ENVIRON

Summary Site Audit Report

Honeysuckle Development
Lot 22 and Part Lot 23 Lee 5 South

for

Honeysuckle Development Corporation

June 2004

Ref. Number: 31-0069B

Audit GN 74-2

ENVIRON

30 June 2004 Ref. 31-0069B

Honeysuckle Development Corporation
Level 2
251 Wharf Road
Newcastle, NSW 2300

Attention: Peter Bowles
Development Manager

Dear Peter,

Summary Site Audit Report
Honeysuckle Development, Lot 22 and Part 23 Lee 5 South

I have pleasure in submitting the Summary Site Audit Report for the subject site, the western portion of Lee 5 South. Honeysuckle Development Corporation commissioned the Audit to assess the suitability of the site for the intended landuse. The Site Audit Statement produced in accordance with the Contaminated Land Management Act follows this letter. The Audit is not currently required for statutory purposes.

Thank you for giving me the opportunity to conduct this Audit. Please call me on (02) 9954 8100 if you have any questions.

Yours faithfully,
ENVIRON Australia Pty Ltd

Graeme Nyland
EPA Accredited Site Auditor 9808

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 Graeme Nyland**	**Phone:**	**02 9954 8101**
Company:	**ENVIRON Australia Pty Ltd**	**Fax:**	**02 9954 8150**
Address:	**Level 5, 60 Miller Street**	**Accred. No:**	**9808**
	NORTH SYDNEY NSW 2060		

SITE AUDIT STATEMENT NO: *GN 74-2*

SITE DETAILS:

Address: *Honeysuckle Drive, Newcastle*

Postcode: *NSW 2300*

Lot and DP number: *Lot 22 and Part Lot 23 which have not yet been gazetted. The site is currently still part of the larger Lot 1111 DP 1027135 (see Attachment).*

Local government area: *Newcastle City Council*

SITE AUDIT REQUESTED BY:

Name: *Peter Bowles*

Company: *Honeysuckle Development Corporation*

Address: *Level 2, 251 Wharf Road, Newcastle, NSW*

Postcode: *2300*

Phone: *02 4927 3813* **Fax:** *02 4929 3813*

Name of contact person (if different from above):

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

PPK Environment and Infrastructure (PPK) Pty Ltd.

Parsons Brinkerhoff (PB) Australia Pty Ltd (formerly PPK).

Robert Carr & Associates Pty Ltd.

RCA Australia (formerly Robert Carr & Associates Pty Ltd.)

Title(s) of report(s) reviewed:

- *'Draft Sampling and Analysis Plan Honeysuckle Development'. January 2002 by PPK.*
- *'Sampling and Analysis Plan Honeysuckle Development'. March 2002, by PPK.*
- *'Draft Environmental Assessment, Lee 5 South, (Lot 1111 DP 1027135), Honeysuckle, NSW'. May 2002 by PPK.*
- *'Draft Quality Assurance and Quality Control Report, Environmental Site Assessment, Honeysuckle, NSW.' October 2002, by PB.*
- *'Quality Assurance and Quality Control Report, Environmental Site Assessment, Honeysuckle, NSW.' February 2003, by PB.*
- *'Honeysuckle Delineation Sampling Plan – Lee 5 South.' 28 October 2002, by PB.*
- *'Proposal for Phase 3 Delineation Investigation, Lee 5 South, Honeysuckle, NSW'. 8 November 2002, by PB.*
- *'Draft Contaminant Delineation Investigation for Lee 5 South, Honeysuckle, NSW.' February 2003, by PB.*
- *'Contaminant Delineation Investigation for Lee 5 South, Honeysuckle, NSW.' February 2003, by PB.*
- *'Remedial Action Plan. Lot 22, Lee 5 South, Honeysuckle Development Estate'. June 2003, by RCA.*
- *'Draft Implementation of Remedial Action Plan Lot 22, Lee 5 South, Honeysuckle Development Estate'. March 2004 by RCA.*
- *'Final Implementation of Remedial Action Plan Lot 22, Lee 5 South, Honeysuckle Development Estate'. April 2004 by RCA.*

Other information reviewed: N/A

Summary Site Audit Report

Title: *Summary Site Audit Report – Honeysuckle Development, Lot 22 and Part Lot 23, Lee 5 South*

Date: *June 2004*

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):

  The site will be suitable for commercial/industrial use

subject to:

✓ Condition(s) (please specify):

- *Capping of the site with suitable materials that may include clean soil or building slab ensuring that materials are not readily accessible to site users. Where capping is not feasible, validation should be to at least "recreational open space" standard to a minimum depth of 0.5 m.*
- *Notation of the presence of contaminated soil on the Section 149 certificate for the site so that the contamination can be managed in any future redevelopment.*
- *Maintenance of site capping.*
- *Groundwater is not abstracted for use.*

☐ ~~is not suitable for any beneficial use due to risk of harm from contamination.~~

✓ (Comments):

This Audit has not been prepared for a statutory purpose. To be used for a statutory purpose, it is envisaged that a management plan that specifically addresses the above Conditions and includes a mechanism to implement them would need to be prepared and incorporated into the Audit Conditions and any Development Consents.

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

Accreditation Number: 9808

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.

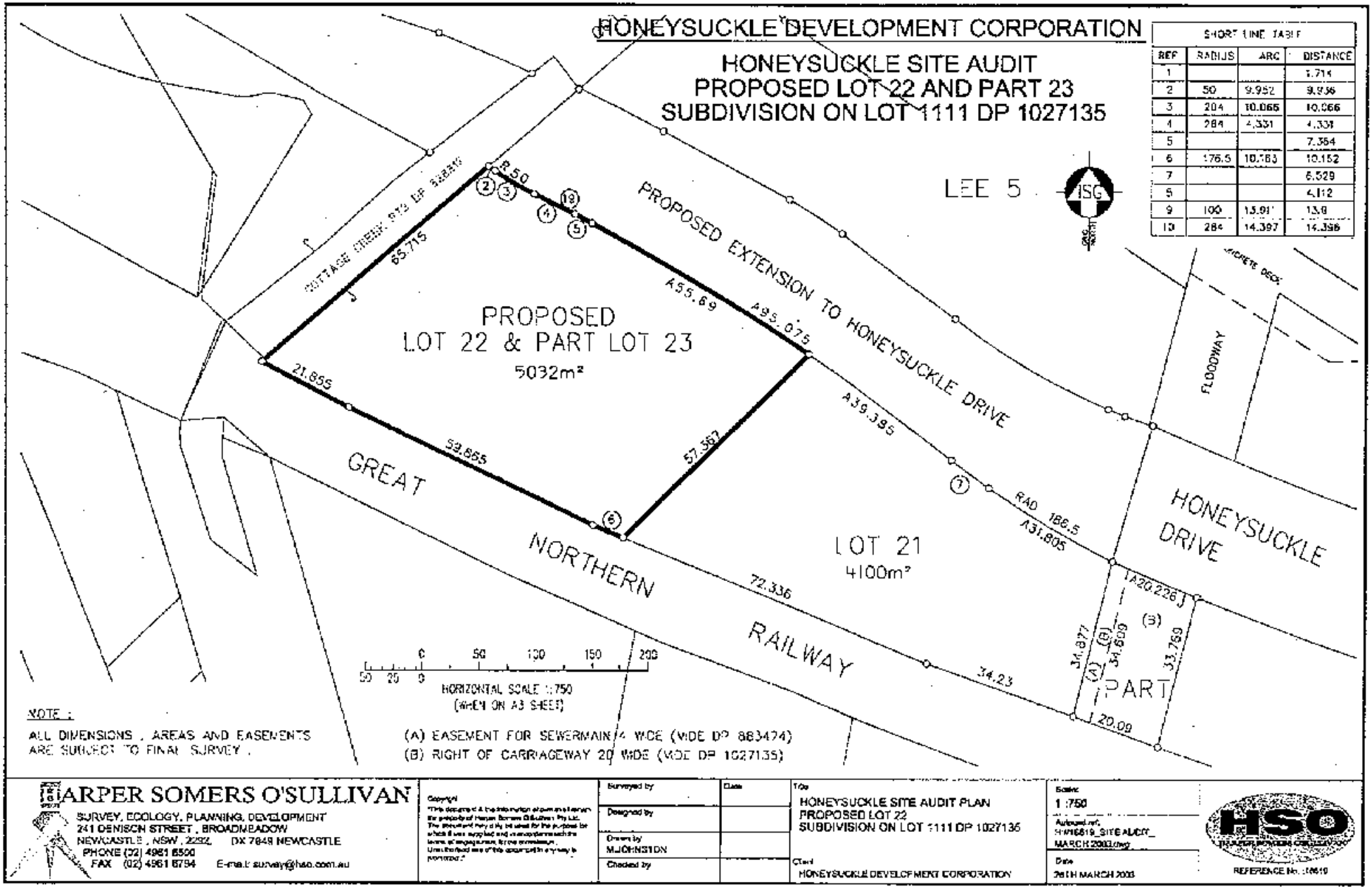
I am aware that there are penalties for wilfully submitting false, inaccurate or incomplete information.

Signed: ORIGINAL SIGNED BY GRAEME NYLAND **Date:** 30 JUNE 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

Attachment: Survey Plan



ATTACHMENT : Survey Plan

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AHD	Australian Height Datum
ALS	Australian Laboratory Services
Amdel	Amdel Laboratories
ANZECC	Australian and New Zealand Environment and Conservation Council
AST	Above ground Storage Tank
BaP	Benzo(a)pyrene
Bgl	Below Ground Level
BTEX	Benzene, Toluene, Ethylbenzene & Xylenes (Monoaromatic Hydrocarbons)
CN	Cyanide (total or free)
DP	Deposited Plan
DSNR	Department of Sustainable Natural Resources (formerly DLWC)
EPA	Environment Protection Authority (NSW)
ESA	Environmental Site Assessment
ha	Hectare
HDA	Honeysuckle Development Area
HDC	Honeysuckle Development Corporation
LOR	Limit of Reporting
Mercury	Inorganic mercury unless noted otherwise
Metals	As: Arsenic, Cd: Cadmium, Cr: Chromium, Cu: Copper, Fe: Iron, Ni: Nickel, Pb: Lead, Zn: Zinc, Hg: Mercury, Sn: Tin
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Litre
µg/L	Micrograms per Litre
NATA	National Association of Testing Authorities
NC	Not Calculated
ND	Not Detected
ng/L	Nanograms per Litre
NEHF	National Environmental Health Forum
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
n	Number of Samples
OCPs	Organochlorine Pesticides
OH&S	Occupational Health & Safety
OPPs	Organophosphorus Pesticides
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PID	Photolonisation Detector
PQL	Practical Quantitation Limit
pH	a measure of acidity, hydrogen ion activity
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RPD	Relative Percent Difference
SAS	Site Audit Statement
SMP	Site Management Plan
SSAR	Summary Site Audit Report
SVOCs	Semi Volatile Organic Compounds
SWL	Standing Water Level
TOM	Total Organic Matter
TPHs	Total Petroleum Hydrocarbons
UCL	Upper Confidence Limit
UST	Underground Storage Tank
VOCs	Volatile Organic Compounds
-	On tables is "not calculated", "no criteria" or "not applicable"

1 INTRODUCTION

A site contamination audit has been conducted relating to the western portion of 'Lee 5 South" within the Honeysuckle Development Area, Newcastle. The Audit is required by the Honeysuckle Development Corporation to determine the suitability of the site for the intended land use, i.e. an audit for the purpose stated in Section 47 (1) (b) (iia) of the NSW Contaminated Land Management Act 1997. It is understood that the intended use of the site is commercial.

The Honeysuckle Development Area (HDA) is located adjacent to Newcastle Harbour and consists of reclaimed land that was previously used for rail and port related activities. The Honeysuckle Development Corporation is coordinating the redevelopment of a number of other properties within the HDA. Separate Site Audit Reports and Site Audit Statements have been or will be prepared for these sites by the appointed Auditor.

This Audit has been conducted with regard to the western portion of what was known as 'Lee 5 South'. This western section has been designated as Lot 22 and Part Lot 23. Parsons Brinkerhoff (formerly PPK) investigated the whole of 'Lee 5 South', which consists of Lot 21, Lot 22 and Part Lot 23.

Details of the audit are:

Requested by:	Peter Bowles on behalf of Honeysuckle Development Corporation.
Request/Commencement Date:	8 February 2002
Auditor:	Graeme Nyland
Accreditation No.:	9808

The audit included:

- A review of the following reports:
  - 'Draft Sampling and Analysis Plan Honeysuckle Development'. January 2002 by PPK Environment and Infrastructure Pty Ltd (PPK).
  - 'Sampling and Analysis Plan Honeysuckle Development'. March 2002, by PPK.
  - 'Draft Environmental Assessment, Lee 5 South, (Lot 1111 DP 1027135), Honeysuckle, NSW'. May 2002 by PPK.
  - 'Draft Quality Assurance and Quality Control Report, Environmental Site Assessment, Honeysuckle, NSW.' October 2002, by Parsons Brinckerhoff (PB).
  - 'Quality Assurance and Quality Control Report, Environmental Site Assessment, Honeysuckle, NSW.' February 2003, by PB.
  - 'Honeysuckle Delineation Sampling Plan – Lee 5 South.' 28 October 2002, by PB.
  - 'Proposal for Phase 3 Delineation Investigation, Lee 5 South, Honeysuckle,

NSW', 8 November 2002, by PB.

- 'Draft Contaminant Delineation Investigation for Lee 5 South, Honeysuckle, NSW.' February 2003, by PB.
- 'Contaminant Delineation Investigation for Lee 5 South, Honeysuckle, NSW.' February 2003, by PB.
- 'Remedial Action Plan, Lot 22, Lee 5 South, Honeysuckle Development Estate.' June 2003, by RCA Australia Pty Ltd (RCA).
- 'Draft Implementation of Remedial Action Plan Lot 22, Lee 5 South, Honeysuckle Development Estate.' March 2004 by RCA.
- 'Final Implementation of Remedial Action Plan Lot 22, Lee 5 South, Honeysuckle Development Estate.' April 2004 by RCA.

- Site visits on 19/02/02, 5/04/02, 11/04/02 and 05/06/03.
- Discussions with PPK (PB), RCA and the Client. This included email correspondence.

The Sampling and Analysis Plan was prepared for 12 sites within the HDA. It included a review of previous reports and aerial photographs. Plans relevant to each site were also included.

The Quality Assurance and Quality Control Report was prepared for the environmental site assessments undertaken by PPK for 12 sites within the HDA. It included the data quality objectives and the field and laboratory QA/QC results.

The PB and PPK Environmental Site Assessment Reports and the Delineation Investigation included soil and groundwater analytical results for Lee 5 South (Lot 21, Lot 22 and Part Lot 23). Groundwater results for the remaining HDA were tabulated.

The Remedial Action Plan included details of the proposed soil remediation and validation sampling for the western portion of Lee 5 South, Lot 22 and Part Lot 23.

The Implementation of the Remedial Action Plan included further site and groundwater characterisation and validation results for Lot 22 and Part Lot 23 Lee 5 South. The Report also included a draft Site Management Plan for Lot 22 and Part Lot 23 Lee 5 South.

2 SITE DETAILS

2.1 Location

The Honeysuckle Development Area is located adjacent to Newcastle Harbour in Newcastle. This entire development area consists of seven 'precincts', most of which have either been sold or developed. Current investigations being undertaken for the Honeysuckle Development Corporation (HDC) extend from 'Fig Tree Park' to 'Lee Wharf A Curtilage' and cover only two of the seven 'precincts', which for the purposes of this Audit will be referred to as the HDA.

Located within the HDA is Lee 5 South, which consists of Lot 22 and Part Lot 23, the subject of this Audit, and Lot 21. A site plan of the HDA, indicating the location of Lee 5 South is shown as Attachment 1, Appendix A. A survey plan of the site is attached as Attachment 2, Appendix A. The northern boundary of the site is defined by Honeysuckle Drive, which is known as Road Reserve. The southern boundary is defined by a fence separating the site from the railway line.

Further site details include:

Street address:	HDA is located at Honeysuckle Drive, Newcastle, NSW.
Identifier:	Lot 22 and Part Lot 23 DP1027135 (referred to as Lot 2) have not yet been gazetted. The site is currently still part of the larger Lot 1111 DP 1027135 (see Attachment 2, Appendix A).
Local Government:	Newcastle City Council
Owner:	Honeysuckle Development Corporation
Site Area:	5032m^2

2.2 Zoning

According to the Newcastle Draft Local Environmental Plan (LEP) 2003 the site is zoned as 3 (c) City Centre.

2.3 Adjacent Uses

Lot 22 Lee 5 South is located within HDA, which, at the time of inspection remained predominantly undeveloped i.e., vacant grassed land.

Surrounding landuses include:

- to the north-west, commercial (marinas, offices) and residential uses (apartments) within other precincts of the HDA;
- to the south, proposed commercial (hotel) and residential uses (apartments), existing commercial premises and the railway line;
- to the east, predominately commercial premises;
- to the north, Newcastle Harbour.

The site is located within a predominantly commercial area with some residential land uses.

2.4 Proposed Development

It is understood that while there is no specific development proposed at this stage, that future development at the site is likely to be for commercial uses. The data will be assessed against the 'commercial/industrial' land use scenario.

2.5 Site Condition

Prior to the remediation works, Lot 22 Lee 5 South was partly covered by a grassed mound approximately 2 m in height. At the time of the Auditor's visit in June 2003, materials excavated from the adjacent property had been stockpiled over Lot 22. RCA indicated that these materials, flattened and trenched while at the site for an asbestos survey, were removed and disposed of to landfill as inert waste.

Photos provided by RCA following the remediation works show the site to be relatively flat with only minor areas of grass. There are currently no structures located over the site. A gravel track has been formed along the northern boundary.

Surface water that flows to the north of the site would be intercepted by the storm water system along Honeysuckle Drive that discharges into the nearest surface water receptor, Newcastle Harbour. Surface water would also flow directly into Cottage Creek.

3 STRATIGRAPHY AND HYDROGEOLOGY

3.1 Stratigraphy

The majority of land within the HDA has been reclaimed from Newcastle Harbour and Cottage Creek using fill materials. The depth of these materials varies across the HDA, increasing towards the harbour. Previous and current investigations indicate that the fill materials used across the HDA contain substances that are associated with the following:

- past rail activities i.e. railway sleepers, rail spikes;
- energy production i.e. coal ash, chitter, coal tar and slag; and
- construction activities i.e. pipes, wood, building rubble.

Following filling at Lot 22 Lee 5 South, road base and cobbles were used as a base for a loading platform over the site.

Soil, excavated from Worth Place and Honeysuckle Drive were then stockpiled at Lee 5 South. As these materials had been excavated from other parts of the HDA, the materials encountered at this site are similar in composition to fill materials across the HDA.

The stratigraphy at Lot 22 Lee 5 South as outlined by RCA (May 2003) is summarised as Table 3.1.

Table 3.1 – Stratigraphy of Lot 22 Lee 5 South

Approximate Depth (m)	Layer (as indicated by RCA)	Description
0	A & B	Silty sand with some coal, ash, gravel particles, plastic and metal debris. Both soils occur as the top and the underlying layers.
1 – 1.5	C &D	Silty gravel including some slag, coal and cobbles of sandstone that are coated in tar. These materials were found to be associated with Layers G and E.
1.5 – 1.6	G	Roadbase consisting of gravels and tar. RCA notes that Layer G is *'compacted road gravel impregnated with a tarry road seal which is typically only 0.05m in thickness'*.
1.6 – 1.7	E	Compacted cobble sandstone within a sandy matrix. Visible tarry material occurs within the joints and the voids of the cobbles. Directly underlain by the alluvial sand materials. Typically 0.1 to 0.2 thickness.
1.6 – 1.8	H & I	Clay fill containing coal, sandstone and claystone overlying silty sand containing shell, coal and gravel. RCA indicate that these occur as sporadic lenses in limited areas across the site.
1.7 – continues	F	Alluvial sands. The depth below ground level varies due to mounding of fill.

These soil descriptions are fairly consistent with those provided for Lot 21 Lee 5 South.

3.2 Hydrogeology

Groundwater across the HDA is relatively shallow and given its close proximity to Newcastle Harbour, is tidally influenced. Wells installed adjacent to the harbour reported salinity similar to that expected of seawater. Overall flow direction is towards Newcastle Harbour.

At Lee 5 South, groundwater was encountered at depths of between 3.2 and 4.2 m within the natural alluvial sands well below the fill materials.

Nine registered bore wells for domestic, recreational and industrial use are located within a 1 km radius of the site. The depth to water ranged in depth from 4.9 to 10.1 m.

4 SITE HISTORY

The majority of land within the HDA was reclaimed from Newcastle Harbour and the mouth of Cottage Creek sometime between 1896 and 1944. The HDA has previously been used by various government authorities for rail and port related activities. The site history for Lot 22 Lee 5 South and the HDA has been summarised in Table 4.1.

Table 4.1 – Site History

Date	**Activity at and adjacent to Lot 22 Lee 5 South**
1866	The Great Northern Railway was first documented in 1866 to the south of Lot 22 along 'the coast'.
1872	The Honeysuckle Point Railway Station was located to the east of Lot 22 until approximately 1936.
1896	The majority of the HDA was reclaimed from Newcastle Harbour and the mouth of Cottage Creek sometime between 1896 and 1944. Cottage Creek had flowed over Lot 22.
Unknown	Land in the vicinity of Lot 22 Lee 5 South has been part of the 'Trackfast' site used for handling rail cargo. Until 1993, Lot 22 Lee 5 South contained railway lines and part of the loading bank of the 'Trackfast' site.
1977	Various materials were previously stockpiled at various sites over the HDA including part of Worth Place Park, Park Residential, Wright Lane, Lee 5 South, South Park and Park Residential. Soil excavated from Worth Place and Honeysuckle Drive has been stockpiled at Lot 22 Lee 5 South since 1997.
Current	Unoccupied

It is the Auditor's opinion that the site history of both the HDA and Lot 22 Lee 5 South is adequately known.

5 PREVIOUS RESULTS

Environmental site assessments have been undertaken by PB for a number of 'sites' across the HDA, from Fig Tree Park to Lee Wharf A Curtilage. The initial results obtained prior to May 2003 indicated the following:

- Only one of the 45 samples submitted for OCP analysis within the fill materials reported an OCP, chlordane-trans, at a low concentration below the criteria. This sample was collected from the surface.
- OPPs were not detected above PQLs within the 12 samples submitted for analyses.
- PCBs were not detected above PQLs within the 46 samples submitted for analyses.
- BTEX compounds were only detected within three of the 147 samples submitted for analysis. These have since been shown to be associated with former bulk fuel storage and have been targeted for remediation;
- Metals, particularly copper, lead and zinc, TPHs and PAHs, including benzo(a)pyrene have been detected at elevated concentrations across the HDA.

These results confirm those from the seven earlier investigations (1995-1999) summarised by PB (March 2002) where OCPs, OPPs, and PCBs were not detected above PQLs and where metals, TPHs and PAHs were shown to be the main contaminants of concern.

Following this review, it is the Auditor's opinion that OCPs, OPPs and PCBs are not contaminants of concern within the fill materials and require no further investigation. Pesticides could still be a contaminant of concern in some locations due to surface spraying.

RCA indicate that materials stockpiled at Lot 22, sourced from the adjacent Lot 21 Lee 5 South site, had been inspected by Pickford Consulting with 'one small piece of asbestos' found. Further inspections were undertaken following flattening and trenching of the materials. One sample collected for analysis did not report asbestos fibres. The advice obtained by Pickford Consulting indicated that the stockpiled material is 'free of visible asbestos-cement'. These results indicate that there is a low risk of visible asbestos-cement within fill at the Lot 22 Lee 5 South site. Other results obtained for the adjacent site, Lot 21 Lee 5 South, are discussed in Section 9.

6 CONTAMINANTS OF CONCERN

Following a review of the site history and previous investigations undertaken adjacent to the site, the Auditor has identified the key contamination sources and activities. These have been tabulated within Table 6.1. These are similar to those identified by the Consultant.

Table 6.1 – Contaminants of Concern

Activity	Contaminants of Concern
Filling	Petroleum hydrocarbons, PAHs, heavy metals (especially Cu, Pb, Zn)
Railway lines and associated pesticide spraying	Petroleum hydrocarbons, PAHs, heavy metals, OCPs
Loading bank	Petroleum hydrocarbons, PAHs, heavy metals (especially Cu, Pb, Zn)
Stockpiling	Petroleum hydrocarbons, PAHs, heavy metals

In addition to those contaminants of concern outlined in Table 6.1, PPK (2002) identified:

- asbestos as a contaminant of concern for railway facilities and workshops. No asbestos containing materials were noted during the PB and PPK investigations and two samples submitted for analysis by PB did not report the presence of asbestos. No asbestos was observed during field investigations; and
- phenols within stockpiled soil. This was not reflected in the analytical suite and given that the stockpiled materials have been sourced from the HDA it is unlikely that phenols are a contaminant of concern.

In the Auditor's opinion the contaminants of concern listed in Table 6.1 are reflected in the analytical suite used by the Consultants, PB and RCA. The individual substances included in each analytical suite are listed in Appendix D.

7 EVALUATION OF QUALITY ASSURANCE AND QUALITY CONTROL

The Auditor has assessed the overall quality of the sampling and analysis program outlined in the following reports in reference to EPA (1997) 'Guidelines for Consultants Reporting on Contaminated Sites':

- PPK (2002) 'Environmental Site Assessment, Lee 5 South, Honeysuckle, NSW'
- PB (2003) 'Contaminant Delineation Investigation for Lee 5 South, Honeysuckle, NSW'; and
- RCA (2004) 'Implementation of Remedial Action Plan'.

The Auditor's assessment follows in Tables 7.1 and 7.2.

Table 7.1 – QA/QC – Sampling and Analysis Methodology Assessment

Sampling and Analysis Plan and Sampling Methodology	Comments
Representative Sampling: Sampling Pattern and Density Depth and Material Type	**Soil**: Numerous boreholes were excavated over the site by PPK (PB) and RCA. Much of the site has also been excavated during remediation works. Similar materials were encountered at Lot 21 where numerous boreholes and excavations for remedial works were undertaken. The Auditor considers that sufficient excavations have been undertaken to characterise the stratigraphy of the site, including those areas not included within the bounds of the remediation works. The various fill materials and the underlying alluvial sands have been targeted for PAH, TPH and metals analysis. In the Auditors opinion, the coverage and sampling densities for these contaminants are considered appropriate. **Validation**: Only base samples were collected. As the excavations were visually validated for tar impacted materials, the lack of wall validation samples is not considered significant. RCA indicate that although most of the impacted materials were removed, that there may be some residual material (not containing tar) that could not be visually identified. The density of sampling was at approximately 9.5 m intervals within the natural sands. Validation sampling of Layers A and B (top fill) combining all previous sample results with 44 samples for 5000m² equalled at a density of a 10 m grid.

Sampling and Analysis Plan and Sampling Methodology	Comments
	These densities are considered to be appropriate. **Groundwater:** Four groundwater wells are located over Lot 22 Lee 5 South. An additional well is located down-gradient and three wells are located adjacent to the site at Lot 21 Lee South. A network of wells is also located across the remainder of the Honeysuckle Development Area.
Sample Collection	**Soil:** PB conducted sample collection via a solid flight auger or an excavator. Samples were collected with an SPT except for surface samples which were collected from the base of the auger, which can result in a loss of volatiles. Samples were also collected by hand from the excavator bucket. RCA conducted sample collection via an excavator. Samples were collected by hand from the excavator bucket or directly from the walls of the excavation. **Groundwater:** New disposable bailers were used by PB for each well across the Honeysuckle Development Area. RCA used a bladder pump to develop the wells and a bailer to purge and sample.
Well Construction	**PB and PPK:** No construction details were provided for the well located at Lot 22. RCA do not indicate the depth of screening. However groundwater was encountered within the alluvial sands. **RCA:** The wells were completed at between approximately 4 and 6 metres depth. These wells were screened over the natural sands and into the lower levels of the fill materials well above the standing water levels.
Detailed description of sampling methods	All samples were placed into appropriately prepared and preserved sampling bottles provided by the laboratory and chilled during transport to the labs Groundwater samples to be analysed for heavy metals were field filtered by RCA. PB and PPK do not indicate whether metals were field filtered prior to analysis. As the metals concentrations reported by PB and PPK may be over- or under-estimated depending on the groundwater pH, the results obtained by RCA will be referred to.
Chain of custody	Chain of Custody for all samples were provided for all of the samples submitted to ALS, AMDEL and LabMark for analysis.
Detailed description of field screening protocols	PB and PPK undertook field screening with the results reported within the test pit/borehole logs. PID screening procedure was not provided. Calibration field day sheets were provided. **PB:** The most elevated PID reading of 35ppm was reported in sand containing tar. This sample was submitted for TPH

Sampling and Analysis Plan and Sampling Methodology	Comments
	analysis. All other readings were relatively low. **PPK:** The most elevated PID reading of 19ppm was detected in a gravely sand. This was not submitted for TPH analysis. **RCA:** Field screening with a PID was not undertaken. This is considered appropriate given that the main contaminants of concern were associated with visually obvious tar.
Decontamination Procedures	**PB and PPK:** All sampling equipment including trowels, augers and split spoon samplers were decontaminated between sampling locations. New disposable bailers were used for each well. **All:** The excavator was not decontaminated as samples were collected from the body of the soil within the bucket. The Auditor considers this to be appropriate. **RCA** decontaminated the bailer between sampling points. No decontamination was undertaken during soil sampling as disposable gloves were worn and collected directly from the excavator bucket.
Sampling Logs (indicating sample depth)	Sample depths were indicated, as was the stratigraphy of the test pits/boreholes. The stratigraphy noted for each layer was identical within each borehole log. The Auditor notes that more details are provided in the text. It is therefore difficult to determine an association between elevated concentrations of the contaminants and differences in material types between borehole logs.
Sampling Splitting Techniques	**PB and PPK:** Samples were split by splitting the sample i.e. no mixing. **RCA:** Samples for volatiles analysis were transferred directly from the sampling device to the sampling bottle.

The sampling and analysis methodology is considered appropriate as:

- the sampling density and depth indicate that there is a low risk of substantially higher concentrations remaining undetected at the site; and
- sample collection was undertaken appropriately under chain of custody.

Table 7.2 – QA/QC – Laboratory and Field QA/QC Assessment

Lab and Field QA/QC	Comments
Practical Quantitation Limits (PQLs).	**RCA**: The PQLs for anthracene of 0.1µg/L were greater than the trigger value of 0.01µg/L. While the PQL for cadmium of 0.1 mg/L was greater than the trigger value of 0.0007 mg/L, cadmium was detected in all three RCA groundwater wells. A number of PAHs and cadmium for the PB and PPK groundwater monitoring rounds also exceeded the low reliability trigger values for groundwater. These wells were located across the remainder of the HDA, the results of which have been used to provide an indication of background concentrations.
Field Quality Control Samples	Field quality control samples including field duplicates (intra-lab "blind" and inter-lab "split"), trip blanks (PPK) and trip spikes (PPK) were undertaken at appropriate frequencies. Groundwater field quality control samples were undertaken by PPK for the whole of the HDA. No trip blanks or trip spikes were analysed by RCA. This was not considered to affect the usability of the data as only low levels of TPH C6-C9 and BTEX have been detected within the soils. Trip spikes were not used by PB. Wash blanks were not required as dedicated sampling equipment was used for each location for groundwater sampling and gloves were changed for each sample location for soil sampling.
Field QA/QC undertaken	The results from most laboratory quality control samples were within appropriate limits. RPD reported by **PPK** for the inter-laboratory soil duplicate sample for lead was 112%. This result was less than the criteria. **PB** reported RPDs from 44% to 96% for arsenic, copper and mercury within one intra-lab duplicate pair and RPDs from 46% to 82% for these metals plus chromium and nickel for the same inter-lab duplicate pair. The results illustrate that the contaminants within this soil sample are variable in concentration. From the log it appears that this sample contained tarry materials. **PPK**: Trip blanks for the HDA reported copper (2), zinc (7) and mercury (2) marginally above PQLs. Trip blanks are usually only used to measure incidental or accidental contamination of VOCs. The results indicate the potential

Lab and Field QA/QC	Comments
	for additional metal concentrations in the samples. This should be considered when evaluating the results for zinc where concentrations marginally in excess of the trigger values were detected. **RCA:** Three **intra-laboratory duplicates** were submitted for analysis. Two of these reported quite high RPDs (maximum of 167%) for TPH, PAHs, arsenic and copper. The results indicate that these analytes may have been slightly under-reported by Labmark. This is in agreement with the laboratory duplicates where high variation was noted. **Inter-laboratory duplicate** RPDs were all reported within control limits except one where RPD > 30% that was also greater than 10% LOR for copper. . It is noted that most concentrations were reported at low concentrations or were non-detect. The **field blanks** did not report analytes above the PQLs.
Data Quality Objectives (DQOs)	DQOs were set and discussed in relation to the results.
NATA registered laboratory and NATA endorsed methods	Laboratory certificates supplied by ALS, AMDEL and LabMark were all NATA stamped.
Analytical methods and holding times	Samples were extracted and analysed within the appropriate holding times. Method codes and methods were supplied in the laboratory certificates.
Laboratory quality control samples	Laboratory quality control samples including surrogates, matrix spikes, method blanks, laboratory control samples and laboratory duplicates were undertaken by the laboratory at appropriate frequencies.
Laboratory QA/QC undertaken	Generally, the laboratory quality control samples were reported within control limits. The exceptions are discussed below: The two **matrix spikes** for copper, nickel and lead could not be reported due to elevated concentrations. These reported concentrations did not appear to be particularly elevated however the lab indicates that the concentrations were more than four times the matrix spike concentration. The matrix spike concentration was not provided. Two matrix spikes for fluoranthene and pyrene could also not be reported due to elevated concentrations. RPDs for five laboratory **duplicates** were reported well above 30%. RCA indicate that sample heterogeneity is

Lab and Field QA/QC	Comments
	the likely source of the discrepancy. In the Auditor's opinion, previous results should be used to determine the expected magnitude to compensate for some variability in results and the risk that the concentrations have been under-reported. One shallow fill validation sample reported concentrations of PAHs in a triplicate sample at a magnitude well above those previously detected and the primary sample. The variability with regard to characterisation of the material is discussed in Section 11. The most elevated concentrations were not always reported by RCA. The Auditor has included the most elevated concentrations in the assessment of soil results. Surrogates could not be reported for a number of samples either due to matrix interference that required dilution or the significant concentrations in the samples.
QA/QC Data Evaluation	As three separate investigations have been conducted at Lot 22 Lee 5 South by two separate consultancies there has been little consistency in borehole logging techniques between the reports. It is in the Auditors opinion that the RCA borehole logs provide the most detailed and representative logs. The Audit of the results has been based on the layers identified by RCA.

RCA determined that the QA/QC is 'of sufficient quality to consider acceptable to comply with the RCA Australia's quality protocols' and that the data and field duplicate results are 'free from systematic and method biases'.

In the Auditor's opinion, the variability of the results for the laboratory duplicates and the inter-laboratory duplicates indicate either the heterogeneity of the materials or the poor precision and accuracy of the laboratory. Given that the most impacted materials have been removed from the site and that those retained have been well characterised following in-situ and validation sampling over this and the adjacent site, the QA/QC discrepancies are not considered to be significant.

In considering the data as a whole, the Auditor concludes that the data is likely to be reliable and useable for the purpose of this audit.

8 ENVIRONMENTAL QUALITY CRITERIA

The Auditor has assessed the soil data provided by the Consultant in reference to Soil Investigation Levels for Urban Redevelopment Sites in NSW (Column 4 – 'commercial/industrial' in "Guidelines for the NSW Site Auditor Scheme", 1998). NSW EPA (1994) "Guidelines for Assessing Service Station Sites" have also been referred to for assessing TPH and BTEX results.

The Auditor has assessed the groundwater data in reference to ANZECC (2000) "Australian and New Zealand Guidelines for Fresh and Marine Water Quality" for marine waters. Trigger levels provided are concentrations that, if exceeded, indicate a potential environmental problem and "trigger" further investigation.

The current criteria for individual substances are reproduced in Appendix B.

Low reliability ANZECC (2000) trigger values have been used where they exist for the individual PAHs (Appendix B). However, a trigger level for total PAHs within groundwater is not provided within the ANZECC (2000) guidelines. As such, the threshold level of 3µg/L from the NSW EPA (1994) Service Station Guidelines has been adopted.

9 EVALUATION OF SOIL ANALYTICAL RESULTS

PPK (2002) and PB (2003) have previously undertaken intrusive investigations over the site. The results of these investigations indicated that the site was impacted by PAHs and TPH in association with materials such as coal tar and 'black materials'. In some cases there were no visual indications.

RCA (2003) excavated boreholes to provide a more detailed inspection of the stratigraphy of the site. The results obtained by RCA have been tabulated and are discussed below. The data obtained by PB/PPK has been summarised where appropriate. Remediation works have also been undertaken involving the excavation and removal of layers C, G and E from the site. Validation results and characterisation of these materials are discussed in Section 10.

RCA provided detailed borehole logs and collected representative samples from each fill and natural layer. These results have been tabulated for discussion while the results obtained by PPK (2002) and PB (2003) have been summarised.

Soil sampling locations are shown as Attachment 3, Appendix A.

9.1 Evaluation of PAH and TPH C10-C36 Analytical Results

PAHs were the main contaminants of concern and at this site generally occur in association with elevated levels of TPH c10-c36.

The in-situ results for layers A and B are summarised in Table 9.1. These materials were excavated temporarily to allow remediation of the underlying layers and were reinstated. The validation results obtained prior to backfilling are discussed in Section 11.

Table 9.1 - Evaluation of Soil Analytical Results for Layer A (Silty Sands) and Layer B (Sands) Summary Table (mg/kg).

Analyte	n	Detections	Maximum	n > SIL Column 4 *(EPA 1998)*	*n* >EPA *(1994)*
Benzo(a)pyrene	7	5	22	1	N/A
Total PAHs	7	5	322	1	N/A
TPH C10-C36	7	1	690	N/A	0

Representative samples were collected from the silty sands (layer A) and sands (layer B) and the results are indicative of the material retained.

Benzo(a)pyrene and total PAHs were reported in excess of the SILs within only one of the seven samples collected. The other six samples reported relatively low levels of total PAHs with a maximum of 45mg/kg. These results are consistent with those reported for Lot 21. RCA noted that the materials reporting the highest concentration of PAHs could not be distinguished visually from those with low contaminant levels.

TCLP results undertaken by PPK and included in the RCA report indicate that only minor amounts of PAHs leach from the sandy fill materials. The maximum leachate potential for the sandy fill materials was sourced from a soil reporting total PAHs of

494 mg/kg, similar to the maximum level reported for sandy fill at the site. Materials containing tar have the potential to leach high amounts of PAHs. These materials have been removed from the site as discussed in Section 11.

Table 9.2 - Leaching Potential of Sand Fill and Tar Layers for Lot 22 (as summarised by RCA)

Leachate Potential of:	Fill (sand, no obvious tar) *n=5*		Fill Containing Tar *n=4*	
	Maximum	Mean	Maximum	Mean
Naphthalene	23	7	6080	2164
Phenanthrene	21	6	400	237
Anthracene	3	0.9	9.6	3
Fluoranthene	5	1.5	50	31
B(a)P	< LOR	NA	4	1.1

Layer D consists of gravels and was encountered in association with the former loading bank. Total PAHs (maximum of 47mg/kg) and benzo(a)pyrene (maximum of 3mg/kg) were detected below the SILs. TPH was not detected above PQLs within the two samples.

Layer H consists of clays that include coal, sandstone and claystone. Layer I consists of silty sands containing shell, coal and gravel. RCA indicate that these occur as sporadic lenses in limited areas across the site.

PAHs and petroleum hydrocarbons were not detected above PQLs within layer H. Lead was however detected at an elevated concentration of 2080 mg/kg as discussed below.

The sample collected from layer I reported benzo(a)pyrene at 5.4mg/kg marginally above the SIL with total PAHs at 61mg/kg. TPH C10-C36 at 340mg/kg was reported below the criteria. Given that the extent of this material is likely to be limited to these 'sporadic lenses' the Auditor does not consider it significant that the material has been retained at the site.

A number of samples were collected from alluvial sands underlying the tar road base and sandstone layer. PAHs were not detected above the LORS within the majority of the alluvial sands submitted for analysis. TPH c10-c36 was not detected above LORs.

Table 9.3 - Evaluation of Soil Analytical Results for Layer F (Alluvial Sands) Summary Table (mg/kg).

Analyte	n	Detections	Maximum	n > SIL Column 4 *(EPA 1998)*	*n* >EPA *(1994)*
Benzo(a)pyrene	4	0	-	0	N/A
Total PAHs	4	1	1.3	0	N/A
TPH C10-C36	4	0	-	0	N/A

9.2 Evaluation of All Other Analytical Results

Soil samples were also tested for a variety of contaminants including TPH C6-C9, BTEX, OCPs and heavy metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg). Overall results for the fill and natural materials sampled, excluding Layers C, G and E, have been summarised in Table 9.4.

Table 9.4 - Evaluation of Soil Analytical Results - Overall Summary Table (mg/kg).

Analyte	n	Detections	Maximum	n > SIL Column 4 *(EPA 1998)*	*n* >EPA *(1994)*
Asbestos	2	0	Nil	N/A	N/A
Arsenic	13	13	36	0	N/A
Cadmium	13	7	1.6	0	N/A
Total Chromium	13	11	10	0	N/A
Copper	13	13	390	0	N/A
Lead	13	12	2080 (layer H)	1	N/A
Nickel	13	8	14	0	N/A
Zinc	13	12	770 (layer H)	0	N/A
Mercury (inorganic)	13	6	0.53	0	N/A
TPH (c6-c9)*	13	0	-	N/A	0
PCB*	4	0	-	0	N/A
OCPs*	4	0	-	0	N/A
Total phenolics	2	0	-	0	N/A
Other VOCs	3	0	-	0	N/A

Heavy metals, particularly copper, lead and zinc were detected at slightly elevated concentrations within the fill materials.

A particularly elevated concentration of lead was detected in Layer H at 2080mg/kg. The distribution of the elevated concentration appears random and delineation would be difficult. The extent of impacted soils appears limited.

The results reported by RCA are similar to those reported by PPK for Lee 5 South and RCA and PB for Lot 21 Lee 5 South and for the Honeysuckle Development Area. A number of fill materials across the site contained slag. The concentrations of metals were no greater within these samples.

TPH C6-C9, OCPs or PCBs were not detected above the PQL s which is consistent with results for materials over Lot 21 and those obtained for the HDA.

9.3 Summary

Silty sands (layer A) and sandy fill (layer B) that have been retained across the site are known, from previous and current investigations, to contain elevated levels of PAHs and TPH above the human health based threshold concentrations. These elevated levels appear to occur randomly within the fill materials and cannot be identified visually by the Consultant. The Auditor considers that further investigation would not provide any further clarity on the distribution of the high PAH concentrations, and that selective removal of "hot spots" is not feasible.

In the Auditor's opinion, the soil analytical results are consistent with the site history and field observations. The results indicate that fill has been impacted by PAHs and petroleum hydrocarbons. The Auditor is satisfied that fill and alluvial materials at the site have been adequately characterised and that no further investigations are needed.

10 EVALUATION OF GROUNDWATER ANALYTICAL RESULTS

Fill materials across the HDA are characterised by elevated concentrations of PAHs and TPHs. Fill over some areas of the HDA have also been impacted by elevated concentrations of metals. Considering the distribution of these impacted materials across the HDA and the arbitrary boundaries between land parcels, groundwater at the HDA has been considered as one data set.

Groundwater samples collected from over the Honeysuckle Development Area were tested for a variety of contaminants including PAHs, TPH, BTEX, OCPs and heavy metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg). Twenty-one of the wells were sampled and analysed in April 2002. One further groundwater bore was installed and sampled at Lee 5 in January 2003. Three new groundwater wells were installed by RCA over the adjacent Lot 21 Lee 5 South and sampled on 17 and 18 May 2003.

Three wells were installed over Lot 22 Lee 5 South and sampled in August 2003 prior to remedial works at the site. The results have been summarised in Table 10.1.

The analytical suite included the most likely contaminants of concern for the HDA.

Overall results have been summarised in Table 10.1. Groundwater sampling locations at and down-gradient of Lee 5 South are shown as Attachment 4, Appendix A.

Table 10.1 - Evaluation of Groundwater Analytical Results – Summary Table (µg/L).

Analyte	Honeysuckle Development Area			Lot 22 Lee 5 South		
	Detections $n = 25$	Maximum	n > trigger values	Detections $n = 3$	Maximum	n > trigger values
Arsenic	21	130	**20**	3	34	**2**
Cadmium	3	0.4	0	1	0.3	0
Total Chromium	9	7	0	0	-	0
Copper	21	59	**20**	1	2	1
Lead	12	86	**8**	0	-	0
Manganese	22	1240	**15**	NA	NA	NA
Nickel	18	8	**2**	3	-	0
Zinc	25	101	**13**	3	95	**3**
Mercury (inorganic)	0	-	0	0	-	NA
TPH (c6-c9) (µg/L)	2 (n=21)	56	N/A	0	-	NA
TPH (c10-c36) (µg/L)	4 (n=21)	334	N/A	190	-	NA
BTEX	0 (n=21)	-	N/A	NA	NA	NA
Benzo(a)pyrene	1	2	1	0	-	0
Naphthalene	3	0.8	0	3	0.3	0
Phenanthrene	3	4.6	**2**	3	1.9	0
Anthracene	1	1.7	1	3	1.2	1
Fluroanthene	8	4	**6**	3	1.7	1
PAHs – total*	7	19	**7**	3	11	1

Notes: NA - not analysed *assessed NSW EPA (1994)

10.1 PAHs and Other Hydrocarbons

PAHs are the most common contaminants found in the fill materials over the HDA with the greatest concentrations detected in association with coal tar. The vertical extent of these elevated PAHs over most of the HDA is not clear, given the limited characterisation of both the fill materials and the underlying materials. However, the vertical extent of these materials at Lot 22 Lee 5 South has been determined and the fill materials have been adequately characterised.

Low reliability ANZECC (2000) trigger values have been used where they exist for the individual PAHs and as there is no EPA endorsed criteria for total PAHs the NSW EPA (1994) guidelines have been referenced.

While the concentrations of PAHs detected have generally been low, their presence is likely to be related to their presence in the fill materials across the HDA. The location of the source is not clear given that PAH concentrations within the wells range from elevated to non-detect down-gradient of impacted fill materials.

As the intention is to retain impacted fill materials on-site at Lot 22 Lee 5 South, a targeted assessment has been undertaken following remediation to assess the localised impacts from PAHs. Three wells have been installed over Lot 22 Lee 5 South, with three other wells located on the adjacent Lot 21 Lee 5 South.

The most elevated concentrations of total PAHs at 11 µg/L were detected above the criteria of 3 µg/L, on the up-gradient side of the site. Reduced levels (maximum total PAHs 2.9 µg/L) below the criteria were detected within the two down-gradient wells. These wells were located within the same fill materials and were located on the down-gradient boundary of the site. These wells appeared to be located on the edges of the site and not directly down-gradient of the excavation. However, the results are similar to those reported for wells down-gradient at Lot 21 Lee 5 South.

It is not clear whether the PAHs have originated from off-site. Naphthalene and anthracene, not previously detected at the HDA, were detected. The leachate tests undertaken by PB indicated that these contaminants have a high leachate potential from the tar materials. These tar materials have since been removed.

TPH C29-C36 was detected in one of the down-gradient wells at 190mg/L. TPH was not detected in any other wells in the near vicinity of Lee 5 South. The PQL for TPH C15-C28 was fairly elevated at 400 mg/L.

Given that tar at the site reported particularly elevated concentrations of TPH (maximum of 252,200 mg/kg) in association with elevated concentrations of PAHs it is possible that the TPH in groundwater was sourced from the tar materials. The concentration of 150 mg/L is not considered to require remediation as the tar materials have since been removed.

TPH C6-C9 and BTEX were not detected above LORs within any of the on-site and off-site groundwater wells.

10.2 Metals

Copper and zinc were found at elevated concentrations in some fill materials across the HDA, with manganese almost inherent at elevated levels within the fill materials.

Heavy metals, principally copper, lead and zinc, but also arsenic, cobalt and nickel in places, was found at concentrations above trigger values in many wells over the HDA. Manganese was also detected within groundwater across the HDA.

While concentrations of metals generally appeared consistent across the HDA, two wells stand out as having elevated concentrations of zinc and copper above these 'background concentrations'. These were detected adjacent to Newcastle Harbour where elevated concentrations of these metals had been detected in the fill.

Lot 22 Lee 5 South reported relatively low concentrations of heavy metals in the fill. Only low concentrations of metals have been detected in groundwater down-gradient at Lee 5.

10.3 Conclusion

The results for **Lot 22 Lee 5 South** indicate that:

- Elevated levels of PAHs were detected within the up-gradient wells at Lot 21 and Lot 22 Lee 5 South. Those wells in similar fill materials and down-gradient of these wells reported reduced levels of PAHs in the groundwater. In addition, three PAHs previously not detected at the HDA were detected. Considering these details it is likely that the source of the PAHs is located off-site and up-gradient.

  As only low levels of PAHs were detected on the down-gradient section of the site and down-gradient at Lee 5, no further assessment is considered necessary.

- Generally, low concentrations of metals were reported for the fill materials at Lot 22 Lee 5 South and the adjacent site. It is likely that source of the elevated levels of heavy metals detected in the groundwater is located off-site and up-gradient, or are the result of a widespread regional source.

- TPH C29-C26 was detected at a low level in one of the down-gradient wells. Given that tar has since been removed and that petroleum hydrocarbons were not detected above the PQLs within the groundwater at other wells over Lot 22 Lee 5 South, Lot 21 Lee 5 South or at the two down-gradient wells over Lee 5, the detection is not considered to require further assessment or remediation.

Given that the proposed land use is for a commercial purpose, it is unlikely that water would be abstracted for use. Groundwater is located approximately 3 m BGL in this area.

Groundwater for the HDA or at Lot 22 Lee 5 South has not been assessed for all possible uses. If use of the groundwater is proposed, a licence from the Department of Sustainable Natural Resources (DSNR) should be obtained.

11 EVALUATION OF REMEDIATION

PB (2003) concluded that the site was 'unsuitable for the proposed commercial land use'. PB recommended 'that remediation and/or management of PAH, TPH and heavy metal (lead) contaminated material' be undertaken prior to development of Lee 5 South. A remediation action plan (RAP) was prepared by RCA in consideration of the investigations undertaken by PPK, PB and RCA. Remediation has since been conducted by excavation and removal of the tar impacted material.

11.1 Remediation Required

Based on the investigations completed by PPK, PB and RCA, the contaminants of concern targeted by the RAP included PAHs and TPH in association with tars within both the gravel road base material (layer G) and the sandstone cobbles (Layer E).

RCA (June 2003) indicated that remedial works would focus on chasing out of the tar impacted hardstand area that was likely to extend over the site. RCA estimated the extent based on their knowledge of the adjoining Lot 21 Lee 5 South and the site history.

RCA presented a number of options for remediation works and concluded that there was only one 'viable alternative'. This involved the excavation 'of the identified soil contamination' followed by either landfarming or disposal to landfill. RCA did not discuss the possibility of cap and contain of any remaining impacted materials.

The RAP prepared by RCA was found to mostly address the required information. The checklist included in "Guidelines for Consultants Reporting on Contaminated Sites" was completed for the RAP.

It is considered that the remediation approach recommended by RCA was generally appropriate. It should be noted that following comments provided by the Auditor and further investigative works by RCA that the remediation approach was modified to reflect this more detailed information.

11.2 Remediation and Validation Activities

Remediation works were undertaken generally in accordance with the RAP, as modified to address the Auditor's comments and actual conditions encountered in the field during remediation activities.

11.2.1 Excavation

Soils impacted by tar (layer G and E) including the gravel road base materials and the underlying sandstone cobbles were excavated and removed from site. Tar had been visible in the joints and voids of the cobbles. These materials were associated with particularly elevated concentrations of PAHs (maximum of 243, 717mg/kg) and TPH C10-C36. RCA limited the excavations mainly to these impacted layers as the material had been shown to leach.

Due to limited stockpile space, validation and backfilling occurred progressively during the remediation. RCA noted that the materials transported off-site included a significant amount of overlying sand. This indicates that the materials were not screened on-site with a 'screening bucket' to separate the tar impacted sandstone

boulders from the sand fill as had been undertaken at Lot 21 Lee 5 South. During the investigation at Lot 21 RCA noted that the tar adhered to the sandstone.

These materials were 'visually easy to distinguish' in the field and the soils were excavated until no more tar was visible. Validation samples were used to confirm these visual observations. The excavated area and the final validation sample locations are shown as Appendix A, Attachment 5.

A summary of the PAH and TPH validation results have been tabulated in Table 11.1.

These results do not include samples analysed by PB, PPK and RCA that have since been excavated due to elevated concentrations of PAHs or that of Layers A and B that have been used to reinstate the site.

Table 11.1 - Evaluation of Base Soil Validation Analytical Results for Excavations Summary Table (mg/kg).

Analyte	n	Detections	Maximum	n > SIL Column 4 *(EPA 1998)*	*n* >EPA *(1994)*
Benzo(a)pyrene	43	24	17	4	N/A
Total PAHs	43	28	262	2	N/A
TPH C10-C36	43	4	440	N/A	0

Elevated concentrations of benzo(a)pyrene were detected in four of the validation samples above the SIL. Two of these also reported total PAHs in excess of the SIL. TPHc10-c36 was detected in association with the elevated concentrations of PAHs. These samples were all located at the edge of the validation areas.

Given that the excavation was visually validated for tar impacted materials, that the gravely sands have been shown to have a low leachate potential and that the concentrations were similar to those reported in fill retained at the site, the Auditor considers that the excavation has been adequately validated both visually and analytically. No further assessment is considered necessary.

Layer C consists of gravels and coal that reported elevated concentrations of total PAHs (maximum of 1151 mg/kg) and benzo(a)pyrene (maximum of 69mg/kg). This layer was also removed from the site. Previously only low concentrations of PAHs were detected in this layer over Lot 21 (total PAHs max 8 mg/kg). RCA note that the 'majority' of the material, which is 'the same sandy material which is present in the overlying fill layers', was removed. RCA does not provide a clear indication of how much residual might remain at the site. In the Auditor's opinion, it is likely that the most elevated concentrations were associated with the cobbles that were coated in tar that were visually removed. The Auditor is satisfied that the layer is likely to be limited in extent and that further excavations to target this particular layer would not be feasible.

RCA indicate that two large areas were excavated prior to the documented remedial works 'to remove material from the area of the proposed road extension' and to 'remove fill from the floodway'. According to RCA these were the 'starting points' of the main excavations.

11.2.2 Cap and Contain

The remaining PAH impacted fill materials were retained over the site and include silty sands (layer A) and sandy fill (layer B). Layers A and B were used as backfill materials following validation sampling. A summary of the results is provided in Table 11.2.

Table 11.2 - Evaluation of Soil Validation Analytical Results for Layers A and B Used to Reinstate the Site. Summary Table (mg/kg).

Analyte	n	Detections	Maximum	n > SIL Column 4 *(EPA 1998)*	*n* >EPA *(1994)*
Benzo(a)pyrene	10	10	33	**4**	N/A
Total PAHs	10	10	624	**3**	N/A
TPH C10-C36	10	5	970	N/A	0

Total PAHs (maximum of 624 mg/kg) and TPH c10-c36 (maximum of 970mg/kg) were detected above the site criteria within four of the validation samples. These are not dissimilar to those previously detected within the sandy fill. RCA had observed that the sands were not impacted by the tar materials. These materials were used to backfill the excavation. The Auditor considers this to be appropriate.

The primary, duplicate and triplicate of one sample excluded from Table 11.2, reported total PAHs at 53mg/kg, 740mg/kg and 2376mg/kg. The elevated concentration is uncharacteristic of the fill material.

The elevated concentration is not discussed by RCA in terms of extent or risk. This was one of 44 samples collected from Layers A and B during the course of the investigation in-situ and ex-situ over Lot 21 and Lot 22. In the Auditor's opinion, the risk of significant amounts remaining at the site is likely to be low. RCA note in their quality evaluation that sample variances 'were due to sample heterogeneity and are not of concern'. While the variance is of concern to the Auditor, in consideration of all data, the Auditor concludes that no further assessment of the variance is necessary.

Metals results were all less than the SILs.

RCA propose to cap and contain these materials using the proposed commercial development. It is understood that the details of the proposed development have not yet been finalised.

The Auditor considers this remediation option to be appropriate as:

- stratigraphy at the site is well characterised and the nature of the impact is well known i.e. elevated concentrations within the sandy fill are randomly distributed;
- other targeted remediation works would be difficult given the random distribution of PAH impacted materials;
- other methods would have a high relative cost; and

- access to the soils would be limited by the commercial development and is likely to provide adequate protection for future site users. However, as the details of the proposed development are not finalised, there is limited assurance of protection in these areas i.e. integrity of capping.

RCA has prepared a Site Management Plan. The Site Management Plan (SMP) is based on the Woodward Clyde (1999) Environmental Management Plan for the Honeysuckle Development. The SMP appears appropriate to reduce the risk to human health during construction works as the plan:

- requires that safety plans and briefings for all personnel be undertaken. This will effectively notify and adequately protect personnel who may come into contact with materials from the presence of the residual contaminants;
- requires that any soils that are excavated are classified for disposal or reuse in accordance with applicable guidelines and that any imported soil would have to be validated; and
- provides contingency plans and provides procedures to ensure that soils are managed in accordance with the applicable legislation and guidelines.

This SMP does not address the risk to human health following completion of the commercial development.

11.3 Conclusion

The remediation consisted of excavation and offsite disposal of heavily contaminated material, and retention on site for capping during site redevelopment of less contaminated material. In the Auditor's opinion, the highly contaminated material has been effectively removed. In the Auditor's opinion, capping of the less heavily contaminated material on site can be achieved to manage risk to human health and the environment, and the only viable alternative to capping of the less heavily contaminated material on site is to remove all potentially impacted fill.

12 ASSESSMENT OF RISK

Based on the overall assessment results and comparisons with guidelines, it is the Auditor's opinion that:

- the elevated concentrations of PAHs associated with the fill materials at the site could pose a risk to human health in unsealed areas and during any excavations. Capping of the site will minimise this risk;
- given that the stratigraphy and distribution of the contaminants within these materials is well known, the risk of major pockets of undetected contamination, both in terms of concentration and extent, is low; and
- contaminants within the groundwater are not likely to pose a risk to human health as abstraction and use on-site is not expected given the site use and the tidal and saline nature of groundwater in the vicinity.

13 CONTAMINATION MIGRATION POTENTIAL

The site is currently unsealed and therefore there is a risk of contaminant migration as a result of dust or surface water runoff currently and during construction works. Following capping of the site with the proposed commercial development the risk of contaminant migration as a result of these pathways would be negligible.

PAHs were detected in association with the fill materials located across the site. Only low levels of PAHs were detected in the underlying alluvial sands and only low levels of PAHs were detected within groundwater analysed down-gradient of the site. These results indicate a low potential for off-site migration in groundwater of contaminants sourced from this site, however there is contamination in groundwater which appears to be migrating onto the site and could pass under the site.

14 COMPLIANCE WITH REGULATORY GUIDELINES AND DIRECTIONS

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

The *Environmental Site Assessment* was generally prepared in accordance with the *Guidelines for Consultants Reporting on Contaminated Sites*. The checklist included in that document has been completed and is kept on file. The EPA's *Checklist for Site Auditors using the EPA Guidelines for the NSW Site Auditor Scheme 1998* has also been completed and is kept in file.

The Auditor concludes that the reports have been prepared generally in accordance with EPA guidelines.

Waste disposal dockets were obtained by RCA. Waste was classified as 'truck sorted demolition waste' and 'inert' waste disposed of at the Summerhill Waste Centre. RCA indicated that the tar impacted materials from Lot 22 and those temporarily stockpiled at the site sourced from Lot 21, were sent to Summerhill as 'inert waste, i.e. asphalt'. RCA do not discuss or provide any other documentation regarding the classification of the wastes. It is not clear whether the wastes were classified in accordance with the EPA (1999) *"Assessment, Classification and Management of Liquid and Non-Liquid Wastes"*.

The Consultant does not indicate whether Department of Sustainable Natural Resources licences were obtained for the installation of the groundwater bores.

15 CONCLUSIONS AND RECOMMENDATIONS

The Consultant, PPK (now PB) who undertook the 'Environmental Site Assessment' concluded that remediation of TPH and PAH would be required for commercial/industrial land uses.

The Consultant, PB who undertook the 'Contaminant Delineation Investigation' concluded that:

- *'the contamination conditions present at Lee 5 South results in the site in its current state being unsuitable for the proposed commercial land use'; and*
- *'remediation and/or management of PAH, TPH and heavy metal (lead) contaminated material is required prior to development on the site'.*

The Consultant, RCA, who undertook the 'Implementation of the Remedial Action Plan' concluded that:

- *'in its remediated state the site is considered suitable for the proposed industrial/commercial development which conforms to HIL E, as long as the Site Management Plan is followed'*. The SMP indicates that the site is suitable for the proposed development 'providing the site is capped'.

Based on the information presented in the Consultant's reports and observations made on site, and following *EPA (1998) Decision Process for Assessing Urban Redevelopment Sites*, the Auditor concludes that the site could be suitable for the purposes of commercial/industrial land uses if the following were undertaken:

- capping of the site with suitable materials that may include clean soil or building slab ensuring that materials are not readily accessible to site users. Where capping is not feasible, validation should be to at least 'recreational open space' standard to a minimum depth of 0.5 m;
- notation of the presence of contaminated soil on the Section 149 certificate for the site so that the contamination can be managed in any future redevelopment; and
- groundwater is not abstracted for use.

This Audit has not been prepared for a statutory purpose. To be used for a statutory purpose, it is envisaged that a management plan that specifically addresses the above Conditions and includes a mechanism to implement them would need to be prepared and incorporated into the Audit Conditions and any Development Consents.

16 OTHER RELEVANT INFORMATION

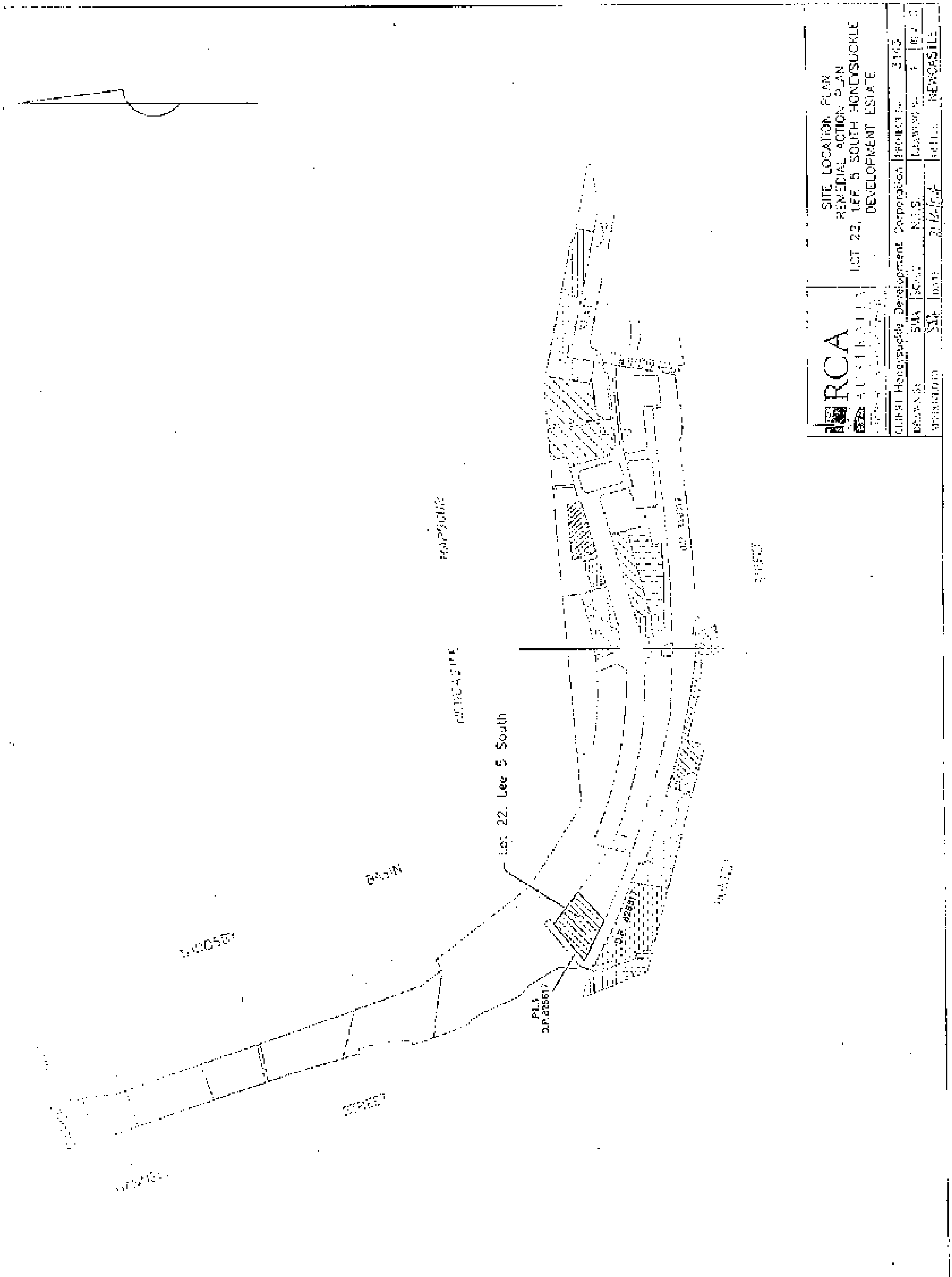
This Audit was conducted for *Honeysuckle Development Corporation* for the purpose of determining the suitability of the site for its intended landuse. The Audit falls within the definition of an audit under Section 47(1)(b)(iia) of the *NSW Contaminated Land Management Act 1997*, No. 140. This audit report may not be suitable for other uses. The Auditor has prepared this document in good faith, but is unable to provide certification outside of areas over which he had some control or is reasonably able to check.

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

APPENDIX A

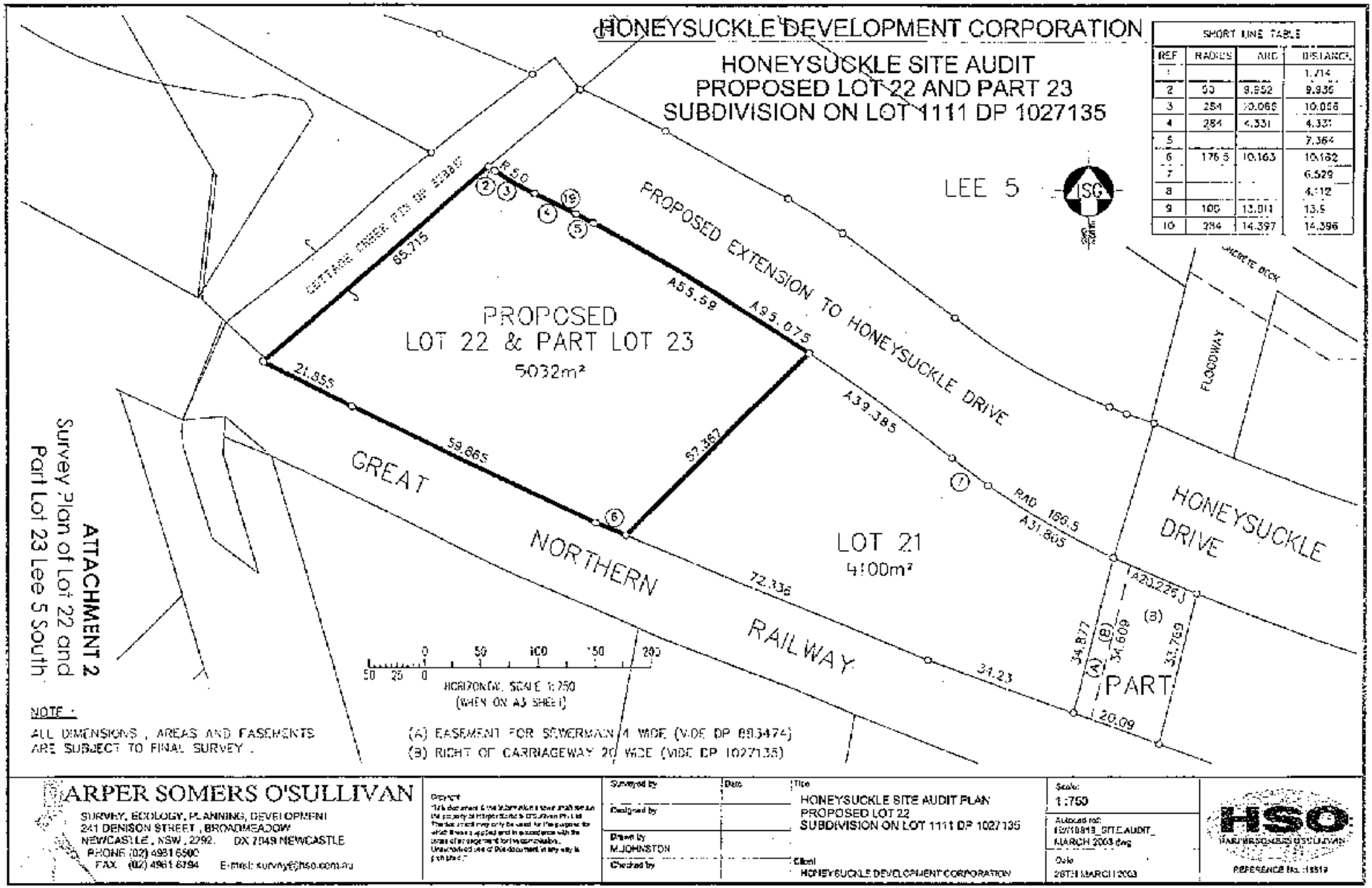
ATTACHMENTS

1. Honeysuckle Development Area
2. Survey Plan of Lot 22 and Part Lot 23 Lee 5 South
3. Soil Sampling Locations – Lot 22 and Part Lot 23 Lee 5 South
4. Groundwater Sampling Locations
5. Remediation Excavation – Lot 22 and Part Lot 23 Lee 5 South



ATTACHMENT 1

Honeysuckle Development Area



HARPER SOMERS O'SULLIVAN
SURVEY, ECOLOGY, PLANNING, DEVELOPMENT
241 DENISON STREET , BROADMEADOW
NEWCASTLE , NSW , 2292. DX 7849 NEWCASTLE
PHONE (02) 4961 6500
FAX (02) 4961 6794 E-mail: survey@hso.com.au

Surveyed by | Date
Designed by
Drawn by M.JOHNSTON
Checked by

Title: HONEYSUCKLE SITE AUDIT PLAN
PROPOSED LOT 22
SUBDIVISION ON LOT 1111 DP 1027135

Client: HONEYSUCKLE DEVELOPMENT CORPORATION

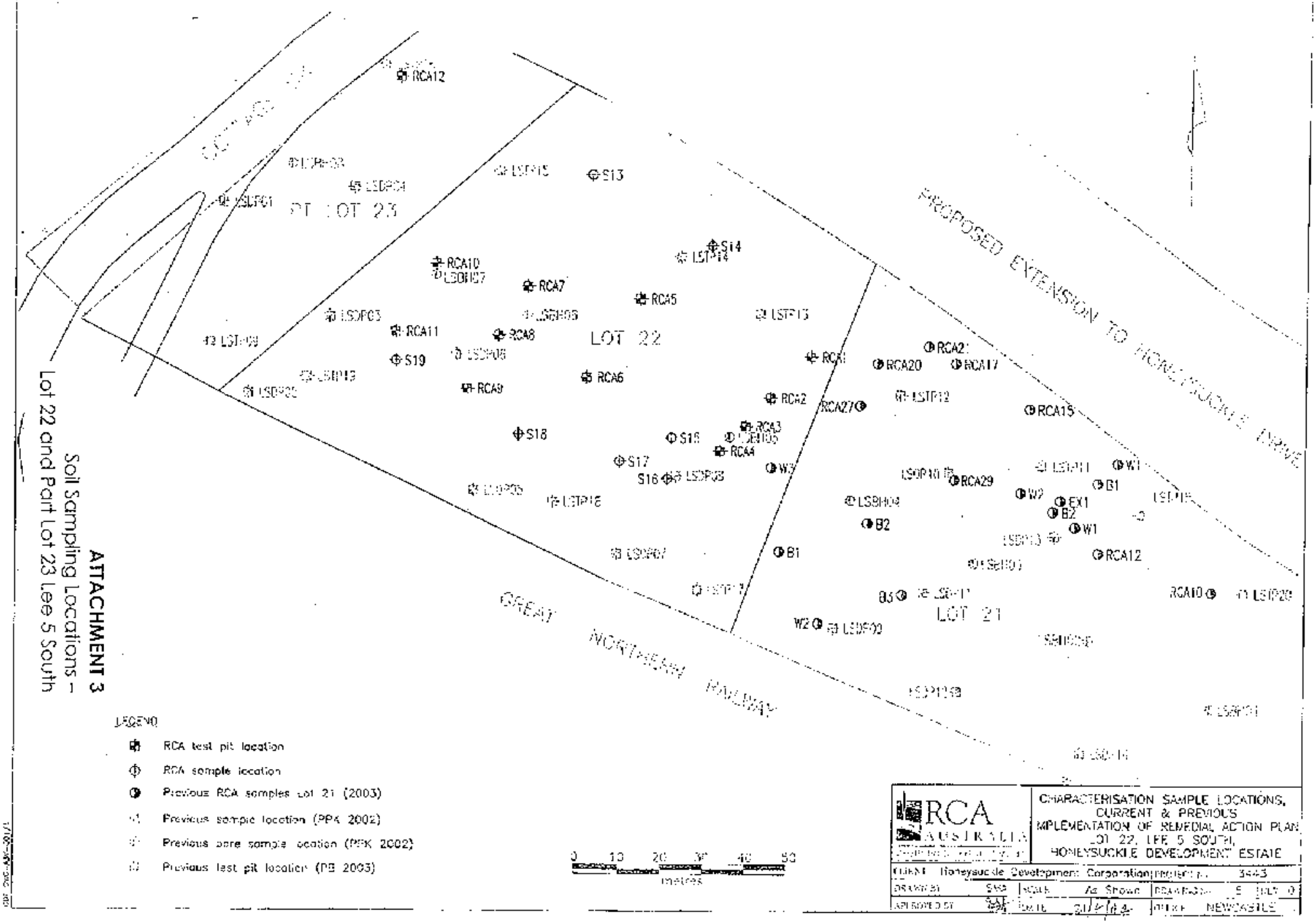
Scale: 1:750

Autocad ref: 6910819_SITE AUDIT_MARCH 2003.dwg

Date: 28TH MARCH 2003

HSO HARPER SOMERS O'SULLIVAN

REFERENCE No. 6910



ATTACHMENT 3

Soil Sampling Locations –
Lot 22 and Part Lot 23 Lee 5 South

RCA AUSTRALIA

CHARACTERISATION SAMPLE LOCATIONS, CURRENT & PREVIOUS IMPLEMENTATION OF REMEDIAL ACTION PLAN LOT 22, LEE 5 SOUTH, HONEYSUCKLE DEVELOPMENT ESTATE

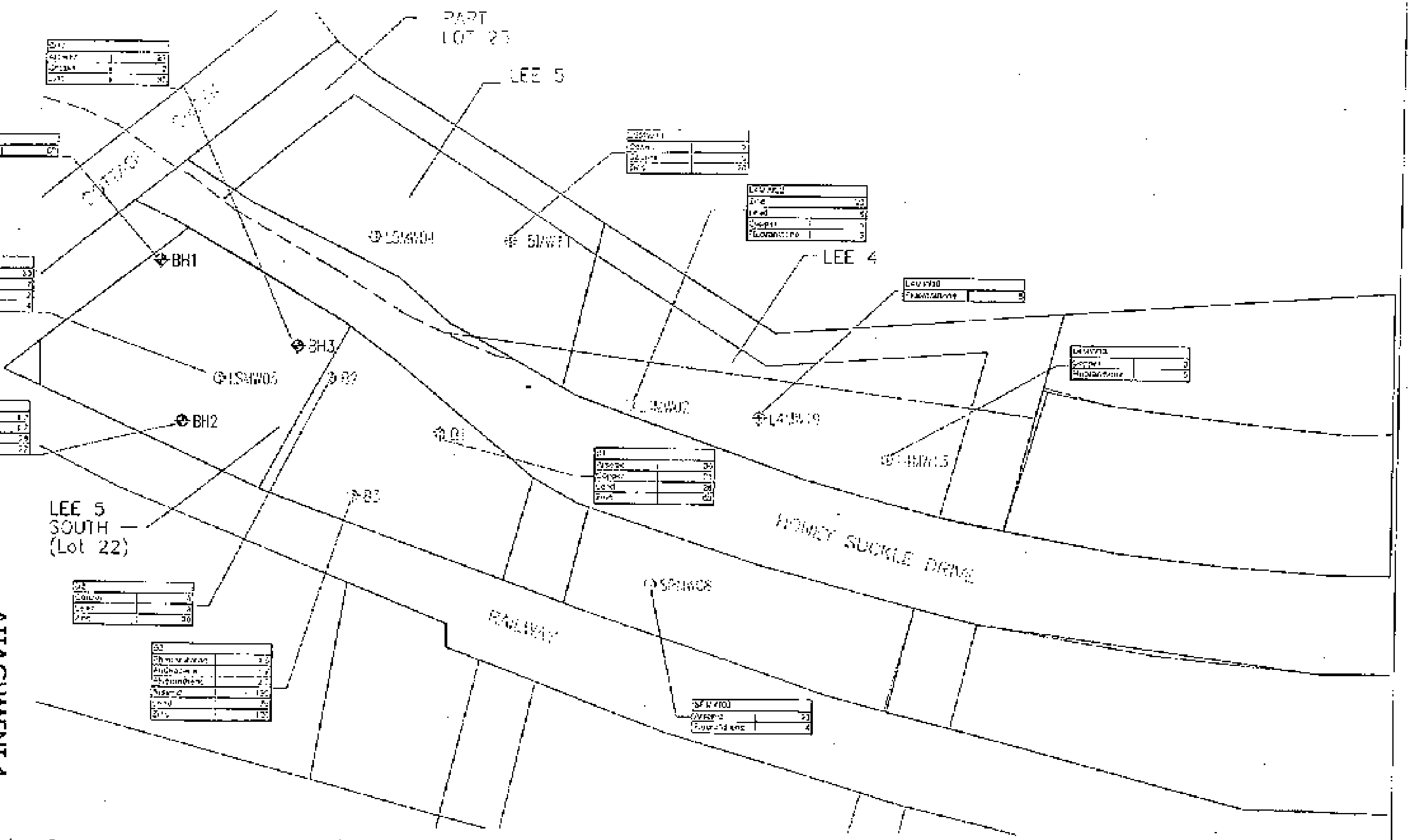
CLIENT: Honeysuckle Development Corporation | PROJECT No.: 3443

DRAWN: SKB | SCALE: As Shown | DRAWING No.: 5 | LOT: 0

APPROVED BY: | DATE: | OFFICE: NEWCASTLE

ATTACHMENT 4

Groundwater Sampling Locations



LEGEND

- Previous Groundwater Monitoring Well Location (PPK, Mar 02)
- Previous Groundwater Monitoring Well Location (PB, Mar 03)
- Perivous Groundwater Monitoring Well Location (RCA, Mar 03)
- Current Groundwater Mointoring Well Location (RCA, Aug 03)

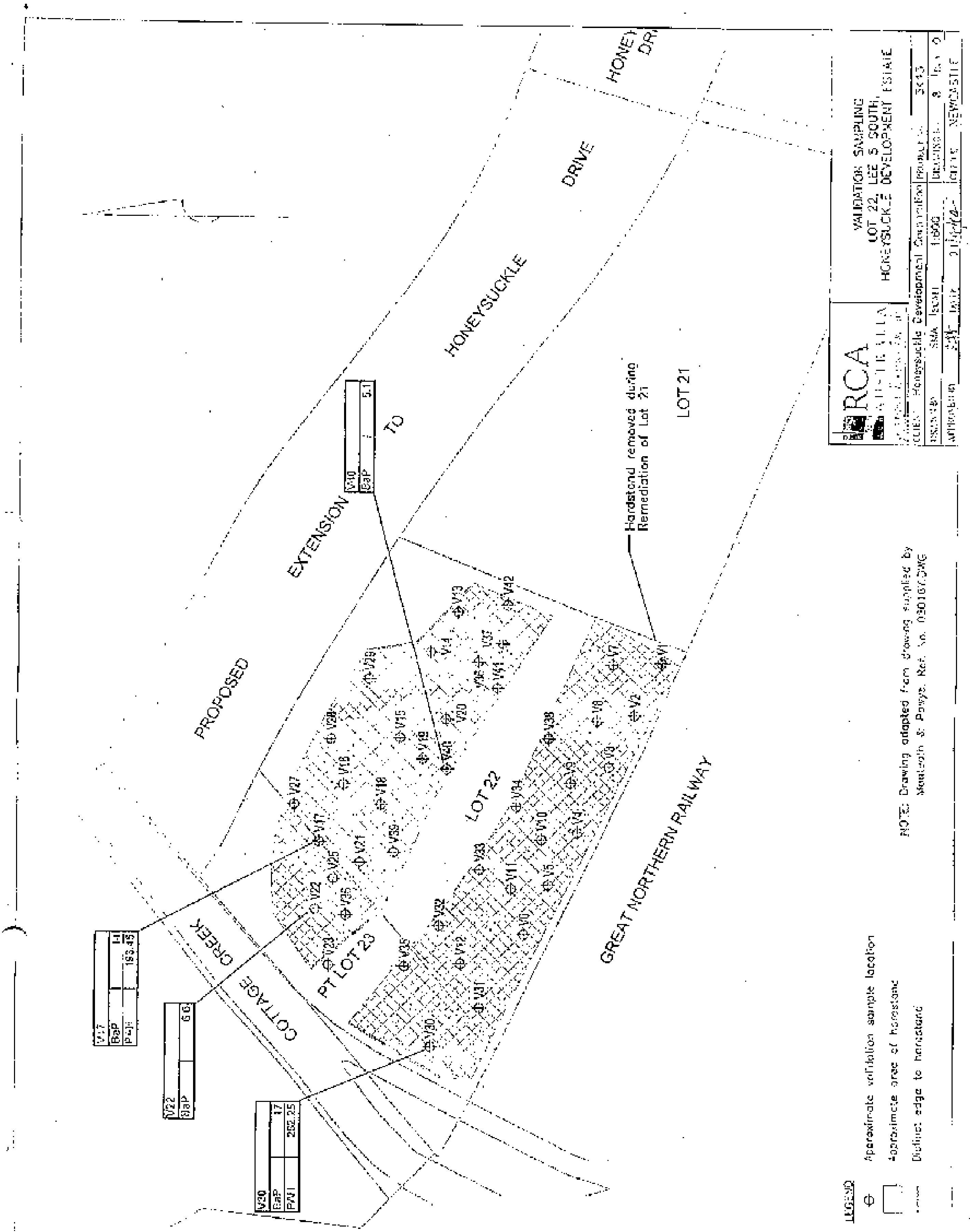
Note: All units in ug/L.
Drawing taken from PPK Drawing 2122252A\CAD\LL_0423\Figure03.pdf
Laboratory detection limits, for PPK (2002)/PB (2003) PAH results are above the relevant guideline. As a result additional PAH compounds could be classified as exceedances other than stated here

0 10 20 30 40 50
metres

RCA AUSTRALIA

GROUNDWATER BORE LOCATIONS & EXCEEDANCES IMPLEMENTATION OF REMEDIAL ACTION PLAN LOT 22, LEE 5 SOUTH, HONEYSUCKLE DEVELOPMENT ESTATE

CLIENT	Honeysuckle Development Corporation			PROJECT #	3445
DRAWN BY	SMA	SCALE	As Shown	DRAWING #	7 REV 0
APPROVED BY	[illegible]	DATE	[illegible]	OFFICE	NEWCASTLE



ATTACHMENT 5

Remediation Excavation –
Lot 22 and Part Lot 23 Lee 5 South

APPENDIX B

SOIL AND GROUNDWATER CRITERIA

Soil Investigation Levels for Urban Redevelopment Sites in NSW (EPA 1998)

Health-based investigation levels (mg/kg)					
Substance	Residential with gardens and accessible soil (home-grown produce contributing less than 10% fruit and vegetable intake; no poultry), including children's day-care centres, preschools and primary schools, or town houses or villas (NEHF A)	Residential with minimal access to soil including high-rise apartments and flats (NEHF D)	Parks, recreational open space, playing fields including secondary schools (NEHF E)	Commercial or Industrial (NEHF F)	Provisional phytotoxicity-based investigation levels for sandy loams pH 6-8 (mg/kg)
	Column 1	Column 2	Column 3	Column 4	Column 5
Aldrin + Dieldrin	10	40	20	50	-
Arsenic (total)	100	400	200	500	20
Benzo(a)pyrene	1	4	2	5	-
Beryllium	20	80	40	100	-
Cadmium	20	80	40	100	3
Chlordane	50	200	100	250	-
Chromium (III) [2]	12%	48%	24%	60%	400
Chromium (VI)	100	400	200	500	1
Copper	1000	4000	2000	5000	100
Cyanides (complex)	500	2000	1000	2500	-
DDT	200	800	400	1000	-
Heptachlor	10	40	20	50	-
Lead	300	1200	600	1500	600
Manganese	1500	6000	3000	7500	-
Methyl mercury	10	40	20	50	-
Mercury (inorganic)	15	60	30	75	1 [b]
Nickel	600	2400	600	3000	60
PAHs (total)	20	80	40	100	-
PCBs (total)	10	40	20	50	-
Phenol [3]	8500	34000	17000	42500	70
Zinc	7000	28000	14000	35000	200

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

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

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

Non-Metallic Inorganics		
Ammonia Total – NH_3 (at pH of 8)	910	ANZECC (2000) 95% protection levels.
Cyanide (Free or unionised HCN)	4	

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

Threshold Concentration for Sensitive Land Use – Soils
Guidelines for Assessing Service Station Site (NSW EPA 1994)

Contaminant	Threshold Concentration (mg/kg)
TPH (C_6-C_9)	65
TPH (C_{10}-C_{36})	1,000
Benzene	1
Toluene	1.4
Ethylbenzene	3.1
Xylenes (total)	14

APPENDIX C

EPA APPROVED GUIDELINES

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

(as of 17 March 2004)

Guidelines made by the EPA

- *Contaminated Sites: Guidelines for Assessing Service Station Sites*, December 1994
- *Contaminated Sites: Guidelines for the vertical mixing of soil on former broad-acre agricultural land*, January 1995.
- *Contaminated Sites: Sampling Design Guidelines*, September 1995
- *Contaminated Sites: Guidelines for Assessing Banana Plantation Sites*, October 1997
- *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites*, November 1997
- *Contaminated Sites: Guidelines for the NSW site auditor scheme*, June 1998
- *Contaminated Sites: Guidelines on Significant Risk of Harm from Contaminated Land and the Duty to Report*, April 1999.

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

Guidelines approved by the EPA

ANZECC publications

- *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*, published by Australian and New Zealand Environment and Conservation Council (ANZECC) and the National Health and Medical Research Council (NHMRC), January 1992
- *Australian Water Quality Guidelines for Fresh and Marine Waters*, Australian and New Zealand Environment and Conservation Council (ANZECC), November 1992, which are only approved for the purposes of contaminated site assessment, investigation, remediation and site auditing under the Contaminated Land Management Act (or other relevant legislation) commenced before September 2001
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Paper No 4, October 2000

EnHealth publications (formerly National Environmental Health Forum monographs)

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

National Environment Protection Council publications

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

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

B(1) *Guideline on Investigation Levels for Soil and Groundwater*

B(2) *Guideline on Data Collection, Sample Design and Reporting*

B(3) *Guideline on Laboratory Analysis of Potentially Contaminated Soils*

B(4) *Guideline on Health Risk Assessment Methodology*

B(5) *Guideline on Ecological Risk Assessment*

B(6) *Guideline on Risk Based Assessment of Groundwater Contamination*

B(7a) *Guideline on Health-Based Investigation Levels*

B(7b) *Guideline on Exposure Scenarios and Exposure Settings*

B(8) *Guideline on Community Consultation and Risk Communication*

B(9) *Guideline on Protection of Health and the Environment During the Assessment of Site Contamination*

B(10) *Guideline on Competencies & Acceptance of Environmental Auditors and Related Professionals*

Other documents

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

APPENDIX D

ANALYTICAL LISTS AND METHODS

AMDEL ANALYTICAL LISTS AND METHODS

TARGET COMPOUNDS	AMDEL METHOD ID	METHODOLOGY SUMMARY
POLYAROMATIC HYDROCARBONS		
Naphthalene	E1110	Soil – Acetone/DCM Sonication USEPA 3550B, GC/FID.
Acenaphthylene		
Acenaphthene		
Fluorene		
Phenanthrene		
Anthracene		
Fluoranthene		
Pyrene		
Benz[a]anthracene		
Chrysene		
Benzo(b)&(k)fluoranthene		
Benzo(a)pyrene		
Indeno(1.2.3-c,d)pyrene		
Dibenz(a,h)anthracene		
Benzo(g,h,i)perylene		
HEAVY METALS		
Arsenic	E-5910	Soil – HNO_3, HCL & H_2O_2 digestion USEPA 200.2 (modification), ICP-AES
Cadmium		
Chromium		
Copper		
Nickel		
Lead		
Zinc		
Mercury	E5950	Soil – Kmn04 digestion USEPA 3051, CV-AAS.
BTEX COMPOUNDS		
Benzene	E1010	Soil – Methanol Extraction USEPA 5035, GC/MS Purge & Trap
Toluene		
Ethylbenzene		
meta- & para-Xylene		
ortho-Xylene		
TOTAL PETROLEUM HYDROCARBONS		
C6-C9 Fraction	E1230	Soil – Methanol extraction USEPA 5035, Purge and trap/GC-MS
C10-C14 Fraction	E1221	Soil – Acetone/DCM Sonication USEPA 3550B, GC/MS
C15-C28 Fraction		
C29-C36 Fraction		

LABMARK ANALYTICAL LISTS AND METHODS

TARGET COMPOUNDS	LABMARK METHOD ID	METHODOLOGY SUMMARY
POLYAROMATIC HYDROCARBONS		
Naphthalene	E007.2, E007.3	E007.2: (Soil) 8-10g soil extracted with 20mL DCM/acetone (8:2), Analysis by GC/MS. E007.3: (Water) Triple extraction with DCM followed by concentrations step. Analysis by GC/MS.
Acenaphthylene		
Acenaphthene		
Fluorene		
Phenanthrene		
Anthracene		
Fluoranthene		
Pyrene		
Benz(a)anthracene		
Chrysene		
Benzo(b)&(k)fluoranthene		
Benzo(a)pyrene		
Indeno(1.2.3-c,d)pyrene		
Dibenz(a,h)anthracene		
Benzo(g,h,i)perylene		
HEAVY METALS		
Arsenic	E022.1 E022.2	E022.1: (Water) Filtered HNO3 preserved sample directly analysed by ICP-MS. E022.2: (Soil) 0.5g digested in nitric/ hydrochloric acid. Analysis by ICP-MS.
Cadmium		
Chromium		
Copper		
Nickel		
Lead		
Zinc		
Mercury	E026.1	E026.1 (Water) Analysis by CV-ICP-MS following BrCl pre-treatment.
	E026.2	E026.2: (Soil) 0.5g digested with nitric/ hydrochloric acid. Analysis by CV-ICP-MS or FIMS.
TOTAL PETROLEUM HYDROCARBONS		
C6-C9 Fraction	E003.2	8-10g soil extracted with 20mL methanol. Analysis by P&T/GC/FID.
C10-C14 Fraction	E006.2	8-10g soil extracted with 20mL DCM/Acetone (8:2). Analysis by GC/FID.
C15-C28 Fraction		
C29-C36 Fraction		
PHENOLS		
Phenol	E008.2	8-10g soil extracted with 20ml DCM/acetone (8:2). Analysis by GC/MS
2-chlorophenol		
2-methylphenol		
4-methylphenol		
2-nitrophenol		
2,4-dimethylphenol		
2,4-dichlorophenol		
4-chloro-3-methylphenol		
2,4,6-tricholrophenol		
2,4,5-trichlorophenol		
Pentachlorophenol		