R E P O R T

BP Darwin Terminal Facility
Lot B of Remediation Zone 1
Environmental Audit Report

Volume 1 of 2

Prepared for

BP Australia Pty Ltd

701 Kingsford Smith Drive W
Whinstanes, Qld 4007

May 2004

51614-011-6000-R500

URS

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Summary Details

Name and address of the site being audited:	Lot B of Remediation Zone 1 BP Darwin Terminal Dinah Beach Road Stuart Park, Darwin NT
Property Description:	Portion of Lot 5719, Town of Darwin Plan S 89/230A
Local Government Authority:	Darwin City Council
Ownership from CT:	Frances Park (Darwin) Pty Ltd
Occupier of Site:	Frances Park (Darwin) Pty Ltd
Name of Auditor:	Mr Adrian Hall URS Australia Pty Ltd
State of Accreditation	Victoria
Date of Appointment as an Accredited Environmental Auditor:	7 January 1997 (accreditation renewed 29 January 2003)
Name of person making a request for an Environmental Audit Report:	Mr Perry McGarry BP Australia Pty Ltd
Date of appointment as auditor of this site:	15 September 2003
Date of notification of NT DIPE:	22 September 2003
Date of Completion of Audit	May 2004

Statement of Environmental Audit

I, Adrian Michael Dickinson Hall of URS Australia Pty Ltd, a person appointed by the Environment Protection Authority of Victoria ('the Authority') under the *Environment Protection Act* 1970 ('the Act') as an environmental auditor for the purposes of the Act, having

1. been requested by BP Australia Pty Ltd to issue a certificate of environmental audit in relation to the site located at Lot B of Remediation Zone 1 of the Dinah Beach Road Terminal, Darwin ('the site') owned / occupied by Frances Park (Darwin) Pty Ltd

2. had regard to, amongst other things,

   (i) guidelines issued by the Authority for the purposes of Part IXD of the Act, and endorsed by the Department of Infrastructure, Planning and Environment, Northern Territory

   (ii) the beneficial uses that may be made of the site, and

   (iii) relevant environment protection policies / industrial waste management policies,

   in making a total assessment of the nature and extent of any harm or detriment caused to, or the risk of any possible harm or detriment which may be caused to, any beneficial use made of the site by any industrial processes or activity, waste or substance (including any chemical substance), and

   completed an environmental audit report in accordance with section 53X of the Act, a copy of which has been sent to the Department of Infrastructure, Planning and Environment, Northern Territory.

   HEREBY STATE that I am of the opinion that

1. The site is suitable for the following beneficial uses subject to the conditions attached thereto:

   - mixed residential living
   - all uses permitted under the Darwin Town Plan 1990, as amended on 20 February 2002, for Specific Use (SU52) Zone.

   Subject to

   (i) there should be no use of phreatic groundwater from the site, other than for the purposes of environmental monitoring

   (ii) there should be a program of groundwater monitoring for Lots A and B of Remediation Zone 1, as outlined in Section 6 of the Environmental Audit Report; a review of the program should be undertaken by the auditor periodically, and the program should be continued until the auditor is satisfied that all nominated Groundwater Investigation Levels (GILs) are met, and that the contaminated groundwater plume no longer poses unacceptable human health or environmental risks.

2. The condition of the site is detrimental or potentially detrimental to any (one or more) beneficial uses of the site. Accordingly, I have not issued a Certificate of Environmental Audit for the site in its

current condition, the reasons for which are presented in the environmental audit report and are summarised as follows:

(i) groundwater is polluted in wells in the vicinity of the site, with elevated levels of petroleum hydrocarbons and some heavy metals.

The Statement forms part of the following environmental audit report:

- URS Australia Pty Ltd (2004), BP Darwin Terminal Facility, Lot B of Remediation Zone 1, Environmental Audit Report, for BP Australia Pty Ltd, Report No 51614-011-6000-R500, May 2004.

Further details regarding the condition of the site may be found in the environmental audit report.

DATED 7 May 2004

Signed: A.M-D Hall

ENVIRONMENTAL AUDITOR (CONTAMINATED LAND)

1.1 General

Mr Adrian Hall was appointed by BP Australia Pty Ltd in September 2003, to act as the Environmental Auditor for Lot B of Remediation Zone 1 of the redevelopment of the BP Dinah Beach Road Terminal Facility Darwin. The site is being redeveloped by the owner, Frances Park (Darwin) Pty Ltd, for mixed residential use. A Site Location Plan is given in Figure 1.

The Department of Infrastructure, Planning and Environment, Northern Territory (DIPE) requested that the proposed remediation works be reviewed by a Victorian EPA accredited Environmental Auditor, to the same standards as would apply in Victoria. BP engaged the services of Mr Adrian Hall, in order to comply with this requirement.

In October 2002 Mr Adrian Hall completed the following audit report for Lot A:

- URS Australia Pty Ltd (2002), BP Darwin Terminal Facility, Lot A of Remediation Zone 1, Environmental Audit Report, for BP Australia Pty Ltd, Report No 51614-008-R005, October 2002.

A List of Abbreviations and Acronyms is provided in Appendix 1, and a Glossary of Terms applying to environmental audits of land is provided in Appendix 2. Quality Assurance / Quality Control (QA/QC) Explanatory Notes are given in Appendix 3.

1.2 Site Identification

The Lot B of Remediation Zone 1 of the BP Darwin Terminal Facility is located on Dinah Beach Road in Stuart Park, Darwin, and comprises a portion of Lot 5719, Town of Darwin, Plan S 89/230A. A site plan showing Lot B (the extent of this audit) is given in Figure 2. Hereinafter Lot B of Remediation Zone 1 is termed ‘the site’.

1.3 Purpose of the Report

It is intended that the site will be used for mixed residential development, in accordance with the provisions of the Specific Use (SU52) Zone under the Darwin Town Plan 1990, as amended on 20 February 2002.

The purpose of this document is to provide an Environmental Audit Report which

- Assesses the current contamination status of the site;
- Identifies the beneficial uses for which the site is suitable; and
- Specifies the types of land use or development which are not compromised by on-site contamination.

This audit will therefore assess whether health and environmental risks from possible exposure to the soil and groundwater at this site are acceptably low, and thus facilitate planning approvals for the proposed future use of the site.

1.4 Parties Involved

Site Owner(s):	Frances Park (Darwin) Pty Ltd
Site Occupier(s):	Frances Park (Darwin) Pty Ltd
Environmental Site Assessor(s):	BP Australia Pty Ltd
	GHD Pty Ltd
Primary Laboratory Used by Assessor(s):	Australian Government Analytical Laboratories (AGAL)
	Amdel and ALS Environmental
Secondary Laboratory Used by Assessor(s):	Amdel and AGAL
Remediation Contractor(s):	BMD Constructions Pty Ltd

1.5 Background to Clean Up Criteria

The Northern Territory Department of Infrastructure, Planning and Environment (DIPE) issued a Pollution Abatement Notice (No 2003/1) under the Waste Management and Pollution Control Act to Frances Park. A copy of this notice is provided in Appendix 4. The notice required Frances Park to take remedial action to return the land as far as possible to a condition such that the levels of lead, benzene, toluene, ethylbenzene, xylenes and total petroleum hydrocarbons in soil and groundwater were equal to or below the levels specified in the notice.

1.6 DIPE Approval of Remediation Activities

A Remedial Action Plan (RAP) was written for Remediation Zone 1, documenting the strategies to remediate soil and groundwater (BP, 2000a). Its stated objectives for soil and groundwater remediation were to:

- Remove all accessible soil impacted with petroleum hydrocarbon concentrations in excess of the relevant criteria; and
- Remove the source of impact to groundwater beneath the site to facilitate natural degradation of any residual hydrocarbon impact.

DIPE gave approval for remediation and validation of Remediation Zone 1 in accordance with the RAP and its supporting documents, in correspondence dated 15 May 2001.

DIPE's approval to proceed with demolition and remediation works was granted on the basis of the following documents:

- BP Australia Pty Ltd (2000a), Remedial Action Plan (RAP), Darwin Terminal, Remediation Zone 1 – Tank DR8 Area, December 2000
- BP Australia Pty Ltd (2000b), Environmental Management Plan (EMP), Darwin Terminal, Remediation Zone 1 – Tank DR8 Area, December 2000
- Letter from BP Australia Pty Ltd to DLPE dated 4 May 2001.

A copy of the Remedial Action Plan is provided in Appendix 3, and a copy of the Environmental Management Plan is provided in Appendix 4.

1.7 Documentation Reviewed

The auditor has reviewed the following documentation regarding the assessment, remediation and validation of the site:

- BP Australia Pty Ltd (2000a), Remedial Action Plan, Darwin Terminal, Remediation Zone 1 – Tank DR8 Area, December 2000
- BP Australia Pty Ltd (2000b), Environmental Management Plan, Darwin Terminal, Remediation Zone 1 – Tank DR8 Area, December 2000
- BP Australia Pty Ltd (2001), Site History Report, BP Darwin Terminal Facility, Dinah Beach Road, Stuart Park, Darwin, Northern Territory, May 2001
- BP Australia Pty Ltd (2002), Groundwater Monitoring and Management Plan (GMMP), Darwin Terminal, Lot B of Remediation Zone 1, 17 October 2002
- BP Australia Pty Ltd (2004), Site Decommissioning and Environmental Validation Report, Darwin Terminal, Lot B of Remediation Zone 1, March 2004.

As part of a separate programme of assessment by the auditor, the following groundwater monitoring reports have also been reviewed:

- GHD Pty Ltd (2003), BP Darwin Terminal, Groundwater Monitoring and Management Plan – March 2003 Monitoring Results, Letter report to BP Australia Pty Ltd, 31 July 2003
- GHD Pty Ltd (2004), BP Darwin Terminal Remediation Zone 1 Lot A, Groundwater Monitoring Report, September – October 2003, for BP Australia Pty Ltd, February 2004.

1.8 Summary of Audit Activities

The auditor was engaged in September 2003. The auditor's role has included the following activities:

- Provision of advice on treatment and disposal of lead impacted soils;
- Provision of advice on characterisation of lead impacted soil stockpiles;
- Review of groundwater monitoring reports for 2003, and advice on locations of new groundwater monitoring wells;
- Liaison with BP Australia Pty Ltd and DIPE; and
- Preparation of Environmental Audit Report and Statement of Environmental Audit.

1.9 Relevant Guidance Documents

The auditor has prepared this Environmental Audit Report with reference to the following NT DIPE endorsed guidance documents:

- EPA Victoria (2001), Environmental Auditor (Contaminated land) Guidelines for Issue of Certificates and Statements of Environmental Audit, Publication 759, May 2001
- EPA Victoria (2002a), The Clean Up and Management of Polluted Groundwater, Publication 840, April 2002
- EPA Victoria (2002b), Environmental Auditor Guidelines for Appointment and Conduct, Publication 865, August 2002.

The auditor has also referred to the following Victorian SEPP issued under the Environment Protection Act 1970:

- State Environment Protection Policy (Prevention and Management of Contamination of Land), Victoria Government Gazette, 4 June 2002.

In addition, the Auditor has referred to the following document:

- NEPC (1999), National Environment Protection (Assessment of Site Contamination) Measure (NEPM), December 1999.

2.1 General

Site information was provided in the following report given in Appendix 13:

- BP Australia Pty Ltd (2004), Site Decommissioning and Environmental Validation Report, Darwin Terminal, Lot B of Remediation Zone 1, March 2004.

2.2 Site Description and Condition

Lot B of Remediation Zone 1 forms part of Lot 5719, Town of Darwin, Plan S89/230A. Site features that were present prior to the commencement of the remediation works were described by BP (2004) as follows. The plates refer to the site photographs given in Appendix B of the BP (2004) report. Site features and surrounding land uses that were present prior to the commencement of the remediation works are shown in Figure 2.

- The land slopes moderately to the south.
- The eastern portion of Lot B, including the stop butt soil mound, was covered in dense vegetation. This was removed between 17 – 21 April 2002 and transported to Darwin City Council's registered landfill facility. The remaining portion of Lot B was free of vegetation and being used by the terminal.
- A former rifle range stop butt soil mound (approximately 28 m x 5 m x 3.5 m height) was located at the eastern boundary of the site. The target sites were identified to the west of the stop butt soil mound following the removal of the dense vegetation. Bullet fragments were found in surface soils in this area.
- Tank DR5's bund was partially located in the south-west corner of Lot B. Clean stormwater was diverted around this bund via a partially eroded earthen drain that discharged to Tiger Brennan Drive.
- Five abandoned fuel storage tanks and manifold piping were located in the northern part of Lot B. These were relocated inside the terminal prior to the initial remediation work commencing in May 2002.

The nearest off-site receptor is the Darwin Fishing Harbour Mooring Basin located approximately 250 m to the south of Lot B.

2.3 Surrounding Land Use and Zoning

The Terminal Facility is bounded by Duke Street to the north, and by Dinah Beach Road and Tiger Brennan Drive to the south. Table 1 of the BP (2004) report provided a description of the surrounding land uses.

Surrounding land uses include:

- Medium to high density residential development to the north (formerly Lot A of Remediation Zone 1);
- Medium to high density residential development to the east;
- A Telstra receiving station located further to the south of Dinah Beach Road; and
- Bulk fuel storage facilities to the west.

Lot 5719 is currently described as 'Specific Use (SU52) Zone' under the Darwin City Council's 'Darwin Town Plan' (as amended as at 20 February 2002). The specific use zoning allows for specified residential and commercial purposes, subject to the consent of the administering authority of the plan. The terminal is currently operating on part of the land under 'existing use' rights. Once bulk fuel storage activities cease, they will not be allowed to recommence.

Excerpts from the Darwin Town Plan, including a map showing the extent of the Special Use (SU52) Zone for Lots 1662 and 5715, and a list of consent uses, is provided in Appendix 2.

2.4 Geology and Hydrogeology

The Australia 1:100,000 Geological Series 'Darwin Sheet 5073' (Northern Territory Geological Survey, 1983) indicates that the Terminal is situated on the Burrell Creek Formation, which in turn is part of the Finniss River Group. The NTGS describes the Burrell Creek Formation as the youngest Early Proterozoic sedimentary unit in the Darwin region. This formation comprises lutites, sandstone (quartz arenite, sublitharenite), and quartz-pebble conglomerate. BP (2001) commented that the lutites, consisting of shale, siltstone and phyllite, comprise possibly greater than 80 percent of the formation. They are described as essentially rocks consisting of clay, very fine incipient sericite that imparts a slight sheen in places, and iron oxide, which in the siltstone acts as a matrix to silt size quartz grains. The slaty cleavage is moderately to well developed and dominates over bedding in outcrop. The bedding is displayed by weak colour bands, and variations in grain size from fine sand to clay.

The Bathurst Island Formation overlies the Burrell Creek Formation along the Terminal's northern boundary. This unit is made up of radiolarian and sandy claystone, clayey sandstone, quartz sandstone, ferruginous sandstone, glauconitic sandstone and basal conglomerate. Quaternary sediments comprising mud, clay, silt and marine alluvium overly the Burrell Creek Formation, along the Terminal's southern boundary. The Burrell Creek Formation siltstones and shale are described as relatively impermeable and transmit only small amounts of groundwater. The sandstones are described as slightly more permeable (NTGS, 1983).

The DIPE Darwin office advised that bores in the area were used for irrigation purposes only, however information on groundwater quality characteristics was not available. Information provided by the DIPE indicated that the nearest bore is approximately 300 metres north-east of Lot B.

A review of the terminal's historical groundwater monitoring results has indicated that:

- Groundwater is mildly to moderately acidic and has conductivity values below the suggested guideline value for freshwater ecosystems.
- Interpreted groundwater flow direction is towards the south and south east.
- Groundwater levels fluctuate by greater than 2 metres between the wet and dry seasons. In the wet season, the groundwater table consistently rises to less than 2 m depth, and freshwater springs may appear at this. A BP environmental scientist observed a number of these springs within the Terminal during fieldwork in April 2002. In the dry season groundwater has been encountered in isolated locations only, at depths of greater than 4 m.
- The depth to groundwater varies across the site due to the sites change in elevation. The depth to groundwater is greater in elevated areas at the northern parts of the site than in low-lying areas in the southern parts of the site.

Review of Site History and Potential for Contamination

SECTION 3

3.1 General

The Site History was documented in the following reports included in Appendices 8 and 13:

- BP Australia Pty Ltd (2001), Site History Report, BP Darwin Terminal Facility, Dinah Beach Road, Stuart Park, Darwin, Northern Territory, May 2001; and
- BP Australia Pty Ltd (2004), Site Decommissioning and Environmental Validation Report, Darwin Terminal, Lot B of Remediation Zone 1, March 2004.

It should be noted that the BP (2001) report covers the whole of the Dinah Beach Road Terminal Facility. This Environmental Audit report is for Lot B of Remediation Zone 1 only. Therefore the following review is limited to the aspects of the Site History report that are relevant to Lot B.

3.2 Sources of Information

The historical investigations carried out by BP included information obtained from the following sources:

- Historical aerial photographs (obtained from DIPE and other sources);
- Land Title documents;
- BP plans and reports;
- Tank history data sheets;
- Spill record / data sheets; and
- Anecdotal information.

3.3 Ownership History

Based on Title documents reviewed by BP (2001), Table 3.1 provides a summary of chronological ownership and land use for Lot 5719.

Table 3.1 Lot 5719 Ownership and Land Use

Period	Registered Owner	Land Use
Pre 1944	Crown Land	Rifle Range
1944 - 1959	HC Sleigh Ltd (Golden Fleece)	Petroleum Product Storage
c 1966 - 1999	BP Australia Limited	Petroleum Product Storage
1999 - present	Frances Park (Darwin) Pty Ltd	Petroleum Product Storage

3.4 Summary of Site History for Lot B

BP Australia (2001) compiled a Site History Report to assess the historical land uses associated with Lot 5719, and to identify potential on-site and off-site sources of contamination. Information relevant to Lot B was summarised by BP (2004) as follows.

- Lot 5719 was Crown Land until 1944. Between 1944 and 1959, H C Sleigh was the registered owner of Lot 5719. BP became the registered owner of Lot 5719 circa 1966.
- Lot 5719 was used as a rifle range up to 1945. Noting Plans from the 1920s and 1930s identify two rifle ranges running south west to north east. The ranges are identified as the Port Darwin Rifle Club Range and the Palmerston Rifle Club Range. The range ran from north east to south west. The stop butt area was located towards the northeast with various firing points located up range to the south west.
- Tank DR8 was located to the north of Lot B and was removed during April 2002. Tanks DR5 and DR12 are located to the west of Lot B.
- Lot B began to be used for the storage of abandoned tanks around 1981.
- Anecdotal evidence suggests that some hydrocarbon impacted soil was land farmed within the bunded area surrounding DR2 and DR5 during the mid to late 1980s. The impacted soil was reportedly farmed on plastic sheeting to prevent vertical migration of contaminants. The eventual fate of this soil is not known.
- Contaminated sludge from the periodic cleaning of the Terminal's fuel storage tanks has historically been incorporated into the earthen bunds surrounding the vertical aboveground fuel storage tanks. Since the introduction of guidelines for the disposal of this type of waste, licensed waste contractors transport it off site. The part of Tank DR5's bund that was within Lot B was relocated within the Terminal following Remediation Zone 1's release to Trafalgar Corporate.
- A review of the Terminal's Material Safety Data Sheets indicated that 'Diurex (R) WG Herbicide, Arsenal 250A Herbicide, Starane 200 Herbicide, and Weedmaster 360 Herbicide' have been used for weed control. It is understood that compounds containing arsenic or DDT have not been used at the Terminal. 'Roundup' has been the predominant weed control agent used in recent years.

3.5 Previous Site Assessments

BP (2004) summarised the results of assessments carried out within Remediation Zone 1 as follows. Figure 3 of the BP (2004) report shows the locations of groundwater monitoring wells installed as part of these assessments.

- Egis Consulting installed three monitoring wells surrounding Tank DR8 (MW16, MW17 and MW18), and one monitoring well at the southern side of Remediation Zone 1 (MW19), in August

1999. The wells were installed to an average depth of 6 m, except for MW19 that was installed to 9 m depth.

Two soil samples were selected from each borehole during the drilling. Hydrocarbon and lead concentrations in all the samples were below the levels of reporting.

Monitoring wells MW16 – MW18 were dry during the November 1999 sampling round. One groundwater sample was collected from MW19. Hydrocarbon concentrations were below the adopted investigation thresholds.

- BP installed four monitoring wells to the east and west of Tank DR8 (MW21A, MW21B, MW22A, and MW22B), two monitoring wells adjacent to the western boundary of Remediation Zone 1 (MW20A and MW20B), and one monitoring well in the south west corner of Remediation Zone 1 (MW23). These wells were installed during March 2000. Shallow and deeper monitoring wells were installed at locations MW20, MW21 and MW22 to cater for the large seasonal variation in groundwater levels. The depths of the deeper monitoring wells MW20A, MW21A and MW22A were 7.0, 8.5, and 9.7 m, respectively. The average depth of shallow monitoring wells MW20B, MW21B, MW22B and MW23 was 3 m.

  Two soil samples were selected from MW20A and one sample from MW21A, MW22A and MW23, during the drilling. Hydrocarbon and lead concentrations in all the samples were below the levels of reporting.

  Each of the seven monitoring wells was sampled during March 2000. The sample from monitoring well MW21A detected hydrocarbon concentrations above the adopted investigation threshold. Hydrocarbon concentrations were below the adopted investigation threshold in samples collected from the remaining wells.

- Egis Consulting conducted bi-annual groundwater monitoring at the Terminal since September 2000. Historical groundwater analytical results were provided in Table C1 in Appendix C of the BP (2001) report. Dissolved phase hydrocarbons were present in groundwater from monitoring wells MW19 and MW21A during September 2000, MW21B during March 2001, MW19 and MW20B during October 2001 and MW18, MW19, MW20A and MW23 during March 2002. These wells are downgradient of Tank DR8.

- BP remediated soil from Lot A of Remediation Zone 1 during April to June 2002. The work comprised assessment and validation sampling following the excavation of soil from beneath Tank DR8 and an associated oily-water drain. The excavated soil was landfarmed within Tank DR5's bunded area that was present on Lot B of Remediation Zone 1 at this time.

  Following the completion of remediation, six monitoring wells (MW24A, MW24B, MW25A, MW25B, MW26A and MW26B) were installed at three locations upgradient and downgradient of the former location of Tank DR8. At each location, the deep well was given the suffix 'A' and the shallow well was given the suffix 'B'. The wells were used to investigate groundwater quality in shallow weathered material and deeper bedrock around the former location of Tank DR8.

Soil samples were not collected during the drilling program. Groundwater samples were collected from the deeper wells and analysed for a suite of parameters including TPH, BTEX and lead. Monitoring well MW25A contained TPH (carbon chainlength C10-C28) concentrations above the former Pollution Abatement Notice (2001/1) criteria. Monitoring wells MW24A and MW26A contained lead concentrations above the former Pollution Abatement Notice (2001/1) criteria.

- GHD Pty Ltd conducted groundwater monitoring from selected wells in Remediation Zone 1 during March 2003 and October 2003. The results indicated that TPH, BTEX and lead were below the Pollution Abatement Notice (2003/1) criteria.

3.6 Potential Sources of Contamination

In the Site History Report, BP Australia (2001) identified the following site features with potential for site contamination:

- The stop butt area associated with the rifle ranges, located in the north east portion of Lot B;
- Contaminated sludge from the periodic cleaning of the Terminal's fuel storage tanks, historically incorporated into the earthen bunds surrounding the vertical aboveground fuel storage tanks; and
- Herbicides used for weed control.

Contaminants of concern were assumed to include:

- TPH, BTEX and lead;
- Heavy metals (As, Cd, Cr, Co, Cu, Pb, Hg, Ni, Zn);
- PAHs;
- Phenols;
- OCPs and OPPs; and
- Chlorinated hydrocarbons.

3.7 Auditor Endorsement of Contaminants of Concern

On reviewing the above information prepared by BP, the auditor is of the opinion that the potential contaminants of concern associated with the historical and current use of the site would be those listed in Section 3.6 above.

4.1 Assessment of Beneficial Uses

The issue of a Certificate of Audit requires the auditor to be satisfied that the environmental condition of the land at the site is neither detrimental nor potentially detrimental to any beneficial use of the land.

"Beneficial use" means a use of the environment or any element or segment of the environment which:

a) is conducive to public benefit, welfare, safety, health or aesthetic enjoyment and which requires protection from the effects of waste discharges, emissions or deposits or of the emission of noise; or

b) is declared by State environment protection policy to be a beneficial use.

In determining the environmental condition of the subject site, the auditor took into account the following beneficial uses of the land at the site:

- The life, health and well-being of humans both on the site and external to the site;
- The life, health and well-being of other forms of life, including relevant flora and fauna, both on and external to the site;
- Impact on surface waters and groundwater;
- Impact on the ecology, and the production of food, on or immediately contiguous with the site; and
- The protection of buildings and structures with regard to corrosion, chemical degradation, fire or explosion risk related to contamination.

Where the land at a site is contaminated to a level that precludes the protection of a beneficial use listed above, the auditor is prevented from issuing a Certificate of Audit, and will conclude that a state of pollution exists. In this event, the auditor will direct that the land must be:

- Cleaned up to a level where the contamination does not preclude protection of any beneficial use or the beneficial uses designated by the auditor; or
- Managed to a level where the contamination does not preclude protection of the beneficial uses designated by the auditor.

4.2 Relevant Elements

An element of the environment is any of the principal constituent parts of the environment including water, atmosphere, land, vegetation, climate, sound, odour, aesthetics, fish and wildlife.

For this site relevant elements are considered to be the following;

- Surface water runoff from the site and receiving waters;

- Groundwaters beneath the surface of the site and down-hydraulic gradient of the site;
- Land on the site;
- Atmosphere and odour at the site and within any proposed buildings at the site;
- Terrestrial flora and fauna, on and near the site; and
- Aesthetics of land and waters on and near the site.

On this basis, the above elements are considered relevant and therefore part of the relevant segment for the purposes of the environmental audit.

4.3 Proposed Beneficial Uses of the Land

4.3.1 Land

Table 4.1 below outlines the beneficial uses that the auditor considers would apply to the land within the site area of Lot B of Remediation Zone 1 of the BP Darwin Terminal:

Table 4.1 Protected Beneficial Uses of Land

Beneficial Use Category	Protected Beneficial Uses for the Relevant Segments							Comment on Relevance to this Site
	Parks & reserves	Agriculture	Residential (high density)	Residential (medium and low density)	Recreation /Open Space	Commercial	Industrial	
Maintenance of natural ecosystems	✓							These are generally in non-urban areas.
Maintenance of modified ecosystems	✓	✓		✓	✓			The site may contain modified ecosystems in open grassed areas.
Maintenance of highly modified ecosystems		✓	✓	✓	✓	✓	✓	More highly cultivated areas of the site may be considered as highly modified ecosystems. These would be expected in any standard residential land use in garden and lawn areas.
Human Health	✓	✓	✓	✓	✓	✓	✓	Persons may be exposed to uncovered soil (eg where buildings or pavements do not exist and garden areas). Workers engaged in subsequent excavations for construction or maintenance purposes may also be exposed to the soil.
Buildings and Structures	✓	✓	✓	✓	✓	✓	✓	The soils should not attack or degrade building materials such as buried unprotected steel or concrete.
Aesthetics	✓		✓	✓	✓	✓		The soil should not be offensive to the senses of human beings (eg visually offensive or odorous).
Production of food, flora and fibre	✓	✓		✓				Food, flora or timber is unlikely be grown in these segments.

In accordance with the requirements of the Victorian State Environment Protection Policy (SEPP) (Prevention and Management of Contaminated Land) (2002), the proposed mixed residential land use requires the following beneficial uses to be protected:

- Maintenance of modified and highly modified ecosystems;
- Human Health;
- Buildings and Structures; and
- Aesthetics.

4.3.2 Groundwater

Current and realistic future beneficial uses of groundwater to be protected within this segment are:

- Maintenance of Ecosystems;
- Agriculture, Parks and Gardens;
- Stock Watering;
- Industrial Water Use;
- Primary Contact Recreation; and
- Buildings and Structures.

5.1 General

Selection of site specific assessment criteria can include the adoption of published criteria from regulatory authorities and from overseas publications, or the conduct of human health and ecological risk assessments.

For the purposes of this audit, reference has been made to the published criteria detailed below. These risk-based guidelines have been adopted based on future residential land use of the site, together with the need to protect the local soil, surface water and groundwater ecosystems.

Reference has also been made to the criteria specified in the DIPE Pollution Abatement Notice (PAN), given in Appendix 1. The Pollution Abatement Notice requires remedial action so that concentrations of these contaminants in soil and groundwater are equal to, or lower than, the levels given in that table.

5.2 Assessment Criteria for Soils

For the assessment of potential human health risks, soil analytical results have been compared by the auditor to the following reference criteria:

- National Environment Protection (Assessment of Site Contamination) Measure (NEPM), Health Investigation Level A, 'Standard' residential with garden / accessible soil (home-grown produce contributing less than 10% of vegetable and fruit intake; no poultry) (NEPC, 1999); and
- NSW EPA Guidelines for Assessment Service Stations: Threshold Concentrations for Sensitive Land Use – Soils (NSW EPA, 1994).

For the assessment of potential ecological risks, soil analytical results have been compared by the auditor to the following reference criteria:

- National Environment Protection (Assessment of Site Contamination) Measure (NEPM), Interim Urban Ecological Investigation Levels (NEPC, 1999).

Assessment criteria for soils adopted by the auditor, together with the Pollution Abatement Notice levels, are summarised in Table 5.1.

Table 5.1 Audit Assessment Criteria for Soils

Substance	Health-based assessment criteria (mg/kg)	Ecological assessment criteria (mg/kg)	DIPE Pollution Abatement Notice (2003/1) criteria (mg/kg)
TPH C_6-C_9	65		65
TPH C_{10}-C_{36}	1,000		1,000
Benzene	1		1
Toluene	1.4		1.4
Ethylbenzene	3.1		3.1
Xylenes	14		14
Arsenic	100	20	
Cadmium	20	3	
Chromium (VI)	100	1	
Copper	1,000	100	
Nickel	600	60	
Lead	300	600	300
Zinc	7,000	200	
Mercury	15	1	
Benzo(a)pyrene	1		
Total PAHs	20		
Phenols	8,500	70	
Heptachlor	10		
Aldrin + Dieldrin	10		
Chlordane	50		
DDT + DDD + DDE	200		
Total PCBs	10		

5.3 Assessment Criteria for Groundwater

For the assessment of groundwater contaminant levels, groundwater analysis results have been compared by the auditor to the following guidelines:

- National Environment Protection Measure (NEPM) Investigation Levels for Aquatic Ecosystems – Fresh Waters (NEPC 1999);
- NSW EPA Guidelines for Assessing Service Stations: Threshold Concentrations for Protection of Aquatic Ecosystems (NSW EPA, 1994); and
- Intervention and Target Values – Soil Quality Standards: Dutch Intervention Values and Indicative Groundwater Concentration Values for Clean Up (MHSPE, 1994).

Assessment criteria for groundwater adopted by the auditor, together with the Pollution Abatement Notice levels, are summarised in Table 5.2.

Table 5.2 Audit Assessment Criteria for Groundwater

Substance	Auditor adopted groundwater assessment criteria (µg/L)	DIPE Pollution Abatement Notice (2003/1) criteria (µg/L)
TPH C_6-C_9	150	150
TPH C_{10}-C_{36}	600	600
Benzene	300	300
Toluene	300	300
Ethylbenzene	140	140
Xylenes	380	380
Arsenic	50	
Cadmium	2	
Chromium (total)	10	
Copper	5	
Nickel	15	
Lead	5	5
Zinc	50	
Mercury	0.1	
Total PAHs	3	

6.1 Introduction to GMMP for Lot A

In order to address the need for ongoing groundwater monitoring for Remediation Zone 1, as required by the auditor, BP set out a Groundwater Monitoring and Management Plan in the following document, provided in Appendix 9.

- BP Australia Pty Ltd (2002), Groundwater Monitoring and Management Plan (GMMP), Darwin Terminal, Lot A of Remediation Zone 1, 17 October 2002.

In that document, BP stated that following completion of the remedial works for Lot A, six groundwater monitoring wells (MW24A/B, MW25A/B, MW26A/B) were installed and strategically located to target 'hot spots' that were identified during the soil remediation program.

6.2 Objective of GMMP for Lot A

BP (2002) stated that the objective of the GMMP was to manage groundwater contamination remaining on Lot A of Remediation Zone 1 in a manner that would be protective of human health and the environment.

6.3 Achievement and Maintenance of Objective

BP (2002) stated that it would ensure that the following conditions were complied with, so that the plan's objective was achieved and maintained.

Monitoring Locations

- Groundwater quality at the site would be verified by gauging and sampling monitoring wells MW20A, MB20B, MW23, MW24A, MW24B, MW25A, MW25B, MW26A and MW26B. The locations of these wells are shown in Figure 2.
- The wells would be surveyed to Australian Height Datum (AHD) and Australian Map Grid (AMG) coordinates.
- The wells would be maintained in a sound operating condition at all times. In the event of damage to the wells, BP would ensure that the wells were reinstated prior to the next scheduled monitoring event, to maintain continuity of monitoring information.

Monitoring Frequency

- All wells would be gauged and sampled every six months (i.e. both during the wet and dry seasons) for a period of three years commencing from the date of the Site Audit Statement for Lot A of Remediation Zone 1.

- The wells would be sampled every three months if monitoring results indicated that phase separated hydrocarbons had entered the wells, or if the auditor considered that there had been a significant increase in groundwater contaminant concentrations.

Monitoring Parameters

- All samples would be analysed by a National Association of Testing Authority (NATA) accredited laboratory.
- For each groundwater sampling event:
  - All groundwater samples would be analysed for TPH, BTEX and lead.
  - Two groundwater samples (including one background location) would also be analysed for an extended metal suite (Sb, Be, Cd, Cr, Co, Cu, Pb, Hg, Mo, Ni, Se, Sn, Zn), PAHs, phenols, OCPs, OPPs, chlorinated hydrocarbons.
  - One groundwater sample would be analysed for nitrate, ferrous iron, sulphate, methane, heterotrophic and contaminant utilising bacteria, and total dissolved solids (TDS).
  - Groundwater field parameters would be collected from each well. The field parameters would include dissolved oxygen, reduction/oxidation potential, temperature and pH.

6.4 GMMP Reporting

On completion of each sampling event, a brief letter report would be submitted to the auditor for review. If the auditor considered that there was a significant risk of harm to human health or to the environment based on these reports, the DIPE would be notified.

On completion of the groundwater sampling program, a report would be submitted to DIPE, providing information on the condition of the groundwater compared to historical monitoring results. The report would recommend no further groundwater monitoring if groundwater contaminant concentrations from the final year's sampling events were below the investigation levels. If groundwater contaminant concentrations were above the investigation levels, a health and environmental risk assessment regarding the site contamination would be produced and recommendations would be made based on its conclusions.

For the purpose of reporting, the investigation levels for TPH, BTEX and lead would be those levels specified in the DIPE's Pollution Abatement Notice.

The National Environment Protection (Assessment of Site Contamination) Measure 1999 and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 would be used for the assessment of all other contaminants in groundwater.

6.5 Auditor Requirements for GMMP for Lot A

The auditor generally concurred with BP's GMMP for Lot A as set out above. However, in the Environmental Audit report for Lot A (URS, 2002), the auditor set out additional requirements, as follows:

1. Given the elevated concentrations of copper, lead and zinc identified in MW24A and MW26A, all groundwater samples should be analysed for the standard suite of heavy metals (i.e. arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc).

2. For each groundwater monitoring event, a minimum of two groundwater samples, taken from different wells, should be analysed for nitrate, ferrous iron, sulphate, methane, heterotrophic and contaminant utilising bacteria, and total dissolved solids (TDS).

3. All relevant industry standard groundwater sampling procedures and protocols should be followed, including filtering in the field for heavy metals analysis.

4. During the first groundwater monitoring event conducted during the wet season, hydraulic conductivities should again be measured in wells MW20A, MW23 and MW25A by means of 'rising head' slug tests, or similar approved methods, and using an appropriate method for analysing the test data.

5. For each groundwater monitoring event, one blind replicate (BFD) sample should be taken and submitted to the primary laboratory for analysis, and one split sample (ILD) should be taken and submitted to a second NATA accredited laboratory for analysis. Both QA/QC samples should be analysed for TPH, BTEX and the standard suite of heavy metals; one of the QA/QC samples should also be analysed for the extended metal suite, PAHs, phenols, OCPs and OPPs, and chlorinated hydrocarbons. In addition, one rinsate blank should be taken and analysed for TPH, BTEX and the standard suite of heavy metals.

6.6 Reports on Groundwater Monitoring Events for 2003

6.6.1 General

GHD carried out groundwater monitoring events (GMEs) in March 2003 and in September / October 2003 at the BP Darwin Terminal Remediation Zone 1 site.

The GMEs were documented in the following reports included in Appendices 10 and 11:

- GHD Pty Ltd (2003), BP Darwin Terminal, Groundwater Monitoring and Management Plan – March 2003 Monitoring Results, Letter report to BP Australia Pty Ltd, 31 July 2003; and

- GHD Pty Ltd (2004), BP Darwin Terminal Remediation Zone 1 Lot A, Groundwater Monitoring Report, September – October 2003, for BP Australia Pty Ltd, February 2004.

6.6.2 Auditor Review of March 2003 GME

The auditor conducted a detailed review of the GHD (2003) report in August 2003, and pointed out that the Auditor Comments and Requirements set out in the URS (2002) Environmental Audit Report for Lot A of Remediation Zone 1 had not been adhered to. The review highlighted various shortcomings including insufficient analyses for some groundwater samples, lack of analysis for natural attenuation parameters, failure to measure hydraulic conductivities and lack of QA/QC samples.

With reference to the auditor requirements for the GMMP, as set out in Section 6.5 above, the auditor drew attention to the following shortcomings in the GHD (2003) report, in a fax to BP dated 22 August 2003:

1. ***Given the elevated concentrations of copper, lead and zinc identified in MW24A and MW26A – which have not been satisfactorily explained – the auditor requires that until advised otherwise all groundwater samples should be analysed for the standard suite of heavy metals (i.e. arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc).***

   It was noted that no groundwater samples were analysed for arsenic, and that of the four groundwater samples taken, only two (MW24A and MW26A) were analysed for other heavy metals, i.e. groundwater samples from MW20A and MW23 were not analysed for metals.

2. ***A minimum of two groundwater samples, taken from different wells, should be analysed for nitrate, ferrous iron, sulphate, methane, heterotrophic and contaminant utilising bacteria, and total dissolved solids (TDS).***

   Only one groundwater sample (MW26A) was analysed for the above.

3. ***All relevant industry standard groundwater sampling procedures and protocols should be followed, including filtering in the field for heavy metals analysis.***

   No purge sheets or details of purging procedures and results were presented in the GHD report. The methodology section of the report stated that three well volumes were purged from the well prior to sample collection – ideally samples should be taken when physical parameters have stabilised.

   No chain of custody documentation was provided with the report.

   The report contained no discussion as to whether or not the groundwater samples collected for heavy metals analysis were filtered in the field.

   The actual sampling methodology – i.e. whether bailers or pumps were used – was not discussed in the report.

4. ***Hydraulic conductivities should again be measured in wells MW20A, MW23 and MW25A by means of 'rising head' slug tests, or similar approved methods, and using an appropriate method for analysing the test data.***

   This did not appear to have been done.

5. ***For each groundwater monitoring event, one blind replicate (BFD) sample should be taken and submitted to the primary laboratory for analysis, and one split sample (ILD) should be taken and submitted to a second NATA accredited laboratory for analysis. Both QA/QC samples should be analysed for TPH, BTEX and the standard suite of heavy metals; one of the QA/QC samples should also be analysed for the extended metal suite, PAHs, phenols, OCPs and OPPs, and chlorinated hydrocarbons. In addition, one rinsate blank should be taken and analysed for TPH, BTEX and the standard suite of heavy metals.***

   Based on the GHD report, it did not appear that a blind replicate sample (BFD), split sample (ILD) or rinsate blank was taken and analysed.

In addition, there were a number of other issues, which were brought to the attention of BP and GHD. BP responded to those issues in a fax to URS dated 12 December 2003.

6.6.3 Auditor Comments on September – October 2003 GME

The auditor also reviewed the GHD (2004) report, and noted that where possible the above shortcomings had been addressed. The auditor also noted that the September / October 2003 groundwater monitoring round was undertaken at the end of the dry season, characterised by shallow wells drying up and significantly depressed groundwater levels in the deep aquifer wells. This in combination with very slow recovery / recharge rates meant that generally only limited volumes were available for sample collection and the intended analytical program was not possible.

Of the five wells that could be sampled (MW20A, MW23, MW25A, MW25B and MW26A), GHD (2004) presented and discussed laboratory analysis results as follows:

BTEX and TPH

Samples from all five wells were analysed for BTEX and TPH. BTEX concentrations were all below laboratory PQLs. Minor concentrations of TPH $C_{10} – C_{36}$ were recorded in MW23, MW25A and MW25B, all well below the auditor adopted criteria (600 μg/L).

Heavy Metals

Samples from three wells (MW20A, MW25B and MW26A) were analysed for eight priority heavy metals, while the sample from MW23 was analysed for an extended heavy metal suite. Some exceedances were reported, as summarised in Table 6.1 below.

Table 6.1 Heavy Metal Exceedances in Groundwater (Sept – Oct 2003 GME)

Substance	Auditor adopted criteria (µg/L)	MW23	MW26A	QA3 (ILD of MW23)
Copper	5		11	28
Lead	5			8
Nickel	15	33		
Zinc	50	100	60	68

PAHs

Samples from MW23 and MW25A were analysed for PAHs. All results were below laboratory PQLs.

OCPs and OPPs

Samples from MW23 and MW25A were analysed for OCPs and OPPs. All results were below laboratory PQLs.

Chlorinated Hydrocarbons

Samples from MW23 and MW25A were analysed for chlorinated hydrocarbons. All results were below laboratory PQLs.

Natural Attenuation Parameters

The sample from MW20A was analysed for nitrate, sulphate, ferrous iron, hydrocarbon utilising bacteria and methane, in order to review the secondary line of evidence of natural attenuation of the contaminant plume. GHD (2004) explained that monitoring wells within the plume were either dry or had insufficient sample available to conduct this analysis during the September – October 2003 GME.

The results for MW20A, together with TPH, BTEX dissolved oxygen and redox potential, were assessed to provide an indication of the potential for natural attenuation. GHD commented that despite the fact that TPH and BTEX were not present in the sample, the analysis provided a useful insight into plume biodegradation potential. GHD commented that the relatively low levels of nitrate (0.43 mg/L), the relatively high levels of ferrous iron (10.4 mg/L), together with the dissolved oxygen and redox results, indicated that the site conditions would tend towards anaerobic biodegradation. Furthermore the microbial testing conducted indicated relatively high bacterial activity in the sample analysed. GHD concluded that overall the conditions appeared to be favourable for natural attenuation of the hydrocarbon plume.

GHD (2004) concluded their GME report with the following:

The analytical results from the wells… from the current monitoring round do not indicate significant environmental or health issues… Whilst some wells recorded detectable concentrations of TPH, the levels were below the remedial objectives defined in the Pollution Abatement Notice and Remedial Action

Plan. Other results were assessed against relevant guidelines and in general compliance was achieved. Future monitoring results will continue to be assessed and reviewed with a view to providing further confidence in these statements and an overall conclusion as to the ongoing status of groundwater after the three year monitoring period defined in the Groundwater Monitoring and Management Plan.

The auditor generally concurred with the above conclusions.

The two GHD GME reports, together with the auditor's comments, were submitted to the DIPE on 9 March 2004.

6.7 New Groundwater Monitoring Wells for Lot B

In order to continue with the GMMP for Remediation Zone 1, and in particular to provide additional coverage for Lot B, the auditor proposed that the following two new well pairs should be installed:

- MW27A/B – downgradient of the lead contamination area; and
- MW28A/B – downgradient of the former landfarm area and close to the downgradient boundary of the site.

The locations of the two new well pairs are shown in Figure 2.

A revised GMMP will be prepared by BP that contains similar conditions to the original GMMP prepared for Remediation Zone 1, and incorporates the sampling of these new wells. The revised GMMP will be approved by the auditor prior to its implementation.

7.1 General

Remediation and validation of Lot B of Remediation Zone 1 was documented in the following report provided in Appendix 13:

- BP Australia Pty Ltd (2004), Site Decommissioning and Environmental Validation Report, Darwin Terminal, Lot B of Remediation Zone 1, March 2004.

The above report included a chronological summary of the sampling that was completed in Lot B between April 2002 and April 2004. BP (2004) commented that the sampling during fieldwork in April and May 2002 was undertaken to characterise the whole of Remediation Zone 1; however, the sampling that was done outside Lot B during this fieldwork was not discussed in the report.

7.2 Soil Sampling Program

7.2.1 Sampling Rationale

BP (2004) commented that the following documents were used as a guide for collecting sufficient and reliable information for the assessment:

- Schedule B(2) of the National Environment Protection (Assessment of Site Contamination) Measure (NEPM) (NEPC 1999); and
- AS4482.1-1997, Guideline to the sampling and investigation of potentially contaminated soil, Part 1: Non-volatile and semi-volatile compounds.

7.2.2 Sampling Procedures

BP (2004) reported in Section 3.2 of the Validation Report that the following procedures were employed to obtain soil samples from test pits for description of the substrate, field screening and laboratory analysis for validation:

- Disposable latex gloves were worn during the sampling, decontamination and cleaning of sampling equipment. Gloves were replaced between samples to prevent cross contamination.
- During the excavation works, soil samples were taken as grab samples from the middle of the excavator or backhoe bucket. Fresh samples were collected from the landfarmed soil by turning the stockpile with the excavator and immediately collecting soil from the excavator bucket. The bucket was inspected to ensure that the soil was not carried over between samples.
- Soil samples were placed directly in clean ‘zip-lock’ plastic bags for headspace analysis of volatile organic compounds (VOCs) using a photoionisation detector (PID) calibrated to a known concentration of isobutylene in air. The detection limit of the PID is generally considered to be

between 0.5 to 1.0 ppmv. The headspace above the collected soil sample was allowed to equilibrate for 5 minutes before the PID suction tube punctured the air tight plastic bag to screen for VOCs. PID readings were recorded in a field notebook and were later used for selecting soil samples for laboratory analysis.

- Visual and odour characteristics were also used in field screening as an aid to select soil samples for laboratory analysis.
- Samples selected for laboratory analysis were sealed in new 250 mL glass containers with Teflon inserts, screw cap lids and labelled with waterproof pens. The samples jars were then wrapped in bubble wrap and immediately placed in a cooler with dry ice.
- The sample was described in the field logs. Information included:
    - soil/rock type;
    - sample location and identification;
    - colour;
    - staining and odour; and
    - headspace VOC concentration as measured with a PID.
- A chain of custody form was completed. Samples were stored in coolers filled with dry ice after sampling and prior to transportation for laboratory analysis. The sample sets were transported to a NATA registered laboratory (AGAL or Amdel) for analysis.

7.2.3 Soil Sampling in April and May 2002

BP (2004) reported in Section 3.4 that fieldwork was performed between 15 April and 3 May 2002 by a BP environmental scientist. Sample locations are shown in Figure 3. BP reported that the following work was completed:

- A total of twenty-three test pits (TP20 – TP43) was excavated across Lot B using a non-biased 20 m x 20 m grid. Samples were inspected at the surface (0 – 300 mm) and then at 0.5 m, 1.0 m and then every 1.0 m thereafter and at geological profile changes. The samples were collected within a 100 to 150 mm vertical interval at the sampling depth indicated on the test pit field logs. One sample was initially selected from each test pit to be analysed for total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylene (BTEX), and lead.
- Four test pits (SBTP1 to SBTP4) were excavated using a non-biased 20 x 20 m grid within the former rifle range stop butt and target area. The samples were collected at selected depths in the same manner as described above. The samples were analysed for the following:

  - Four samples (SBTP1-0.5m, SBTP2-0.5m, SBTP3-0.5m, and SBTP4-0.5m) were analysed for arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), zinc (Zn), nickel (Ni), and mercury (Hg).
  - Four samples (SBTP1-2.6m, SBTP2-1.3m, SBTP3-3.5m, and SBTP4-1.1m) were analysed for TPH, BTEX and lead.

- Two samples (SBTP1-Fill and SBTP2-Fill) were taken from the stop butt soil mound. The samples were taken at test pits locations SBTP1 and SBTP2 and were analysed for metals, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs), and organophosphorous pesticides (OPPs).
- Based on visual evidence (i.e. bullet fragments) approximately 50 cubic metres of lead contaminated soil was scraped from the western side of the stop butt soil mound and stockpiled separately. Two samples (SBSS1 and SBSS2) were collected from this material and analysed for metals.

7.2.4 Soil Sampling in July 2003

BP (2004) reported in Section 3.5 that based on the results of the April-May 2002 assessment, soil sampling was undertaken by a BP environmental scientist on 21 and 22 July 2003 to delineate lead impact in shallow surface soils. Descriptions of the validation samples taken were included in Appendix E of the BP (2004) report. The sampling locations are shown in Figure 4. The following work was completed:

- Shallow soil excavation (34 m x 16 m x 300 mm depth) in the vicinity of the former inspection pit locations TP30 and TP31. The soil was excavated and stockpiled adjacent to this area. Twenty sampling locations (VS1/TPA – VS20/TPA) were used to validate the excavation. Five inspection pits (VS25/TPA – VS29/TPA) were dug approximately 2 m distance from the edge of the excavation to an average depth of 0.5 m. Samples were collected at the surface and at the base of each inspection pit.

  The samples collected from the excavation, the inspection pits, and the stockpiled soil were analysed for the following:

  - Thirty eight samples (VS1:0.3-0.4m/TPA to VS20:0.3-0.4m/TPA, VS21/TPA, VS23/TPA, VS24/TPA, VS25:0.3-0.5m, VS26:0-0.3m/TPA to VS29:0-0.3m/TPA, VS8:0.5-0.6m/TPA, VS13:0.5-0.6m/TPA, VS16:0.5-0.6m/TPA, VS18:0.5-0.6m/TPA, VS19:0.5-0.6m/TPA, VS26:0.3-0.5m/TPA, QC1/TPA to QC4/TPA) were analysed for total lead.
  - Four samples (VS13:0.3-0.4m/TPA, VS18:0.3-0.4m/TPA, VS23/TPA and QC1/TPA) were analysed for leachable lead using the Toxicity Characteristic Leaching Procedure (TCLP) – US EPA Method 1311.
  - For quality control, blind field duplicate samples QC1/TPA and QC3/TPA were collected at sampling locations TP13:0.3-0.4m/TPA and TP14:0.3-0.4m/TPA, respectively. Both samples were analysed for lead and QC1/TPA was also analysed for leachable lead. Split samples

QC2/TPA and QC4/TPA were also collected at sampling locations TP13:0.3-0.4m/TPA and TP14:0.3-0.4m/TPA, and sent to a second laboratory for lead analysis.

- Nine inspection pits (VS1/SBSS to VS9/SBSS) were excavated using a non-biased 5 m x 7 m grid to investigate the former rifle range target area and the location of the contaminated soil stockpiled adjacent to the stop butt during the April-May 2002 assessment. This stockpile was not able to be located due to approximately 500 m^3 of soil from Lot A being placed over it. The inspection pits were excavated to a maximum depth of approximately 1.3 m below ground surface and samples were collected from the surface, at 0.5 m depth and from the base.

  The samples were analysed for the following:

  – Twenty-four samples (VS1:0-0.5m/SBSS to VS9:0-0.5m/SBSS, VS1:0.5-1m/SBSS to VS9:0.5-1m/SBSS, VS4:1-1.3m/SBSS, VS9:1-1.2m/SBSS, QC1/SBSS to QC4/SBSS) were analysed for total lead.

  – Four samples (VS4:0-0.5m/SBSS, VS4:0.5-1m/SBSS, VS7:0.5-1m/SBSS, VS8:0.5-1m/SBSS) were analysed for leachable lead using the TCLP.

  – For quality control, blind field duplicate samples QC1/SBSS and QC3/SBSS were collected at sampling locations VS5:0.5-1m/SBSS and VS7:0.5-1m/SBSS, respectively. Both samples were analysed for lead. Split samples QC2/SBSS and QC4/SBSS were also collected at sampling locations VS5:0.5-1m/SBSS and VS7:0.5-1m/SBSS and sent to a second laboratory for lead analysis.

- Four inspection pits (VS1/SBSM to VS4/SBSM) were excavated beneath the stop butt soil mound and six inspections pits (VS5/SBSM to VS10/SBSM) were excavated at locations approximately 2 m distance around the soil mound. The inspection pits were excavated to approximately 0.5 m below ground surface and samples were collected from the surface and from the base of each. Four samples (VS11/SBSM to VS14/SBSM) were taken of the soil mound material at each of the test pit locations (i.e. VS1/SBSM to VS4/SBSM).

  The samples were analysed for the following:

  – Twenty-five samples (VS1:0-0.2m/SBSM to VS10:0-0.2m/SBSM, VS4:0.2-0.5m/SBSM, VS5:0.2-0.5m/SBSM, VS7:0.2-0.5m/SBSM, VS8:0.2-0.5m/SBSM, VS10:0.2-0.5m/SBSM, VS11/SBSM to VS14/SBSM, QC1/SBSM to QC4/SBSM) were analysed for total lead.

  – Four samples (VS5:0-0.2m/SBSM, VS10:0-0.2m/SBSM, VS14/SBSM, VS16/SBSM) were analysed for leachable lead using the TCLP.

  – For quality control, blind field duplicate samples QC1/SBSM and QC3/SBSM were collected at sampling locations VS11/SBSM and VS12/SBSM, respectively. Both samples were analysed for lead. Split samples QC2/SBSM and QC4/SBSM were also collected at sampling locations VS5:0.5-1m/SBSS and VS7:0.5-1m/SBSS and sent to a second laboratory for lead analysis.

7.2.5 Soil sampling in October 2003

BP (2004) reported in Section 3.6 that based on the results of the July 2003 assessment, impacted soil was excavated and stockpiled, and final validation sampling completed by a BP environmental scientist between 15 and 19 October 2003. Descriptions of the validation samples collected were included in Appendix F of the BP (2004) report. The sampling locations are shown in Figure 5. The following work was completed:

- Excavations were conducted in two areas. The first excavation (24 m x 34 m x 0.5 m depth) was a continuation of the work undertaken during July 2003 to validate shallow soil at the former inspection pit locations TP30 and TP31. The second excavation was beneath the former rifle range stop butt soil mound and the target area. The area of the excavation was approximately 1,400 square metres. Its depth was generally between 0.5 to 1 m below ground surface but extended to approximately 3 m depth beneath the target area.

  Twenty-seven validation samples (VE1 to VE27) were collected and analysed for total lead. For quality control, blind field duplicate samples VEQC1, VEQC3, and VEQC5 were collected at sampling locations VE8, VE16 and VE24, respectively. Split samples VEQC2, VEQC4, and VEQC6 were also collected at sampling locations VE8, VE16 and VE24, respectively, and sent to a second laboratory for lead analysis.

- The material excavated was separated in two stockpiles described as:

  – Stockpile A: Approximately 1,300 cubic metres (loose) of 'natural' silty clay material. This soil was from areas surrounding previous inspection pit locations TP30 and TP31 and the former rifle range target area.

  – Stockpile B: Approximately 1,300 cubic metres (loose) of clayey sand material. This soil was excavated from the stop butt soil mound and beneath the former rifle range target area.

An engineer from BMD Constructions Pty Ltd (BMD) sampled the stockpiles during the week 20 to 24 October 2003. Approximately 100 kg of soil was collected from each stockpile by taking grab samples from different parts. The samples were delivered by BMD to Douglas Partners who organised for these to be couriered to the laboratory. Four samples from Stockpile A (termed Stockpile 1 to 4) and four samples from Stockpile B (termed Stopbutt 1 to 4) were analysed for total lead.

7.2.6 Soil sampling in January 2004

BP (2004) reported in Section 3.7 that a GHD scientist re-sampled the stockpiles on 28 January 2004. The purpose of this sampling was to obtain a statistically valid number of results that could be used to confidently determine the average lead concentration in each stockpile. Each stockpile was sampled at a total rate of approximately one sample per 100 cubic metres of stockpile material. Given that four samples had previously been taken from each stockpile, it was determined that a further eight samples per stockpile were required (making a total of 12 samples per stockpile). Each stockpile was therefore

divided into eight equal rectangular zones. One discrete sample was then randomly taken from each zone. Of the eight samples, two were taken from the surface, two were taken from 1 m depth, two from 2 m depth and two from 3 m depth (i.e. the base).

The eight samples from Stockpile A (PA-S1, PA-S2, PA-1M1, PA-1M2, PA-2M1, PA-2M2, PA-3M1, PA-3M2) and eight samples from Stockpile B (PB-S1, PB-S2, PB-1M1, PB-1M2, PB-2M1, PB-2M2, PB-3M1, PB-3M2) were analysed for total lead. For quality control, a blind field duplicate sample PA-3M3 was collected at sampling location PA-3M2. A split sample 'PB-2M2 Split' was collected at sampling location PB-2M2 and sent to a second laboratory for lead analysis.

Based on the results, samples with the highest lead concentration from Stockpile A (PA-2M2) and Stockpile B (PB-S2, PB-3M1, PB-2M2) were analysed for leachable lead using the Synthetic Precipitation Leaching Procedure (SPLP) - US EPA Method 1312. This method was used to provide a realistic measure of leachate concentrations that would occur if the soil was disposed of to a place that was not a putrescible landfill or a place where organic acids (i.e. acetic acid) would not be present.

7.2.7 Soil sampling in April 2004

BP (2004) reported in Section 3.8 that Stockpile B was removed to Tank DR6's bunded area in the BP Darwin Terminal between 8 and 19 April 2004. A GHD scientist collected validation samples on 14 and 19 April 2004. The sampling locations are provided in Figure 6. The following work was completed:

- Three surface samples (SB1 to SB3) were collected from beneath the former location of Stockpile B on 14 April 2004 and analysed for total lead. The results from this sampling indicated that lead impacted soil was still present. Soil was excavated to a depth of 300 mm below ground surface beneath the former location of Stockpile B on the 19 April 2004. Three samples (SB6 to SB8) were collected and analysed for lead.

- Six surface samples (LF1 to LF6) were collected on the 14 April 2004 from the area used to landfarm soil during April to October 2002. The samples were collected based on a non-biased grid pattern and analysed for TPH.

- One sample VE28 was collected on the 14 April 2004 from previous sampling location VE11. Prior to collecting the sample, a volume of approximately 2 cubic metres was excavated and added to Stockpile B. The sample was analysed for total lead.

- Two samples VE29 and VE30 were collected on the 14 April 2004 from previous sampling locations VE17 and VE19, respectively. The samples were located on the long side walls of the deep excavation at approximately 2 m depth. Prior to collecting the samples, the walls were scraped by the excavator to allow 'fresh' bedrock to be sampled. The samples were analysed for total lead.

- For quality control, blind field duplicate samples SB9, SB10 and SB11 were collected on 19 April 2004 at sampling locations SB6, SB7 and SB8, respectively, and analysed for total lead. Split

samples SB4 and SB5 were also collected on 14 April 2004 at sampling locations SB2 and SB3 and sent to a second laboratory for lead analysis.

7.3 Geology and Hydrogeology Encountered

With respect to the geology and hydrogeology encountered, BP (2004) reported as follows:

The general soil profile at the northern part of Lot B (i.e. the former rifle range area) was described as:

0 – 0.4 m depth	GRAVELLY CLAY – Orangey brown, dry, semi-loose, some weathered bedrock sized between medium gravel to cobbles, heterogeneous.
0.4 – 1.5 m depth	WEATHERED SILTSTONE – Orangey brown, dry, hard but friable, orange colour from iron staining, mottled.
1.5 – 3 m depth	SILTSTONE – Orangey brown, dry, hard, soapy texture, some lamination.

The general soil profile at the southern part of Lot B was described as:

0 – 0.4 m depth	SILTY CLAY (Topsoil) – Brown, damp, soft, medium plasticity when damp, heterogeneous.
0.4 – 1.6 m depth	GRAVELLY CLAY – Orangey brown, damp, soft, medium plasticity when damp, medium gravel to cobbles (well rounded quartz cobbles), heterogeneous.
1.5 – 2 m depth	WEATHERED BEDROCK – Orangey brown/grey, dry, hard, soapy texture, some lamination.

Soil from the stop butt soil mound and beneath the target locations was described as GRAVELLY SAND (Imported Fill?) – Brown, dry, loose, medium grained, some coarse gravel to cobbles, some shell fragments.

During the April-May 2002 assessment, shallow groundwater was intersected at varying depths beneath the southern and western parts of the site (i.e. inspection pits TP21-TP25, TP27-TP29, TP30, TP32 and TP35). The minimum depth to groundwater was 0.5 m in inspection pit TP23 and the maximum depth to groundwater was 1.8 m in inspection pit TP21. It was noted on the field logs that where groundwater occurred, the gravelly clay appeared moist to wet but the underlying siltstone was dry.

7.4 Laboratory Analysis Program

7.4.1 Analysing Laboratories

Laboratory analyses were undertaken by Australian Government Analytical Laboratories (AGAL), Amdel and ALS Environmental, all NATA accredited for the analyses conducted.

7.4.2 Laboratory Reports

Laboratory reports were provided in Appendix K, as a separate volume to the BP (2004) report, provided in Appendix 13.

Appendix K: Laboratory Certificates for Lot B of Remediation Zone 1 was subdivided as follows:

- April – May 2002: Soil analytical results for grid sampling and investigation of the former rifle range area
- July 2003: Soil analytical results for delineation of lead impacted soil at inspection pits TP30/TP31 and the former rifle range
- October 2003: Soil analytical results for validation of excavations to remove lead impacted soil
- April 2004: Soil analytical results for validation of areas beneath Stockpile B, the former landfarm area, and isolated 'hot spots' within the excavation beneath the former rifle range target area.

Detection limits and analytical methods performed by the analysing laboratories were referenced in the laboratory reports.

7.5 Assessment Criteria

BP stated in Section 3.1 of the BP (2004) report that the criteria used to assess lead, benzene, toluene, ethylbenzene, and xylene (BTEX), and total petroleum hydrocarbons (TPH) concentrations in soil and groundwater were as given in the Pollution Abatement Notice (2003/1), as reproduced in Table 3 of the BP (2004) report. The Pollution Abatement Notice (PAN) requires remedial action so that concentrations of these contaminants in soil and groundwater are equal to, or lower than, the levels given in that table.

BP stated that for the assessment of other analytes, reference was made to the following guideline:

- National Environment Protection (Assessment of Site Contamination) Measure (NEPM), Health Investigation Level A, 'standard' residential with garden/accessible soil (NEPC, 1999).

7.6 Soil Contamination Assessment

7.6.1 Grid sampling (April-May 2002)

Soil analytical results were presented in Table D1 – D3 in Appendix D of the BP (2004) report. The results indicated that:

- Samples TP30-0.5m and TP31-0.5m had lead concentrations of 1,200 mg/kg and 360 mg/kg, respectively, exceeding the Pollution Abatement Notice (PAN 2003/1) criteria. These samples were

taken from 0.5 m depth from inspection pits TP30 and TP31 respectively. The inspection pits were located in the central northern part of Lot B.

- Sample SBSS1 had a lead concentration of 6,230 mg/kg, exceeding the PAN 2003/1 criteria. This sample was collected from the soil separated from the stop butt soil mound based on visual evidence of contamination (i.e. bullet fragments in soil).

- Sample SBTP2-Fill had a lead concentration of 840 mg/kg, exceeding the PAN 2003/1 criteria. This sample was collected from the fill material used to construct the stop butt soil mound.

7.6.2 Lead Impacted Soil Delineation (July 2003)

Soil analytical results were presented in Table E1 – E3 in Appendix E of the BP (2004) report. The results indicated that:

- Samples VS8:0.3-0.4m/TPA, VS13:0.3-0.4m/TPA, VS16:0.3-0.4m/TPA, VS18:0.3-0.4m/TPA, VS19:0.3-0.4m/TPA, VS26:0-0.3m/TPA and VS26:0.3-0.5m/TPA had lead concentrations that ranged from 330 mg/kg to 7,130 mg/kg, thus exceeding the PAN 2003/1 criteria. These samples were used to delineate lead impacted soil in the vicinity of former inspection pit locations TP30 and TP31.

- Samples VS23/TPA and VS24/TPA had lead concentrations of 1,220 mg/kg and 580 mg/kg, exceeding the PAN 2003/1 criteria. These samples were collected from the stockpiled soil excavated in the vicinity of former inspection pit locations TP30 and TP31.

- Samples VS1:0.5-1m/SBSS, VS4:0-0.5m/SBSS, VS4:0.5-1m/SBSS, VS4:1-1.3m/SBSS, VS5:0-0.5m/SBSS, VS7:0.5-1m/SBSS, VS8:0.5-1m/SBSS, VS9:0.5-1m/SBSS, and VS9:1-1.2m/SBSS had lead concentrations that ranged from 560 mg/kg to 3,970 mg/kg, exceeding the PAN 2003/1 criteria. These samples were used to delineate lead impacted soil in the vicinity of the former rifle range target area.

- Samples VS4:0-0.2m/SBSM, VS5:0-0.2m/SBSM, VS7:0-0.2m/SBSM, VS7:0.2-0.5m/SBSM, VS8:0-0.2m/SBSM, VS10:0-0.2m/SBSM, and VS10:0.2-0.5m/SBSM had lead concentrations ranging from 370 mg/kg to 6,370 mg/kg, exceeding the PAN 2003/1 criteria. These samples were used to delineate lead impacted soil in the vicinity and beneath the former rifle range soil stop butt soil mound.

- Samples VS14/SBSM and VS16/SBSM had lead concentrations of 2,840 mg/kg and 4.030 mg/kg, respectively, exceeding the PAN 2003/1 criteria. These samples were used to investigate lead concentrations in soil used to form the stop butt soil mound.

- Samples VS13:0.3-0.4m/TPA, VS18:0.3-0.4m/TPA and VS23/TPA showed lead leachate concentrations ranging from 0.36 mg/L to 5.9 mg/L, exceeding the ANZECC (2000) trigger value for 95% protection of species in freshwater ecosystems (i.e. 0.0034 mg/L). The samples were collected from the vicinity of the former inspection pits TP30 and TP31.

- Samples VS4:0-0.5m/SBSS, VS4:0.5-1m/SBSS, VS7:0.5-1m/SBSS and VS8:0.5-1m/SBSS showed lead leachate concentrations ranging from 1.6 mg/L to 38 mg/L, exceeding the ANZECC (2000) trigger value for 95% protection of species in freshwater ecosystems. The samples were collected from the vicinity of the former rifle range target area.

- Samples VS5:0-0.2m/SBSM, VS10:0-0.2m/SBSM, VS14/SBSM and VS16/SBSM showed lead leachate concentrations that ranged from 3.7 mg/L to 160 mg/L, exceeding the ANZECC (2000) trigger value for 95% protection of species in freshwater ecosystems. The samples were collected from the vicinity of the former rifle range stop butt soil mound.

7.6.3 Excavation and Stockpile Validation Sampling (October 2003)

Soil analytical results were presented in Tables F1 and F2 in Appendix F of the BP (2004) report. The results indicated that:

- Samples VE11, VE17 and VE19 had lead concentrations of 1,120 mg/kg, 640 mg/kg and 1,710 mg/kg, respectively, exceeding the PAN 2003/1 criteria. Sample VE11 was collected from 0.5 m depth from the western wall of the excavation used to remove lead impacted soil from the vicinity of the target area. Samples VE17 and VE19 were collected from 2 metres depth directly beneath the former location of the target area.

- Samples Stopbutt 1 to Stopbutt 4 had lead concentrations ranging from 540 mg/kg to 760 mg/kg, exceeding the PAN 2003/1 criteria. These samples were collected from Stockpile B that comprised soil from the stop butt soil mound and soil excavated from beneath the target area.

7.6.4 Stockpile A and B Validation Sampling (January 2004)

Soil analytical results were presented in Table G1 in Appendix G of the BP (2004) report. The results indicated that:

- Sample PA-2M2 contained a lead concentration of 540 mg/kg, exceeding the PAN 2003/1 criteria. This sample was collected from Stockpile A that comprised soil excavated from the vicinity of former inspection pits TP30 and TP31 and soil excavated from the vicinity of the target area.

- Samples PB-S1, PB-S2, PB-1M1, PB-1M2, PB-2M2, PB-3M1 and PB-3M2 had lead concentrations that ranged from 310 mg/kg to 1,310 mg/kg, exceeding the PAN 2003/1 criteria. These samples were collected from Stockpile B.

- Samples PA-2M2, PB-S2, PB-2M2 and PB-3M1 showed lead leachate concentrations ranging from 0.01 mg/L to 0.06 mg/L, above the ANZECC (2000) trigger value for 95% protection of species in freshwater ecosystems. Sample PA-2M2 (with a lead leachate concentration of 0.01 mg/L) was collected from Stockpile A. The remaining samples were collected from Stockpile B.

7.6.5 Validation Sampling (April 2004)

Soil analytical results were presented in Tables H1 and H2 in Appendix H of the BP (2004) report. The results indicated that:

- Samples SB1 to SB3 had lead concentrations of 880 mg/kg, 550 mg/kg and 300 mg/kg respectively, exceeding the PAN 2003/1 soil criteria. These samples were collected from beneath the former location of Stockpile B.
- Following further excavation of 300 mm depth, Samples SB6 – SB8 returned lead concentrations below the PAN 2003/1 soil criteria, thus confirming that the area beneath Stockpile B had been successfully remediated.
- The six surface samples LF1 – LF6 from the former landfarm area returned TPH concentrations below the PAN 2003/1 soil criteria, confirming validation of this area.
- Sample VE28, collected after further excavation around the VE11 hotspot, had a lead concentration below the PAN 2003/1 soil criteria, confirming successful remediation of that hotspot.
- Samples VE29 and VE30, collected after further excavation in the vicinity of the VE17 and VE19 hotspots, had lead concentrations below the PAN 2003/1 soil criteria, confirming successful remediation of those hotspots.

7.6.6 Stockpiles A and B Characterisation

The 95% upper confidence limits (95% UCL) for the arithmetic average lead concentration in Stockpiles A and B were calculated by BP (2004) using the results from the October 2003 and January 2004 sampling rounds. The assumptions for these calculations were included in Appendix I of the BP (2004) report. BP commented that the statistical analyses indicated that:

- There is a 95% probability that the arithmetic average lead concentration in Stockpile A will not exceed 262 mg/kg. The 95% UCL concentration is below the PAN 2003/1 soil criteria for lead.
- There is a 95% probability that the arithmetic average lead concentration in Stockpile B will not exceed 778 mg/kg. The 95% UCL concentration is above the PAN 2003/1 soil criterion for lead.

Auditor comment –

As a check, the auditor performed statistics on the Stockpiles A and B samples. The 95% non-parametric UCL values for the lead concentrations for Stockpile A (257 mg/kg) and for Stockpile B (766 mg/kg) were comparable to the figures given by BP (262 mg/kg for Stockpile A and 778 mg/kg for Stockpile B). The difference is as a result of slightly different calculation methodologies.

7.7 Quality Assurance and Quality Control (QA/QC)

7.7.1 General

BP reported that blind field duplicate and split sample results were presented in tables in Appendices E to H of the BP (2004) report. Relative Percentage Difference (RPD) calculations for those samples were presented in Table J1 of Appendix J of the BP (2004) report.

Laboratory quality control (QC) results were presented with the laboratory certificates in Appendix K of the BP (2004) report.

7.7.2 Field QA/QC Results

BP (2004) reported that the field QA/QC results indicated the following:

- RPDs for intralaboratory blind field duplicate samples QC1/TPA, QC3/TPA, QC1/SBSS and QC3/SBSS were above the acceptable limits;
- RPDs for the remaining blind field duplicate samples were within the acceptable limits;
- RPDs for inter-laboratory split samples QC2/TPA, QC4/TPA, QC2/SBSS, QC4/SBSS, QC2/SBSM, QC4/SBSM, VEQC4 and VEQC6 were above the acceptable limits; and
- RPDs for the remaining interlaboratory split samples were within the acceptable limits.

Apparent discrepancies in the obtained results were attributed by BP to one or more of the following:

- Inherent difficulty in accurately splitting the soil samples;
- Differences in laboratory analytical laboratory quantification techniques; and
- Uneven contaminant distribution that can exist on a micro-scale due to textural differences in the soil matrices.

Auditor comments –

1. ***The auditor notes the very high RPDs (over 100%) for several of the sample / duplicate pairs, particularly during the July 2003 sampling events. In the majority of cases, the elevated RPDs were associated with high lead concentrations in soils that were subsequently remediated by excavation, stockpiling and removal from the site. The auditor is of the opinion that the high RPDs were mainly due to sample heterogeneity, in that some samples contained bullet 'fragments' giving rise to high lead concentrations, whereas their duplicates might have contained fewer or no fragments, or vice versa. For the final validation samples, the auditor notes that RPDs were mainly within acceptable limits.***

2. ***The auditor queried the reference to "inter-laboratory" splits in Tables E1, E2 and E3, since on checking through the laboratory reports, it appeared that all samples were analysed by AGAL in Brisbane and that no secondary laboratory was used. BP followed up this query with AGAL, who explained that the inter-lab splits were sent from AGAL's Brisbane laboratory to their Melbourne laboratory for independent analysis. Copies of the relevant e-mail correspondence are provided in Appendix 12.***

   The auditor followed up the enquiry independently by telephoning the Customer Service Manager of AGAL, Mr Brian Woodward. By way of example, with reference to the primary sample VS13:0.3-0.4m/TPA (which returned a lead concentration of 7,130 mg/kg) and the inter-laboratory split sample QC2/TPA (which had a lead concentration of 3,000 mg/kg), Mr Woodward explained that the primary sample was analysed in AGAL's NSW laboratory (Report No RN375747), whereas the duplicate sample was analysed in AGAL's Victoria laboratory (Report No RN376015). The laboratory reports appeared to indicate different methods of analysis (NT2_49 for the primary sample and VL239 for the duplicate sample); however, Mr Woodward explained that these were only internal codes, and the reference methods were the same in both laboratories, i.e. ICP-MS, as per the NEPM Schedule B(3) guidelines. Thus the high RPD (81.5%) is regarded as mainly due to sample heterogeneity, rather than any fundamental difference in laboratory procedures.

3. ***The auditor notes that for the July 2003 and subsequent sampling events, 141 primary samples were analysed for lead. In addition, 25 duplicates were analysed, of which several were 'true' inter-laboratory splits (i.e. sent to a different laboratory organisation). Thus the QA/QC requirements of AS4482.1-1997 (i.e. 5% blind field duplicates and 5% splits) are likely to have been satisfied.***

Soil laboratory QC

- No target analytes were detected in the analysis blanks.
- The RPDs for the duplicate samples were within the acceptable range. The consistent zero RPD result was partly due to the low contaminant concentrations in both original and duplicate samples.
- The percentage recovery results for matrix spikes and matrix spike duplicates were within the acceptable range.

Auditor comment –

The auditor notes that no rinsate blanks were collected. This was explained in the second point of Section 3.2 of BP's (2004) Validation Report, which states: "During the remediation works, soil samples were taken as grab samples from the middle of the excavator or backhoe bucket. The bucket was inspected to ensure that the soil was not carried over between samples. Where samples are collected in this manner, equipment rinsate blanks are not collected as part of the QA/QC sampling program."

7.8 Conclusions

Based on the results of the environmental assessment and validation work, BP (2004) concluded the following:

- Lot B was an operational terminal since approximately 1944. There were no reported petroleum hydrocarbon spills or losses that could have resulted in significant impact to the soil and groundwater. A former rifle range that was located at the northern part of Lot B prior to the site's use as a fuel terminal was believed to have caused lead contamination in that area.
- The soil profile consisted of gravelly clays that overlie siltstone. Weathered siltstone appears at approximately 1.5 m depth. In the southern part of Lot B, well round quartz material was present within the gravelly clay.
- The depth to groundwater increases towards the northern and eastern parts of Lot B. Previous gauging results indicated that the direction of groundwater flow is south to south east.
- Lead contaminated soil at the northern part of the site that exceeded the PAN 2003/1 criteria was delineated and excavated. The soil sample results indicate that the excavation walls and base had been validated.
- Excavated soil was separated into two stockpiles (Stockpile A and Stockpile B) based on the material's description and source. The 95% UCL for the average concentration of lead in soil was used to validate Stockpile A. The 95% UCL for the average concentration of lead in soil from Stockpile B exceeded the PAN 2003/1 criteria. This soil was removed from the site and placed in a bunded area within the adjacent BP Darwin Terminal. The area beneath Stockpile B was then validated for lead.
- Grid soil sampling results indicated the remaining parts of the site have been validated.

7.9 Additional Laboratory Analyses

On reviewing the final validation data for Lot B, the auditor was concerned that there was insufficient site coverage for priority heavy metals, soil pH and OCPs / OPPs. As given in Table D3 of the BP (2004) report, samples from test pits SBTP1, SBTP2, SBTP3 and SBTP4 from the April – May 2002 sampling event had been analysed for heavy metals, PAHs and OCPs / OPPs. However, all of these test pits were located in the north-east portion of Lot B (refer to Figure 3).

Therefore in order to improve the coverage across the site, the auditor requested that the following recently collected samples be dearchived and analysed as set out below:

- LF1 – LF6 and SB6 – SB8 Soil pH, priority heavy metals
- LF2, LF5 and SB6 – SB8 OCPs / OPPs.

Sample locations are shown in Figure 6. Samples LF1 – LF6 represent the western portion of the site, while samples SB6 – SB8 represent the south-eastern portion of the site.

The analyses were performed by Amdel, and the analysis results were presented in the following Amdel reports:

- Report No 119744 – heavy metals and pH for LF1 – LF6; OCPs / OPPs for LF2 and LF5
- Report No 119745 – heavy metals, pH and OCPs / OPPs for SB6 – SB8.

All results were below laboratory PQLs or below the audit assessment criteria.

Copies of relevant e-mail correspondence and the above Amdel reports are included in Appendix 12.

7.10 Auditor Comments and Conclusions

Following a detailed review of the remediation and validation work for Lot B of Remediation Zone 1 conducted by BP Australia Pty Ltd between April 2002 and May 2004, the auditor is of the opinion that the work done generally complied with the relevant guidelines. Generally the auditor concurs with BP's conclusions as detailed above.

It is the auditor's opinion that the data obtained, in the context of both field observations and laboratory results, are valid and representative of site conditions, despite some shortfalls in the QA/QC program as noted above, and that the information is sufficient to assist in forming an assessment of the environmental status of the site.

8.1 General

Examination of the precision and quality of the data from the environmental investigations was undertaken by the auditor in order to provide an assessment of the current status of the site.

It is the auditor's opinion that the data obtained, in the context of both field observations and laboratory results, are valid and representative of site conditions, despite some shortfalls in the QA/QC program as noted above, and that the information is sufficient to assist in forming an assessment of the contamination status of the site.

8.2 Human and Ecological Receptors

Having regard for the future residential use of the site, the exposure duration for all categories of human receptors must be consistent with a residential setting. Residential exposures represent the highest risk, i.e. the lowest, or most stringent acceptance criteria. The child resident is the most sensitive receptor; therefore, the criteria designed to protect children will also protect adult residents, construction or utility workers exposed to excavations at the site, and visitors and trespassers exposed to surface soils.

Ecological receptors identified at the site include plants that have their roots in and uptake nutrients from site soils, and terrestrial organisms.

8.3 Exposure Concentrations

In accordance with Schedule B (7A) of the NEPM (1999) guidelines, in comparing site concentrations of contaminants with the health-based soil guidelines (e.g. the NEPM A HBILs), Note 5 to Table 11-A states:

> *These values must only be used where there has been adequate characterisation of the site (i.e. sufficient and appropriate sampling). The arithmetic mean must be compared to the values given in Table 11-A. The relevance of localised elevated values must be considered and should not be obscured by consideration only of the arithmetic mean of the results. The results must also meet the following criteria:*
>
> - *The standard deviation of the results must be less than 50% of the values given in Table 11-A*
> - *No single value exceeds 250% of the relevant value given in Table 11-A.*

In order to evaluate risks, site concentrations of contaminants were compared to the relevant assessment criteria, as discussed in Section 5, having regard for the NEPM guidelines quoted above.

8.4 Human Health and Ecological Risks

Based on a comparison of the final (i.e. post-remediation) validation soil sampling results against the health-based and ecological assessment criteria as presented in Table 5.1, concentrations of all contaminants in all relevant samples were below the criteria.

The auditor is therefore of the opinion that site soils do not constitute an unacceptable human health risk. Contamination levels on this site are also such that there are no unacceptable risks to plants that have their root systems in, or uptake nutrients from, site soils.

With regard to the protection of terrestrial organisms, it can be noted that the audit assessment criteria for toluene, ethylbenzene and total xylenes in soil (1.4, 3.1 and 14 mg/kg, respectively), as stated in the Explanatory Notes for Table 3 in the NSW EPA (1994) Guidelines for Assessing Service Station Sites, are based on the Netherlands maximum permissible concentrations, where the maximum permissible concentration (MPC) is the 'concentration that fully protects 95% of the species in an ecosystem.' The audit criteria can thus be considered protective of terrestrial organisms in soil, and it can be noted that contaminant concentrations in soil did not exceed these criteria for toluene, ethylbenzene and total xylenes, or the ecological assessment criteria based on the NEPM Interim Urban Ecological Investigation Levels.

In summary, it is concluded that soils remaining on site do not constitute an unacceptable human health risk and are unlikely to pose unacceptable risks to ecological receptors.

8.5 Groundwater Quality

The auditor noted that the September / October 2003 groundwater monitoring round was undertaken at the end of the dry season, characterised by shallow wells drying up and significantly depressed groundwater levels in the deep aquifer wells. This in combination with very slow recovery / recharge rates meant that generally only limited volumes were available for sample collection and the intended analytical program was not possible.

Of the five wells that could be sampled (MW20A, MW23, MW25A, MW25B and MW26A), laboratory analysis results were as follows:

BTEX and TPH: Samples from all five wells were analysed for BTEX and TPH. BTEX concentrations were all below laboratory PQLs. Minor concentrations of TPH $C_{10} - C_{36}$ were recorded in MW23, MW25A and MW25B, all well below the auditor adopted criteria (600 μg/L).

Heavy Metals: Samples from three wells (MW20A, MW25B and MW26A) were analysed for eight priority heavy metals, while the sample from MW23 was analysed for an extended heavy metal suite. Some exceedances were reported, as summarised in Table 6.1.

Other Analytes: Samples from MW23 and MW25A were analysed for PAHs, OCPs / OPPs and chlorinated hydrocarbons. All results were below laboratory PQLs.

The auditor is therefore of the opinion that there is some groundwater contamination in wells in the vicinity of the site, with elevated levels of petroleum hydrocarbons and some heavy metals, as a result of previous on-site uses.

The situation is at this stage being satisfactorily addressed by the implementation of the Groundwater Monitoring and Management Plan (GMMP), as detailed in Section 6.

8.6 Potential Off-site Impacts

Based on the groundwater monitoring undertaken to date, there is a potential for off-site impacts as a result of the off-site migration of impacted groundwater.

This situation is at this stage being satisfactorily addressed by the implementation of the Groundwater Monitoring and Management Plan (GMMP), as detailed in Section 6.

8.7 Conclusion on Contaminants of Concern

With reference to the contaminants of concern, as listed in Section 3.6, the auditor concludes that all potential contaminants of concern have been satisfactorily addressed in terms of the investigations, remediation and validation of the site.

9.1 General

Mr Adrian Hall was appointed by BP Australia Pty Ltd in September 2003, to act as the Environmental Auditor for Lot B of Remediation Zone 1 of the redevelopment of the BP Dinah Beach Road Terminal Facility Darwin. The site is being redeveloped by the owner, Frances Park (Darwin) Pty Ltd, for mixed residential use. The Department of Infrastructure, Planning and Environment, Northern Territory (DIPE) requested that the proposed remediation works be reviewed by a Victorian EPA accredited Environmental Auditor, to the same standards as would apply in Victoria. BP engaged the services of Mr Adrian Hall, in order to comply with this requirement. In September 2003 BP requested the auditor to prepare an Environmental Audit Report for the southern portion of Remediation Zone 1, designated 'Lot B'.

In order to assess whether the environmental consultants' investigations have been satisfactory, the Auditor must determine whether the:

- Site history adequately identifies the potential contaminants;
- Sample density and testing frequency gives a representative picture of site conditions;
- Selection of analytes adequately represents the potential site contamination; and
- Selection of acceptance criteria is appropriate.

In determining the condition of the site, the auditor must consider issues relating to:

- The health and well being of humans, on or off the site;
- Environmental impacts to flora and fauna;
- Impacts of soil contamination on surface water and groundwater; and
- Impacts of groundwater, both on site and off site.

A Statement of Environmental Audit (and accompanying Environmental Audit Report) is generated as a result of conducting an 'environmental audit' of a site. Using the definition contained in the Environment Protection Act (Victoria) 1970:

> *"Environmental audit" means the total assessment of the nature and extent of any harm or detriment caused to, or the risk of any possible harm or detriment which may be caused to, any beneficial use made of any segment of the environment by any industrial process or activity, waste, substance (including any chemical substance) or noise.*

In broad terms, "total assessment" is considered to mean the evaluation and interpretation of information about contamination conditions at a site at a nominated point in time, including consideration of:

- All plausible beneficial uses of land at the site, which are consistent with current planning constraints and the context of land uses around the site; and

- All existing and potential beneficial uses of groundwater, both on site, and also within off site areas actually or potentially affected by groundwater quality at the site.

9.2 Auditor's Conclusions

The conclusions of this environmental audit are set out as follows:

1. The investigations conducted by BP Australia Pty Ltd were assessed by the auditor as being adequate to determine the contamination status of the site.

2. The overall sampling frequency (i.e. test locations and selection of samples) is considered by the auditor to be acceptable. The analytical parameters are considered by the auditor to be sufficient to adequately characterise the level of soil contamination on the site.

3. The remediation and validation works supervised by BP were assessed by the auditor as being adequate for the purposes of this audit.

4. The overall QA/QC methodology and procedures employed by BP are considered by the auditor to be acceptable for the purposes of this audit.

5. Soils remaining on site do not constitute an unacceptable human health risk.

6. Soils remaining on site are also unlikely to pose unacceptable risks to ecological receptors.

7. Groundwater underlying the site has been impacted by on-site uses. This situation is at this stage being satisfactorily addressed by the implementation of the Groundwater Monitoring and Management Plan (GMMP).

8. Based on the groundwater monitoring undertaken to date, there is a potential for off-site impacts as a result of the off-site migration of impacted groundwater. This situation is at this stage being satisfactorily addressed by the implementation of the Groundwater Monitoring and Management Plan (GMMP).

On the basis of the above conclusions, the auditor considers that the site is suitable for the following beneficial uses:

- Mixed residential living; and

- All uses permitted under the Darwin Town Plan 1990, as amended on 20 February 2002, for Specific Use (SU52) Zone (see Appendix 11),

subject to the following conditions:

1. There should be no use of phreatic groundwater from the site, other than for the purposes of environmental monitoring.

2. There should be a program of groundwater monitoring for Lots A and B of Remediation Zone 1, as outlined in Section 6 of the Environmental Audit Report; a review of the program should be undertaken by the auditor periodically, and the program should be continued until the auditor is satisfied that all nominated Groundwater Investigation Levels (GILs) are met, and that the contaminated groundwater plume no longer poses unacceptable human health or environmental risks.

The auditor advises that all owners and/or occupiers of the site (both current and future) should be made aware of the above conditions.

Signed:

A.M.D. Hall

Adrian MD Hall

Senior Principal Environment Auditor

URS AUSTRALIA PTY LTD

Date: 7 May 2004

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15. NSW EPA (1994), Guidelines for Assessing Service Station Sites, NSW Environment Protection Authority, December 1994

16. NSW EPA (1998), Guidelines for the NSW Site Auditor Scheme, NSW Environment Protection Authority, June 1998

17. State Environment Protection Policy (Prevention and Management of Contamination of Land), Victoria Government Gazette, 4 June 2002

Limitations

SECTION 11

URS Australia Pty Ltd (URS) has prepared this report for the use of BP Australia Pty Ltd in accordance with generally accepted consulting practice, and in accordance with relevant Northern territory Government and EPA Victoria technical policy documents. No other warranty is expressed or implied.

Information provided to us by third parties has been assumed to be correct and complete. URS does not assume any liability for misrepresentation of information by third parties or for matters not visible, accessible or present on the subject property during any site inspections conducted during the audit.

Whilst to the best of URS' knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels and contaminants concentrations, can change in a limited time.

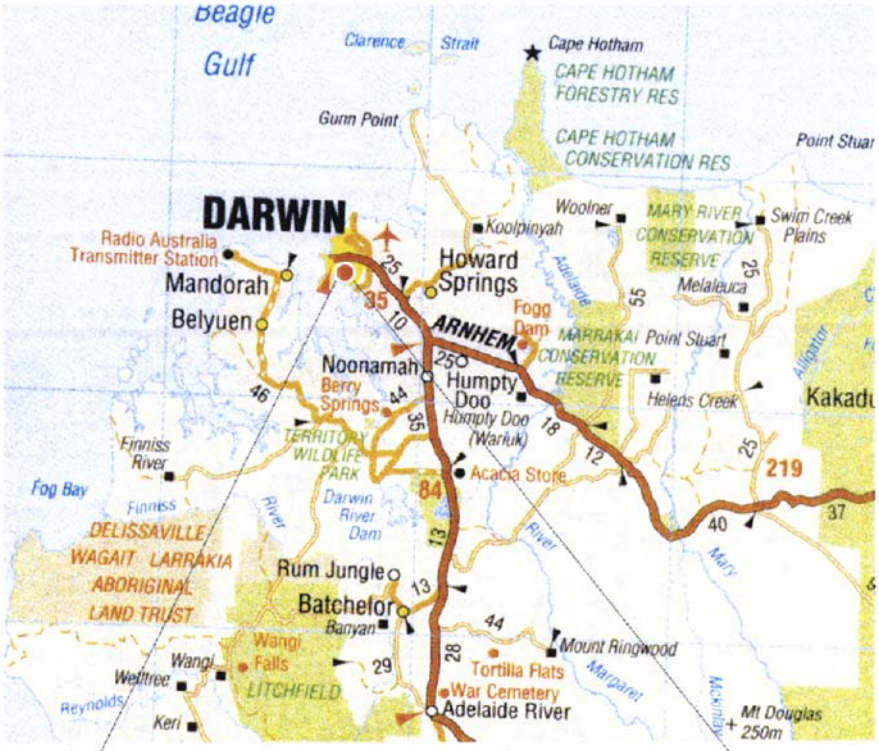
There are always some variations in subsurface conditions across a site that cannot be fully defined by sampling. Hence it is possible that the measurements and values obtained from sampling and testing during the investigations may not necessarily represent the extremes of conditions that exist within the site. Further, because regulatory criteria are constantly changing, concentrations of contaminants considered acceptable at the time of this audit may, in future, become subject to different regulatory standards.

Opinions and judgments expressed herein are based on URS' understanding of current regulatory standards and should not be construed as legal opinions. This document and the information contained herein has been prepared for the use of the client and the Northern Territory Department of Infrastructure, Planning and Environment. Any reliance on this report by third parties shall be at such parties' risk.

In the event that changes in conditions on or near the site occur after the date of signing of a Certificate or Statement of Environmental Audit, the auditor disclaims responsibility for the occurrence or ownership or effects of such conditions or materials, whether they be hazardous or otherwise.

Figures

A4



From the Touring Atlas of Australia, Penguine Books 1995

SOURCE: BP AUSTRALIA PTY LTD - SITE DECOMMISSIONING AND ENVIRONMENTAL VALIDATION REPORT - APRIL 2004

Designed: AH	Approved:	Client: BP AUSTRALIA PTY LTD	Project No: 51614-011 / Date: MAY 2004
Drawn: KWB	Scales: NOT TO SCALE		CAD File No: 51614-011-001.DWG / Status: FINAL
Checked:		Project: DARWIN LOT B AUDIT	Title: SITE LOCATION PLAN

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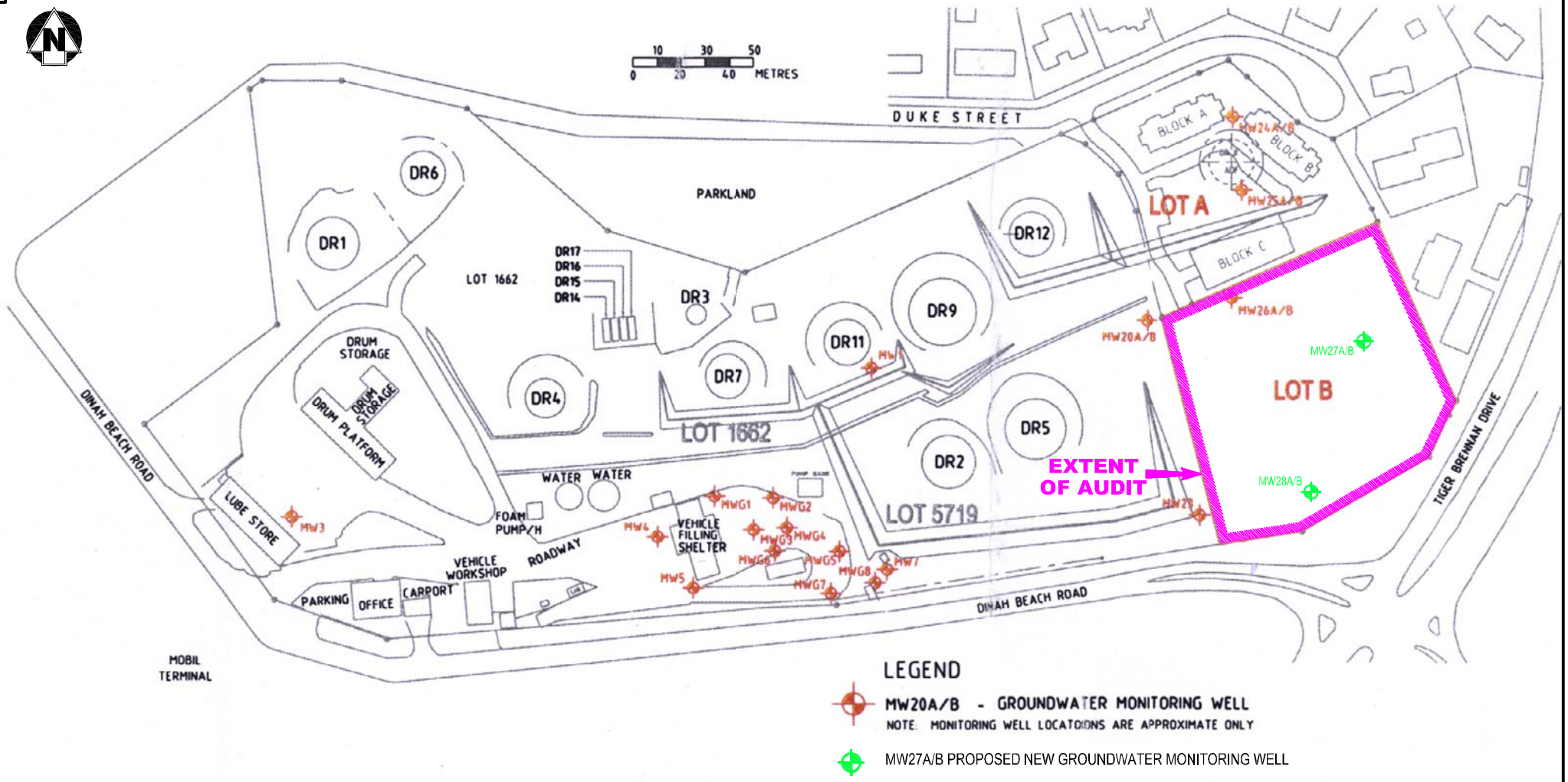
Figure: 1 Rev A

A4



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Project
DARWIN LOT B AUDIT

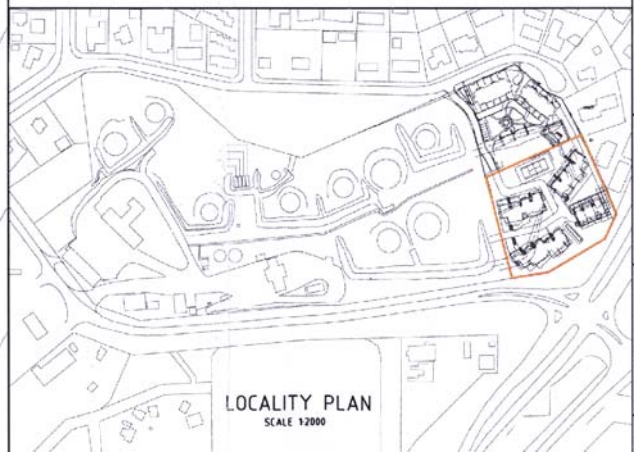
Project No: 51614-011	Date: MAY 2004
CAD File No: 51614-011-002-01	Status: FINAL

Title:
LOT B GROUNDWATER MONITORING WELL LOCATIONS AND EXTENT OF AUDIT

Figure: **2**

Rev **A**

A4



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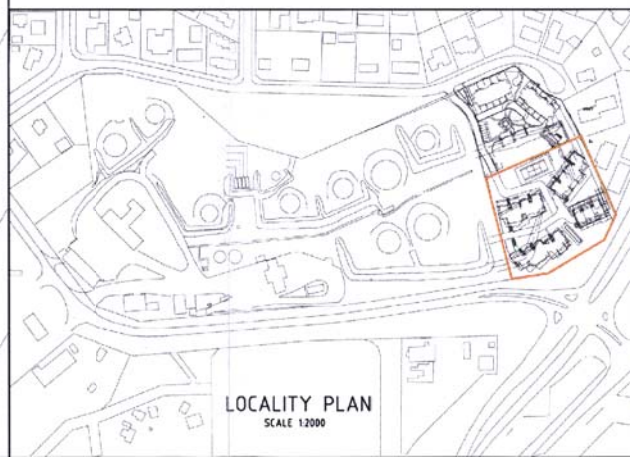
Project No: 51614-011	Date: MAY 2004
CAD File No: 51614-011-002-02	Status: FINAL

Title:
LOT B SAMPLE LOCATIONS
APRIL - MAY 2002

Figure: **3**

Rev **A**

A4



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Project
DARWIN LOT B AUDIT

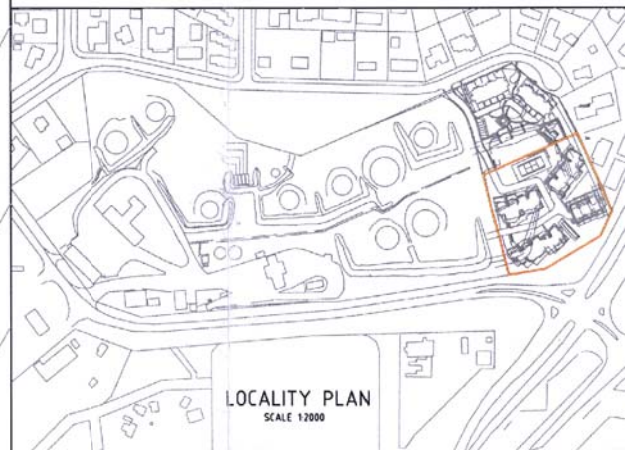
Project No: 51614-011	Date: MAY 2004
CAD File No: 51614-011-002-03	Status: FINAL

Title:
LOT B SAMPLE LOCATIONS
JULY 2003

Figure: **4**

Rev **A**

A4



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Project
DARWIN LOT B AUDIT

Project No: 51614-011	Date: MAY 2004
CAD File No: 51614-011-002-04	Status: FINAL

Title:
LOT B SAMPLE LOCATIONS
OCTOBER 2003

Figure: **5**

Rev **A**

A4

VE30 — SAMPLE LOCATIONS : 14 APRIL 2004

SB6 — SAMPLE LOCATIONS : 19 APRIL 2004

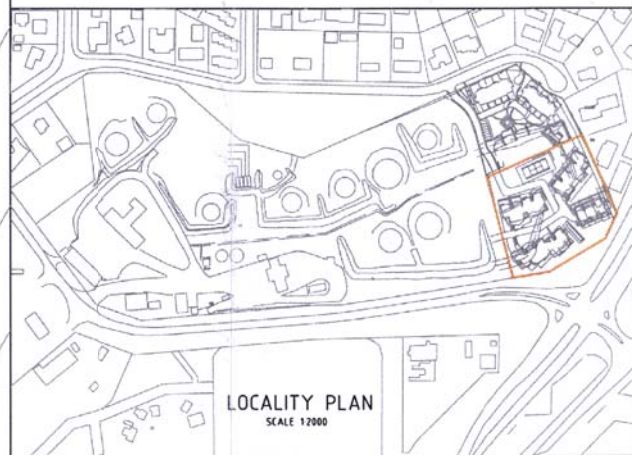

FIGURE 6 : SAMPLING LOCATIONS (APRIL 2004)

NOTE:- ALL SAMPLING LOCATIONS ARE APPROXIMATE ONLY

0 10 20 30 40 50 METRES

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Project No: 51614-011	Date: MAY 2004
CAD File No: 51614-011-002-05	Status: FINAL

Title:
LOT B SAMPLE LOCATIONS
APRIL 2004

Figure: **6**

Rev **A**

Appendix 1
List of Abbreviations and Acronyms

Appendix 1
List of Abbreviations and Acronyms

AHD	Australian Height Datum
ANZECC	Australia and New Zealand Environment and Conservation Council
AMG	Australian Map Grid
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BFD	Blind Field Duplicate
BTEX	Benzene, toluene, ethylbenzene and xylenes
DDD	Dichlorodiphenyldichloroethane
DIPE	Department of Infrastructure, Planning and Environment (Northern Territory)
DLPE	Department of Lands, Planning and Environment (Northern Territory)
EIL	Environmental Investigation Level
EPA	Environment Protection Agency
ESA	Environmental Site Assessment
HASP	Health and Safety Plan
HBIL	Health-based Investigation Level
ILD	Interlaboratory Duplicate
LOR	Limit of Reporting
µg/L	micrograms per litre
mg/kg	milligrams per kilogram
NATA	National Association of Testing Authorities
NEHF	National Environmental Health Forum
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
OCPs	Organochlorine Pesticides
OPPs	Organophosphate Pesticides
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PID	Photoionisation Detector
PQL	Practical Quantitation Limit
PSH	Phase Separated Hydrocarbons
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RPD	Relative Percent Difference
SWL	Standing Water Level
TOC	Top of Casing
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbons
UCL	Upper Confidence Limit
ULP	Unleaded Petrol
UST	Underground Fuel Storage Tank
VACs	Volatile Aromatic Compounds
VHCs	Volatile Halogenated Compounds
VOCs	Volatile Organic Compounds

Appendix 2
Glossary of Terms

Appendix 2
Glossary of Terms

Total Assessment

In the context of environmental auditing of potentially contaminated land, "total assessment" is the evaluation and interpretation of the information about contamination conditions at a site. This evaluation and interpretation involves consideration by the auditor of:

- Whether or not there is enough information of sufficient quality to be able to form reliable conclusions about the presence of contamination and its potential impact on relevant beneficial uses and elements of the environment on and off site. This consideration inevitably involves extrapolations and professional judgements using a finite information set, which is often gathered from a sampling program derived from a statistics-based methodology. In many cases, the ideal amount of information is always more than that which it is practicable to obtain. One of the Auditor's functions, therefore, is to judge what constitutes the minimum sufficient information to reduce uncertainties in the consequent assessment;

- All plausible beneficial uses of land at the site which are consistent with current planning constraints and EPA policies and guidelines;

- Existing, likely and unlikely beneficial uses (which are consistent with the classification of background groundwater as per the SEPP (Groundwaters of Victoria)) of groundwater both onsite and also within offsite areas potentially or actually affected by groundwater quality at the site; and

- The risks of existing and potential detrimental impacts on beneficial uses and elements of the environment from the contamination conditions, once the Auditor is satisfied when there is enough information of sufficient quality and relevance as per 1 above.

Potential Beneficial Uses of Land
(based on SEPP – Prevention and Management of Contamination of Land)

Protected beneficial uses of land include:

- Maintenance of Ecosystems:
    - Natural ecosystems
    - Modified ecosystems
    - Highly modified ecosystems
- Human health
- Buildings and structures
- Aesthetics
- Production of food and flora

Appendix 2
Glossary of Terms

Potential Beneficial Uses of Groundwater

These are defined in the SEPP (Groundwaters of Victoria) as follows:

Maintenance of ecosystems	Stock watering
Potable water supply	Industrial water use
Potable mineral water supply	Primary contact recreation
Agriculture, parks and gardens (irrigation)	Buildings and structures

Segment of the Environment

A segment is defined in the Act as any portion or portions of the environment expressed in terms of volume, space, area, quantity, quality, or time or any combination therefore. When auditing contaminated land, the relevant segment is the site (not only the land at the site).

Groundwater

Any water contained in or occurring in a geological structure or formation or an artificial landfill.

Receptor

This is a person (child or adult) or some flora or fauna, which may experience exposure to the contamination.

Ecological Toxicity Reference Value (TRV)

A concentration of chemical in the medium of interest below which the selected toxic effect does not occur in the defined percentage of the population of the species.

Domain

This is a region in a given medium, which it is sensible to characterise by a single exposure concentrations for each chemical. Thus, a domain is a region where a consistent pattern of exposure (ie: use) could occur. Examples of domains are:

- Surface soils (say 0 -0.5 m depth) in a residential allotment, or in a public open space.
- Sediment in a section of river bed occupied by habitats/ecological populations of interest.
- A mixing zone in a surface water body affected by surface run-off or groundwater seepage.
- The radius and depth of influence, “zone of influence”, around an abstraction bore in a body of groundwater.
- A zone of a particular type of fill material buried beneath a surface capping layer.

Appendix 2
Glossary of Terms

Exposure

This is the process by which a receptor comes into contact with a contaminant. Exposure can be direct or indirect. Examples of direct exposure are:

- Ingestion of contaminated soil or groundwater;
- Inhalation of contaminated dusts or vapours; and
- Dermal absorption of contaminated soil or groundwater.

Examples of indirect exposure are:

- Ingestion of plants, fish, animals which themselves have been exposed to contaminants from the site.

Exposure Concentrations

These are interpreted values of concentrations that are considered to characterise the domain in which exposure to chemicals can occur. These are intended to represent the average condition of the domain over the period of time in which this exposure can occur.

Exposure concentrations must be interpreted from measurements at specific points in space and time, using professional judgments, which are assisted by modelling of spatial and temporal trends in data, by statistical analyses, and by an understanding of the physical-chemical-biological characteristics of the domain.

Adverse Effects or Detrimental Impacts

Health Effects or Impacts

The screening criteria are intended to limit risks from long-term effects or impacts such as chronic (non-carcinogenic), carcinogenic effects.

Ecological Effects

The screening criteria are intended to limit risks from phytotoxicity and other observable adverse effects.

Risk

Risk is the probability of occurrence of defined adverse effect or detrimental impact. A finite risk requires the presence of a hazard (in this case contamination) an active pathway for exposure to occur, and a receptor or group of receptors.

This term should not be confused with “hazard”. Risk is the probability of occurrence of an adverse effect to people or ecological species, resulting from exposure to a hazard caused by contamination. If exposure to a hazard is impossible then the risk is zero, even if the hazard exists.

Risk reduction can involve one or more of the following:

- Hazard reduction or removal by remediation;
- Pathway constriction or removal by remediation of constraints on use of the medium contaminated.
- Receptor removal by constraints on use of the contaminated medium.

Risk Rank

A qualitative description of the relative severity of the health or ecological risk posed by chemicals in a domain. This description is based on the extent by which screening criteria are exceeded, the importance of the species exposed to the chemicals and the uncertainties in the data and information used to estimate exposure concentrations and screening criteria.

Screening Criteria

These represent thresholds for exposure concentrations below which risks are considered negligible, and above which risks need closer examination, and perhaps calculation using site specific assumptions. Exceedance of screening criteria does not mean risks are automatically unacceptable.

Acceptance Criteria

These represent thresholds for exposure concentrations above which risks are unacceptable.

Contamination

Contamination means the condition of land or water where any chemical substance or waste has been added at above background level and represents, or potentially represents, an adverse health or environmental impact (NEPC, 1999).

Pollution

This has a specific meaning in the Environment Protection Act 1970 (Victoria). In the context of contaminated land, it represents contamination that is severe enough to have resulted in or to have the potential to result in adverse impacts on beneficial uses of the land.

Appendix 2
Glossary of Terms

Remediation

This is the process by which hazards are reduced or removed, or exposure pathways constricted.

Examples are:

Hazard Reduction	Natural Attenuation Pump as treat groundwater Soil vapour extraction Excavation and chemical/thermal treatment Air sparging Bioremediation Solidification/stabilisation
Hazard Removal	Excavation to off-site landfill.
Pathway Constriction	Excavation to on-site repository or on-site burial beneath some for m of cap. Administrative or other constraints. Use of groundwater.

Clean-up 'To the Extent Practicable'

This is site clean-up using available technology that is has been proven effective and is commercially feasible, so that pollution is reduced to contamination; or failing this, pollution is reduced to the greatest limit achievable. The technology must be safe to use and cause negligible adverse impacts on health and the environment. The EPA have a preference, all other factors being equal, for the practicable technology that achieves clean up in the shorter time to be used.

Aquifer

This is the soil or rock in which groundwater exists. The water table may be at or below the top of the aquifer.

Smear Zone

This is a zone of soil extending from just above to just below the water table in an aquifer which has been smeared by phase separated hydrocarbons floating on top of a fluctuating water table.

Non Aqueous Phase Liquid

This is a liquid that has a low solubility in water and exists in sufficient quantity to form a discrete layer or separate phase in surface water or groundwater. Dense Non-Aqueous Phase Liquids have a specific gravity greater than that of water. Light Non-Aqueous Phase Liquids have a specific gravity lighter than that of water.

Appendix 2
Glossary of Terms

Non Aqueous Phase Liquids are considered likely to be present in a groundwater aquifer if their measured (apparent) thickness exceeds 3 mm in a properly constructed monitoring well drilled into the aquifer.

The propensity of non-aqueous phase liquids to be mobile within an aquifer depends on the properties of the liquid (density, viscosity etc) and on the aquifer. Aquifer characteristics which need to be considered include the degree of homogeneity and structure of the material matrix (e.g. fissured rock or granular soils).

Phase Separated Hydrocarbons (PSH)

These are Light Non-Aqueous Phase Liquids derived from petroleum hydrocarbons and associated organic chemicals such as benzene, toluene, ethylbenzene and xylenes. They are at sufficiently high concentrations as not to be adsorbed phase or dissolved phase hydrocarbons.

Adsorbed Phase Hydrocarbon (APH)

These are petroleum hydrocarbons and associated organic chemicals which have adhered to soil particles or rock surfaces and are not above to move readily.

Dissolved Phase Hydrocarbons (DPH)

These are petroleum hydrocarbons and associated organic chemicals which have dissolved in water.

Appendix 3
Quality Assurance/Quality Control (QA/QC) Explanatory Notes

Appendix 3
Quality Assurance/Quality Control (QA/QC) Explanatory Notes

The specific methods recommended for checking compliance and assessing precision, accuracy and useability of analytical data for ESA work are described as follows.

Blanks

Blank samples are required in order to monitor the introduction of artefacts or interferences into the sampling and analysis programs of ESAs, which may lead to the reporting of false positive data. The most common types of blanks utilised in ESA work are referred to as field, trip and laboratory blanks.

Field Blanks

Field blanks are samples of water from a known or controlled source (that ideally do not contain project analytes) prepared by sampling personnel in the same manner as regular samples. The associated sampling equipment is rinsed with this water at the completion of equipment decontamination. The rinsate is collected directly into the same types of containers used for regular samples. The collection of field blanks enables the measurement of incidental or accidental contamination during sampling, transport, sample preparation and analysis.

Trip Blanks

Trip blanks are used when project analytes include volatile organic compounds (VOCs). Trip blanks are prepared within the laboratory by placing VOC free water into VOC collection vials. They are then handled in the same manner as regular VOC sample collection vials (i.e. they are transported to and stored in the field, placed in ice chests and returned to the laboratory for analysis) with the exception that they remain unopened within the field. The collection of trip blanks enables the measurement of incidental or accidental contamination of VOCs during transportation, fieldwork and storage.

Laboratory Blanks

Laboratory blanks consist of reagents specific to each individual analytical method prepared and analysed by the laboratory in the same manner as regular samples. The preparation and analysis of laboratory blanks enables the measurement of incidental or accidental contamination within the laboratory.

Occurrence Of Positive Blank Results

Ideally, no contamination should be present in blanks. However, the occurrence of positive blank results may mean that falsely positive sample data have been reported. If this is the case, appropriate corrective action must be taken.

Appendix 3
Quality Assurance/Quality Control (QA/QC) Explanatory Notes

In the event that blank contamination is detected, the following corrective actions are recommended by the US EPA:

- No positive results are reported unless the analyte concentration within a sample exceeds 10 times the amount in any blank for common contaminants, or five times the amount for any other analyte;
- The results are not corrected by subtracting any blank value; and
- If an analyte is found in a blank but not in a sample, no action is taken.

Professional judgement is used where little or no contamination is present in the associated blanks, but contamination is suspected in actual samples.

Obviously it is important that the source of such contamination be identified and eliminated wherever possible.

Field Duplicates

Field duplicates are a set of two discrete samples collected from the one sampling point. They are submitted to one laboratory as two independently labelled samples. Field duplicates are used to assess the combined precision of sampling, sample preparation and analysis. Significant variation in field duplicate results is often observed (particularly for solid matrix samples) due to sample heterogeneity. Subsequently, professional judgement should be exercised when assessing field duplicate data.

Split Samples

Split samples are samples prepared by mixing and splitting one large sample into two portions. One of these samples is submitted to the primary analytical laboratory, whilst the remaining sample is submitted to an independent laboratory for the identical suite of analyses. Split samples are prepared and analysed in order to check the accuracy of data generated by the primary laboratory. Significant variation in split sample results is often observed due to sample heterogeneity and/or differences in analytical techniques employed by the laboratories involved.

External Check Standards

External check standards are prepared by an independent laboratory and submitted to the laboratories being utilised for a given ESA. Where possible, these standards are prepared by utilising the same or similar sample matrix to that present at the site under investigation. External check standards are used to assess laboratory accuracy. The use of these types of standards, rather than the use of split samples to evaluate laboratory performance, has the advantage of minimising or eliminating imprecision due to sample heterogeneity and/or differences in inter-laboratory analytical techniques.

Appendix 3
Quality Assurance/Quality Control (QA/QC) Explanatory Notes

Laboratory Duplicates

Laboratory duplicates are samples prepared within the laboratory by dividing a field sample into two aliquots and analysing separately. The analysis of laboratory duplicate samples provides an indication of analytical precision and may also be influenced by sample heterogeneity.

Matrix Spike/Matrix Spike Duplicates

Matrix spike/matrix spike duplicates (MS/MSDs) are samples prepared within the laboratory by dividing a field sample or an aliquot of a field sample in half, then spiking each of these with identical concentrations of specific analytes. The matrix spike (MS) and matrix spike duplicate (MSD) are then analysed separately and the results are used to assess the effects of the sample matrix on the precision and accuracy of the analyses. The evaluation of MS/MSD results is not necessarily straightforward, since the sample itself may produce effects due to such factors as the presence of interfering species within the sample and the occurrence of high concentrations of analytes. Since these effects are outside the control of the laboratory, evaluation is often subjective and requires a considerable input of professional judgement. In addition, MS/MSD data should be evaluated in conjunction with other QC criteria, rather than assessing the MS/MSD data in isolation.

Surrogates

Surrogates (or system monitoring compounds) are used to assess the accuracy of organic analyses that involve chromatographic techniques. These compounds are spiked into all sample aliquots at the commencement of sample preparation. The spiked sample aliquots then undergo normal extraction and analysis procedures.

Appropriate surrogate compounds may be chosen based upon the following selection criteria:

- They must be similar to the organic analytes of interest in chemical composition, extraction and chromatographic behaviour, but must not be normally found in field samples;
- They must not interfere with the measurement of the analytes of interest; and
- Where possible, they should provide feedback to a range of critical performance aspects of the analysis (e.g. losses due to volatilisation, vessel transfer, photo-degradation, etc).

In order to achieve the latter criteria, it is usually necessary to spike a range of surrogate compounds of different chemical properties into each sample aliquot.

As with MS/MSDs, the evaluation of surrogate spike results is not necessarily straightforward, since the sample itself may produce effects due to such factors as the presence of interferences and high

concentrations of analytes. Since these effects are outside the control of the laboratory, evaluation is often subjective and requires a considerable input of professional judgement.

The precision of field duplicate, split sample, laboratory duplicate and MS/MSD analyses can be assessed by calculation of the *relative percent difference* (RPD), where:

$$RPD = \frac{(D1 - D2)}{(D1 + D2)/2} \times 100\%$$

where D1 = first sample measurement

D2 = duplicate sample measurement

Precision can also be assessed by the method described by Thompson and Howarth. In this method the mean of the duplicates is plotted against the difference between the duplicates. Superimposed on these plots are the normal distribution confidence intervals of the differences between the duplicates at a chosen level of acceptable precision (e.g. 10%). A comparison of the duplicate mean versus duplicate difference plots with the chosen confidence intervals allows an assessment of whether overall precision falls within acceptable limits. This technique is particularly useful for the assessment of precision where analyte concentrations approach the limit of detection, where sole reliance on RPD values can often be misleading.

Accuracy of MS/MSD and surrogate spike results is normally assessed by calculation of *percent recovery*, where:

$$\text{percent recovery (PR)} = X/T \times 100\%,$$

where X = the observed value of measurement

T = "true" value

It is important that an appropriate frequency of conducting quality control measurements is maintained during an ESA, in order that sufficient data are available to adequately assess accuracy and precision. Recommended frequencies for conducting the various quality control measurements described, together with a summary of recommended acceptance criteria for each, are provided in Table 1. It is emphasised that the frequencies and acceptance criteria provided are indicative only. Specific requirements for a given ESA may be such that more stringent or relaxed frequencies and criteria are appropriate.

Occurrence of Apparently Unusual or Anomalous Results

Results that appear to be unusually high or low, or that are inconsistent with anticipated results based on site history, field observations and common sense are often encountered in ESA work. More detailed

attention should be provided to these types of data in order to verify their accuracy. More often than not the occurrence of an anomalous result is due to an obvious error.

Corrective Actions

If data are found to fall outside the accepted limits of precision and accuracy adopted for a given ESA, then the following corrective actions may be undertaken:

- Reanalyse suspect samples, provided sample or extract holding times have not been exceeded;
- Resampling and reanalysis;
- Evaluate and amend sampling and/or analytical procedures;
- Accept data with an acknowledged level of bias and imprecision;
- Discard the data.

In the event that data of questionable reliability are used, then it is essential that any restrictions and limitations associated with the use of such data are clearly identified.

Appendix 3
Quality Assurance/Quality Control (QA/QC) Explanatory Notes

Recommended Frequency of Quality Control Measurements and Indicative Acceptance Criteria (taking into account AS4481.1)

Measurement	Frequency	Acceptance Criteria	
		RPD (%)	Recovery (%)
Field Blanks	1 in 20 samples collected	-	-
Trip Blanks	1 per ice chest	-	-
Laboratory Blanks	1 in 20 samples collected	-	-
Field Duplicates	1 in 20 samples collected	30-50	-
Split Samples	1 in 20 samples collected	30-50	-
External Check Standards	1 in 10 samples collected	-	80 - 120
Laboratory Duplicates	1 in 20 samples collected	20	-
MS/MSDs	1 in 20 samples collected	30	70 - 130
Surrogates	Each analysis where appropriate	-	70 - 130

Appendix 4
DIPE (2003)
Pollution Abatement Notice No 2003/1

Northern Territory Government
Department of Infrastructure, Planning and Environment

No.__2003/1____

POLLUTION ABATEMENT NOTICE

(Issued pursuant to section 77 of the *Waste Management and Pollution Control Act*)

Issued to :

Name :	Frances Park (Darwin) Pty. Ltd. (ACN 090 382 219)
Address :	Level 4, 111 Harrington Street, The Rocks, Sydney NSW 2000
Tel:	02 92524211
Fax:	02 92521585

In relation to premises:

The parcel of land within Lots 1662 and 5719, Town of Darwin, defined in red on the attached plan Drawing No 02/4763/12 ("the land").

Reason :

Frances Park (Darwin) Pty Ltd (ACN 090 382 219) is the owner or occupier of land that is polluted.

Particulars

The land, including the soil and groundwater, is polluted with levels of contaminants exceeding Health Based Investigation Levels as stated in Schedule B(1) (Guidelines on Investigation Levels for Soil and Groundwater) of the National Environment Protection (Assessment of Site Contamination) Measure 1999. The pollution is such that the land is unsuitable for its intended use of mixed residential.

Action Required

1. By 22 December 2004 Frances Park (Darwin) Pty Ltd (ACN 090 382 219) is required to take remedial action to return the land as far as possible to the following condition (which the Minister thinks appropriate for the protection of the environment or the use of the land):

> A condition such that the levels of the substances specified in the table below are equal to or lower than the levels specified for soil and groundwater in the table, so that the land is suitable for mixed residential land use.

Substance	Soil (mg/kg)	Groundwater (µg/L)
Lead	300	5
Benzene	1	300
Toluene	1.4	300
Ethyl benzene	3.1	140
Xylene	14	380
Total Petroleum Hydrocarbons $_{C6-C9}$ fractions	65	150
Total Petroleum Hydrocarbons $_{C10-C14}$ fractions	1000	600
Total Petroleum Hydrocarbons $_{C15-C35}$ fractions		

2. Remedial action required by this notice shall be undertaken in accordance with the approved remedial action plan. Frances Park (Darwin) Pty Ltd shall prepare and submit any changes to the approved remedial action plan to the Department of Infrastructure, Planning and Environment for approval. The approved remedial action plan or approved amendments shall specify the means by which the remedial action shall achieve the condition of the land specified in the table above and shall be consistent with Schedule B(2) of the National Environment Protection (Assessment of Site Contamination) Measure 1999 made pursuant to the *National Environment Protection Council (Northern Territory) Act.*

3. Frances Park (Darwin) Pty Ltd shall submit an audit report prior to the land being used for the purposes of mixed residential living. The audit report shall validate that the levels of contaminants specified by this notice have been met and that the land is suitable for its intended use. The audit report shall be prepared and signed by an Environmental Auditor (Contaminated Land) appointed under the Victorian EPA auditor scheme under section 57 (1) of the *Environment Protection Act* 1970 (Victoria).

4. In accordance with section 79 (1) (a) of the Act, Frances Park (Darwin) Pty Ltd shall comply with the General Environmental Duty specified in section 12 (1) of the Act. In so doing, contaminated or potentially contaminated soil and water must be, wherever possible, treated on-site. If it is not possible to treat the material on-site, approval must be sought from the Department of Infrastructure, Planning and Environment for off site treatment of excavated soil and/or pumped water. If off site treatment is undertaken the treated material must subsequently be returned to the site. If implementation of either of the above options is not possible the Department of Infrastructure, Planning and Environment must be notified and approval sought for an alternative remedial action method.

5. In accordance with section 79 (1) (b) of the Act, Frances Park (Darwin) Pty Ltd shall notify the Department of Infrastructure, Planning and Environment of any incidents arising from the remedial action that cause or threaten to cause material or serious environmental harm, as required under section 14 of the Act.

Notice Issued By :

_____ / / _____

Date **Time**

BARBARA JOAN SINGER
Executive Director, Environment and Heritage
Acting with the
delegated authority of the
Chief Executive
Department of Infrastructure,
Planning and Environment

Important Notice

Failure to comply with this notice is an offence under section 80 of the *Waste Management and Pollution Control Act* and may incur significant penalties and/or other statutory action.

This notice takes effect on the date on which it is served upon you. Pursuant to section 108 of the *Waste Management and Pollution Control Act*, **you have the right to apply for a review of the decision to issue you with this Pollution Abatement Notice. If you intend to apply for a review, YOU MUST MAKE AN APPLICATION NOT LATER THAN 7 DAYS after the date you were served with this notice.** For information on how to lodge an application for review, contact the Office of Environment and Heritage, Department of Infrastructure, Planning and Environment; telephone 89244139.

Pursuant to section 112 of the *Waste Management and Pollution Control Act* the person issued with this notice must fulfil certain obligations before selling, leasing, sub-leasing, giving or exchanging land, premises, a vehicle or business which is the subject of this Notice.

Office Use Only - Service of Notice

Personal or by Post : (Circle as appropriate)

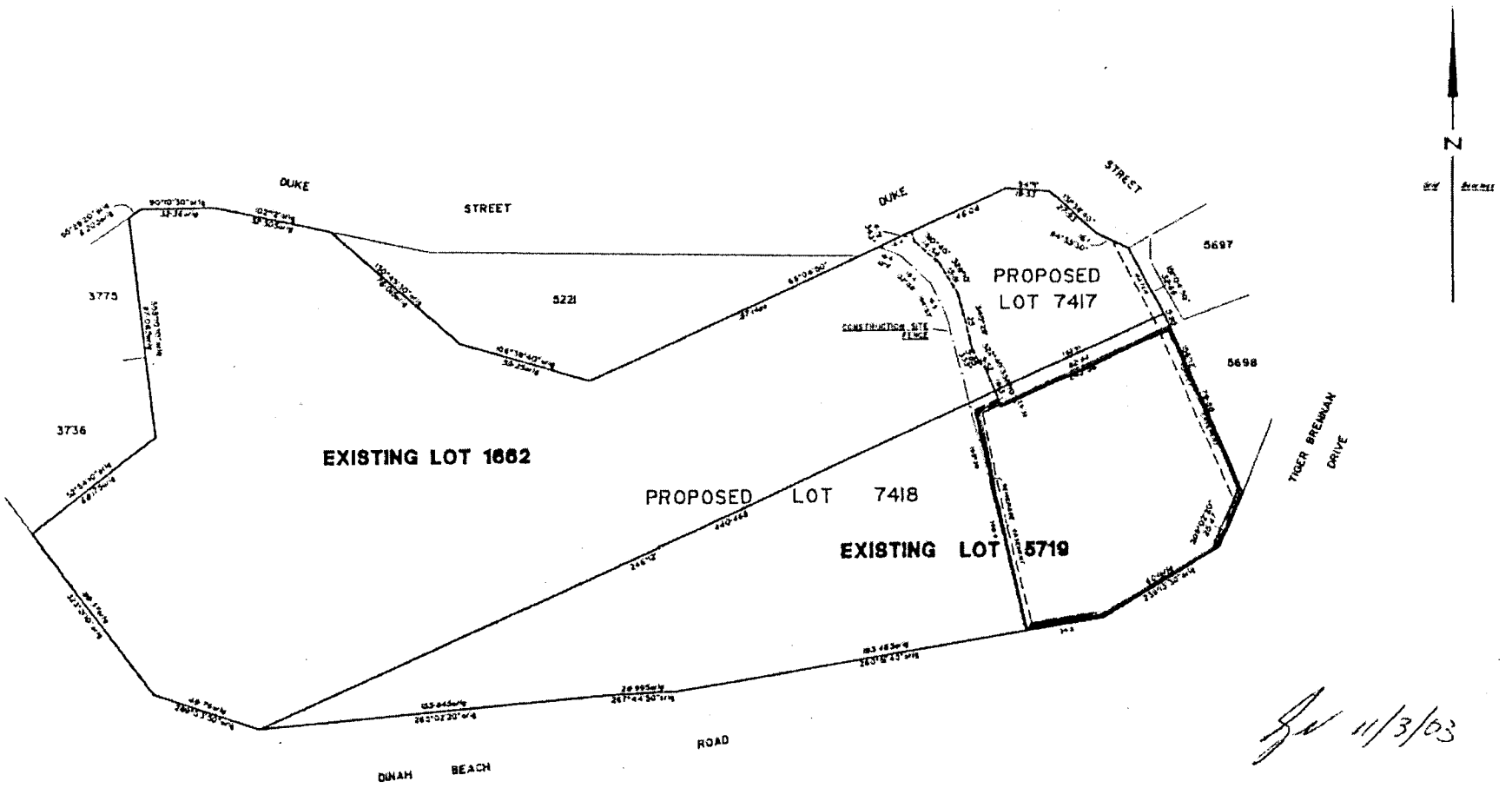
If **Personal** : Served to : _____ at : _____

Date : / / Time :_____

By : Name : _____ Signature : _____

Agency : _____

If **Post** : Registered or certified mail no : _____



11/3/03

EARL JAMES & ASSOCIATES SURVEY & PLANNING CONSULTANTS 10 HARVEY STREET DARWIN NT 0801 PH: (08) 8981 2494 FAX: (08) 8981 5265 EMAIL: darwin@eja.com.au	©	Licensed Surveyor: KSLS Date: 9/1/03. Drawn by: KS Date: 7/1/03 Cad File: 4763-12.DWG	**LOTS 1662 AND 5719** **TOWN OF DARWIN** **EXISTING AND PROPOSED BOUNDARIES** Client: **TRAFALGAR CORPORATE**	Scale: 1:2000 (A1) Datum: Drawing No. 02/4763/12

Appendix 5
Extracts from Darwin Town Plan 1990

bp 07 33647102

BP Australia Limited
701 Kingsford Smith Drive
WHINSTANES QLD 4007
PO Box 718
HAMILTON QLD 4007

facsimile

Date:	16 October 2002	**From:**	Perry McGarry
To:	Adrian Hall	**Dept:**	BP Environmental QLD/NT
Fax Number:	08 – 8366 1001	**Telephone:**	0414 567 751
Pages to follow:	3	**Fax:**	(07) 3364 7111
Subject:	**BP Darwin Terminal - URGENT**		

Direct: 0414 567 751
Main: (07) 3364 7111
Mobile: 0414 567 751
Fax: (07) 3364 7102
mcgarrp@ez1.bp.com

Adrian,

This is from the Darwin Town Plan 1990 (as amended as at 20 February 2002)

My notes also say that the purpose of this SU52 Zone is that it allows the administering authority flexibility with future assessments about land suitability.

Regards,

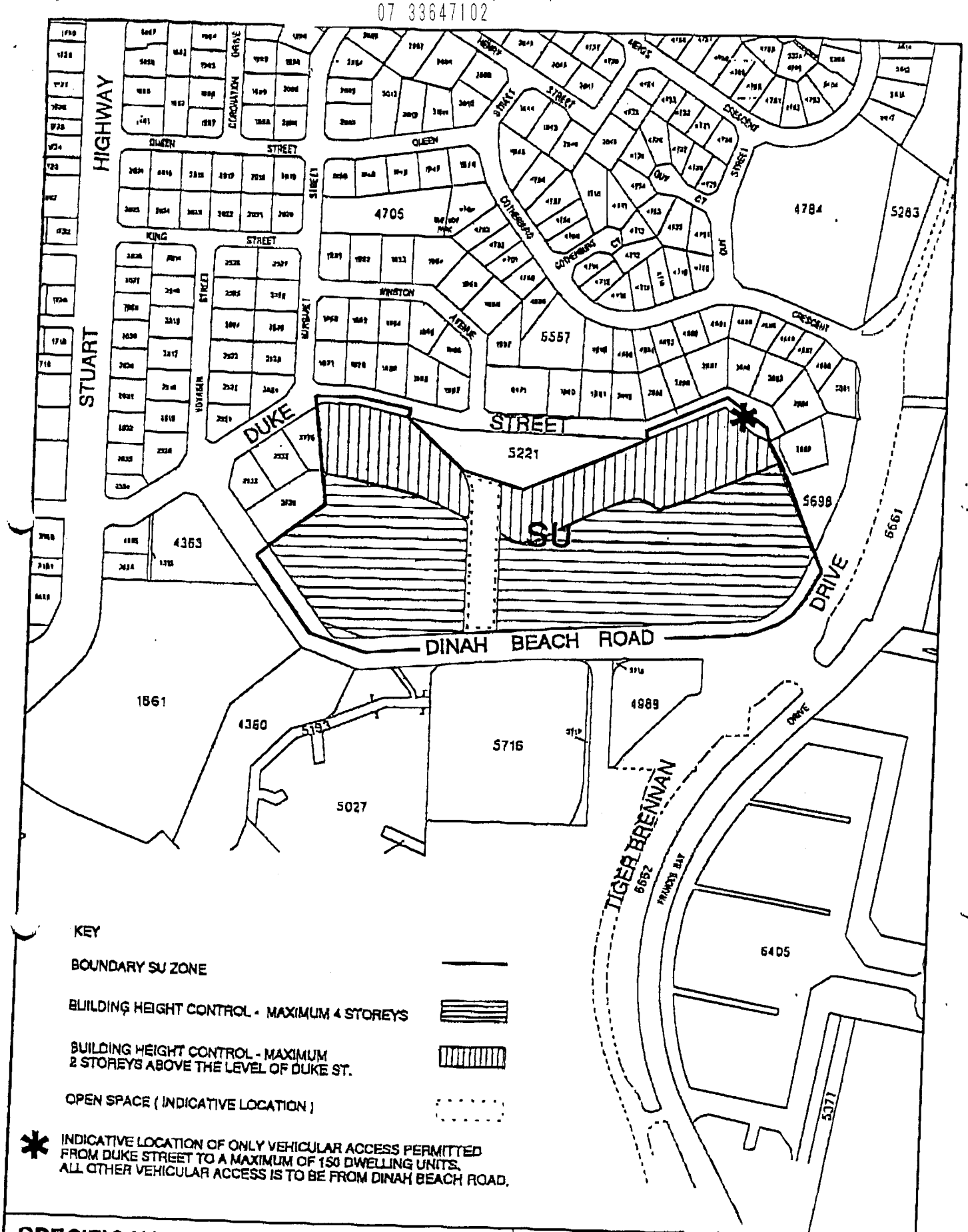
Perry McGarry

Environmental Officer – QLD/NT

BP Australia Limited
701 Kingsford Smith Drive
WHINSTANES QLD 4007
PO Box 718
HAMILTON QLD 4007

Darwin Town Plan

07 33647102



KEY

BOUNDARY SU ZONE

BUILDING HEIGHT CONTROL - MAXIMUM 4 STOREYS

BUILDING HEIGHT CONTROL - MAXIMUM 2 STOREYS ABOVE THE LEVEL OF DUKE ST.

OPEN SPACE (INDICATIVE LOCATION)

* INDICATIVE LOCATION OF ONLY VEHICULAR ACCESS PERMITTED FROM DUKE STREET TO A MAXIMUM OF 150 DWELLING UNITS. ALL OTHER VEHICULAR ACCESS IS TO BE FROM DINAH BEACH ROAD.

SPECIFIC USE (SU52) ZONE

LOTS 1662 & 5719
TOWN OF DARWIN

Diagrams to clause 15.23.1

LANDS PLANNING & ENVIRONMENT
Northern Territory Government

0 50 100 150 200 250 300m

Scale 1:5000

File No : PA99/1612 Date: 9/10/2000

Drawing Name
W:\DWN\DWN99511A.DGN

COLUMN 1	COLUMN 2
(51) Lots 6833 and 6834 Leanyer Drive, Town of Sanderson	With the consent of the Authority – (a) village-style housing comprising 46 single-storey **dwellings** for persons, predominantly pensioners, who are 55 years of age or more; and (b) a meeting room.
(52) Lots 1662 and 5719 Dinah Beach Road and Duke Street, Town of Darwin	1. With the consent of the Authority, for the following purposes: (a) **child care centre;** (b) **cluster dwellings;** (c) **community centre;** (d) **detached dwelling;** (e) **educational establishment;** (f) **flats;** (g) **guest-house and hostel;** (h) **home occupation;** (j) **hotel;** (k) **medical consulting rooms;** (m) **motel;** (n) **place of worship;** (p) **restaurant;** (q) **shop;** (r) **sports and recreation;** (s) **supporting accommodation.**

COLUMN 1	COLUMN 2
	2. A use or development for a purpose specified in paragraph 1 is subject to the following conditions: (a) building heights, open spaces and vehicular access are to be in accordance with the building heights, open spaces and vehicular access specified in the diagram to clause 15.23.1 headed "Item (52) Specific Use (SU) Zone Lots 1662 and 5719, Town of Darwin"; (b) buildings are not to cover more than 50% of each site at ground level; (c) landscaping is to occur on not less than 30% of each site at ground level; (d) landscaping plans are to be submitted with each development application; (e) loading and unloading areas for commercial developments are to be screened from passing traffic and pedestrians and located, where possible, on streets other than main streets. 3. The Authority may vary a condition specified in paragraph 2 if it is of the opinion that there are exceptional circumstances or better design solutions.