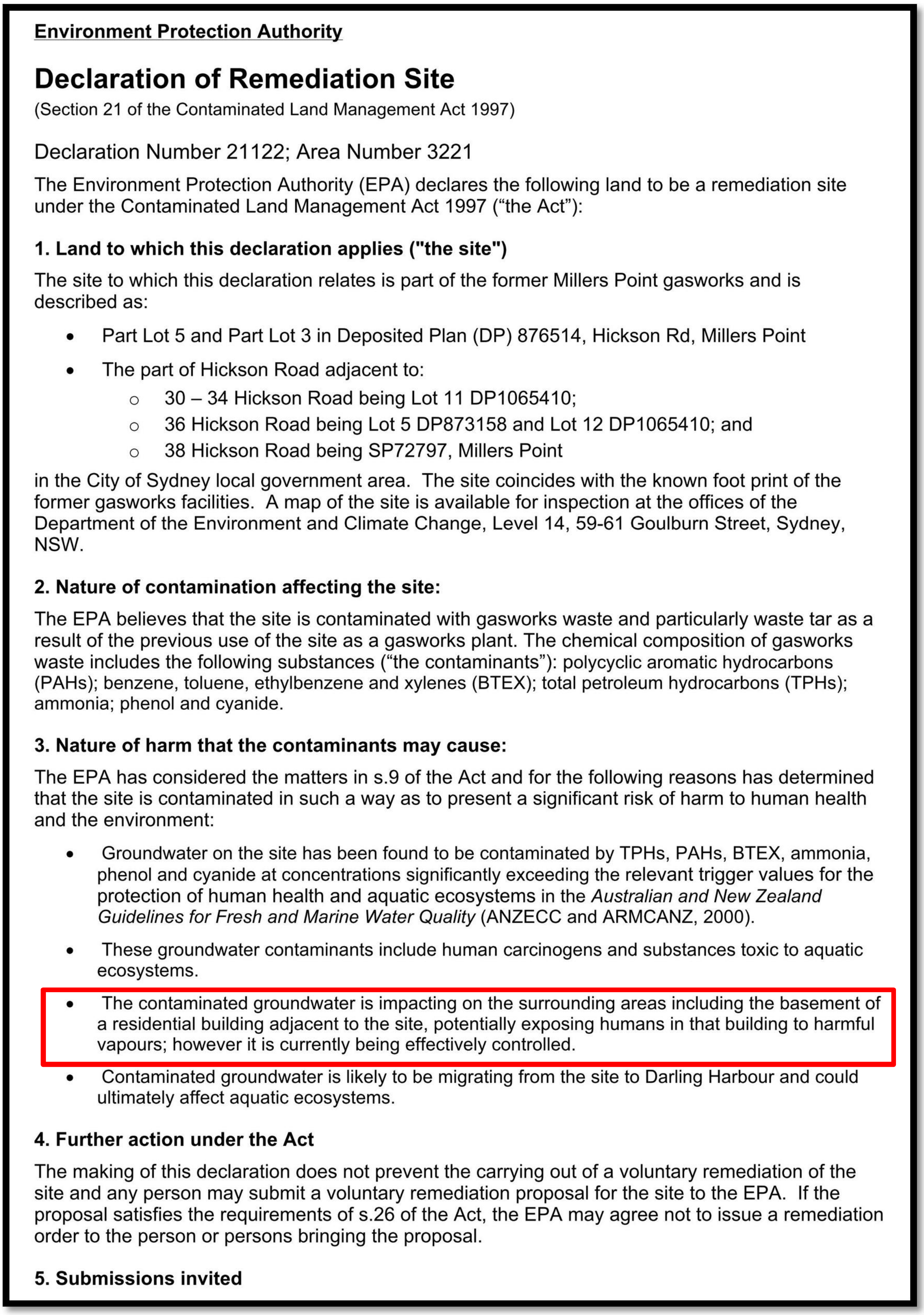
[142] URS (25 June 2003) "*Validation Report, 38 Hickson Road, Millers Point, NSW*". Prepared for Bovis Lend Lease

[143] Section ES3.4, URS (25 June 2003)

[144] Executive Summary, Sections 4.1, 5.4.4 & 10.1, AECOM HHERA

DOCUMENT (C-3) – Page 1 of NSW EPA (6 May 2009) Declaration of Remediation Site



Environment Protection Authority

Declaration of Remediation Site

(Section 21 of the Contaminated Land Management Act 1997)

Declaration Number 21122; Area Number 3221

The Environment Protection Authority (EPA) declares the following land to be a remediation site under the Contaminated Land Management Act 1997 (“the Act”):

1. Land to which this declaration applies ("the site")

The site to which this declaration relates is part of the former Millers Point gasworks and is described as:

- Part Lot 5 and Part Lot 3 in Deposited Plan (DP) 876514, Hickson Rd, Millers Point
- The part of Hickson Road adjacent to:
  - 30 – 34 Hickson Road being Lot 11 DP1065410;
  - 36 Hickson Road being Lot 5 DP873158 and Lot 12 DP1065410; and
  - 38 Hickson Road being SP72797, Millers Point

in the City of Sydney local government area. The site coincides with the known foot print of the former gasworks facilities. A map of the site is available for inspection at the offices of the Department of the Environment and Climate Change, Level 14, 59-61 Goulburn Street, Sydney, NSW.

2. Nature of contamination affecting the site:

The EPA believes that the site is contaminated with gasworks waste and particularly waste tar as a result of the previous use of the site as a gasworks plant. The chemical composition of gasworks waste includes the following substances (“the contaminants”): polycyclic aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene and xylenes (BTEX); total petroleum hydrocarbons (TPHs); ammonia; phenol and cyanide.

3. Nature of harm that the contaminants may cause:

The EPA has considered the matters in s.9 of the Act and for the following reasons has determined that the site is contaminated in such a way as to present a significant risk of harm to human health and the environment:

- Groundwater on the site has been found to be contaminated by TPHs, PAHs, BTEX, ammonia, phenol and cyanide at concentrations significantly exceeding the relevant trigger values for the protection of human health and aquatic ecosystems in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000).
- These groundwater contaminants include human carcinogens and substances toxic to aquatic ecosystems.
- The contaminated groundwater is impacting on the surrounding areas including the basement of a residential building adjacent to the site, potentially exposing humans in that building to harmful vapours; however it is currently being effectively controlled.
- Contaminated groundwater is likely to be migrating from the site to Darling Harbour and could ultimately affect aquatic ecosystems.

4. Further action under the Act

The making of this declaration does not prevent the carrying out of a voluntary remediation of the site and any person may submit a voluntary remediation proposal for the site to the EPA. If the proposal satisfies the requirements of s.26 of the Act, the EPA may agree not to issue a remediation order to the person or persons bringing the proposal.

5. Submissions invited

APPENDIX D
DETAILED REVIEW ON AECOM ERROR IN SOIL-SKIN ADHERENCE FACTOR

The AECOM HHERA used an incorrect soil-to-skin adherence factor in their human health risk assessment, which caused the risks from dermal exposure to soil for an unprotected maintenance worker in a trench to be exaggerated by 14 times.

This error initially arose in a HHERA prepared by AECOM in June 2011 for the central part of the Barangaroo development site[145], which includes the *Declared Area* (**Figure 3-7**). This document stated that the soil-to-skin adherence factor of 1.5 mg/cm^2 was adopted because it was meant to have been the average value of a range of values (1.4 – 1.6 mg/cm^2) for a construction worker given in the USEPA (July 2009) guideline[146]. A copy of the relevant part of this AECOM report is provided at the end of this appendix (**DOCUMENT D-1**).

This was an error because Table 7-17 of the USEPA (July 2009) guideline (**DOCUMENT D-2**) clearly shows that the 1.4 – 1.6 mg/cm^2 range and the 1.5 mg/cm^2 value are standard deviations not mean values. The range of mean values given by the USEPA document for construction workers was actually 0.029 – 0.24 mg/cm^2, with the correct average of these values being 0.108mg/cm^2. The AECOM report indicates that it had been reviewed by the NSW EPA and Site Auditor on 3 occasions after it was first issued on 12 April 2011 and prior to the fourth and final version being issued on 9 June 2011.

This error was perpetuated in the first draft version of the AECOM HHERA produced for the case where the land use of the *Declared Area* remains unchanged. The report was dated 21 March 2012 and a copy of Table 15 shows that a soil-to-skin adherence factor of 1.5 mg/cm^2 was again adopted (**DOCUMENT D-3**).

This error was identified by SKM in a letter dated 10 May 2012 and drawn to the attention of AECOM. However, AECOM decided to carry this error through into subsequent versions of their HHERA, including the most recent 9 October 2012 version. AECOM advised [147] that they were instructed to adopt this value by the Site Auditor and the NSW EPA to ensure consistency between the AECOM HHERA for Barangaroo South and another HHERA prepared by JBS for Headland Park (**DOCUMENT D-4**).

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[145] AECOM (9 June 2011) “*Human Health and Ecological Risk Assessment, Declaration Site (Development Works) Remediation Works Area – Barangaroo*”

[146] USEPA (July 2009) “Exposure Factors Handbook: 2009 Update”

[147] Barangaroo Delivery Authority (23 July 2012) Letter “*Declaration 21122 – Hickson Road, Millers Point – Draft HHERA*”. 23 pages

DOCUMENT (D-1) - Table 34 from AECOM (9 June 2011) HHERA

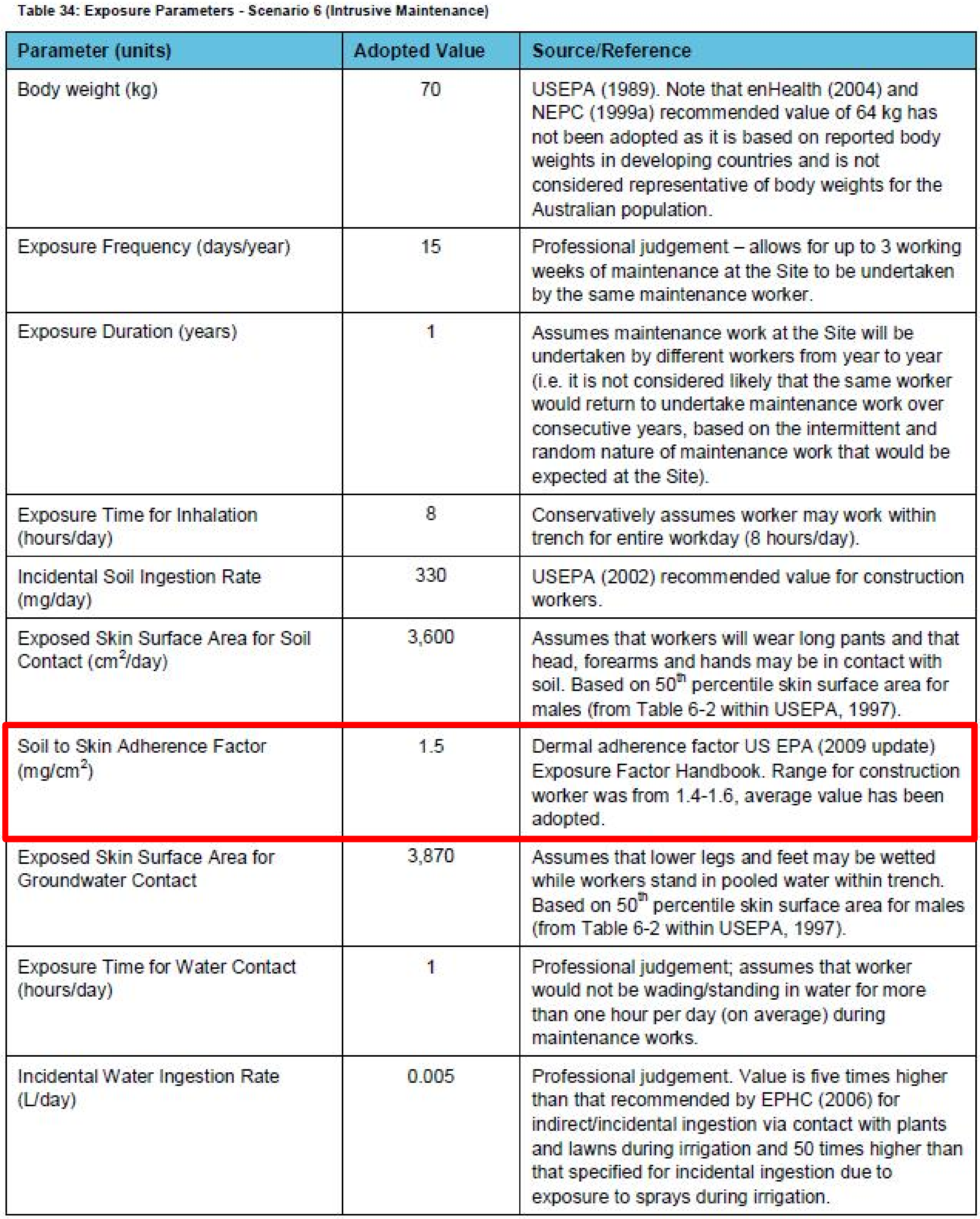
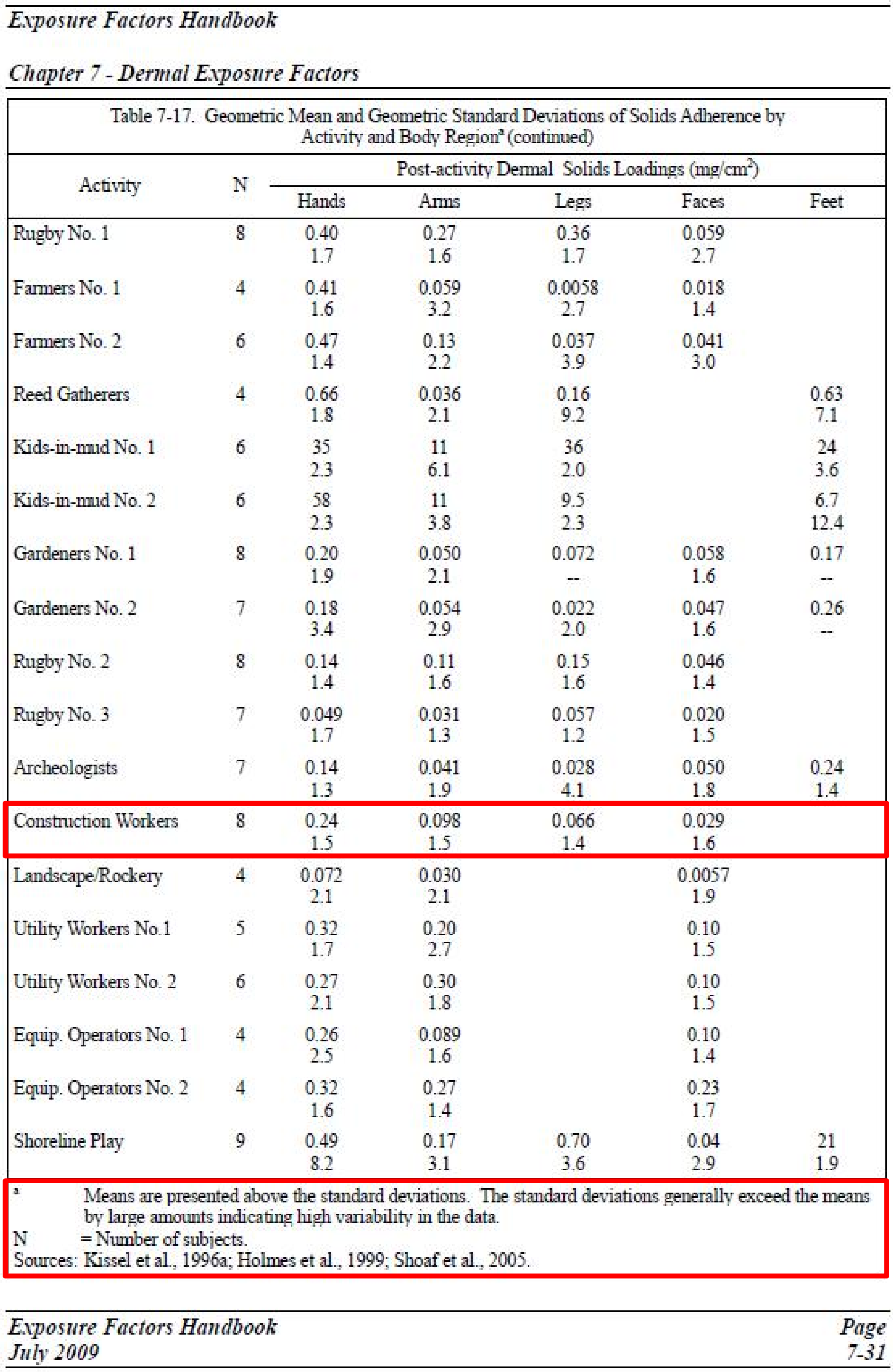


Table 34: Exposure Parameters - Scenario 6 (Intrusive Maintenance)

Parameter (units)	Adopted Value	Source/Reference
Body weight (kg)	70	USEPA (1989). Note that enHealth (2004) and NEPC (1999a) recommended value of 64 kg has not been adopted as it is based on reported body weights in developing countries and is not considered representative of body weights for the Australian population.
Exposure Frequency (days/year)	15	Professional judgement – allows for up to 3 working weeks of maintenance at the Site to be undertaken by the same maintenance worker.
Exposure Duration (years)	1	Assumes maintenance work at the Site will be undertaken by different workers from year to year (i.e. it is not considered likely that the same worker would return to undertake maintenance work over consecutive years, based on the intermittent and random nature of maintenance work that would be expected at the Site).
Exposure Time for Inhalation (hours/day)	8	Conservatively assumes worker may work within trench for entire workday (8 hours/day).
Incidental Soil Ingestion Rate (mg/day)	330	USEPA (2002) recommended value for construction workers.
Exposed Skin Surface Area for Soil Contact (cm^2/day)	3,600	Assumes that workers will wear long pants and that head, forearms and hands may be in contact with soil. Based on 50th percentile skin surface area for males (from Table 6-2 within USEPA, 1997).
Soil to Skin Adherence Factor (mg/cm^2)	1.5	Dermal adherence factor US EPA (2009 update) Exposure Factor Handbook. Range for construction worker was from 1.4-1.6, average value has been adopted.
Exposed Skin Surface Area for Groundwater Contact	3,870	Assumes that lower legs and feet may be wetted while workers stand in pooled water within trench. Based on 50th percentile skin surface area for males (from Table 6-2 within USEPA, 1997).
Exposure Time for Water Contact (hours/day)	1	Professional judgement; assumes that worker would not be wading/standing in water for more than one hour per day (on average) during maintenance works.
Incidental Water Ingestion Rate (L/day)	0.005	Professional judgement. Value is five times higher than that recommended by EPHC (2006) for indirect/incidental ingestion via contact with plants and lawns during irrigation and 50 times higher than that specified for incidental ingestion due to exposure to sprays during irrigation.

DOCUMENT (D-2) - Table 7-17 from USEPA (July 2009) “*Exposure Factors Handbook*”



Exposure Factors Handbook

Chapter 7 - Dermal Exposure Factors

Table 7-17. Geometric Mean and Geometric Standard Deviations of Solids Adherence by Activity and Body Region[a] (continued)

Activity	N	Post-activity Dermal Solids Loadings (mg/cm²)				
		Hands	Arms	Legs	Faces	Feet
Rugby No. 1	8	0.40 1.7	0.27 1.6	0.36 1.7	0.059 2.7	
Farmers No. 1	4	0.41 1.6	0.059 3.2	0.0058 2.7	0.018 1.4	
Farmers No. 2	6	0.47 1.4	0.13 2.2	0.037 3.9	0.041 3.0	
Reed Gatherers	4	0.66 1.8	0.036 2.1	0.16 9.2		0.63 7.1
Kids-in-mud No. 1	6	35 2.3	11 6.1	36 2.0		24 3.6
Kids-in-mud No. 2	6	58 2.3	11 3.8	9.5 2.3		6.7 12.4
Gardeners No. 1	8	0.20 1.9	0.050 2.1	0.072 --	0.058 1.6	0.17 --
Gardeners No. 2	7	0.18 3.4	0.054 2.9	0.022 2.0	0.047 1.6	0.26 --
Rugby No. 2	8	0.14 1.4	0.11 1.6	0.15 1.6	0.046 1.4	
Rugby No. 3	7	0.049 1.7	0.031 1.3	0.057 1.2	0.020 1.5	
Archeologists	7	0.14 1.3	0.041 1.9	0.028 4.1	0.050 1.8	0.24 1.4
Construction Workers	8	0.24 1.5	0.098 1.5	0.066 1.4	0.029 1.6	
Landscape/Rockery	4	0.072 2.1	0.030 2.1		0.0057 1.9	
Utility Workers No.1	5	0.32 1.7	0.20 2.7		0.10 1.5	
Utility Workers No. 2	6	0.27 2.1	0.30 1.8		0.10 1.5	
Equip. Operators No. 1	4	0.26 2.5	0.089 1.6		0.10 1.4	
Equip. Operators No. 2	4	0.32 1.6	0.27 1.4		0.23 1.7	
Shoreline Play	9	0.49 8.2	0.17 3.1	0.70 3.6	0.04 2.9	21 1.9

[a] Means are presented above the standard deviations. The standard deviations generally exceed the means by large amounts indicating high variability in the data.

N = Number of subjects.

Sources: Kissel et al., 1996a; Holmes et al., 1999; Shoaf et al., 2005.

Exposure Factors Handbook
July 2009

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DOCUMENT (D-3) - Table 15 from AECOM (21 March 012) HHERA

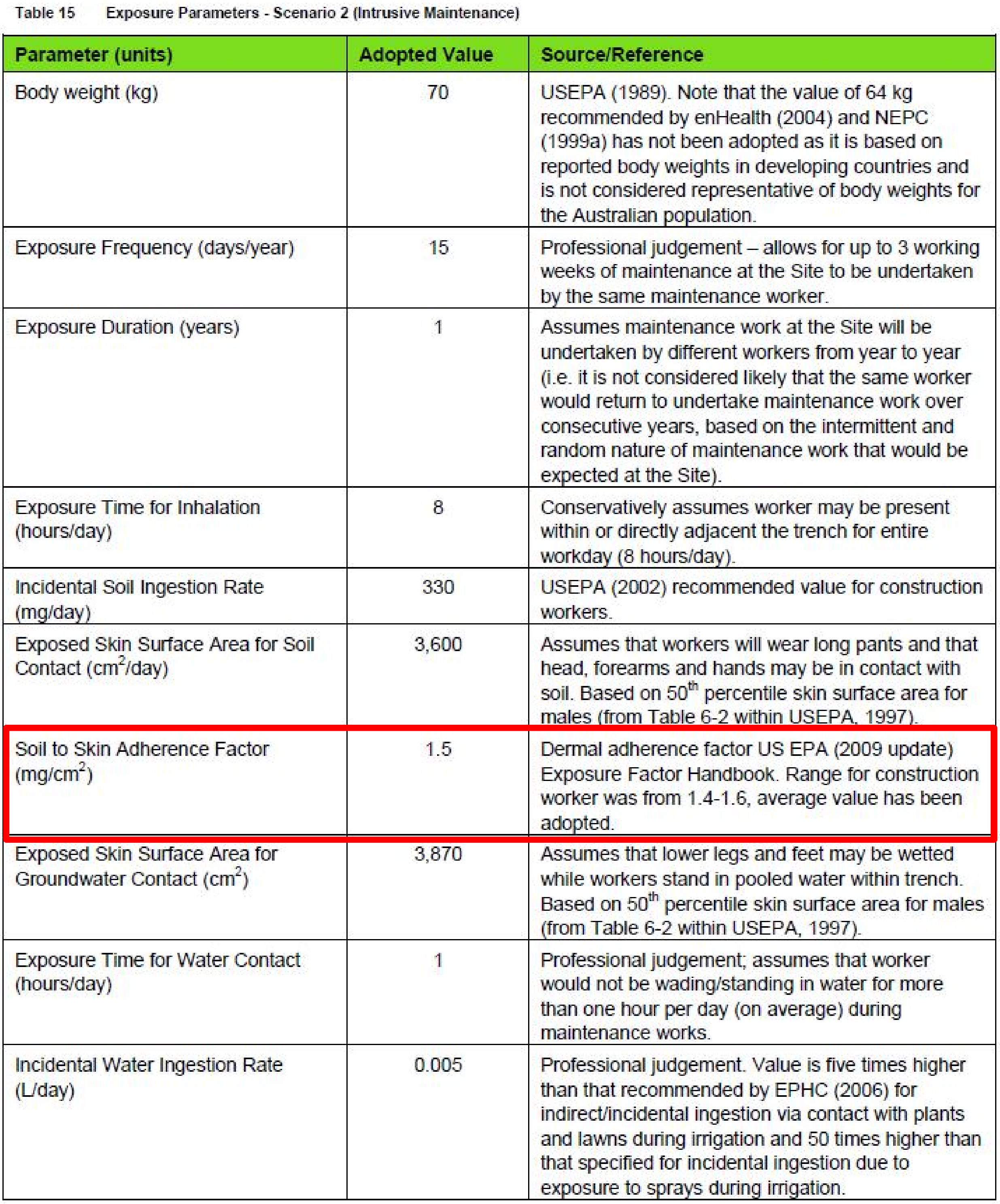

Table 15 Exposure Parameters - Scenario 2 (Intrusive Maintenance)

Parameter (units)	Adopted Value	Source/Reference
Body weight (kg)	70	USEPA (1989). Note that the value of 64 kg recommended by enHealth (2004) and NEPC (1999a) has not been adopted as it is based on reported body weights in developing countries and is not considered representative of body weights for the Australian population.
Exposure Frequency (days/year)	15	Professional judgement – allows for up to 3 working weeks of maintenance at the Site to be undertaken by the same maintenance worker.
Exposure Duration (years)	1	Assumes maintenance work at the Site will be undertaken by different workers from year to year (i.e. it is not considered likely that the same worker would return to undertake maintenance work over consecutive years, based on the intermittent and random nature of maintenance work that would be expected at the Site).
Exposure Time for Inhalation (hours/day)	8	Conservatively assumes worker may be present within or directly adjacent the trench for entire workday (8 hours/day).
Incidental Soil Ingestion Rate (mg/day)	330	USEPA (2002) recommended value for construction workers.
Exposed Skin Surface Area for Soil Contact (cm^2/day)	3,600	Assumes that workers will wear long pants and that head, forearms and hands may be in contact with soil. Based on 50th percentile skin surface area for males (from Table 6-2 within USEPA, 1997).
Soil to Skin Adherence Factor (mg/cm^2)	1.5	Dermal adherence factor US EPA (2009 update) Exposure Factor Handbook. Range for construction worker was from 1.4-1.6, average value has been adopted.
Exposed Skin Surface Area for Groundwater Contact (cm^2)	3,870	Assumes that lower legs and feet may be wetted while workers stand in pooled water within trench. Based on 50th percentile skin surface area for males (from Table 6-2 within USEPA, 1997).
Exposure Time for Water Contact (hours/day)	1	Professional judgement; assumes that worker would not be wading/standing in water for more than one hour per day (on average) during maintenance works.
Incidental Water Ingestion Rate (L/day)	0.005	Professional judgement. Value is five times higher than that recommended by EPHC (2006) for indirect/incidental ingestion via contact with plants and lawns during irrigation and 50 times higher than that specified for incidental ingestion due to exposure to sprays during irrigation.

- **DOCUMENT (D-4) Extract from BDA (23 July 2012) Letter**

Ref.	Comment	AECOM Response	Report Reference
	AECOM risk assessment applied the soil criteria derived for benzo(a)pyrene of 67.2 mg/kd to all carcinogenic PAHs, which caused the health risks to a worker from exposure to shallow soils to be exaggerated. I corrected this error by converting the other 7 PAH compounds to benzo(a)pyrene equivalent concentrations are reduced on average by a factor of 4. The results of this calculation are summarised in **Table B-1** in **Appendix B**. This error caused the health risks calculated by AECOM to be exaggerated by 4 times.	adopted TEFs (as outlined in the PAH toxicity profile contained within Appendix D) to the individual analyte concentration for each carcinogenic PAH, and then compare the total sum (based on the TEFs) to the derived total carcinogenic PAH criteria of 67 mg/kg.	
2.1.b.ii	The AECOM HHERA adopted a soil to skin adherence factor of 1.5 mg/cm^2, which was reported by AECOM to be the mid-range of average values specified in a USEPA (July 2009) document[4] for construction workers. This is an error since the values used by AECOM were the standard deviations given by the USEPA document. The average values given by the USEPA document actually range from 0.029 to 0.24, with the average of the four average values being 0.1, which is consistent with the geometric mean value given in the main USEPA health risk guidance document issued in 2004[5]. This error caused the dermal health risks calculated by AECOM to be exaggerated by a factor of 15 times. This is a significant error given that dermal exposure represents the main exposure pathway for the short term intrusive maintenance worker in contact with shallow soil. When the correct skin adherence factor is used, the benzo(a)pyrene equivalent soil criteria increases 13 times from 67.2 mg/kg to 871 mg/kg.	AECOM was instructed to adopt this value by the Auditor and EPA. It is understood that the request was to ensure consistency between the AECOM HHERA for Barangaroo South and JBS HHERA for Headland Park. It is understood that the source of this value is from Risk Assessment Guidance for Superfund, Part A (RAGs, Part A).	Section 5.3.6.3
2.1.b.iii	The AECOM HHERA assessed health risks based on contaminant concentrations measured in individual soil samples rather than using conservative estimates of the true mean concentration in shallow soils from across the *Declared Area* and adjacent areas. The approach recommended by the NSW EPA[6] and NEPM[7] guidelines is to undertake a statistical	AECOM prepared a document which derived Site Specific Target Criteria (SSTC) and Site Specific Ecological Screening Criteria (SSESC) for the purposes of adoption as remedial criteria. AECOM did not perform a forward risk assessment based on	Human Health Section 5.6.3, Odour Section 6.1, Ecological Section 7.8.

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[4] Table 7-17 in USEPA(July 2009) *"Exposure Factors Handbook, Chapter 7 – Dermal Exposure Factors*"

[5] Exhibit 3-3 in USEPA (July 2004) "*Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*

[6] NSw EPA (September 1995) *"Sampling Design Guidelines"*

[7] NEPC (199) *"Schedule B(2) Guideline on Data Collection, Sample Design and Reporting"*, National Environment Protection (Assessment of Site Contamination) Measure 1999

APPENDIX E

SUMMARY OF SKM HEALTH RISK ASSESSMENT RESULTS FOR DECLARED AREA REMAINING IN CURRENT FORM

LOCATION BH087 / MW015 - SHORT TERM RISKS

	Total Risk for All Soil Exposure Pathways			Total Risk for All GW Exposure Pathways			Combined Total Risk for All Exposure Pathways		
Chemical	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic
Acenaphthene	9.89E-05	9.89E-05	9.89E-05	3.87E-05	3.87E-05	3.87E-05	1.38E-04	1.38E-04	1.38E-04
Acenaphthylene	7.97E-04	7.97E-04	7.97E-04	2.24E-04	2.24E-04	2.24E-04	1.02E-03	1.02E-03	1.02E-03
Ammonia	--	--	--	3.73E-02	3.73E-02	3.73E-02	3.73E-02	3.73E-02	3.73E-02
Anthracene	1.12E-04	1.12E-04	1.12E-04	1.23E-05	1.23E-05	1.23E-05	1.24E-04	1.24E-04	1.24E-04
Benzene	4.65E-04	4.65E-04	4.65E-04	5.02E-01	5.02E-01	5.02E-01	5.03E-01	5.03E-01	5.03E-01
Ethylbenzene	3.96E-06	3.96E-06	3.96E-06	2.49E-05	2.49E-05	2.49E-05	2.89E-05	2.89E-05	2.89E-05
Fluoranthene	2.00E-03	2.00E-03	2.00E-03	1.63E-04	1.63E-04	1.63E-04	2.17E-03	2.17E-03	2.17E-03
Fluorene	1.13E-03	1.13E-03	1.13E-03	1.63E-04	1.63E-04	1.63E-04	1.29E-03	1.29E-03	1.29E-03
Naphthalene	1.90E-02	1.90E-02	1.90E-02	5.35E-02	5.35E-02	5.35E-02	7.25E-02	7.25E-02	7.25E-02
Phenanthrene	2.04E-03	2.04E-03	2.04E-03	1.08E-04	1.08E-04	1.08E-04	2.14E-03	2.14E-03	2.14E-03
Phenol	--	--	--	7.89E-05	7.89E-05	7.89E-05	7.89E-05	7.89E-05	7.89E-05
Pyrene	2.18E-03	2.18E-03	2.18E-03	1.42E-04	1.42E-04	1.42E-04	2.32E-03	2.32E-03	2.32E-03
Toluene	1.05E-06	1.05E-06	1.05E-06	1.15E-03	1.15E-03	1.15E-03	1.15E-03	1.15E-03	1.15E-03
TPH C6-C9 aliphatic	4.75E-06	2.38E-06	0.00E+00	1.28E-03	6.40E-04	0.00E+00	1.28E-03	6.42E-04	0.00E+00
TPH C6-C9 aromatic	--	--	--	--	--	--	--	--	--
TPH C10-C14 aliphatic	2.99E-03	1.49E-03	0.00E+00	2.80E+00	1.40E+00	0.00E+00	2.80E+00	1.40E+00	0.00E+00
TPH C10-C14 aromatic	0.00E+00	3.73E-03	7.46E-03	0.00E+00	3.52E-01	7.04E-01	0.00E+00	3.56E-01	7.12E-01
TPH C15-C28 aliphatic	4.68E-04	2.34E-04	0.00E+00	8.19E-03	4.10E-03	0.00E+00	8.66E-03	4.33E-03	0.00E+00
TPH C15-C28 aromatic	0.00E+00	1.56E-02	3.12E-02	0.00E+00	1.92E-01	3.85E-01	0.00E+00	2.08E-01	4.16E-01
TPH C29-C36 aliphatic	1.22E-04	6.10E-05	0.00E+00	7.06E-05	3.53E-05	0.00E+00	1.93E-04	9.63E-05	0.00E+00
TPH C29-C36 aromatic	0.00E+00	4.09E-03	8.17E-03	0.00E+00	3.42E-03	6.84E-03	0.00E+00	7.51E-03	1.50E-02
Xylenes (total)	1.89E-05	1.89E-05	1.89E-05	1.38E-03	1.38E-03	1.38E-03	1.40E-03	1.40E-03	1.40E-03
Total Risk	3.14E-02	5.31E-02	7.47E-02	3.41E+00	2.55E+00	1.69E+00	3.44E+00	2.60E+00	1.77E+00

Legend

🟨 Risk exceeds target criteria of 1.0

LOCATION BH204D/MW204D - SHORT TERM RISKS

	Total Risk for All Soil Exposure Pathways			Total Risk for All GW Exposure Pathways			Combined Total Risk for All Exposure Pathways		
Chemical	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic
Acenaphthene	1.02E-03	1.02E-03	1.02E-03	5.16E-04	5.16E-04	5.16E-04	1.53E-03	1.53E-03	1.53E-03
Acenaphthylene	2.72E-03	2.72E-03	2.72E-03	1.45E-03	1.45E-03	1.45E-03	4.17E-03	4.17E-03	4.17E-03
Ammonia	--	--	--	5.67E-01	5.67E-01	5.67E-01	5.67E-01	5.67E-01	5.67E-01
Anthracene	9.85E-04	9.85E-04	9.85E-04	6.38E-04	6.38E-04	6.38E-04	1.62E-03	1.62E-03	1.62E-03
Benzene	4.05E-02	4.05E-02	4.05E-02	9.34E-01	9.34E-01	9.34E-01	9.75E-01	9.75E-01	9.75E-01
Ethylbenzene	2.31E-05	2.31E-05	2.31E-05	1.51E-04	1.51E-04	1.51E-04	1.74E-04	1.74E-04	1.74E-04
Fluoranthene	9.55E-03	9.55E-03	9.55E-03	1.36E-02	1.36E-02	1.36E-02	2.32E-02	2.32E-02	2.32E-02
Fluorene	7.39E-03	7.39E-03	7.39E-03	3.31E-03	3.31E-03	3.31E-03	1.07E-02	1.07E-02	1.07E-02
Naphthalene	1.73E-01	1.73E-01	1.73E-01	1.30E-01	1.30E-01	1.30E-01	3.03E-01	3.03E-01	3.03E-01
Phenanthrene	1.11E-02	1.11E-02	1.11E-02	7.82E-03	7.82E-03	7.82E-03	1.89E-02	1.89E-02	1.89E-02
Phenol	--	--	--	7.50E-04	7.50E-04	7.50E-04	7.50E-04	7.50E-04	7.50E-04
Pyrene	1.24E-02	1.24E-02	1.24E-02	1.13E-02	1.13E-02	1.13E-02	2.37E-02	2.37E-02	2.37E-02
Toluene	9.07E-05	9.07E-05	9.07E-05	2.39E-03	2.39E-03	2.39E-03	2.48E-03	2.48E-03	2.48E-03
TPH C6-C9 aliphatic	6.00E-05	3.00E-05	0.00E+00	3.54E-03	1.77E-03	0.00E+00	3.60E-03	1.80E-03	0.00E+00
TPH C6-C9 aromatic	--	--	--	--	--	--	--	--	--
TPH C10-C14 aliphatic	8.07E-03	4.04E-03	0.00E+00	1.14E+01	5.69E+00	0.00E+00	1.14E+01	5.69E+00	0.00E+00
TPH C10-C14 aromatic	0.00E+00	1.01E-02	2.02E-02	0.00E+00	1.43E+00	2.86E+00	0.00E+00	1.44E+00	2.88E+00
TPH C15-C28 aliphatic	6.50E-03	3.25E-03	0.00E+00	4.01E-02	2.01E-02	0.00E+00	4.66E-02	2.33E-02	0.00E+00
TPH C15-C28 aromatic	0.00E+00	2.17E-01	4.34E-01	0.00E+00	9.42E-01	1.88E+00	0.00E+00	1.16E+00	2.32E+00
TPH C29-C36 aliphatic	1.85E-03	9.24E-04	0.00E+00	4.64E-03	2.32E-03	0.00E+00	6.48E-03	3.24E-03	0.00E+00
TPH C29-C36 aromatic	0.00E+00	6.18E-02	1.24E-01	0.00E+00	2.25E-01	4.49E-01	0.00E+00	2.87E-01	5.73E-01
Xylenes (total)	1.69E-04	1.69E-04	1.69E-04	6.11E-03	6.11E-03	6.11E-03	6.28E-03	6.28E-03	6.28E-03
Total Risk	2.75E-01	5.56E-01	8.36E-01	1.31E+01	9.99E+00	6.88E+00	1.34E+01	1.05E+01	7.71E+00

Legend

🟨	Risk exceeds target criteria of 1.0

LOCATION MW7_ Coffey - SHORT TERM RISKS

	Total Risk for All Soil Exposure Pathways			Total Risk for All GW Exposure Pathways			Combined Total Risk for All Exposure Pathways		
Chemical	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic
Acenaphthene	3.21E-06	3.21E-06	3.21E-06	2.94E-04	2.94E-04	2.94E-04	2.97E-04	2.97E-04	2.97E-04
Acenaphthylene	3.47E-05	3.47E-05	3.47E-05	1.77E-03	1.77E-03	1.77E-03	1.80E-03	1.80E-03	1.80E-03
Ammonia	--	--	--	1.92E+00	1.92E+00	1.92E+00	1.92E+00	1.92E+00	1.92E+00
Anthracene	7.88E-06	7.88E-06	7.88E-06	1.78E-04	1.78E-04	1.78E-04	1.86E-04	1.86E-04	1.86E-04
Benzene	1.33E-04	1.33E-04	1.33E-04	3.06E+00	3.06E+00	3.06E+00	3.06E+00	3.06E+00	3.06E+00
Ethylbenzene	8.25E-07	8.25E-07	8.25E-07	5.90E-05	5.90E-05	5.90E-05	5.99E-05	5.99E-05	5.99E-05
Fluoranthene	2.26E-04	2.26E-04	2.26E-04	1.13E-03	1.13E-03	1.13E-03	1.36E-03	1.36E-03	1.36E-03
Fluorene	1.24E-05	1.24E-05	1.24E-05	5.64E-04	5.64E-04	5.64E-04	5.77E-04	5.77E-04	5.77E-04
Naphthalene	3.29E-05	3.29E-05	3.29E-05	1.59E-01	1.59E-01	1.59E-01	1.59E-01	1.59E-01	1.59E-01
Phenanthrene	1.02E-04	1.02E-04	1.02E-04	2.18E-03	2.18E-03	2.18E-03	2.28E-03	2.28E-03	2.28E-03
Phenol	--	--	--	7.99E-03	7.99E-03	7.99E-03	7.99E-03	7.99E-03	7.99E-03
Pyrene	2.95E-04	2.95E-04	2.95E-04	3.33E-03	3.33E-03	3.33E-03	3.62E-03	3.62E-03	3.62E-03
Toluene	3.28E-07	3.28E-07	3.28E-07	4.22E-03	4.22E-03	4.22E-03	4.22E-03	4.22E-03	4.22E-03
TPH C6-C9 aliphatic	1.59E-06	7.94E-07	0.00E+00	2.97E-03	1.48E-03	0.00E+00	2.97E-03	1.48E-03	0.00E+00
TPH C6-C9 aromatic	--	--	--	--	--	--	--	--	--
TPH C10-C14 aliphatic	4.47E-05	2.23E-05	0.00E+00	1.73E+01	8.64E+00	0.00E+00	1.73E+01	8.64E+00	0.00E+00
TPH C10-C14 aromatic	0.00E+00	5.58E-05	1.12E-04	0.00E+00	2.17E+00	4.35E+00	0.00E+00	2.17E+00	4.35E+00
TPH C15-C28 aliphatic	1.50E-04	7.51E-05	0.00E+00	1.91E-02	9.57E-03	0.00E+00	1.93E-02	9.65E-03	0.00E+00
TPH C15-C28 aromatic	0.00E+00	5.01E-03	1.00E-02	0.00E+00	4.50E-01	9.00E-01	0.00E+00	4.55E-01	9.10E-01
TPH C29-C36 aliphatic	1.35E-04	6.76E-05	0.00E+00	4.83E-04	2.42E-04	0.00E+00	6.18E-04	3.09E-04	0.00E+00
TPH C29-C36 aromatic	0.00E+00	4.52E-03	9.05E-03	0.00E+00	2.34E-02	4.69E-02	0.00E+00	2.80E-02	5.59E-02
Xylenes (total)	9.00E-07	9.00E-07	9.00E-07	3.69E-03	3.69E-03	3.69E-03	3.70E-03	3.70E-03	3.70E-03
Total Risk	1.18E-03	1.06E-02	2.00E-02	2.25E+01	1.65E+01	1.05E+01	2.25E+01	1.65E+01	1.05E+01

Legend

🟨 Risk exceeds target criteria of 1.0

AECOM BH54 / MW54 - SHORT TERM RISKS

	Total Risk for All Soil Exposure Pathways			Total Risk for All GW Exposure Pathways			Combined Total Risk for All Exposure Pathways		
Chemical	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic	TPH all Aliphatic	TPH 50:50 Aliphatic / Aromatic Split	TPH all Aromatic
Acenaphthene	1.25E-03	1.25E-03	1.25E-03	3.04E-04	3.04E-04	3.04E-04	1.55E-03	1.55E-03	1.55E-03
Acenaphthylene	4.50E-03	4.50E-03	4.50E-03	4.91E-04	4.91E-04	4.91E-04	4.99E-03	4.99E-03	4.99E-03
Ammonia	--	--	--	7.04E-02	7.04E-02	7.04E-02	7.04E-02	7.04E-02	7.04E-02
Anthracene	8.78E-04	8.78E-04	8.78E-04	2.55E-05	2.55E-05	2.55E-05	9.03E-04	9.03E-04	9.03E-04
Benzene	2.86E-03	2.86E-03	2.86E-03	7.54E-02	7.54E-02	7.54E-02	7.82E-02	7.82E-02	7.82E-02
Ethylbenzene	2.64E-05	2.64E-05	2.64E-05	7.55E-05	7.55E-05	7.55E-05	1.02E-04	1.02E-04	1.02E-04
Fluoranthene	1.31E-02	1.31E-02	1.31E-02	3.38E-04	3.38E-04	3.38E-04	1.35E-02	1.35E-02	1.35E-02
Fluorene	8.02E-03	8.02E-03	8.02E-03	6.00E-04	6.00E-04	6.00E-04	8.62E-03	8.62E-03	8.62E-03
Naphthalene	1.31E-01	1.31E-01	1.31E-01	1.90E-01	1.90E-01	1.90E-01	3.21E-01	3.21E-01	3.21E-01
Phenanthrene	1.29E-02	1.29E-02	1.29E-02	5.51E-04	5.51E-04	5.51E-04	1.34E-02	1.34E-02	1.34E-02
Phenol	--	--	--	2.11E-07	2.11E-07	2.11E-07	2.11E-07	2.11E-07	2.11E-07
Pyrene	1.37E-02	1.37E-02	1.37E-02	2.17E-04	2.17E-04	2.17E-04	1.39E-02	1.39E-02	1.39E-02
Toluene	2.82E-05	2.82E-05	2.82E-05	3.29E-04	3.29E-04	3.29E-04	3.57E-04	3.57E-04	3.57E-04
TPH C6-C9 aliphatic	4.10E-05	2.05E-05	0.00E+00	3.82E-04	1.91E-04	0.00E+00	4.23E-04	2.11E-04	0.00E+00
TPH C6-C9 aromatic	--	--	--	--	--	--	--	--	--
TPH C10-C14 aliphatic	1.12E-02	5.60E-03	0.00E+00	6.09E-01	3.05E-01	0.00E+00	6.20E-01	3.10E-01	0.00E+00
TPH C10-C14 aromatic	0.00E+00	1.40E-02	2.80E-02	0.00E+00	7.66E-02	1.53E-01	0.00E+00	9.06E-02	1.81E-01
TPH C15-C28 aliphatic	1.80E-03	9.02E-04	0.00E+00	4.65E-03	2.33E-03	0.00E+00	6.46E-03	3.23E-03	0.00E+00
TPH C15-C28 aromatic	0.00E+00	6.02E-02	1.20E-01	0.00E+00	1.09E-01	2.19E-01	0.00E+00	1.70E-01	3.39E-01
TPH C29-C36 aliphatic	5.84E-04	2.92E-04	0.00E+00	1.52E-04	7.60E-05	0.00E+00	7.36E-04	3.68E-04	0.00E+00
TPH C29-C36 aromatic	0.00E+00	1.95E-02	3.91E-02	0.00E+00	7.37E-03	1.47E-02	0.00E+00	2.69E-02	5.38E-02
Xylenes (total)	1.59E-04	1.59E-04	1.59E-04	1.98E-03	1.98E-03	1.98E-03	2.14E-03	2.14E-03	2.14E-03
Total Risk	2.02E-01	2.89E-01	3.76E-01	9.55E-01	8.41E-01	7.28E-01	1.16E+00	1.13E+00	1.10E+00

Legend

🟨 Risk exceeds target criteria of 1.0

LONG TERM RISKS

LOCATION BH087 / MW015

	Total Risks		
Chemical	All Soil Exposure Pathways	All GW Exposure Pathways	Combined Risk for All Pathways
Benz(a)anthracene	1.90E-08	1.31E-09	2.03E-08
Benzene	2.27E-10	5.82E-07	5.82E-07
Benzo(a)pyrene	1.44E-07	1.02E-08	1.54E-07
Benzo(b)fluoranthene	1.39E-08	8.59E-10	1.48E-08
Benzo(g,h,i)perylene	5.67E-10	6.18E-11	6.29E-10
Benzo(k)fluoranthene	5.86E-09	3.40E-10	6.20E-09
Chrysene	1.16E-09	9.36E-11	1.25E-09
Dibenz(a,h)anthracene	1.43E-08	1.20E-09	1.55E-08
Indeno(1,2,3-cd)pyrene	5.20E-09	6.32E-10	5.83E-09
Total Risk	2.04E-07	5.97E-07	8.01E-07

LOCATION BH204D / MW204D

	Total Risks		
Chemical	All Soil Exposure Pathways	All GW Exposure Pathways	Combined Risk for All Pathways
Benz(a)anthracene	1.37E-07	2.30E-09	1.39E-07
Benzene	1.98E-08	3.11E-07	3.31E-07
Benzo(a)pyrene	1.20E-06	1.62E-08	1.21E-06
Benzo(b)fluoranthene	9.78E-08	1.35E-09	9.92E-08
Benzo(g,h,i)perylene	5.09E-09	1.05E-10	5.19E-09
Benzo(k)fluoranthene	3.85E-08	8.79E-10	3.94E-08
Chrysene	1.05E-08	2.02E-10	1.07E-08
Dibenz(a,h)anthracene	1.19E-07	2.79E-09	1.22E-07
Indeno(1,2,3-cd)pyrene	4.12E-08	9.58E-10	4.21E-08
Total Risk	1.67E-06	3.36E-07	2.00E-06

LOCATION MW7_Coffey

	Total Risks		
Chemical	All Soil Exposure Pathways	All GW Exposure Pathways	Combined Risk for All Pathways
Benz(a)anthracene	6.85E-09	7.53E-10	7.60E-09
Benzene	6.50E-11	1.02E-06	1.02E-06
Benzo(a)pyrene	5.90E-08	7.83E-09	6.68E-08
Benzo(b)fluoranthene	4.08E-09	4.94E-10	4.58E-09
Benzo(g,h,i)perylene	2.33E-11	5.61E-11	7.94E-11
Benzo(k)fluoranthene	4.08E-09	3.46E-10	4.43E-09
Chrysene	2.68E-10	6.63E-11	3.35E-10
Dibenz(a,h)anthracene	2.83E-09	1.09E-09	3.92E-09
Indeno(1,2,3-cd)pyrene	1.08E-09	5.35E-10	1.62E-09
Total Risk	7.82E-08	1.03E-06	1.11E-06

AECOM BH54 / MW54

	Total Risks		
Chemical	All Soil Exposure Pathways	All GW Exposure Pathways	Combined Risk for All Pathways
Benz(a)anthracene	1.52E-07	2.71E-11	1.52E-07
Benzene	1.40E-09	2.51E-08	2.65E-08
Benzo(a)pyrene	9.79E-07	1.12E-10	9.79E-07
Benzo(b)fluoranthene	1.37E-07	7.28E-12	1.37E-07
Benzo(g,h,i)perylene	4.14E-09	1.65E-12	4.14E-09
Benzo(k)fluoranthene	5.40E-08	1.09E-11	5.40E-08
Chrysene	9.15E-09	1.92E-12	9.15E-09
Dibenz(a,h)anthracene	1.21E-07	1.43E-10	1.21E-07
Indeno(1,2,3-cd)pyrene	3.85E-08	1.81E-11	3.85E-08
Total Risk	1.50E-06	2.54E-08	1.52E-06

Legend

🟨 Risk exceeds target criteria of 1.0 x 10^{-5}

APPENDIX F

SITE AUDIT STATEMENTS FOR 30 – 34, 36 & 38 HICKSON ROAD

NSW Environment Protection Authority

SITE AUDIT STATEMENT

Schedule 1, Form 2 (Contaminated Land Management Regulation 1998)

SITE AUDITOR (accredited under the *Contaminated Land Management Act 1997*):

Name:	Mr Ross McFarland	**Phone:**	02 9950 0200
Company:	CH2M HILL Australia Pty Ltd	**Fax:**	02 9950 0600
Address:	Level 7, 9 Help Street CHATSWOOD NSW 2067	**Accred. No:**	9819

SITE AUDIT STATEMENT NO: R2002/17/A

SITE DETAILS:

Address: 30-34 Hickson Rd, Millers Point - see attached survey plan showing area marked

Postcode: 2000

Lot and DP number: Lot 2 in Deposited Plan 873158

Local government area: Sydney City Council

SITE AUDIT REQUESTED BY:

Name: Mark Burns

Company: Bovis Lendlease Pty Ltd

Address: Level 13, Tower Building, Australia Square
SYDNEY, NSW Postcode: 2000

Phone: 02 - 9237 6194 Fax: 02 - 9237 5744

Name of contact person (if different from above):

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

URS Pty Ltd

Axis Environmental Pty Ltd

Hyder Consulting

Johnstone Environmental Technology

Title(s) of report(s) reviewed:

- URS (2003) Remediation Validation Report, 30-34 Hickson Road, Millers Point, NSW. Final Report. 14 March 2003.

Other information reviewed:

- URS (2002) Groundwater Investigation, 30-38 Hickson Road, Miller's Point, Sydney NSW. 1 February 2002.
- URS (2002) Remediation Action Plan, 30-38 Hickson Road, Miller's Point, Sydney NSW. 10 April 2002.
- URS (2002) In-Situ Material Classification and Further Delineation of the Location of the Annulus - 30-38 Hickson Road, Miller's Point, Sydney, NSW. 14 May 2002.
- URS (2002) Further Groundwater Investigations at 30-38 Hickson Road, Miller's Point, Sydney NSW. 15 May 2002.
- URS (2002) Risk Assessment, Bovis Lend Lease Hickson Road, Miller's Point. 31 May 2002.
- Axis Environmental Consultants Pty Ltd (1994) Environmental Assessment Report, Hickson Road Site for Maritime Services Board. 4 August 1994.
- Axis Environmental Consultants Pty Lt. (1994) Summary Contamination Assessment Report, Hickson Road Site for Maritime Services Board. 18 August 1994.
- Hyder Consulting (1998) Environmental Site Assessment, Hickson Road and Port Area, Millers Point, Sydney. September 1998.
- Johnstone Environmental Technology (JET) (1993) Report of Contamination Investigation at MSB Property, Hickson Road, Sydney. August 1993.

Summary Site Audit Report

Title: ___30-34 Hickson Road, Millers Point, NSW, Summary Site Audit Report (SSAR 2002/17/A)

Date : ___March 2003________________________

I have completed a site audit (as defined in the *Contaminated Land Management Act 1997*) and reviewed the reports and information referred to above with due regard to relevant laws and guidelines. I certify that the site (tick all appropriate boxes):

(a) **is suitable for the following use(s):**

☐ ~~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;~~
☐ ~~residential with minimal opportunity for soil access, including units;~~
☐ ~~daycare centre, preschool, primary school;~~
☐ ~~secondary school;~~
☐ ~~park, recreational open space, playing field;~~
✓ commercial/industrial use;
✓ other (please specify): __ may include the provision of a Child Care Centre within the property

~~**subject to:**~~

☐ ~~condition(s) (please specify):~~ ______________________________

~~(b) Is not suitable for any beneficial use due to risk of harm from contamination.~~

~~☐ (comments):~~

I am accredited by the NSW Environment Protection Authority under *the Contaminated Land Management Act 1997* as a Site Auditor.

Accreditation Number: 9819

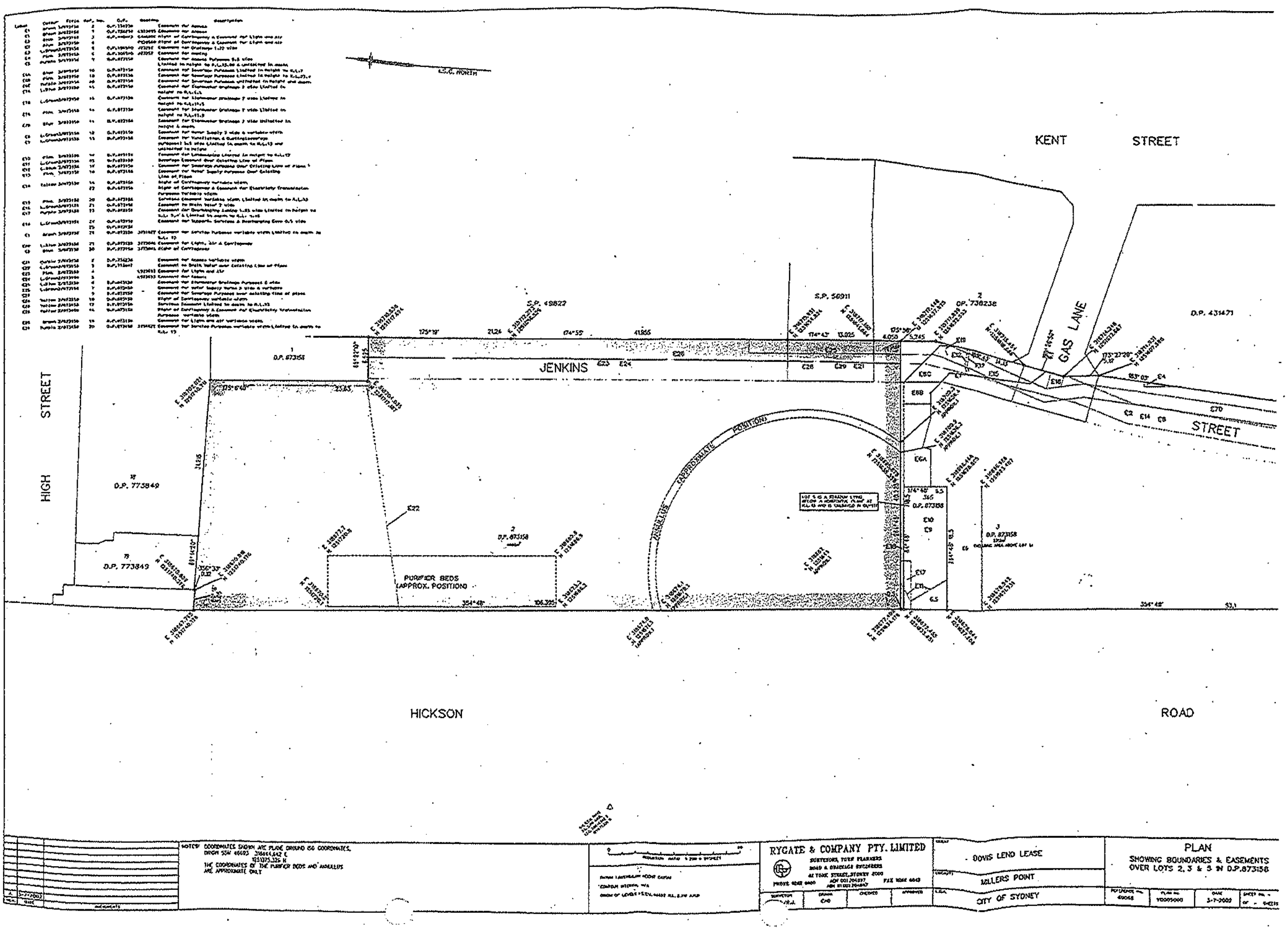
I certify that:
- (a) I have personally examined and am familiar with the information contained in this statement, including the reports and information referred to in this statement, and
- (b) this statement is, to the best of my knowledge, true, accurate and complete, and
- (c) on the basis of my inquiries made to those individuals immediately responsible for making the reports, and obtaining the information, referred to in this statement, those reports and that information are, to the best of my knowledge, true, accurate and complete.

I am aware that there are penalties for wilfully submitting false, inaccurate or incomplete information.

Signed: **Date:** 19 March 2003

FORWARD TO:
Manager, Contaminated Sites Section
NSW Environment Protection Authority
PO Box A290
SYDNEY SOUTH NSW 1232

Phone: 02 9995 5614
Fax: 02 9995 5999


KENT STREET
GAS LANE
STREET
JENKINS
HIGH STREET
HICKSON ROAD
S.P. 49822
S.P. 56911
2 DP. 738238
D.P. 431471
1 D.P. 873158
2 D.P. 873158
3 D.P. 873158
5 D.P. 873158
D.P. 773849
D.P. 773849
PURIFIER BEDS (APPROX. POSITION)
ANNULUS (APPROXIMATE POSITION)
I.S.G. NORTH
E22
E23
E24
E26
E28
E29
E21
E18
E16
E15
E4
E2
E14
E8
E70
E5C
E6B
E6A
E10
E9
E17
E11
E5
175°19'
174°55'
174°43'
175°36'
175°6'40"
354°48'
356°33'
21.26
41.865
13.025
4.050
5.745
106.395
53.1
23.65
NOTES: COORDINATES SHOWN ARE PLANE GROUND ISG COORDINATES.
ORIGIN SSM 46603 316644.642 E
1251375.326 N
THE COORDINATES OF THE PURIFIER BEDS AND ANNULUS ARE APPROXIMATE ONLY
RYGATE & COMPANY PTY. LIMITED
SURVEYORS, TOWN PLANNERS
ROAD & DRAINAGE ENGINEERS
YORK STREET, SYDNEY 2000
BOVIS LEND LEASE
MILLERS POINT
CITY OF SYDNEY
CAD
PLAN
SHOWING BOUNDARIES & EASEMENTS OVER LOTS 2, 3 & 5 IN D.P.873158
49068
Y0005000
3-7-2002

NSW Environment Protection Authority

SITE AUDIT STATEMENT

Schedule 1, Form 2 (Contaminated Land Management Regulation 1998)

SITE AUDITOR (accredited under the *Contaminated Land Management Act 1997*):

Name:	**Mr Ross McFarland**	Phone:	**02 9950 0200**
Company:	**CH2M HILL Australia Pty Ltd**	Fax:	**02 9950 0600**
Address:	**Level 7, 9 Help Street** **CHATSWOOD NSW 2067**	Accred. No:	**9819**

SITE AUDIT STATEMENT NO: **SAS 2002/17/C**

SITE DETAILS:

Address: 36 Hickson Rd, Millers Point - see attached survey plan showing area marked

Postcode: 2000

Lot and DP number: On commencement of this audit the site was identified as Part of Lot 3 DP 873158. It is understood that the site has since been subdivided as part of the development, and now comprises **PT 12 and PT 5 in DP 873158** as shown on the attached survey plan showing 'Plan of Subdivision of Lots 2 & 3 in DP 873158'

Local government area: Sydney City Council (on commencement of audit) – now part of Greater City of Sydney LGA

SITE AUDIT REQUESTED BY:

Name: **Mark Burns**

Company: **Bovis Lend Lease Pty Ltd**

Address: **Level 13, Tower Building, Australia Square**

SYDNEY, NSW Postcode: **2000**

Phone: **02 - 9237 6194** Fax: **02 - 9237 5744**

Name of contact person (if different from above): **Emma Malherbe (ph: 02 8297 3607)**

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

_____URS Pty Ltd

_____Axis Environmental Pty Ltd

_____Hyder Consulting

_____Johnstone Environmental Technology

Title(s) of report(s) reviewed:

- URS (2003) Remediation Validation Report, 36 Hickson Road, Millers Point, NSW. Final Report. 9 October 2003 (URS Ref: 45529/017-0907).
- URS (Oct 2003b) Site Management Plan, 36 Hickson Road, Miller's Point, Sydney NSW, Final, 9 October 2003 (URS Ref: 45529/017/HERITAGE SITE/SMP/SMP-C.DOC).

Other information reviewed:

- Classic Colour Painting Services Pty Ltd (March 2004) Letter – Lead Paint Treatment to 36 Hickson Rd, Millers Point, Building C.
- URS (July 2003) Memorandum – Preliminary Assessment of Risk Associated with Sewage Pumping Station Proposal, 10 July 2003. This was included in the abovementioned Site Management Plan (as Appendix A) and Remediation Validation Report (as Appendix B2).
- URS (June 2003) Validation Report, 38 Hickson Road, Millers Point, NSW, 25 June 2003.
- URS (March 2003) Remediation Validation Report, 30-34 Hickson Road, Millers Point, NSW, 14 March 2003.
- URS (2002) Groundwater Investigation, 30-38 Hickson Road, Miller's Point, Sydney NSW. 1 February 2002.
- URS (2002) Remediation Action Plan, 30-38 Hickson Road, Miller's Point, Sydney NSW. 10 April 2002.
- URS (2002) In-Situ Material Classification and Further Delineation of the Location of the Annulus - 30-38 Hickson Road, Miller's Point, Sydney, NSW. 14 May 2002.
- URS (2002) Further Groundwater Investigations at 30-38 Hickson Road, Miller's Point, Sydney NSW. 15 May 2002.
- URS (2002) Risk Assessment, Bovis Lend Lease Hickson Road, Miller's Point. 31 May 2002.
- Axis Environmental Consultants Pty Ltd (1994) Environmental Assessment Report, Hickson Road Site for Maritime Services Board. 4 August 1994.
- Axis Environmental Consultants Pty Lt. (1994) Summary Contamination Assessment Report, Hickson Road Site for Maritime Services Board. 18 August 1994.
- Hyder Consulting (1998) Environmental Site Assessment, Hickson Road and Port Area, Millers Point, Sydney. September 1998.
- Johnstone Environmental Technology (JET) (1993) Report of Contamination Investigation at MSB Property, Hickson Road, Sydney. August 1993.

Summary Site Audit Report

Title: ___36 Hickson Road, Millers Point, NSW, Summary Site Audit Report (SSAR 2002/17/C)

Date : ___16 March 2003

I have completed a site audit (as defined in the *Contaminated Land Management Act 1997*) and reviewed the reports and information referred to above with due regard to relevant laws and guidelines. I certify that the site (tick all appropriate boxes):

(a) is suitable for the following use(s):

☐ ~~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;~~

☐ ~~residential with minimal opportunity for soil access, including units;~~

☐ ~~daycare centre, preschool, primary school;~~

☐ ~~secondary school;~~

☐ ~~park, recreational open space, playing field;~~

✓ commercial/industrial use;

✓ other (please specify): __ will include an 'Outdoor Plaza' within the commercial property

subject to:

✓ condition(s) (please specify): The above landuse suitability is subject to the following conditions:

1) The Site Audit Statement is to be read in conjunction with the URS Site Management Plan, 36 Hickson Road, Millers Point, Final, dated 9 October 2003
2) All works in the subject area, as defined in the attached survey plan, are to be undertaken in accordance with the attached SMP.

~~**(b) is not suitable for any beneficial use due to risk of harm from contamination.**~~

✓ (comments): This site audit statement should be read in conjunction with the associated summary site audit report number SSAR 2002/17/C

I am accredited by the NSW Environment Protection Authority under *the Contaminated Land Management Act 1997* as a Site Auditor.

Accreditation Number: 9819

I certify that:

(a) I have personally examined and am familiar with the information contained in this statement, including the reports and information referred to in this statement, and

(b) this statement is, to the best of my knowledge, true, accurate and complete, and

(c) on the basis of my inquiries made to those individuals immediately responsible for making the reports, and obtaining the information, referred to in this statement, those reports and that information are, to the best of my knowledge, true, accurate and complete.

I am aware that there are penalties for wilfully submitting false, inaccurate or incomplete information.

Signed: __________ **Date:** 16 March 2004

FORWARD TO:
Manager, Contaminated Sites Section
NSW Environment Protection Authority
PO Box A290
SYDNEY SOUTH NSW 1232

Phone: 02 9995 5614
Fax: 02 9995 5999

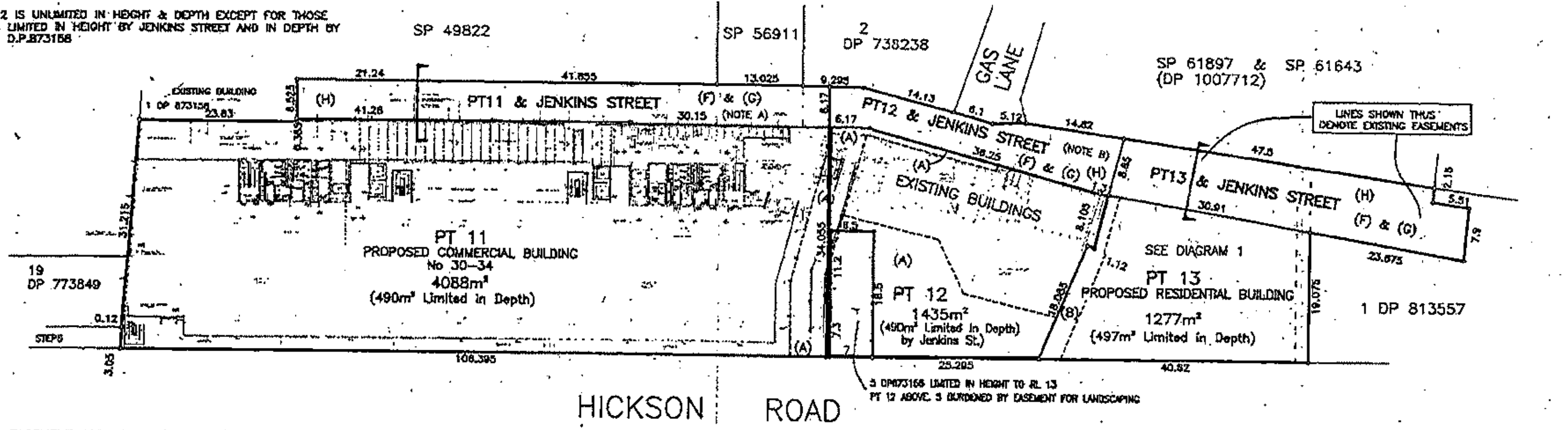
PLAN FORM 2

Plan Drawing only to appear in this space

* OFFICE USE ONLY

LOT 11 & 13 ARE UNLIMITED IN HEIGHT & DEPTH EXCEPT FOR THOSE PARTS LIMITED IN HEIGHT BY JENKINS STREET

LOT 12 IS UNLIMITED IN HEIGHT & DEPTH EXCEPT FOR THOSE PARTS LIMITED IN HEIGHT BY JENKINS STREET AND IN DEPTH BY LOT 5 D.P.873158



(A) EASEMENT FOR PUBLIC ACCESS (A)
(B) EASEMENT FOR LIGHT AND AIR & OVERHANG 3 WIDE AND VARIABLE (B)
(C) EASEMENT TO PERMIT ENCROACHING LIFT TO REMAIN (C)
(D) EASEMENT TO PERMIT STAIR STRUCTURE TO REMAIN (D)
(E) POSITIVE COVENANT FOR MAINTENANCE & REPAIR OF LIFT AND STAIR STRUCTURE (E)
(F) EASEMENT FOR THE SUPPORT OF JENKINS STREET (F)
(G) EASEMENT FOR FUTURE SERVICES (G)
(H) RESTRICTION ON THE USE OF LAND (H)
RESTRICTION (H) BURDENS LOS 11,12 &13 – EXCAVATION MANAGEMENT PLAN

SCHEDULE OF EXISTING EASEMENTS AFFECTING PARTS OF LOTS 11,12,13 & JENKINS ST.

1) EASEMENT FOR LIGHT AND AIR (L923693)
2) EASEMENT FOR ACCESS (L923693)
3) EASEMENT FOR ACCESS (DP 738238)
4) EASEMENT FOR STORMWATER DRAINAGE PURPOSES 2 WIDE (DP 873158)
5) PROPOSED EASEMENT FOR LIGHT AND AIR
6) PROPOSED EASEMENT FOR SERVICES
7) EASEMENT FOR WATER SUPPLY WORKS 3 WIDE & VARIABLE (DP 873158)
8) EASEMENT FOR SEWERAGE PURPOSES OVER EXISTING LINE OF PIPES (DP 873158)
9) RIGHT OF CARRIAGEWAY VARIABLE WIDTH (DP 873158)
10) SERVICES EASEMENT VARIABLE WIDTH (DP 873158)
11) RIGHT OF CARRIAGEWAY & EASEMENT FOR ELECTRICITY TRANSMISSION PURPOSES (DP 873158)
12) EASEMENT FOR DRAINAGE OVER EXISTING LINE OF PIPES (DP873158)
13) EASEMENT FOR SEWERAGE PURPOSES (DP 873158)
14) RIGHT OF CARRIAGEWAY & EASEMENT FOR LIGHT AND AIR (G446006,P238560,DP440413)
15) EASEMENT TO DRAIN WATER (DP 873158)
16) PROPOSED RIGHT OF CARRIAGEWAY (DP 639537)
17) EASEMENT FOR DRAINAGE 1.22 WIDE (J23252 & DP106510)
18) RIGHT OF CARRIAGEWAY & EASEMENT FOR LIGHT AND AIR (DP 238560 & DP 220397)

NOTE A – PT 11 AND JENKINS STREET BURDENED BY EXISTING EASEMENTS 1,2,3,4,5,6,7,8,9,10,11,13

NOTE B – PT 12, PT13 & JENKINS ST. BURDENED BY EXISTING EASEMENTS 2,3,4,6,7,8,9,10,11,12,14,15,16,17,18

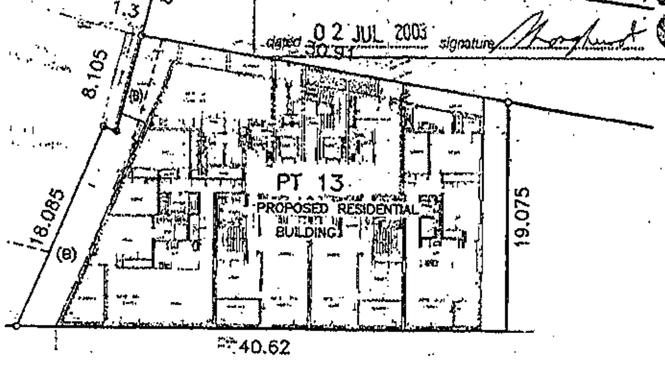
D03/00262 CITY DEVELOPMENT DIVISION

APPROVAL

Development drawings approved subject to conditions by delegation / ~~Council / Central Sydney Planning Committee~~ pursuant to Section 81 (1) (a) of the Environmental Planning & Assessment Act 1979

dated 02 JUL 2003 signature

DIAGRAM 1
1:300



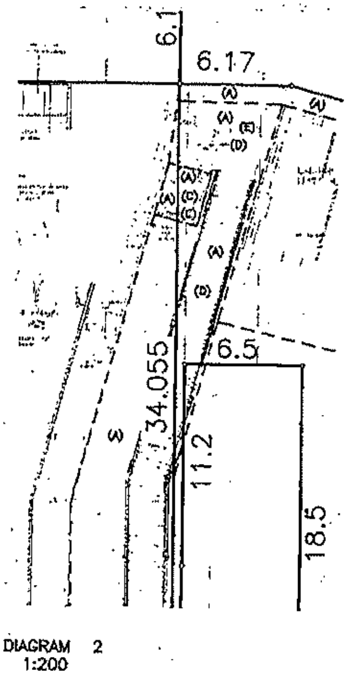
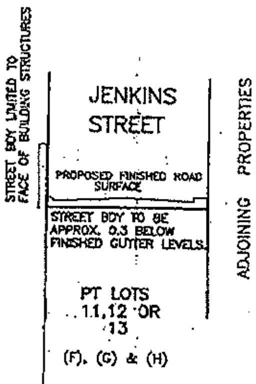


DIAGRAM 2
1:200



TYPICAL SECTION
NOT TO SCALE

CONTRACT PLAN
Plan compiled from architectural CAD data.

Plan is subject to final survey after completion of construction.

PRINTED 10-04-2003
(REVISION 1)

DRAFT PLAN

Registered:
C.A.:
Title System:
Purpose:
Ref.Map:
Last Plan:

PLAN OF PROPOSED SUBDIVISION OF LOTS 2 & 3 IN DP 873158

Lengths are in metres. Reduction Ratio 1: 500

LGA. SYDNEY
Locality: MILLERS POINT
Parish: ST PHILIP
County: CUMBERLAND

This is sheet 1 of my plan in sheets (Delete if inapplicable).

Surveyors (Practice) Regulation 2001

I, TASY MORAITIS of L5, 17 RANDLE ST, SURRY HILLS. NSW. 2010 a surveyor registered under the Surveyors Act 1929, certify that the survey represented in this plan is accurate, has been made in accordance with the Surveyors (Practice) Regulation 2001 and was completed on ....
The survey relates to: ....

(specify the land actually surveyed or specify any land shown in the plan that is not the subject of the survey)

Signature.......................... Dated..............
Surveyor registered under the Surveyor Act 1929
Datum Line: "X"–"Y"
Type: Urban /Rural

Plans used in preparation of survey/compilation
DLP.

PANEL FOR USE ONLY for statements of intention to dedicate public roads, to create public reserves, drainage reserves, easements, restrictions on the use of land or positive covenants

PURSUANT TO SEC. 88B OF THE CONVEYANCING ACT 1919 IT IS INTENDED TO CREATE:

1. EASEMENT FOR PUBLIC ACCESS (A)
2. EASEMENT FOR LIGHT & AIR & OVERHANG (B)
3. EASEMENT TO PERMIT ENCROACHING LIFT TO REMAIN (C)
4. EASEMENT TO PERMIT STAIR STRUCTURE TO REMAIN (D)
5. POSITIVE COVENANT FOR MAINTENANCE & REPAIR (E)
6. EASEMENT FOR SUPPORT OF JENKINS STREET (F)
7. EASEMENT FOR FUTURE SERVICES (G)
8. RESTRICTION ON THE USE OF LAND (H)

IT IS INTENDED TO DEDICATE LOT 19 IN D.P.773849 TO THE PUBLIC AS OPEN SPACE

IT IS INTENDED TO DEDICATE JENKINS STREET TO THE PUBLIC AS ROAD SUBJECT TO THE EXISTING EASEMENTS NOTED IN THE SCHEDULE

C02.02.01.

NSW Environment Protection Authority

SITE AUDIT STATEMENT

Schedule 1, Form 2 (Contaminated Land Management Regulation 1998)

SITE AUDITOR (accredited under the *Contaminated Land Management Act 1997*):

Name:	Mr Ross McFarland	Phone:	02 9950 0200
Company:	CH2M HILL Australia Pty Ltd	Fax:	02 9950 0600
Address:	Level 7, 9 Help Street CHATSWOOD NSW 2067	Accred. No:	9819

SITE AUDIT STATEMENT NO: 2002/17 B

SITE DETAILS:

Address: 38 Hickson Rd, Millers Point

Postcode: 2000

Lot and DP number: Part Lot 3 in Deposited Plan 873158, as shown on attached registered survey plan (Rygate and Company Pty Ltd - reference 69068) with area highlighted by bold outline in attached Architectural plan (reference Number: 64259:AD405003, Issue D)

Local government area: Sydney City Council

SITE AUDIT REQUESTED BY:

Name: Mark Burns

Company: Bovis LendLease Pty Ltd

Address: Level 13, Tower Building, Australia Square
SYDNEY, NSW Postcode: 2000

Phone: 02 - 9237 6194 Fax: 02 - 9237 5744

Name of contact person (if different from above): AS ABOVE

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

URS Australia Pty Ltd
Axis Environmental Pty Ltd
Hyder Consulting
Johnstone Environmental Technology

Title(s) of report(s) reviewed:

- URS (2003) Validation Report, 38 Hickson Road, Millers Point, NSW. Final Report. 25 June 2003., URS reference Number: 45529/017-0807 – R001_Final

Other information reviewed:

- URS (2003) 38 Hickson Road Validation Report – Response to Auditor comments on Draft Validation Report, dated 24 June 2003, (URS Reference Number 45529-021-08).
- Sydney Water Corporation (2003) Consent to Discharge groundwater from 38 Hickson Road to Sydney Water's sewer, letter confirming discharge approval, dated 5 June 2003
- URS (2003) Supplemental Human Health risk Assessment, 38 Hickson road, Millers Point, NSW, dated 14 April 2003, URS Reference Number 45529-017-0810.
- AJM Environmental Services Pty Ltd (2003) Groundwater Handling and treatment Report, 20 January 2003.
- URS (2002) Groundwater Investigation, 30-38 Hickson Road, Miller's Point, Sydney NSW. 1 February 2002.
- URS (2002) Remediation Action Plan, 30-38 Hickson Road, Miller's Point, Sydney NSW. 10 April 2002.
- URS (2002) In-Situ Material Classification and Further Delineation of the Location of the Annulus - 30-38 Hickson Road, Miller's Point, Sydney, NSW. 14 May 2002.
- URS (2002) Further Groundwater Investigations at 30-38 Hickson Road, Miller's Point, Sydney NSW. 15 May 2002.
- URS (2002) Risk Assessment, Bovis Lend Lease Hickson Road, Miller's Point. 31 May 2002.
- Axis Environmental Consultants Pty Ltd (1994) Environmental Assessment Report, Hickson Road Site for Maritime Services Board. 4 August 1994.
- Axis Environmental Consultants Pty Lt. (1994) Summary Contamination Assessment Report, Hickson Road Site for Maritime Services Board. 18 August 1994.
- Hyder Consulting (1998) Environmental Site Assessment, Hickson Road and Port Area, Millers Point, Sydney. September 1998.
- Johnstone Environmental Technology (JET) (1993) Report of Contamination Investigation at MSB Property, Hickson Road, Sydney. August 1993.

Summary Site Audit Report

Title: Residential Sector 38 Hickson Road, Millers Point, NSW, Summary Site Audit Report (SSAR 2002/17 B)

Date : June 2003

I have completed a site audit (as defined in the *Contaminated Land Management Act 1997*) and reviewed the reports and information referred to above with due regard to relevant laws and guidelines. I certify that the site (tick all appropriate boxes):

(a) Is suitable for the following use(s):

☐ ~~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;~~
✓ residential with minimal opportunity for soil access, including units;
☐ ~~daycare centre, preschool, primary school;~~
☐ ~~secondary school;~~
☐ ~~park, recreational open space, playing field~~
☐ ~~commercial/industrial use;~~
✓ other (please specify): may include provision of childcare centre within the property.

~~**subject to;**~~

~~condition(s) (please specify):~~

~~**(b) is not suitable for any beneficial use due to risk of harm from contamination.**~~

☐ ~~(comments):~~

I am accredited by the NSW Environment Protection Authority under *the Contaminated Land Management Act 1997* as a Site Auditor.

Accreditation Number: 9819

I certify that:

(a) I have personally examined and am familiar with the information contained in this statement, including the reports and information referred to in this statement, and
(b) this statement is, to the best of my knowledge, true, accurate and complete, and
(c) on the basis of my inquiries made to those individuals immediately responsible for making the reports, and obtaining the information, referred to in this statement, those reports and that information are, to the best of my knowledge, true, accurate and complete.

I am aware that there are penalties for wilfully submitting false, inaccurate or incomplete information.

Signed: **Date:** 30 June 2003

FORWARD TO:
Manager, Contaminated Sites Section
NSW Environment Protection Authority
PO Box A290
SYDNEY SOUTH NSW 1232

Phone: 02 9995 5614
Fax: 02 9995 5999

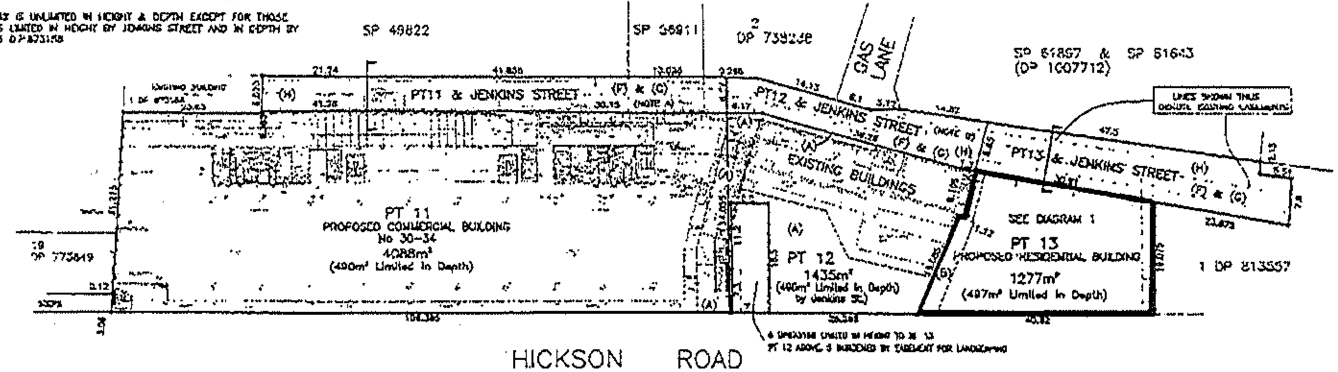
PLAN FORM 2

Plan Drawing only to appear in this space

* OFFICE USE ONLY

LOT 11 & 13 ARE UNLIMITED IN HEIGHT & DEPTH EXCEPT FOR THOSE PARTS LIMITED IN HEIGHT BY JENKINS STREET

LOT 12 IS UNLIMITED IN HEIGHT & DEPTH EXCEPT FOR THOSE PARTS LIMITED IN HEIGHT BY JENKINS STREET AND IN DEPTH BY LOT 5 DP 873158



(A) EASEMENT FOR PUBLIC ACCESS (A)
(B) EASEMENT FOR LIGHT AND AIR & OVERHANG 3 WIDE AND VARIABLE (B)
(C) EASEMENT TO PERMIT ENCROACHING LIFT TO REMAIN (C)
(D) EASEMENT TO PERMIT STAIR STRUCTURE TO REMAIN (D)
(E) POSITIVE COVENANT FOR MAINTENANCE & REPAIR OF LIFT AND STAIR STRUCTURE (E)
(F) EASEMENT FOR THE SUPPORT OF JENKINS STREET (F)
(G) EASEMENT FOR FUTURE SERVICES (G)
(H) RESTRICTION ON THE USE OF LAND (H)
RESTRICTION (H) BURDENS LOT 11,12 &13 ~ EXCAVATION MANAGEMENT PLAN

SCHEDULE OF EXISTING EASEMENTS AFFECTING PARTS OF LOTS 11,12,13 & JENKINS ST.

1) EASEMENT FOR LIGHT AND AIR (L923093)
2) EASEMENT FOR ACCESS (L923693)
3) EASEMENT FOR ACCESS (DP 735238)
4) EASEMENT FOR STORMWATER DRAINAGE PURPOSES 2 WIDE (DP 873158)
5) PROPOSED EASEMENT FOR LIGHT AND AIR
6) PROPOSED EASEMENT FOR SERVICES
7) EASEMENT FOR WATER SUPPLY WORKS 3 WIDE & VARIABLE (DP 873158)
8) EASEMENT FOR SEWERAGE PURPOSES OVER EXISTING LINE OF PIPES (DP 873158)
9) RIGHT OF CARRIAGEWAY VARIABLE WIDTH (DP 873158)
10) SERVICES EASEMENT VARIABLE WIDTH (DP 873158)
11) RIGHT OF CARRIAGEWAY & EASEMENT FOR ELECTRICITY TRANSMISSION PURPOSES (DP 873158)
12) EASEMENT FOR DRAINAGE OVER EXISTING LINE OF PIPES (DP873158)
13) EASEMENT FOR SEWERAGE PURPOSES (DP 873158)
14) RIGHT OF CARRIAGEWAY & EASEMENT FOR LIGHT AND AIR (0446006,P238560,DP440413)
15) EASEMENT TO DRAIN WATER (DP 873158)
16) PROPOSED RIGHT OF CARRIAGEWAY (DP 639537)
17) EASEMENT FOR DRAINAGE 1.22 WIDE (J23252 & DP108510)
18) RIGHT OF CARRIAGEWAY & EASEMENT FOR LIGHT AND AIR (DP 238560 & DP 220397)

NOTE A – PT 11 AND JENKINS STREET BURDENED BY EXISTING EASEMENTS 1,2,3,4,5,6,7,8,9,10,11,13

NOTE B – PT 12, PT13 & JENKINS ST. BURDENED BY EXISTING EASEMENTS 2,3,4,6,7,8,9,10,11,12,14,15,16,17,18

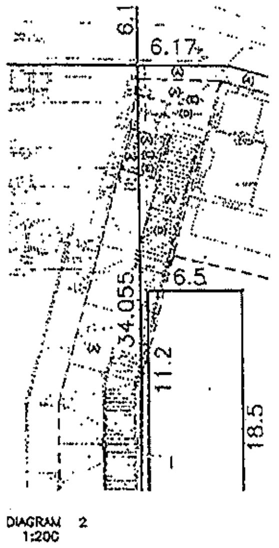
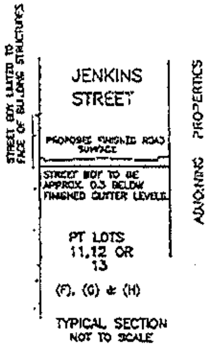
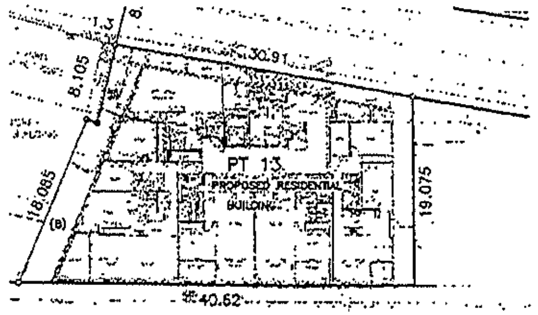


DIAGRAM 2
1:200



TYPICAL SECTION
NOT TO SCALE

DIAGRAM 1
1:300



CONTRACT PLAN
Plan compiled from architectural CAD data.

Plan is subject to final survey after completion of construction.

PRINTED 10-04-2003
(REVISION 1)

SURVEYOR'S REFERENCE: 020906 DRAFT DP

WARNING: CREASING OR FOLDING WILL LEAD TO REJECTION

DRAFT PLAN

Registered
C.A.
Title System
Purpose
Ref.Map
Last Plan

PLAN OF PROPOSED SUBDIVISION OF LOTS 2 & 3 IN DP 873158

Lengths are in metres. Reduction Ratio 1: 500

LGA SYDNEY
Locality: MILLERS POINT
Parish: ST PHILIP
County: CUMBERLAND

This is sheet 1 of my plan in sheets

Surveyors (Practice) Regulation 2001
I, TASY MORAITIS
of L5, 17 HAROLE ST, SURRY HILLS, NSW, 2010 [illegible]

Signature: .... Date: ....
Datum Line: X—Y

Plans used in preparation of survey/compilation D.P.

PANEL FOR USE ONLY for statements of intention to dedicate public roads, to create public reserves, drainage reserves, easements, restrictions on the use of land or positive covenants

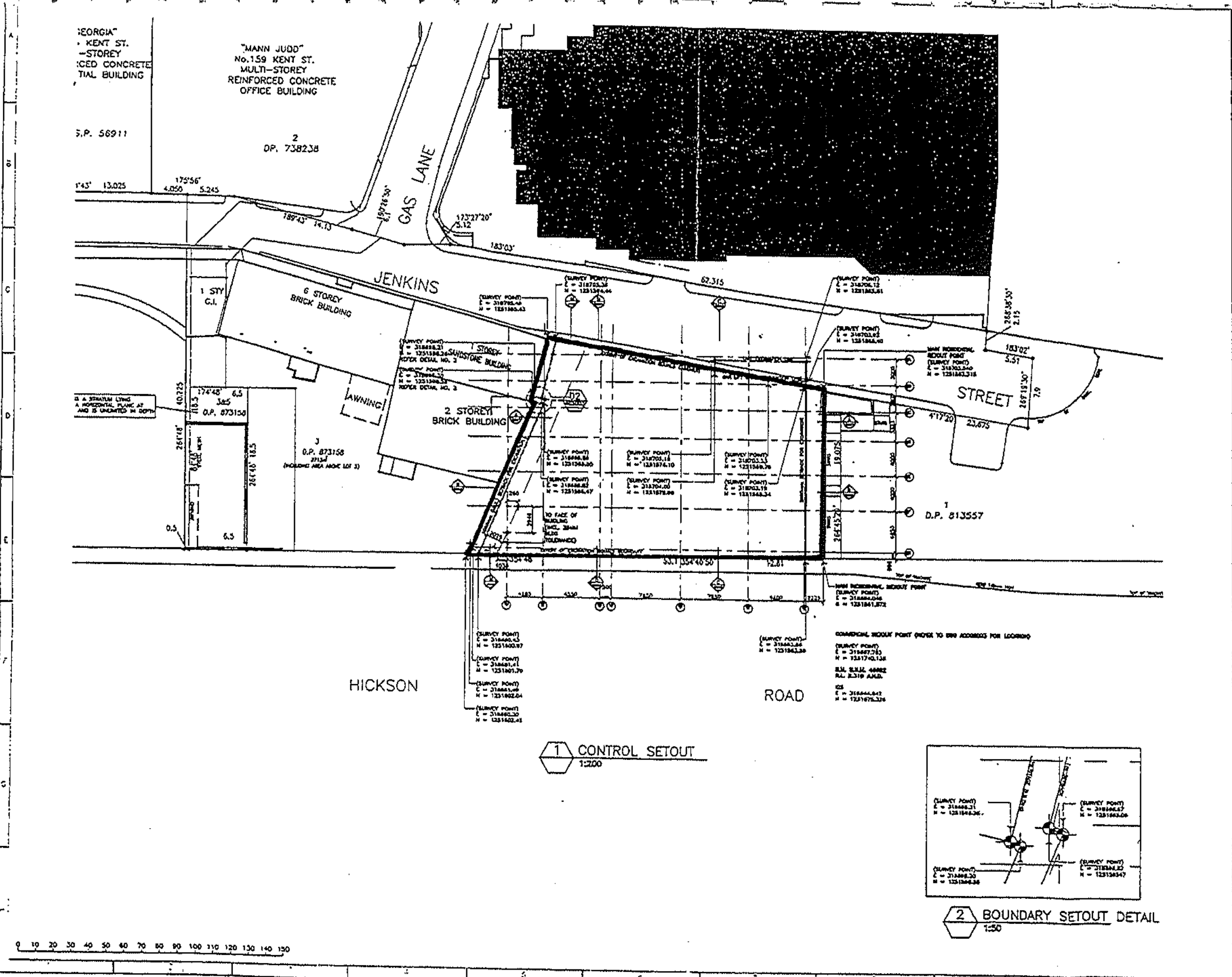
PURSUANT TO SEC. 88B OF THE CONVEYANCING ACT 1919 IT IS INTENDED TO CREATE:

1. EASEMENT FOR PUBLIC ACCESS (A)
2. EASEMENT FOR LIGHT & AIR & OVERHANG (B)
3. EASEMENT TO PERMIT ENCROACHING LIFT TO REMAIN (C)
4. EASEMENT TO PERMIT STAIR STRUCTURE TO REMAIN (D)
5. POSITIVE COVENANT FOR MAINTENANCE & REPAIR (E)
6. EASEMENT FOR SUPPORT OF JENKINS STREET (F)
7. EASEMENT FOR FUTURE SERVICES (G)
8. RESTRICTION ON THE USE OF LAND (H)

IT IS INTENDED TO DEDICATE LOT 19 IN D.P.773849 TO THE PUBLIC AS OPEN SPACE

IT IS INTENDED TO DEDICATE JENKINS STREET TO THE PUBLIC AS ROAD SUBJECT TO THE EXISTING EASEMENTS NOTED IN THE SCHEDULE

K:\CADJOBS\020906_HICKSON-ROAD\DP.DWG



KEY PLAN

Do not scale from drawings. Always take figured dimensions in preference to scaling. verify — all dimensions on site before commencing work. Copying or the reproduction of this drawing is strictly prohibited without the consent of Peddle Thorp & Walker P/L.

Bovis Lend Lease

Bovis Lend Lease Pty. Limited

PTW

Delmo Number 2

38 HICKSON ROAD
RESIDENTIAL BUILDING

CONTROL SETOUT

1/200

16/07/2002

642459-AD405003 D

APPENDIX G

CURRICULUM VITAE FOR DR IAN C SWANE (CPEng)

Dr Ian Swane (CPEng)

Sydney

Qualifications:

PhD (Geotechnical Engineering), University of Sydney, 1983

Bachelor of Engineering (Hons) (Civil), University of Sydney, 1977

Accredited Site Auditor for contaminated sites in NSW, WA, QLD and NT

Affiliations:

Institution of Engineers, Australia (IEAust); Australian Geomechanics Society (AGS); American Society of Civil Engineers (ASCE); International Society of Soil and Rock Mechanics (ISSRM); International Society of Soil Mechanics and Foundation Engineering (ISSMFE); Australian Land and Groundwater Association (ALGA)

Fields of Special Competence

Contaminated Land Management, Civil, Environmental and Geotechnical Engineering, Environmental and Waste Management, Mining and Offshore Engineering. Ian’s expertise covers all facets of contaminated land management, with a particularly high level in geotechnology, hydrogeology, contaminant transport & exposure assessment, human health and environmental risk assessment, data evaluation, risk evaluation, soil / groundwater / sediment sampling, contaminated land management, QA/QC and remedial technologies and associated requirements.

Current Responsibilities

Ian is a Senior Executive Engineer with Sinclair Knight Merz and their Practice Leader for Contaminated Land Management based in Sydney. The main emphasis of the practice is Contaminated Land Management, Environmental Management, Solid & Hazardous Waste Management, “Brown-Field” Property development and Environmental Auditing for clients in Australia and South East Asia. Ian is also an accredited Site Auditor for contaminated sites in NSW, WA, QLD and the NT. For the past three years Ian has also been a guest lecturer in the School of Environment at the University of Technology Sydney.

Relevant Experience

Technical Advisory to Government Agencies

Over the past 10 years Dr Swane has been a Government–appointed technical adviser on major contaminated site projects, which include:

- Steel River Remediation Project (2010-2011): Chairman of an expert panel set up by BHPB and NSW EPA to develop success criteria, success measures and remediation strategy for the former BHP Steelworks waste disposal area now known as Steel River, Hunter River.
- Lake Macquarie City Council (Feb. 2012): Developed/presented 3-day staff training workshop on “Technical Assess/t of Rezoning & Develop/t Applications Requiring Contam. Land Management”

- Homebush Bay Dioxin Remediation Project (1999–2007): Remediation strategy assessment, tender assessment, detailed health and ecological risk assessment for the remediation of the Homebush Bay sediments and technical reviews. This work was provided to Maritime NSW and Dept Public Works. Project value exceeding $100 million.
- BHPB Newcastle Steelworks Remediation Project (2005-2009): Provided expert technical advice to Hunter Development Corporation & NSW EPA on Hunter River contaminated sediment remediation, the design of the emplacement cell at Kooragang Island, and remediation work for the new coal loader. The work involved reviewing investigation reports, stabilisation trials, technology assessments, remediation action plan (RAP), design reports and EMPs
- Contaminated Sediment Reviews (2001-2008): Provided expert technical advice on various waterways in Sydney Harbour and Parramatta River for NSW Maritime. The work involved reviewing investigation reports, ecotoxicological studies, groundwater assessments, health and ecological risk assessments
- Dept. of Defence Technical Adviser (2001-2008): Provided independent expert technical advice for the investigation &/or remediation of HMAS Platypus (Neutral Bay), Adamstown Rifle Range, the Myambat Logistics Depot, Evans Head Air Weapons Range.
- ACT Landfill Inquiry (1999): Provided an expert report on environmental management practices for the West Belconnen Landfill for the ACT Urban Services Dept.

NSW EPA Accredited Contaminated Land Audits (including ACT)

- Undertaken over 220 Statutory and Non-Statutory EPA Site Audits comprising Defence sites, major infrastructure sites, landfills, chemical plants, large communication sites, public open space, residential / commercial developments and agricultural lands across Sydney, Sydney Harbour and regional NSW and the ACT.
- Site auditor to the Department of Defence for the remediation of Belconnen Naval Transmitting Station, Fort Wallace, Stockton Rifle Ranges and training depot at Port Kembla.
- Site Auditor for Cockatoo and Snapper Islands for the Sydney Harbour Federation Trust (2002-present) and Macquarie Lightstation (Sydney) for the Department of Finance.

WA DEC Accredited Contaminated Site Audits

- WA DEC Site Auditor for heavy mineral sand processing sites at Geraldton and Capel, 4 Shell petroleum sites (Perth), oil storage depot (Esperance), Amcor Paper Mill (Bibra Lakes), Australian Fine China site (Subiaco), Pioneer Road Services site (Subiaco), Automasters site (Northbridge), sewage treatment pond (Coral Bay),former Pyrton mental hospital (Bassendean), property developments at Southern River and Baldivis.

Qld DERM Accredited Third Party Reviewer & Vic EPA Contaminated Land Audits

- Third Party Reviewer (TPR) for the Jezzine Barracks (Townsville), the West End Gasworks site for Stocklands and Energex and a residential development in Northgate, Qld
- Channel 7 facilities at Docklands, Melbourne

Contaminated Site Remediation and Rehabilitation

- Assessment of site remediation strategies for the Hickson Road gasworks for Jemena, the Steel River Site in Newcastle for BHPB and the contaminated sediments in Kendall Bay adjacent to former AGL Mortlake Gasworks site Sydney
- Project Manager for the detailed investigation and remediation of the Jervis Bay Range Facility for the Department of Defence since 1999.
- Project Superintendent for contaminated site remediation works at six gasworks sites (Mortlake, Oyster Cove, Maitland, Albury, Manly, Abbotsford), a chemical plant, a pharmaceutical plant, and two oil storage facilities and a railway maintenance facility, having project values exceeding $250 million. Remediation methods include thermal desorption, soil washing, off-site disposal, capping

and containment, co-burning, bioremediation, solidification and stabilisation, incineration, pump-and-treat.

- Project Manager between 1987-1998 for the remediation of the 51ha Mortlake Gasworks site in Sydney, including the management of all site investigations, engineering assessments, detailed design, tender documentation, contract administration and construction management. Projects to date include a $40 million clean-up program for soils and groundwater, a $10 million recovery and recycling program for 33 million litres of coal tar sludges, a $3 million laboratory validation program, a $1 million bioremediation trial, a $250,000 gasholder cleanup program, preparation of an EIS for the entire remediation project, numerous technology trials, preliminary engineering, constructability review, value engineering, strategic planning, risk management. Design and supervision of a $1 million enhanced bioremediation trial.
- Preliminary engineering for the remediation of petroleum sludge lagoons at Sera, Brunei for Shell.
- Design study for the use of coal wash reject for capping a contaminated site in Newcastle.
- Technical adviser on the remediation and management of PCE contamination at the Lawrence Dry Cleaners site (Alexandria), the largest dry cleaning facility in Australia.
- Project Director for the investigation & remediation of asbestos contamination at a proposed methanol facility on the North West Shelf.
- Project Director for the design, construction and operation of an in-situ bioventing and groundwater treatment system at a former petrol station site at Killara, Sydney.
- Project Director & /or Manager for the investigation and design of rehabilitation strategies for commercial developments to be built on former landfill and unhealthy building land sites at St Peters Landfill (South Sydney Council), and Salt Pan Reserve Landfill at Brooklyn (Hornsby Council & NSW Rural Fire Service).
- Project Director for a $3 million project involving the treatment of 7,500t of PCB contaminated soil at a major property development in Manila, using thermal desorption, and the destruction of the PCB rich condensate using plasma arc.
- Project Superintendent for the remediation of pharmaceutical wastes (Merke Sharpe & Dohme).
- Remediation design and costing study for a lead smelter and surrounding environs.
- Remediation design for a PCB decontamination program at a substation.
- Design and supervision of groundwater treatment and disposal systems at rehabilitated sites in Sydney which include gasworks, chemical plant, pharmaceutical plant and a public park.
- Contamination assessments, engineering, and remediation of a former asphalt plant at Wolli Creek, Sydney for State Rail
- Design and supervision of a contaminated site involving cement stabilisation of chrome contaminated soils at Parramatta.
- Detailed design, construction supervision and commissioning of a wastewater treatment system for a Medium Density Fibreboard Plant (NSW).

Contaminated Sites Investigation and Assessment

- Technical reviewer for the investigation & risk assessment of Hickson Road Gasworks (Sydney).
- Contaminated site investigations, design studies, audits, regulatory approvals and licensing, tender documentation for a large number of contaminated sites including nine former gasworks, fuel depots, railway facilities, power facilities, landfills, mines, aluminium smelter, chemical and pharmaceutical plants throughout Australia.
- Contaminated sediment assessments for Jemena at Kendall Bay (Sydney) and BHPB Hunter River
- Contaminated sediment assessments for NSW Waterways Authority for Homebush Bay, Abbotsford Bay, Parramatta River adjacent to former Mortlake Gasworks site, former oil storage/ manufacturing facilities at Ballast Point and Berrys Bay, and marinas at Long Bay and Chiswick.

- Contaminated sediment assessments for the DPWS for Kogarah Bay, Rozelle Bay, Iron Cove, Brays Bay and Curl Curl Lagoon.
- Project Manager for the preliminary and detailed investigation of the Beecroft Naval Weapons Range, Jervis Bay involving contamination, UXO and ecological studies. Project Manager for the preliminary investigation of the Enoggera Gallipoli Barracks (Qld).
- Phase II contamination / risk assessments / RAPs at a putrescible landfill and former sand mine at North Entrance for the local Aboriginal Land Council, at railway maintenance facility at Chullora for Rail Services Australia and Kooragang Island freight terminal for FreightCorp, for properties owned by Sydney Water, at former sewerage treatment plant and night soil disposal sites at West Wallsend and Bankstown, 16 properties owned by Integral Energy, 8 properties owned by EnergyAustralia.
- Contamination assessment / remediation options assessment / engineering for a residential estate in Banksia for Rockdale City Council, the construction of a community facility at the former landfill at Sydney Park, St Peters for South Sydney Council, a former lead battery site at Granville.
- Environmental due diligence audits for FreightCorp’s property portfolio comprising 62 sites in NSW and SA
- HAZOP Study facilitator and reviewer for site remediation projects (eg. at a Sydney landfill, coal tar sludge recycling project).
- Groundwater contamination studies for the Latina, Cirene and Montalto nuclear power plants in Italy involving analyses of groundwater flow, saltwater intrusion and radioactive pollutant migration; design studies for radioactive waste repository at Cirene Nuclear Power Plant, Italy.
- Attended Feb 2012 Advanced LNAPL Site Management and Quantitative Analysis Workshop by Midwest Geosciences Group & ACLCA

Site-Specific Health & Ecological Risk Assessment

- Detailed HHERA for the BHPB Steel River site at Newcastle involving contaminated groundwater, foreshore seeps, sediments, volatile gas emissions, marine fauna & flora studies
- Detailed HHERA’s for contaminated sediments in Homebush Bay sediments for NSW Waterways Authority, for lead and other heavy metal contamination along 3 major water supply pipelines (Sydney) and a former gasworks site at MacDonaldtown (Sydney)
- Detailed HHERA for a former liquid waste disposal centre at Gosnells WA.
- Preliminary HHRA’s for VCH contamination at a rail facility in Botany, and for VOC ground contamination at a residential estate in Banksia for Rockdale City Council
- VOC contamination at a former lead battery site near Duck River at Granville
- Attended May 2010 Australasian College of Toxicology & Risk Assessment (ACTRA) Workshop on Risk Assessment of Carcinogens

Solid & Hazardous Waste Management

- Technical expert to the NSW Government for the Homebush Bay Dioxin Remediation Project since 1999, involving the evaluation of remediation technologies including indirect/direct thermal desorption technologies, base catalytic dechlorination, cap and contain.
- Expert review / reporting of the landfill design and environmental health risks associated with the proposed Ravensworth Waste Management Centre in the Hunter Valley for Singleton Council; environmental management practices for landfills in the ACT for the ACT Government (Urban Services Department); landfill management procedures for the proposed Ardlethan Landfill and testimony at the Commission of Inquiry.
- Design of an oil-sludge compost facility for the Shell Clyde oil refinery, Sydney; design of remedial works for fly ash dams at a decommissioned power station at Tallawarra.

- Managed the design of secure landfills for Albury and Sydney City Council, an aluminium smelter, former gasworks sites, chemical and manufacturing plants (1989-present)
- Appointed by the World Bank to undertake a feasibility study into the design of a Hazardous Waste Landfill for the JABOTABEK region in Indonesia (1992)
- Expert witness for the Bega Valley Shire Council in a Land & Environment Court Case involving the Merimbula Landfill site (1998), in the Commission of Inquiry for the Werribee Secure Landfill, Victoria (1997)
- Investigation and design of secure landfills and containment cells for Albury and Sydney City Council, an aluminium smelter, a 700,00m3 cell at a former gasworks at Mortlake, a containment cell at a former gasworks at Maitland, a chemical plant at Camellia, and a 17,000m3 cell at a former lead battery site at Granville
- Stabilisation and disposal of pesticide contaminated waste for Dow Chemicals

Highways, Foundations, Dams and Tunnels

- Independent geotechnical review for the Alice Springs to Darwin railway.
- Stability assessments for all major road cuttings and embankments in the RTA highway network over Sydney; geotechnical design review for the M5 (East) Highway, for Baulderstone Hornibrook.
- Investigation, design, regulatory approvals, inspections, and construction monitoring for de-watering program, foundations, retaining walls, excavations and slope stabilisation works at the Eastern Distributor Project.
- Investigation, design and construction supervision of retained earth walls, embankments, bridge abutments, cut slopes, support systems at the M5 Tollway and M5 Western Link for Leightons Interlink.
- Geotechnical investigations for the Botany Highway at Mascot, Sydney. Studies included site investigations, embankment instrumentation and monitoring, remedial design of pipeline foundations, and supervision of chemical grouting program.
- Rock slope stability assessment for the spillway abutment at Dartmouth Dam, Victoria; geotechnical design review for two water storage dams and building foundations at the Redbank Power Station for ABB.
- Investigation, design, tender documentation and project supervision for the reconstruction of a failed dam at Mt Annan, New South Wales; rock excavation assessment for Nepean Dam augmentation works.
- Geotechnical investigation and foundation design for telecommunication towers for the Orange Network in Sydney, the SA-NSW Interconnector transmission line for Transgrid; Designing tender documentation and project supervision for the reconstruction of a damaged telecommunications tunnel in Sydney.
- Geotechnical assessments for the Rouse Hill Water Project, Sydney; foundation assessment for a property development at North Ryde for Business Land Group; geotechnical design review for a container crane rail system at Port Botany
- Design for a sheet-pile wall cofferdam for construction of a power station at Yarrawonga on the Murray River; rock excavation and support investigation and design for a rock cavern at the North Head Treatment Works, Sydney.
- Geotechnical investigations for several nuclear power plants in Italy. Studies included foundation designs for retaining walls, rafts and diversion tunnels, and slope stability assessments in soil and rock.

Mining Geotechnical Studies

- Geotechnical investigations and design studies for a proposed Gold Mine, Lihir Island, Papua New Guinea between 1987 and 1992. Investigations included plant sites, dams, wharves, causeways, harbour reclamation, airport, pipelines, haul roads, stockpiles, waste disposal, and economic trade-off studies.

- Stability assessments of Open Pit Slopes for the Iron Monarch and Callide Mines in South Australia and Queensland. Studies involved computer analysis of the rock slopes using Finite Element techniques.
- Geotechnical assessment for a primary crusher facility at a magnesite mine at Young.

Offshore and Coastal Engineering

- Principal offshore Design Engineer for a Saudi Aramco project comprising the design and installation of 31 steel jacket structures in the Arabian Gulf.
- Geotechnical studies for the proposed Goodwyn Platform, Northwest Shelf, Western Australia. Investigations involved pile design studies for the platform. Site selection study for a driven and grouted pile test program for Esso.
- Design of pile foundations in marine soils and weak rock, pile driveability studies, seismic design of foundations, liquefaction assessments, and studies on jack-up rigs for locations in the North Sea, Mediterranean Sea and along the west coast of Africa.
- Design of caissons and port facilities, soil-structure interaction studies, and liquefaction assessments for a port in Algeria; Dynamic analysis of pile foundation for a coal unloading terminal at Milazzo, Sicily.
- Design studies for waterway developments around Sydney, including dredging assessments, dredge spoil disposal schemes, land reclamations, marine foundations, seabed reconnaissance and pollution assessments. Sites include Kogarah Bay, Rozelle Bay, Iron Cove, Brays Bay and Curl Curl Lagoon.
- Offshore geotechnical investigation and engineering design for a large harbour reclamation project in Papua New Guinea.
- Maintenance Dredging study at Brooklyn, NSW.

Expert Witness/Reporting

- Expert witness in the Federal Court for ground contamination matters involving a former timber treatment site at Armidale, a former battery manufacturing plant at North Ryde, and a former petrol station at Killara.
- Expert witness in NSW Supreme Court for contaminated sites at Camperdown, Kurnell (Serenity Cove) and Unanderra; a former night-soil disposal facility at Bankstown; a slope failure at Dural.
- Expert witness in the NSW Land and Environment Court for a proposed commercial development at Kurnell; a waterway development in Sydney; a closure plan for a landfill at Riverstone; and the remediation of a site at Rhodes contaminated with SCW.
- Expert witness in a District Court for a foundation failure in Campbelltown.
- Expert witness in Qld Supreme Court (Mackay) for a former gasworks site
- Expert witness in Commission of Inquiry, Werribee Landfill, Victoria.
- Expert reporting for Federal Government Standing Committee on the remediation of the HMAS Platypus site, Neutral Bay
- Expert reporting in the NSW Supreme Court for the treatment of dioxin contaminated soil by thermal desorption at Homebush Bay; a contaminated site at Marrickville; a soil stabilisation process; the use of coal wash reject at a major residential subdivision at Illawarra; contamination at the Brookvale Brickworks
- Expert reporting for NSW EPA prosecution in Land and Environment Court under EO&P Act for pollution at a manufacturing facility in Tumut, NSW.

- Expert reporting in Land & Environment Court for a pollution incident at the Merimbula Waste Depot; a contaminated Site at HMAS Platypus (North Sydney); the remediation of a service station site at Wollongong.
- Expert reporting for a coronial inquiry into the Coledale landslide for the NSW Coroner.
- Expert reporting for Qld Supreme Court for the remediation of the Newstead Gasworks (Brisbane).
- Expert reporting for contaminated sites at Hickson Road Gasworks Barangaroo, Brookvale Brickpit, Maitland, two at North Ryde, one at Penrith, Gladesville, Camperdown and Condell Park, the thermal desorption of dioxin-contaminated soil at Rhodes, the investigation & remediation of chlorinated solvent contamination at a large dry cleaners operation at Alexandria (Sydney), remediation of Scheduled Chemical Waste at the Olympic Precinct at North Homebush, Sydney; asbestos contamination in a building in NT; a former railway maintenance facility at Chullora; a pesticide pollution incident at Shellharbour, NSW.
- Expert reporting for geotechnical issues at a building in Leichhardt, a retaining wall failure at Stanmore, a buried pipeline failure at the Central Coast, a dam failure at Mount Annan (NSW), a failed sewerage treatment lagoon at Echuca (Vic) and for the impacts of a sand and gravel quarry on the Hunter River and Aberglasslyn House.

Positions Held

Sinclair Knight Merz

2006 to Present

Practice Leader for Contaminated Land Management across SKM.

August 1999 to 2005

Senior Executive Engineer and Manager of the Contaminated Sites and Geotechnical Groups based in Sydney.

Dames & Moore

March 1997 to July 1999

Director, Principal Engineer and Manager of the Major Environmental Projects Office in Sydney. The main emphasis of the Group was the remediation and development of “Brown-Field Sites”, “Environmental Performance Based Contracting” and “Project Management” of major projects for clients in Australia and South East Asia.

March 1989 to March 1997

Principal Engineer and Manager of the Geotechnical and Site Remediation Groups in Sydney.

May 1986 to March 1989

Senior Geotechnical Engineer responsible for the management of geotechnical engineering projects for major infrastructure and mining developments, and for the management of contaminated sites investigations and site remediation projects.

D'Appolonia SPA, Italy & Belgium

1983 to 1986

Senior Engineer. Responsible for the management of projects in offshore engineering, coastal engineering, geotechnical investigations, and groundwater contamination studies.

Sydney University

1979 to 1983

Ph.D Postgraduate Student, University of Sydney. Research topic was the cyclic behaviour of laterally loaded piles, which involved the development of numerical methods for predicting the performance and safety of pile foundations, as typically occur in fixed offshore structures.

Coffey & Partners

1978

Project Engineer involved in groundwater studies, pile design, foundation investigations and stability assessments.

Department of Public Works, New South Wales

1974 to 1978

Cadet Engineer and Assistant Project Engineer, where experience was gained in foundation investigation, design studies, dam construction, engineering geology, and municipal engineering.

Languages

English

Papers and Presentations

- Swane, I.C. November 2011. “Impacts on site auditing from changes to the NEPM”. Australian Sustainability Business Group Contaminated Land Conference
- Swane, I.C. August 2011. “Brownfield development, contaminated land and the planning system in NSW – Site Auditor’s perspective”. ALGA Sydney seminar
- Swane, I.C. March 2011 “Soil Investigation Levels for Radionuclide Contamination from Heavy Mineral Sand Processing”. EcoForum March 2011, Sydney
- Swane, I.C. October 2010. “Cleaning up Clean-ups – Case studies in contamination caused during remediation projects”. WA DEC Site Auditors Meeting, Perth
- Lecturer at University of Technology (UTS) Sydney course 2010-2011: Topics comprised “From site assessment to remediation, clarification of issues” & “Martin Street Armidale – How Things Could Still Go Wrong Even with a Site Auditor”
- Swane, I.C. October 2010. “Cleaning Up Clean-ups – Case Studies in Contamination caused during Remediation Projects”, Presentation to WA Site Auditor Meeting, Perth
- Swane, I.C. Presented “Trends in Contaminated Sediment Remediation in the US: Sustainability Considerations” at EcoForum 2009 & ALGA seminars in Sydney & Newcastle
- Swane, I.C. 2009 “Reliability of Groundwater Computer Models Predicting the Fate of Petroleum Hydrocarbons”. EcoForum 2009, Sydney
- Swane, I.C. 2007. “Contamination & Other Health & Environmental Risk Factors at the Beecroft Weapons Range and Strategies for Sustainable Use”. Contamination CleanUp07, CRC CARE. Adelaide.
- Swane, I.C. 2007. “Investigation Levels for Residential Land Having Substantial Home-grown Produce in Australia”. Contamination CleanUp07, CRC CARE. Adelaide.
- Swane, I.C. September 2004. “Managing Contamination in Endangered Ecosystems – Mary Creek Headwaters Remediation Project”. Contaminated Site Remediation Conference – Special Symposium on Defence Environmental Risk Assessment and Remediation. Department of Defence, Adelaide. 11 pages.
- Swane, I.C., Webb, R., & Moss, D. 2003. “Dioxin Contaminated Sediments & Marine Ecology In Homebush Bay, Sydney”. Second International Conference on the Remediation of Contaminated Sediments, Venice, 30 September – 3 October 2003.
- Swane, I.C., Moss, D. & Webb, R. 2003. “The Homebush Bay Dioxin Remediation Project, Sydney”. Second International Conference on the Remediation of Contaminated Sediments, Venice, 30 September – 3 October 2003.
- Swane, I.C., 2001. “Homebush Bay Dioxin Remediation Project”, GeoEnvironment 2001, 2nd Australia and New Zealand Conference on Environmental Geotechnics, Newcastle. Reprinted in Australian Geomechanics Journal, Vol. 36, No. 4, December 2001, pp 25-42.

- Swane, I.C., 1999, "Cleaner Production – A Case Study on the Food and Automobile Industry", 3rd Philippine International Toxic and Hazardous Waste Congress, Manila.
- Swane, I.C., October 1998, "Managing Contaminated Land in New South Wales, The Auditor's Perspective", Australian Property Institute, Environment Issues – Contaminated Land, Sydney.
- Swane, I.C. & Anderson, E.L., April 1998, "Lessons from the Oyster Cove Gasworks Remediation Project", 4th National Hazardous & Solid Waste Convention, Brisbane.
- Swane, I.C., McLaughlin, M.J., & Bagwell, G, November 1997, "Contaminated Land Remediation in Australia – Recent Developments and State of Play", Geo Environment 97, 1st Australia-New Zealand Conference on Environmental Geotechnics, Melbourne, 21pp.
- Swane, I.C., May 1997, "Environmental Liability and the Role of Site Remediation - Recent Australian Case Studies", IBC Conference on Environmental Liability in Commercial Property Transactions, Sydney.
- Anderson, E., Peyton, A., & Swane, I., March 1997, "Cleaning Up Gasworks Sites - Containment, Treatment or Off-Site Disposal", Waste Technology Conference, AWWA, Melbourne.
- Swane, I.C., Feb 1996, "Contaminated Land and Its Implications for the Building Industry", Presentation to the Australian Institute of Building, Sydney Division, 6 pp.
- Swane, I.C., Nov 1995, "Developments in Remediation Technologies for Gasworks Sites", IBC Conference on Strategies for Effectively Managing Site Contamination and Remediation, Sydney
- Swane, I.C., Nov 1994, "The Application of Landfill Technologies in Australia", Landfill '94 November, Banksia Environmental Foundation Inc. Sydney.
- Swane, I.C., Feb 1994, "Site Remediation Engineering", Guest Lecturer, First Australia-New Zealand Young Geotechnical Professionals Conference, University of NSW.
- Swane, I.C., March 1993, "Dealing with Toxic Environments in Urban Waterfront Development", Urban Waterfront Development Pacific Rim Conference Sydney.
- Swane, I.C., Dunbaven, M. & Riddell, P., 1993, "Remediation of Contaminated Sites in Australia", Conference on Geotechnical Management of Waste and Contamination", IEngs Aust, 22-23 March
- Swane, I.C, 1992, "Little Manly Point Rehabilitation Project", Engineering Excellence Awards, Institution of Engineers Australia, Sydney Division.
- Swane, I.C, 1992, "Rehabilitation of Hazardous Waste Sites", Institution of Engineers Australia, Civil Engineering Panel, Sydney Division.
- Swane, I.C, 1992, "Case Studies in Site Contamination Audits: Lessons Learnt and Problems to be Solved", Second Fulbright Symposium on contaminated Sties in Australia: Challenges for Law and Public Policy.
- Swane, I.C., March 1988, "Engineering Solutions to Using Contaminated Land," Conference on Transportation, Handling and Storage of Hazardous Materials, Institute for International Research, Jakarta.
- Swane, I.C., 1987, "Geotechnical Reconnaissance for Waterway Developments in Sydney", 8th Australian Conf. Coastal and Ocean Engineering, Launceston, Tasmania.
- Swane, I.C. and I. Irvine, 1987, "Contamination of Sediments at Some Waterways in Sydney", 8th Australian Conf. Coastal and Ocean Engineering, Launceston, Tasmania.
- Michalopoulos, A.P., I.C. Swane, G.M. Manfredini, E. Silvestri, and I.V. Constantopoulos, 1985, "Effects of Variability in Soil-Structure Interaction Parameters on Probabilistic Seismic Risk Assessment", Proceedings of the Eight International Conference on Structural Mechanics in Reactor Technology, Brussels, Belgium.
- Swane, I.C., and H.G. Poulos, 1984, "Shakedown Analysis of a Laterally Loaded Pile Tested in Stiff Clay", Proceedings of the Fourth Australia-New Zealand Conference on Geomechanics, Perth.

- Swane, I.C., 1983, "The Cyclic Behaviour of Laterally Loaded Piles", PhD Thesis, School of Civil and Mining Engineering, University of Sydney.
- Michalopoulos, A.P., I.C. Swane and I.V. Constantopoulos, October 1983, "The Role of Large Shaking Tables in Engineering, presented at the Informal Meeting on Vibrating Tables, Commission of the European Communities, Joint Research Center ISPRA.
- Swane I.C., and H.G. Poulos, 1982, "A Theoretical Study of the Cyclic Shakedown of Laterally Loaded Piles", Proceedings of the Fourth International Conference on Numerical Methods in Geomechanics, Edmonton, Canada
- Swane, IC., 1977, "Combination of Finite Element and Equilibrium Methods for Stability Analyses". Undergraduate Thesis, Department of Civil Engineering, University of Sydney.

Awards

- Engineering Excellence High Commendation Award, Environment Category, Sydney Division, Institution of Engineers Australia, 1992.
- D H Trollope Medal, Australian Geomechanics Society, 1988.
- W H Warren Medal, Institution of Engineers, Australia, 1986.
- Five prizes from the University of Sydney, including the prize for most distinguished student graduating with first class honours in Civil Engineering.