Substances	Health Investigation Levels (HILs)						Ecological Investigation Levels (EILs)		Back/ ground Ranges[6]
	A[1]	B[2]	C[3]	D	E	F	REIL[4]	Interim Urban[5]	
PETROLEUM HYDROCARBON COMPONENTS (CONSTITUENTS):									
Total Petroleum Hydrocarbons [15] C_6-C_9	65			65	65	65			
Total Petroleum Hydrocarbons C_{10}-C_{40}	1000			1000	1000	1000			
>C_{16} – C_{35} Aromatics[8]	90			360	180	450			
> C_{16} – C_{35} Aliphatics	5600			22400	11200	28000			
> C_{35} Aliphatics	5600			22400	11200	28000			
OTHER									
Boron	3000			12000	6000	15000			
Cyanides (Complex)	500			2000	1000	2500			
Cyanides (free)	250			1000	500	1250			
Phosphorus								2000	
Sulfur								600	
Sulfate[9]								2000	
Asbestos	No free asbestos fibres at ground surface								

Notes

1. Human exposure settings based on land use have been established for HILs (see Taylor and Langley 1998). These are:

   A. 'Standard' residential with garden/accessible soil (home-grown produce contributing less than 10% of vegetable and fruit intake; no poultry): this category includes children's day-care centres, kindergartens, preschools and primary schools.

   B. Residential with substantial vegetable garden (contributing 10% or more of vegetable and fruit intake) and/or poultry providing any egg or poultry meat dietary intake.

   C. Residential with substantial venerable garden (contributing 10% or more of vegetable and fruit intake); poultry excluded.

   D. Residential with minimal opportunities for soil access: includes dwellings with fully and permanently paved yard space such as high-rise apartments and flats.

   E. Parks, recreational open space and playing fields: includes secondary schools.

   F. Commercial/Industrial: includes premises such as shops and offices as well as factories and industries Sites. (For details on derivation of HILs for human exposure settings based on land use see Schedule B (7A).

2. Site and contaminant specific: on Site sampling is the preferred approach for estimating poultry and plant uptake. Exposure estimates may then be compared to the relevant ADIs, PTWIs and GDs.

3. Site and contaminant specific: on Site sampling is the preferred approach for estimating plant uptake. Exposure estimates may then be compares to the relevant ADIs, PTWIs and GDs.

4. These will be developed for regional areas by jurisdiction as required.

5. Interim EILs for the urban setting are based on considerations of phytotoxicity; ANZECC B levels, and soil survey data from urban residential properties in four Australian capital cities.

6. Background ranges, where HILs or EILs are set, are taken from the Field Geologist's Manual, compiled by D.A. Berkman. Third Edition 1989. Publisher – The Australasian Institute of Mining & Metallurgy. This publication contains information on a more extensive list of soil elements than is included in this Table. Another source of information is Contaminated Sites Monograph No. 4: Trace Element Concentrations in Soils from Rural & Urban Areas of Australia, 1995. South Australian Health Commission.

7. Valance state not distinguished – expected as Cr (III).

8. The carbon number is an 'equivalent carbon number based on a method that standardises according to boiling point. It is a method used by some analytical laboratories to report carbon numbers for chemicals evaluated on a boiling point GC column.

9. For protection of built structures.

10. The toluene threshold concentration is the Netherlands MPC to protect terrestrial organisms in soil. This value was obtained by applying a US EPA assessment factor to terrestrial chronic No observed Effect Concentrations (NOEC) data. The MPC is an 'indicative' value (Van de Plassche *et al.* 1993; Van de Plassche & Bockting, 1993)

11. Human Health and ecologically based protection level for toluene. The threshold concentration presented here is the Netherlands intervention value for the protection of terrestrial organisms. Other considerations such as odours and the protection of groundwater may require a lower remediation criteria.

12. The ethyl benzene threshold concentration is the Netherlands MPC for the protection of terrestrial organisms in soil. No terrestrial ecotoxicological data could be found for use in the Netherlands criteria derivation. Therefore, equilibrium partitioning has been applied to the MPC for water to obtain estimates of the MPC for soil. The MPC for water has been derived from aquatic ecotoxicological data (Van de Plassche et al. 1993, Van de Plassche & Bockting, 1993).

13. Human health based protection level for ethyl benzene or total xylene as shown. The threshold concentration presented here is the Netherlands intervention value. Other considerations such as odours and the protection of groundwater may require a lower remediation criteria.

14. The xylene concentration is the Netherlands MPC for the protection of terrestrial organisms in soil. No terrestrial ecotoxicological data could be found for use in the Netherlands criteria derivation. Therefore, equilibrium partitioning has been applied to the MPC for water to obtain estimates of the MPC for soil. The MPC for water has been derived from aquatic ecotoxicological data. The concentration shown applies to total xylenes and is based on the arithmetic average of the individual xylene MPCs (Van de Plassche et al. 1993, Van de Plassche & Bockting, 1993).

15. Approximate range of petroleum hydrocarbon fractions: petrol C6-C9, kerosene C10-C18, diesel C12-C18 and lubricating oils above C18.

8.1.2 Application of Petroleum Hydrocarbon Criteria

The previous investigations collected data on total petroleum hydrocarbon (TPH) fractions in soils and groundwater. The fractions analysed were unspeciated, meaning that the TPH compounds in a given hydrocarbon range were not differentiated in terms of aliphatic and aromatic compounds. The toxicological risks posed by TPH compounds vary according to both the hydrocarbon fractions and the speciated fractions. Different reference doses have been developed for aliphatic and aromatic (and alkene) compounds to reflect the significant differences in chemical, physical and environmental fate properties. Consequently, a more accurate assessment of health risks from TPH contamination in soils could be obtained by conducting speciated TPH analysis on areas of the site suspected of having elevated TPH concentrations.

This investigation included the collection of soil samples from each of the soil-gas probe locations to assess the likely aromatic and aliphatic TPH concentrations at the site. At least one soil sample was taken from each of the vapour sampling locations and subjected to unspeciated TPH laboratory analysis as well as BTEX. A summary of the laboratory data and the results of statistical analyses are presented in **Tables G - J**.

The data indicate that TPH was recorded in all samples apart from the sample taken at MW32. The maximum TPH concentration recorded was 2723mg/kg at MW33, which primarily consisted of a C16-C35 aromatic compounds at 2124mg/kg (represents 78% of TPH). Of the six samples where TPH concentrations were detected, 4 of the samples (ie. 66%) had high concentrations of the aromatic fractions compared to the aliphatic fractions.

The speciated TPH results indicate that the Investigation Levels for aromatic TPH fractions should be adopted in preference to the aliphatic TPH criteria because:

- A much higher proportion of samples had higher concentrations of aromatic TPH fractions than aliphatic fractions; and
- The NEPM Investigation Levels for aromatic TPH fractions are lower than for aliphatic fractions.

BTEX compounds were not detected in any of the soil samples taken during the installation of the vapour wells.

The data obtained by the soil gas monitoring also indicate that high BTEX soil vapour concentrations do not appear to be linked with high BTEX soil concentrations, suggesting that the volatile hydrocarbons that were measured in the soil vapour wells had largely migrated through the subsurface soils from areas of higher soil or groundwater contamination.

8.2 Groundwater Investigation Levels

The NSW DEC has endorsed the use of water quality criteria in the ANZECC & ARMCANZ (2000) *"Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000" and the NHMRC (2004) "Australian Drinking Water Guidelines"*. The ANZECC & ARMCANZ guidelines provide *Investigation Levels* for the protection of marine and freshwater aquatic ecosystems. The freshwater criteria are the relevant set for the Site given that the nearest water body is the headwaters of Alexandra Canal (Sheas Creek) located some 1.3km to the south of the Site where creek flows would consist of surface water drainage from the Redfern/Alexandria area (ie. non-tidal). The NHMRC (2004) guidelines provide *Investigation Levels* for the protection of human health and aesthetic considerations arising from drinking water.

Where *Investigation Levels* are not available in these guidelines for some of the potential contaminants of concern, water quality criteria have been sourced from other guidelines endorsed by the NSW DEC, which comprise:

- NEPC (1999a) *"Schedule B(1) Guideline on the Investigation Levels for Soil and Groundwater"*; and
- ANZECC (1992) *"Australian Water Quality Guidelines for Fresh and Marine Waters"*.

The ANZECC & ARMCANZ (2000) guidelines do not provide criteria for petroleum hydrocarbons C_{10}-C_{36}. For this analyte, the Dutch (2000) Mineral Oil criteria of 600 µg/L has been adopted. This *Investigation Level* has been adopted because:

- The concentrations of other more toxic hydrocarbon substances that may be detected by the TPH analysis have been individually analysed in this investigation. These other analytes comprise BTEX and PAHs;
- Dutch criteria are referred to in NSW EPA (1994) "Service Stations Guideline". No directive has been issued by the NSW DEC advising that their directive in the 1994 guideline be changed;
- The Dutch criteria were recently reviewed in 2000;
- The low reliability values given in the ANZECC guidelines are exceeding conservative and do not correspond to a 95% level of protection;
- The low reliability values given in the ANZECC guidelines were derived from a toxicological assessment of crude oil, which is not the same material as refined petroleum products. Crude oil contains a complex mix of both petroleum hydrocarbons and PAHs, with the PAHs posing a much greater risk than petroleum products as seen by the much lower criteria given in the ANZECC guidelines for PAHs compared to BTEX compounds;
- The low reliability values given in the ANZECC guidelines were derived for a marine environment rather than a freshwater environment which is more appropriate for this Site;
- The Dutch 2000 TPH criteria is between the ANZECC 2000 guideline values for benzene at a 99% and 95% level of protection in a marine environment. Since one of the most toxic substances in TPH would be benzene, it is reasonable to adopt a TPH criteria that is not less than the benzene criteria;
- No chemical laboratory in Australia is known to have a NATA-accredited test method that can reach the detection limits required by the low reliability values given in the ANZECC guidelines for crude oil; and
- There is a long precedence of using the Dutch TPH water criteria by Site Auditors and Environmental Consultants in many investigations over the past 10 years.

The ANZECC & ARMCANZ (2000) guidelines also do not provide criteria for petroleum hydrocarbons C_6-C_9. For this analyte, the Dutch (2000) Aromatic Solvents criteria of 150 µg/L has been adopted. This criteria seems appropriate since it is less than the ANZECC & ARMCANZ (2000) criteria for benzene and comparable to the toluene, ethylbenzene and xylenes criteria.

For other key contaminants where no health criteria are specified by these guidelines for drinking and recreational water, reference has been made to the USEPA's Preliminary Remedial Goals (PRGs) for Tap Water (www.epa.gov/region09/waste/sfund/prg/files/02table.pdf).

The ANZECC & ARMCANZ (2000) guidelines provide trigger levels for four different levels of protection for fresh and marine water, namely 99%, 95%, 90% and 80%. Here, protection level signifies the percentage of species expected to be protected. The guidelines recommend that these trigger levels be used to assess existing contamination only and are intended to prompt a site-specific assessment when they are exceeded. In addition, relevant *Investigation Levels* need to be developed when:

- *Investigation Levels* are not available for contaminants of concern and/or data are not available to enable the derivation of guideline values;
- Site conditions, receptors and/or exposure pathways differ significantly from those assumed in the derivations of the health based or ecological investigation levels.
- There are significant ecological concerns (eg. critical or sensitive habitat, threatened or endangered species, parklands or nature reserves).
- Observed background groundwater levels are outside the expected range.

Since the Site is more than a kilometre from the nearest waterbody, it is considered that the 95% protection level provides an appropriate trigger level for this study.

The NEPC (1999a) guidelines also advise that groundwater trigger levels (or investigation levels) *"are to be applied at the point of extraction and as response levels at the point of use, or where there is the likelihood of an adverse environmental effect at the point of discharge"*. However, the NSW DEC (1997) Site Auditor Guidelines recommend that groundwater *Investigation Levels* should be applied at the boundary of the Site. For this investigation, it is considered that the groundwater *Investigation Levels* should be applied at the boundary of the Site for the following reasons:

- Residential properties located adjacent to the down-gradient boundary of the Site are being redeveloped with deep basements, which creates a potential exposure pathway for human receptors;
- The NSW DEC (1999) Significant Risk of Harm Guidelines assess the risk of groundwater contamination at the site boundary;
- One of the objectives of the NSW Government's Groundwater Protection Policy is to protect the quality of groundwater resources of the State, to ensure that resources can support their identified uses and values in a sustainable, and economically, socially and environmentally acceptable manner (NSW DEC, 1994); and
- The NSW EPA (1994) Service Station Guidelines recommend that *"Contaminated aquifers and contaminated aquicludes should, as far as practicable, be remediated to the condition they were in before they became contaminated"* and *"If the analyte concentrations in groundwater exceed the relevant thresholds, the groundwater should be remediated to or below the*

threshold concentrations. If the threshold concentrations provided are not applicable, then the EPA should be consulted to determine the remediation goals".

A summary of the water quality criteria is provided in **Table 14** for the potential contaminants of concern at the Site.

- Table 14 Groundwater Investigation Levels (µg/L)

Substance	Fresh Water 95% Protection Level	Drinking Water	
		Health	Aesthetic
Metals/Metalloids			
Arsenic (total)	24 (5)	7	---
Cadmium	0.2	2	---
Chromium (III)	3.3	55000 (3)	---
Chromium (VI)	1.0	50	---
Copper	1.4	2000	1000
Iron	300	---	300
Lead	3.4	10	---
Mercury (inorganic)	0.06 (8)	0.001	
Nickel	11	20	---
Zinc	8	---	3000
PAHs			
PAHs (total)	3 (1,2)	---	---
Benzo(a)pyrene	0.05 (4)	0.01	---
Naphthalene	16	6.2 (3)	---
Fluoranthene	1 (4)	---	---
Phenanthrene	5 (4)	---	---
Anthracene	5 (4)	---	---
Benzo(a)anthracene	0.5 (4)	---	---
Benzo(k)fluoranthene	0.05 (4)	---	---
Indeno(1,2,3-cd) pyrene	0.05 (4)	---	---
Benzo(ghi)perylene	0.05 (4)	---	---
TPH & BTEX			
TPH (C6-C9)	150 (4)	---	---
TPH (C10-C36)	600 (4)	---	---
Benzene	950	1	---
Toluene	180	800	25
Ethylbenzene	50	300	3
o-Xylene	350	600	20
p-Xylene	200		
Phenols			

Substance	Fresh Water 95% Protection Level	Drinking Water	
		Health	Aesthetic
Phenol	320	22000 (3)	---
2-Methylphenol	---	1800 (3)	---
3-Methylphenol	---	1800 (3)	---
4-Methylphenol	---	180 (3)	---
2,4-Dimethylphenol	---	730 (3)	---
Other Organics			
n-Propylbenzene	---	240 (3)	
Styrene	530	30	4
Vinyl chloride	5 (4)	0.3	
Aniline	250	---	---
Dibenzofuran	---	24 (3)	---
Bis(2-ethylhexyl) phthalate	---	4.8 (3)	---
1,2,4- & 1,3,5-Trimethylbenzene	---	12 (3)	---
Other			
Cyanides (total)	7 (6)	---	---
Cyanides (free)	7	80	---
Ammonia	900	(7)	500
Sulfide	1	---	50
pH	6.5 – 9.0 (1)	---	6.5-8.5

Notes:

(1) ANZECC (1992) freshwater criteria
(2) NEPC (1999a) freshwater criteria
(3) USEPA Preliminary Remedial Goal for tap water
(4) Dutch 2000 Groundwater Intervention Value
(5) ANZECC (2000) Arsenic (III) criteria adopted for freshwater ecosystems
(6) A cyanide (total) criteria of 7 should only be used of no free cyanide results are available. If they are, then the free cyanide criteria should be used and not the total cyanide criteria.
(7) Ammonia does not pose a risk to human health since it is naturally occurring at high concentrations in the gut
(8) The 99% fresh water protection level has been adopted for inorganic mercury since the ANZECC & ARMCANZ (2000) guidelines recognise it as a chemical for which possible bioaccumulation and secondary poisioning effects should be considered.

8.3 Soil Gas Investigation Levels

Exposure standards for the occupational workplace published by Worksafe Australia have been adopted as the soil gas investigation levels for the Site. The document, *'Exposure Standards for Atmospheric Contaminants in the Occupational Environment, Worksafe Australia'*, (Worksafe

Australia, May 1995) contain both Guidance Notes [NOHSC:3008 (1995)] and the National Exposure Standards [NOHSC:1003 (1995)]. The document and the exposure standards are updated regularly on the Worksafe Australia website. All values listed below were confirmed through a review of the exposure database

The guidelines and exposure standards detail that the air inhaled at work should not contain chemical agents at concentrations that produce adverse effects on health, safety or well being. The exposure standards represent airborne concentrations of individual chemical substances, which, according to current knowledge, should neither impair the health of nor cause undue discomfort to nearly all workers. Additionally, the exposure standards are believed to guard against narcosis or irritation that could precipitate industrial accidents.

Except where modified by consideration of excursion limits, exposure standards apply to long term exposure to a substance over an eight-hour day, for a five-day working week, over an entire working life. The exposure standards do not represent 'no-effect' levels that guarantee protection to every worker and or occupier. Given the nature of biological variation and the range of individual susceptibility, it is inevitable that a very small proportion of workers who are exposed to concentrations around or below the exposure standard may suffer mild and transitory discomfort. An even smaller number may exhibit symptoms of illness.

Therefore the exposure standards are not fine dividing lines between satisfactory and unsatisfactory working conditions, but rather that they are best used to assess the quality of the working environment and indicate where appropriate control measures are required. The exposure standards listed in this publication only consider absorption via inhalation and are valid only on the condition that significant skin absorption cannot occur.

Benzene, toluene, xylene and PAHs are considered to be the key air toxics of concern at the Macdonaldtown Triangle Site, as indicated in **Section 5.6**. It is proposed that the quality of the air at the sampling locations should not exceed the Worksafe Australia occupational air quality standards given in **Table 15**.