

CONTAMINATED SITES

Guidelines for Assessing Service Station Sites

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PREFACE

The NSW Environment Protection Authority (EPA) has prepared these guidelines for assessing and remediating service station sites in order to protect the environment and minimise the risk to public health from the future use of service station sites in NSW. This document has been prepared by the Contaminated Sites Section, Hazardous Substances Branch of the EPA in consultation with the Department of Water Resources, the Australian Institute of Petroleum and the Service Station Association.

The EPA expects these guidelines will be used by environmental consultants, local councils, real estate agents, valuers and other groups with an interest in this area.

Inquiries may be directed either to the Manager, Contaminated Sites Section, EPA, or to the Manager of your nearest EPA Regional Office (see Appendix A).

The guidelines are scheduled for review in mid 1995, and comment is welcome. Written comments should be sent to the EPA by 28 February 1995, addressed to:

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LIMITATIONS

This document applies only to service station sites. It should be used with other relevant guidelines and information sources, including:

- *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites* (ANZECC/NHMRC 1992)
- *The Health Risk Assessment and Management of Contaminated Sites* (SA Health Commission 1991, 1993)
- *Test Methods for Evaluating Solid Waste — Physical/Chemical Methods SW846* (US EPA 1986, 1992 revision)
- *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association (APHA) et al. 1989).

These guidelines do not contain occupational health and safety procedures — the WorkCover Authority should be consulted regarding such requirements. Appropriate action must be taken to manage any potential hazard on site. Site assessments should document any such incidents.

DISCLAIMER

The EPA has prepared this document in good faith exercising all due care and attention, but no representation or warranty, expressed or implied, is made as to the accuracy, completeness or fitness for purpose of this document in respect of any user's circumstances. Users of this document should carry out their own investigations and where necessary seek appropriate expert advice in relation to their situations.

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LIST OF ACRONYMS

ANZECC — Australian & New Zealand Environment & Conservation Council

ARMCANZ — Agricultural & Resource Management Council of Australia & New Zealand

AWRC — Australian Water Resources Council

EPA — NSW Environment Protection Authority

NHMRC — National Health & Medical Research Council

QA/QC — Quality assurance/quality control

VOC — Volatile organic compound

I INTRODUCTION

The Australian oil industry began to rationalise the number of service station sites in the early 1970s. At that time there were about 20,000 operating service stations in Australia, but the Service Station Association estimates that by the end of this decade there will be only 6,500 stations still in operation (Service Station Association 1992). Of the many thousands of decommissioned service station sites in NSW, there may be some with elevated concentrations of petroleum product in soil and groundwater. Because such elevated concentrations could pose an unacceptable risk to human health and the environment, a site contamination assessment may be necessary.

If a service station site is being redeveloped, the appropriate planning consent authority (e.g. the local council) may require site assessment and remediation as part of the conditions of redevelopment approval (NSW Department of Planning 1991).

2 ASSESSING FORMER SERVICE STATION SITES

Assessment of old service station sites should conform to the Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites (ANZECC/NHMRC 1992). An approach to site assessment is discussed below. The site assessment should be documented in a detailed Site Assessment Report (see Section 5).

2.1 Desktop study before field work

Before the site assessor begins any field work on a decommissioned site, he/she should carry out a desktop study. The study may assist the site assessment by identifying potential on-site contamination, potential off-site receptors and potential routes of contaminant migration.

The desktop study should, where practicable, include:

- a full site identification — street address, DP and Lot Number

- the previous, current and proposed use of the site
- the previous, current and any potential future uses of all adjacent premises
- the names of past and current owner(s) of the site
- aerial and ground-level site photographs
- the results and conclusions of any earlier site assessments
- identification and location of all tanks, lines, bowsers and filling points
- the location and a description of any imported fill
- an inventory control check
- a tank and pipeline history, outlining the age of tanks, cathodic protection, maintenance and records of any product or waste spills and leaks
- details of local geology and hydrogeology, particularly the direction, flow rate and destination of groundwater
- current and potential future use of groundwater
- the location of any underground services that could act as contaminant conduits
- a preliminary assessment of the potential consequences of product spills and leaks.

2.2 Assessing the soil of a former service station site

An assessment of the soil on the site should focus initially on the location of site utilities, e.g. filling points, tanks, feed lines, pump stations, pits and utility trenches. If this utility-focused sampling is not possible, the site assessor should carry out volatile organic compound (VOC) field screening and soil sampling as described below. The site assessor should also record potential contamination of imported fill in the Site Assessment Report.

2.2.1 If the location of site utilities is known . . .

If the site assessor knows the location of utilities at a site, he/she should investigate the full nature and extent of any contamination. A 'Minimum Sampling Protocol' (see Table 1) is provided to help the site assessor select sampling locations, sampling depth, sampling density and to give him/her an idea of the contaminants that may be present. If the site assessor needs to vary this protocol, he/she should

record the reasons for the variations. Samples should be collected in a manner that will minimise the loss of volatiles.

In areas of the site that are not immediately associated with site utilities, the site assessor should carry out soil sampling as described below.

A typical tank installation diagram is shown in Figure 1. Sampling procedures are discussed in Appendix C.

2.2.2 If the location of site utilities is *not* known . . .

If some or all of the service station equipment has been removed from the site and there are no records of the locations of former utilities, the site assessor should use the soil sampling strategy described in Section 2.2.4.

If measured analyte concentrations are above the appropriate threshold concentrations specified in Section 2.5, the site assessor may need to use a more intensive sampling strategy.

NB. A magnetometer may be used to help locate the tanks and associated pipework.

2.2.3 Field screening for VOCs

Field screening, using field photo-ionisation detectors (PIDs) and field flame ionisation detectors (FIDs), is used to gather information that will make the laboratory analyses more focused. Data from PIDs and FIDs provides only non-quantitative information, and needs to be supported by laboratory data.

The site assessor should also screen ambient air and soils at background locations adjacent to the site. These background screening locations should be fully documented.

For field screening, the controlled headspace method may be better than ambient soil gas measurements, so long as it is employed in a way that minimises the loss of volatiles.

PIDs and FIDs should only be operated by trained personnel. The site assessor should keep training records, instrument maintenance records and calibration records.

2.2.4 Proposed general sampling strategy

For a site area of 0.2 hectares, the site assessor should sample at least 28 evenly distributed sampling locations. This corresponds to an

Table I Minimum soil sampling protocol—service station sites

Location	Number of Samples
Underground storage tank (UST) pit backfill sands	Two per tank
UST pit natural soils	Two (may not be necessary if backfill sands are found to be unaffected)
UST pit water	One
Pump station	One per pump station backfill and one per natural soil (if needed)
Fuel feed lines to pumps	One per line
Above-ground fuel storage (drum/tank)	One per 25 m ²
Below-ground waste oil tank 8100	Two per tank
Spent battery storage	One per 25 m ²
Waste disposal areas (including wastewater disposal on site)	One per 25 m ²
Imported fill	One per 100 m ³

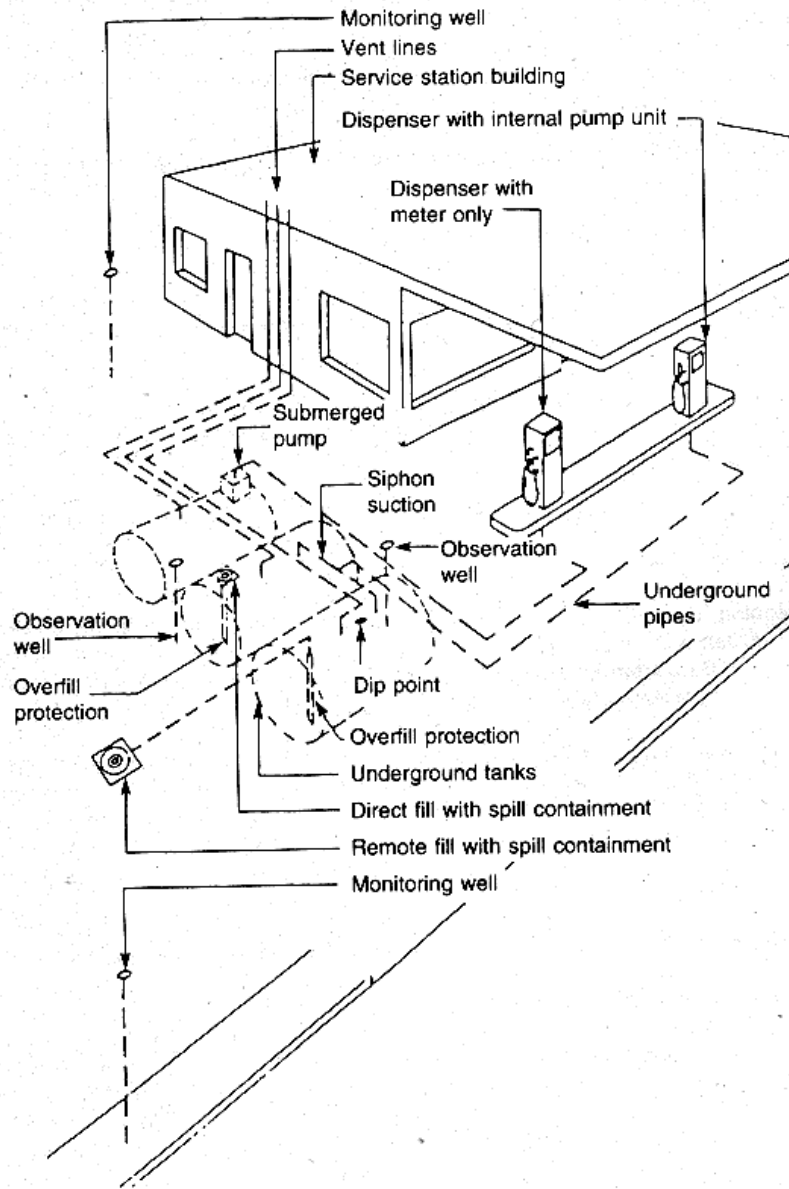
a — total petroleum hydrocarbons: C6–C9 and C10–C36

b — benzene, toluene, ethyl benzene, xylene and total BTEX

c — polycyclic aromatic hydrocarbons

Action	Analytes
Collect auger/borehole samples if tank is to remain in place, or during excavation and tank removal. Samples to be taken at or below the bottom of the tanks.	<ul style="list-style-type: none"> ● TPH^a ● BTEX^b ● lead (if leaded fuel or fuel type unknown)
Samples between 0–200 mm into surrounding soil.	<ul style="list-style-type: none"> ● TPH ● BTEX ● lead (if leaded fuel or fuel type unknown)
Sample if there is water present and backfill sands or natural soils appear contaminated.	<ul style="list-style-type: none"> ● TPH ● BTEX ● lead (if leaded fuel or fuel type unknown)
Sample area adjacent to line and pump junction, taking representative sample of backfill during excavation and removal of pumps; if contamination apparent, sample 0–200 mm into natural soils.	<ul style="list-style-type: none"> ● TPH ● BTEX ● lead (if leaded fuel or fuel type unknown)
Take representative sample of backfill sands and, if it appears contaminated, sample 0–200 mm into natural soils.	<ul style="list-style-type: none"> ● TPH ● BTEX ● lead (if leaded fuel or fuel type unknown)
Collect auger/borehole samples in areas of spills, otherwise collect samples below storage area at depth intervals of 0–200 mm and 200–500 mm.	<ul style="list-style-type: none"> ● TPH ● BTEX ● lead (if leaded fuel or fuel type unknown)
Collect auger/borehole samples if tank is to remain in place or collect samples during excavation and tank removal.	<ul style="list-style-type: none"> ● TPH ● PAHs^c as listed in USEPA SW846 Method ● lead ● phenol
Take representative auger samples in the 0–200 mm layer.	<ul style="list-style-type: none"> ● lead ● pH
Collect auger/borehole samples at the site of contamination or within the disposal area in the 0–200 mm layer.	<ul style="list-style-type: none"> ● TPH ● pH ● lead
Imported fill to be accompanied by certificate from supplier, otherwise collect representative auger/borehole composite samples from surface to natural ground level.	<ul style="list-style-type: none"> ● metals (Pb, Cd, Cr, Zn, Cu, Hg, As) ● TPH ● BTEX ● organochlorine pesticides and PCBs as listed in US EPA SW846 Method 8080

Figure 1 Typical service station layout



evenly-spaced grid of about 8.5 m. This sampling density is based on the 95% probability of finding a circular area 10 m in diameter of elevated analyte concentrations at the soil surface (Gilbert 1987).

At each sampling location, the site assessor should take soil samples at a minimum of three depths. Two of the sampling depths should be between 0–200 mm and 200–500 mm, depending on the soil stratigraphy and any apparent contamination. The third sampling depth should be below the estimated depth of the former tanks. Two samples should be taken at each depth, one for field screening and the other for laboratory analysis.

Not all duplicates may be needed for laboratory analysis. Final selection of samples should be based on site observations, site history and VOC headspace readings. The site assessor should fully document the reasons for selecting each sample.

The ratio of at least 28 locations per 0.2 hectares should be used for all sites where the location of utilities is not known. Based on site history or other evidence, the site assessor may decide to use an alternative sampling strategy, but the reasons for using the alternative strategy should be fully explained and justified in the Site Assessment Report.

The samples should be analysed for all analytes listed in Table I, using the methods outlined in Appendix D. If imported fill is not present, analysis need not be carried out for contaminants associated with imported fill.

2.3 Assessing groundwater at a former service station site

If any groundwater is found at a site, it should be collected and submitted for laboratory analysis. The groundwater samples should be taken at the point where the saturated zone meets the unsaturated zone, or at greater depth based on field observations of contamination, using sampling procedures outlined in Appendix C.

The 'Minimum Sampling Protocol' in Table 2 should help the site assessor select sampling locations, sampling depth and sampling density, and give him/her an idea of the contaminants that may be present. If the site assessor needs to vary this protocol, he/she should record the reasons for the variations.

Where groundwater is present, the site assessor should drill at least one monitoring well on the site to assess groundwater quality. The reasons for the number and location of the well(s) should be documented.

If groundwater contamination is confirmed, then the extent of off-site

Table 2 Minimum groundwater sampling protocol — service station sites			
Location	Minimum no. of boreholes	Action	Analytes
Adjacent to and down hydraulic gradient of any contamination sources on site	One per contaminated area on site	Collect auger/ borehole soil samples and water samples from monitoring wells. The sampling depth will be dictated by the local hydrogeological conditions.	<ul style="list-style-type: none"> ● TPH ^a ● BTEX ^b ● lead (if leaded fuel or fuel type unknown) ● PAHs ^c as listed in US EPA SW846 Method 8100 and phenol if waste oil or source unknown
Adjacent to site perimeter, down hydraulic gradient and off-site where possible with consent and approvals	One per site to check for off-site migration if on-site groundwater contaminated		
Adjacent to site perimeter, up hydraulic gradient and off-site where possible with consent and approvals	One per site as a control if on-site groundwater contaminated		
<p>a — total petroleum hydrocarbons: C6–C9 and C10–C36 b — benzene, toluene, ethyl benzene, xylene and total BTEX c — polycyclic aromatic hydrocarbons</p>			

migration should be assessed by drilling at least two monitoring wells down the hydraulic gradient of the tank pits and/or other potential contaminant sources, and at least one well up the hydraulic gradient as a control. During well construction, soil samples should be collected from the point where the saturated zone meets the unsaturated zone, or at greater depth based on field observations of contamination.

Any groundwater bores, including monitoring wells, must be licensed by the Department of Water Resources under Part V of the Water Act 1912. The construction of groundwater monitoring wells must not lead to contamination of underlying aquifers and aquicludes separated by impervious strata from contaminated surface material.

If the excavation and chemical testing of the tank pits and other areas of elevated contaminant concentrations shows that there has been no migration of contaminants, there may be no need to drill monitoring wells. This should be discussed in the Site Assessment Report.

2.4 Chain of custody

The Site Assessment Report should include a Chain of Custody (COC) form filled out by the people responsible for each stage of the sampling procedure — an example COC form is provided in Appendix B. The COC form should be completed and signed on-site by the field staff and the courier, and later by the laboratory staff.

2.5 Threshold concentrations

Threshold concentrations are included in these guidelines (see Tables 3 and 4) to assist site assessment. However, the scientific information needed to derive threshold concentrations is incomplete for some analytes, and guideline recommendations cannot be made. Threshold concentrations also have to allow for the limitations of available remediation technologies.

The Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites state that:

The goals of contaminated site assessment and clean-up should be to:

- render a site acceptable and safe for the long-term continuation of its existing use
- minimise environmental and health risks both on and off site
- maximise, to the extent practicable, the potential future uses of a site (ANZECC/NHMRC 1992).

If a former service station site is earmarked for a sensitive land use, then the site should be remediated so that analyte concentrations in the soils are at or below the threshold concentrations in Tables 3 and 4, unless otherwise stated.

2.5.1 Groundwater

Groundwater quality is protected in New South Wales by the Environmental Planning and Assessment Act 1979, the Water Administration Act 1986, the Clean Waters Act 1970 and the Water Act 1912. Under those Acts it is an offence to pollute waters, including groundwaters.

The objective of the current *Draft Groundwater Quality Protection Policy for New South Wales* (NSW WRC 1992) 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'.

Table 3 Threshold concentrations for sensitive land use — soils		
Analytes	Threshold concentrations ^a (mg/kg dry wt)	Sources
TPH ^{b, c} : C6–C9	65	see note ^d
TPH ^c : C10–C40 (C10–C14, C15–C28, C29–C40)	1,000	see note ^e
Benzene	1 ^f	ANZECC /NHMRC 1992
Toluene	1.4 ^g / 130 ^h	Netherlands 1994
Ethyl benzene	3.1 ⁱ / 50 ^j	Netherlands 1994
Total Xylenes	14 ^k / 25 ^j	Netherlands 1994
Phenol	— ^l	— ^l
Total Lead	300	ANZECC /NHMRC 1992
Benzo(a)pyrene	1	ANZECC /NHMRC 1992
Total PAHs ^m	20	ANZECC /NHMRC 1992
<p>NB. Scientifically justified alternative threshold concentrations may be acceptable. Thresholds may be reviewed as new scientific information becomes available.</p>		
<p>Explanatory notes for Table 3</p> <p>a Refer to relevant source documents for details.</p> <p>Definitions of terms used in discussion of Netherlands criteria (Denneman 1993) are:</p> <ul style="list-style-type: none"> • The maximum permissible concentration (MPC) is the 'concentration of a toxic substance that fully protects 95% of the species in an ecosystem'. • The intervention level represents 'a level where action is needed because impermissible risks may occur. It depends on other than chemical characteristics if action should take place immediately or not'. In the case of ecological risk, the intervention level 'fully protects 50% of the species in an ecosystem'. <p>Further information regarding MPCs and intervention levels may be found in Denneman & van den Berg 1993.</p> <p>The Netherlands sourced values in Table 2 refer to soil with 10% natural organic matter content. These threshold concentrations must be adjusted for the particular natural organic matter content of the specific site. The natural organic matter content in soil may be determined using the Walkley and Black Method, AS 1289.D1.1–1977, <i>Determination of the Organic Matter Content of a Soil (Standard Method)</i>.</p> <p>The threshold concentrations for ethyl benzene and xylenes to protect terrestrial organisms have been derived from aquatic toxicological data using equilibrium partitioning. Investigations have shown (Van Gestal & Ma 1993) that in the case of earthworms, toxicity is related to the pore water contaminant concentration. The LC₅₀ pore water concentrations for several compounds have been favourably compared with LC₅₀ aquatic toxicological data for fish.</p>		

Explanatory notes for Table 3 (cont.)

The derivations of criteria adopted as threshold concentrations have not explicitly taken account of chemical mixtures. The potential impact of mixtures of chemicals should be assessed on a site-specific basis.

The potential for the generation of odours may mean that lower thresholds than those listed in Table 2 are required for volatile compounds.

- b Total petroleum hydrocarbons
- c Approximate range of petroleum hydrocarbon fractions: petrol C6–C9, kerosene C10–C18, diesel C12–C18 and lubricating oils above C18.
- d The TPH C6–C9 threshold concentration, i.e. 65 mg/kg, applies to soil containing 10% natural organic matter. This concentration has been calculated assuming the following:
 - that there has been a fresh spill of petrol
 - that the aromatic content of the petrol is 30%
 - that the resultant BTEX soils concentrations are at their lower thresholds.TPH C6–C9 concentrations above the relevant threshold may indicate that BTEX concentrations are above their thresholds. This threshold concentration should be interpreted as only an approximate potential indicator of contamination.
- e The TPH C10–C40 threshold concentration is based on a consideration both of the Netherlands Intervention Level for the TPH C10–C40 range and on commonly reported analytical detection limits. The Netherlands intervention value is 5,000 mg/kg dry weight.
- f A lower benzene threshold concentration may be needed to protect groundwater.
- g 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 Concentration (NOEC) data. The MPC is an 'indicative' value (Van de Plassche *et al.* 1993; Van de Plassche & Bockting 1993).
- h 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 criterion.
- i 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).
- j Human health based protection level for ethyl benzene or total xylenes 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 criterion
- k The xylene 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 an estimate 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).
- l Phenol contamination is not expected to be significant at service station sites. Phenol has been included in the analyte list because it is a potential constituent of waste oil. The potential impact of phenol should be evaluated on a site-specific basis. Phenol may have a significant impact on waters.
- m Polycyclic aromatic hydrocarbons

Contaminated aquifers and contaminated aquicludes should, as far as practicable, be remediated to the condition they were in before they became contaminated.

If groundwater is to be used for drinking water, analyte concentrations should not exceed the relevant drinking water guidelines: *Guidelines for Drinking Water Quality in Australia* (NHMRC/ AWRC 1987), and *Draft Australian Drinking Water Guidelines* (NHMRC/ ARMCANZ 1994). The draft NHMRC/ARMCANZ (1994) guidelines have been released for public comment, so some proposed guideline values may change upon review.

Groundwater that enters aquatic ecosystems (freshwater or marine) should not cause concentrations in the receiving ecosystem to exceed the relevant water quality guideline recommendations. See *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 1992).

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.** The site assessor should keep a record of the reasons for selecting particular threshold concentrations. If other groundwater uses (e.g. industrial or agricultural) are affected, then other guideline recommendations should be considered (see ANZECC 1992).

The threshold concentrations may not apply in the following circumstances:

- when an appropriate human health risk assessment or ecological risk assessment demonstrates that lower or higher concentrations may be applicable
- when an appropriate risk-benefit analysis demonstrates that lower or higher concentrations may be acceptable.

2.5.2 How threshold concentrations have been selected

Threshold concentrations have, wherever possible, been selected from Australian sources, including ANZECC, NHMRC and ARMCANZ. In cases where the information was not available locally, Netherlands sources have been used (see Bibliography).

Threshold concentrations for soils are presented in Table 3. The concentrations have been taken from ANZECC/NHMRC (1992), and the Netherlands Ministry of Housing, Environment etc. (1994).

Threshold concentrations for waters are presented in Table 4. The

Table 4 Threshold concentrations—waters					
Analytes	Threshold concentrations (µg/L) ^a				
	Protection of drinking water		Protection of aquatic ecosystems ^b		
	Health-based	Sources	Fresh	Marine	Source
TPH: C6–C9	— ^c	— ^c	— ^e	— ^e	— ^e
TPH: C10–C36	— ^d	— ^d	— ^e	— ^e	— ^e
Benzene	10 ^f	NHMRC/AWRC	300	300	ANZECC
Toluene	800 ^g	NHMRC/ARMCANZ	300	— ^c	ANZECC
Ethyl benzene	300 ^g	NHMRC/ARMCANZ	140	— ^c	ANZECC
Xylene	600 ^g	NHMRC/ARMCANZ	380 ^h	380 ^h	Netherlands 1994
Phenols	2	ANZECC	50	50	ANZECC
Benzo(a)pyrene	0.01	NHMRC/AWRC	— ^c	— ^c	— ^c
PAHs	— ^c	— ^c	3	3	ANZECC
Lead	10	NHMRC/ARMCANZ	1–5 ⁱ	5	ANZECC

NB. Scientifically justified alternative threshold concentrations may be acceptable. Thresholds may be reviewed as new scientific information becomes available.

Explanatory notes for Table 4

a Refer to the relevant source documents for details. The unit µg/L = micrograms per litre.

b Groundwater entering aquatic ecosystems should not cause concentrations to exceed the relevant threshold concentrations.

c Information needed to select threshold concentrations is incomplete.

d Information needed to select threshold concentrations is incomplete. Alkanes in this range have low solubility and are unlikely to be of concern in water. All separate phase products must be removed.

e Information needed to select threshold concentrations is incomplete. The NSW Clean Waters Act 1970 and Clean Waters Regulations 1972 prohibit the pollution of waters by unlicensed contaminated discharges and require licensed discharges to be visually free of oil and grease. Experience has demonstrated that the latter criterion is equivalent to an oil and grease concentration of approximately 10 mg/L.

f NHMRC/ARMCANZ 1994 proposed 1 µg/L as the new benzene guideline concentration. This has not yet been adopted.

g NHMRC/ARMCANZ 1994 proposed concentrations are similar to WHO 1993 drinking-water quality guideline concentrations.

h Netherlands 1994 Maximum Permissible Concentration for total xylenes.

i Dependent on water hardness.

concentrations have been taken from NHMRC/AWRC (1987), NHMRC/ARMCANZ (1994) and ANZECC (1992).

The threshold concentrations are based on an assessment of potential human health and ecological impacts. In some cases, the threshold concentrations may have to be lowered for aesthetic reasons. Threshold concentrations for soil and waters have not been harmonised to equilibrium conditions. Chemical equilibria may affect threshold concentrations.

2.6 Chemical analysis

The EPA recommends that laboratories use US EPA, APHA or equivalent analysis procedures for all analytes (currently recommended analytical methods are outlined in Appendix D). Practical quantitation limits (PQL)¹ and sample quantitation limits (SQL) must be consistent with threshold concentrations. A Site Assessment Report should state the PQL and SQL for each analyte.

All chemical analyses should be carried out by a laboratory that is currently accredited by NATA (or an equivalent organisation) for that particular chemical analysis. If a non-accredited laboratory is chosen for primary assessment work, then 10% of the samples should be duplicated and submitted to an accredited laboratory for the same analysis using an accredited analytical method.

VOC losses may be considerable during field sampling and laboratory analysis. Therefore, it is essential to demonstrate data quality through a data quality assurance and data quality control (QA/QC) program. The QA/QC program should include an estimate of VOC losses.

¹ The practical quantitation limit (PQL) is a testing threshold, the lowest level that can be reliably determined within specified limits of precision and accuracy during routine laboratory operating conditions.

3 REMEDIATING FORMER SERVICE STATION SITES

Remediation strategies should take into account the environmental impact of the actual remediation operations, including the impact on air quality, water quality, noise levels and waste management.

The EPA has identified the following priority environmental outcomes:

- improvement in air quality to protect public health and amenity
- improvement in inland water quality, including groundwater, in both urban and rural areas, acknowledging the value of our waterways to public health, ecosystem sustainability and economic development
- minimisation of noise in urban and rural areas
- reduced volume and toxicity of waste that requires landfill or treatment, including solid waste and hazardous substances
- improved disposal and/or recycling of waste.

Section 19 of the Clean Air Act 1961, which applies to premises not scheduled under the Act, states that the occupier of any premises shall conduct any business or activity 'in or on such premises by such practicable means as may be necessary to prevent or minimise air pollution'. Premises scheduled under this Act are bound by Section 15A which prohibits the emission of any odour from these premises. Section 16 of the Clean Waters Act 1970 prohibits unlicensed contaminated discharges to surface or groundwaters.

Separate phase products must be contained and removed from the site — the site assessor should talk to the nearest Regional Office of the EPA about disposal procedures. Any separate phase product should be fully documented in the Site Assessment Report.

3.1 Hierarchy of remediation methods

The EPA encourages the use of on-site, *in-situ*, emission controlled and economical treatment technologies. The following preferred options, in decreasing order of preference, should be used to remediate contaminated soils at service station sites:

- on-site *in-situ* remediation of soil and groundwater, e.g. air sparging, soil venting, and nutrient injection
- on-site *ex-situ* treatment and remediation of soil and

groundwater, e.g. enclosed bioremediation cells and pump and treat systems with emission controls

- on-site landfarming, with enhanced bioremediation and comprehensive odour and stormwater controls, at sites where the soils are contaminated with low concentrations of volatiles or at sites remote from residential areas
- off-site controlled soil treatment
- off-site controlled remediation of soil at a licensed waste depot and subsequent use as cover material
- off-site disposal to a licensed waste depot as contaminated soil after EPA approval
- 'cap and contain' strategy with human health/ecological risk assessment to confirm remediation is appropriate.

3.2 Approvals

The site assessor may need to get approval from the local Council before he/she begins any demolition, excavation or remediation work. The local Council and/or the EPA can also impose odour, stormwater and/or noise control conditions on a site by issuing an Order or Notice.

Some technologies that are currently used (e.g. pump and treat techniques for groundwater contamination) may require approvals and licences from the EPA. In general, an approval may be required by the EPA under Section 19 of the Clean Waters Act if apparatus, equipment or works are to be installed, constructed or modified for the storage, treatment or discharge of pollutants to any waters.

3.3 Emission controls

If *in-situ* treatment processes designed to prevent emissions cannot be used, then *ex-situ* systems (e.g. enclosed bioremediation cells with exhaust gas treatment) should be used wherever practicable.

Controlled landfarming and enhanced bioremediation may be sufficient remediation for sites that are remote from residential areas or that have soils with low concentrations of volatiles, so long as all potential odour and stormwater problems are thoroughly managed.

However, if there are high concentrations of volatiles present and the soil is to be excavated, the soil may need to be vented and emissions controlled before excavation. During any excavation operation, the site assessor should use work practices that are designed to minimise

the impact of emissions — e.g. using water sprays, minimising the working face, and taking local weather conditions into account.

Using controlled landfarming and enclosed bioremediation cell techniques at landfill depots and other private facilities enables the remediated soil to be used as cover at the depot, or even as clean fill. Such operations must be carried out under the control of the EPA's Regional Office, but they avoid the expensive practice of using waste depots as a direct means of disposing of contaminated soil.

4 VALIDATING FORMER SERVICE STATION SITES

Validation sampling and chemical analyses must be carried out to demonstrate that the site has been remediated to a standard that is suitable for the proposed land use, and is not harmful to human health or the environment. The results of a successful validation should be contained in a Validation Report.

PID and FID data are not enough to validate remediation of a site without supporting laboratory data. QA/QC procedures should be included in the validation sampling and analysis program (US EPA 1989). Judgmental sampling (i.e. sampling that does not use a systematic sampling pattern) is not appropriate for validation sampling.

A systematic sampling pattern is recommended for the validation sampling plan. The data obtained from the validation program should be statistically analysed. For a former service station site to be validated, the upper 95% confidence limit² on the average site concentration for each analyte must be below the relevant threshold concentration.

4.1 Validating surface soils

² The upper confidence limit is a statistically calculated concentration that provides the upper bound measurement of the average concentration of a sampling area.

To validate the remediation of surface soils, samples should be collected on a regular 8.5 metre grid or any demonstrably similar sampling pattern. This sampling density is consistent with that specified in section 2.2 above.

4.2 Validating tank excavation pits

To validate a single tank excavation pit, one sample should be collected from the floor and one from each wall of the pit.

To validate a multiple tank excavation pit, the number of samples should be increased to give a sampling density similar to that used to validate a single tank excavation pit.

4.3 Validating excavated remediated material and imported fill

To validate remediated excavated homogeneous material, one sample per 25 m³ should be collected and analysed for site contaminants. Samples should be collected from the undisturbed bulk of the material, rather than from surface soils.

To validate imported fill, one sample per 25 m³ should be collected and analysed for the site analytes specified for imported fill, as listed in Table I. Samples should be collected from the undisturbed bulk of the imported fill, rather than from surface soils.

5 REPORTING

The site assessor should prepare detailed reports. In some cases, the reporting process may be separated into the following stages:

- Preliminary Work Plan
- Site Assessment Report
- Draft Remedial Action Plan
- Final Report, including site validation.

The following minimum information should be provided in reports:

- 1 Summary
- 2 Table of contents
- 3 Complete site identification
- 4 Name of owner and occupier
- 5 Names of the people responsible for the site assessment
- 6 The site history and proposed future use, including previous, current and proposed land use
- 7 The physical characteristics of the site, including:
 - geology
 - hydrogeology
 - topography
 - background concentrations of analytes in soil and groundwater
- 8 Preliminary site assessment, including:
 - site and background PID and/or FID measurements
 - instrument calibration details
 - reasons for selecting site sampling locations
 - reasons for selecting background sampling locations
 - description of sampling and analysis methodology
 - field observations
 - description of sampling equipment
 - field QA/QC
 - chain of custody details
- 9 Chemical analyses, including:
 - all results presented in tabular form
 - results of analyses of blanks and spike/surrogate recoveries
 - laboratory sheets presented in Appendixes
 - physical units clearly specified
 - reference to laboratory analytical procedures used
 - analytical detection limits
 - practical and sample quantitation limits (PQL and SQL)
 - laboratory QA/QC
 - dates of sample collection and analysis
- 10 Discussion of contamination assessment, including:
 - detailed data evaluation
 - reasons for adopting particular soil and water threshold concentrations
 - clear identification of concentrations that exceed threshold concentrations
 - relationship of site concentrations to background concentrations, to proposed land use, and to proposed

- groundwater use
 - human health and/or ecological risk assessment, where appropriate
 - risk-benefit analysis, where appropriate
 - description of contamination sources and contaminants
 - description of extent of contaminant migration
- 11 Imported fill, including discussion of:
- results of desktop study
 - results of fieldwork
 - results of sampling and chemical analysis
- 12 Remediation strategy(ies), including:
- remediation options
 - remediation costs and benefits, where appropriate
- 13 Recommended remediation strategies, including:
- detailed design
 - estimated duration of field operations
 - approvals/licences required
 - contingency for noise and odour mitigation, and stormwater run-off
 - occupational health and safety plan approved by the WorkCover Authority of NSW
- 14 Validation Report, including:
- size of surface areas and/or volumes validated
 - a plan of sample locations for each analyte
 - the statistical confidence level achieved
 - a statement that the remediated site is suitable for the proposed land use
- 15 Bibliography
- 16 Appendixes, including:
- maps and aerial photographs
 - site photographs
 - certificates of title
 - details of sampling method and procedures
 - borehole logs
 - laboratory data
 - QA/QC protocol
 - certificates of clearance, e.g. for asbestos removal
 - statistical justification for validation strategy
 - risk assessment, where appropriate
 - risk-benefit analysis, where appropriate
 - licences and approvals from the EPA, where appropriate.

6 COSTS AND BENEFITS

At least 500 of the 2,000 service station sites expected to be decommissioned in Australia before the end of this decade are in NSW. The cost of assessing and remediating these sites will vary depending on site-specific factors.

6.1 The costs of *assessing* a site

The current costs of site assessment, not including decommissioning costs, generally range between \$3,500 and \$8,000. The implementation of these guidelines will increase the minimum cost of site assessment to about \$5,500 for sites without groundwater, and to about \$8,000 for sites where groundwater monitoring wells need to be drilled. These cost increases are a result of the more rigorous sampling, analysis and reporting requirements that are needed to provide a greater level of regulatory confidence in the site assessment.

6.2 The costs of *remediating* a site

Remediation costs range from approximately \$10,000 up to, and in some cases exceeding, \$200,000. However, the type and extent of contamination found at most service station sites means that remediation costs are often at the lower end of this range. Where landfarming and direct off-site disposal to a landfill are replaced by alternative technologies (incorporating suitable emission controls), costs may rise by between 25% and 60%.

6.3 The *benefits* of remediating a site

Increased use of emission-controlled on-site and off-site treatments will result in a number of environmental benefits. The treatments proposed in these guidelines will reduce the amount of VOCs, including benzene, that are emitted to the atmosphere, and thereby reduce the incidence of photochemical smog. On-site remediation will also minimise the amount of contaminated soil that needs to be transported off-site. Both on-site and off-site controlled remediation will eliminate the need to use valuable landfill space in metropolitan areas.

There will also be a greater community confidence that soil and groundwater contamination have been detected and remediated,

reducing potential public health risks and maximising potential future land and groundwater use. This increased confidence should mean that remediated sites become more valuable and attract higher land prices.

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APPENDIX A EPA Offices

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APPENDIX C

Sampling and Analysis Procedures

I General

Laboratory-prepared sample jars should be used to collect samples. These are available from analytical laboratories upon request. All samples should be collected quickly to minimise the loss of volatile and semi-volatile compounds.

When collecting samples, the site assessor should make one member of the sampling team responsible for all documentation — e.g. labelling and borehole logs — and the other members should collect samples. The site assessor should also ensure that there is no cross-contamination between sampling events. Once taken, the samples should immediately be sealed and labelled with the following:

- the name of the person who collected the sample
- the date, time and place the sample was collected
- the weather conditions at the time of collection
- an identification of the sample.

All sample containers should then immediately be placed in a plastic bag in a cooler/esky below 4°C, taking care to ensure that melted ice does not cause the sample containers to become submerged.

All sampling equipment must be decontaminated before and between sampling events — the EPA recommends a phosphate-free detergent solution, followed by a tap water rinse and a final rinse with distilled water. Heavy equipment, such as drilling rigs and backhoes, should be thoroughly steam-cleaned or water-blasted before they arrive on site, and again between each sampling event. The site assessor should ensure that the decontamination process does not itself pollute waters or further pollute the land.

2 Soil samples

Refer to US EPA (1986).

2.1 Lead

Samples should be collected in laboratory-prepared polyethylene or glass bottles.

2.2 Volatile organic compounds — C6 to C9 fraction & BTEX

Samples should be collected in laboratory-prepared VOC vials. VOC samples should be taken on an individual rather than a composite basis. All samples should be taken in a manner that minimises VOC losses. The samples should be sealed immediately with zero headspace. The site assessment should quantify VOC losses.

2.3 Non-volatiles & semi-volatiles — C10 to C36 fractions, PAHs & phenol

Samples should be collected in wide-mouthed laboratory-prepared jars. If compositing these samples, stainless steel equipment should be used.

3 Surface water

Refer to American Public Health Association *et al.* (1989).

Samples should be collected in narrow-mouthed laboratory-prepared sample jars. The jars should be rinsed three times with the sample water before the final sample is taken for analysis.

3.1 VOCs

Samples should be acidified with hydrochloric acid to pH 2 and sealed with zero headspace.

3.2 Metals

Samples should be filtered (0.45µm) before being sealed in a polyethylene container. Samples for lead analysis should be preserved by acidifying the sample to pH 2 with nitric acid.

4 Groundwater

The installation of groundwater monitoring wells and sampling of groundwater should be undertaken by suitably qualified personnel using currently acceptable practices. Refer to NSW Department of Water Resources (1992).

5 Field QA/QC

A QA/QC plan should be implemented to ensure a high standard of work when undertaking the site assessment. The QA/QC plan should include as a minimum:

- 10% duplicate sampling of field samples.
- Preparation of rinsate blanks to determine if field sample preparation apparatus were cleaned properly. The rinsate should be analysed. Each batch of samples should contain one preparation rinsate blank.
- Trip blanks to detect any cross contamination during transport.
- Laboratory-prepared spiked VOC samples. These samples should be stored, handled and transported in exactly the same way as the field samples.

APPENDIX D

Recommended Analytical Methods

Analytes	Analytical procedure			
	Water		Soil	
	Extraction	Detection	Extraction	Detection
TPH	418.1 ^a	418.1 FTIR or 8000 GC/FID ^b	3550 ^c sonication ^a	418.1 FTIR 8000 GC/FID ^b
BTEX	5030 purge & trap or 3810 ^d	602 GC/PID/FID/MS or 8020 GC/PID/FID/MS	5030 purge & trap or 3810 ^d	8020 GC/PID/FID/MS or 8020 GC/PID/FID/MS
PAHs	3510 liquid/liquid dichloromethane	8270 GC/MS	3550 sonication dichloromethane	8270 GC/MS
Phenolic compounds	3510 liquid/liquid acidified dichloromethane	8270 GC/MS	3550 sonication acidified dichloromethane	8270 GC/MS
Lead	3005 acid digestion	6010 – ICP/AES 200.8 – ICP/MS 7420 – AAS flame or 7421 furnace 3111B – APHA or 3113B – APHA	3050 acid digestion	6010 – ICP/AES 200.8 – ICP/ MS 7420 – AAS flame or 7421 furnace 3111B – APHA or 3113B – APHA
<p>a Production of fluorocarbon 113, the preferred solvent, will cease at the end of 1995. Alternatives to fluorocarbon 113 could be n-hexane; 80% hexane, 20% methyl-tertbutylether; cyclohexane; perchlorethylene; or supercritical fluid extraction. The site assessor should produce evidence that demonstrates that the solvent used is suitable.</p> <p>b</p> <ul style="list-style-type: none"> ● Selection of detection method should be based on the contaminants of concern, whether distillates or motor oils. ● Where there is some interference with FID, a more selective detector such as MS should be used. <p>c Samples should not be heated or volatile compounds will be lost.</p> <p>d This is a screening method only. Further quantitative testing is necessary.</p> <p>NB. If alternative methods are used, the site assessor should produce evidence that demonstrates that the selected method performs as well as those recommended. Where fill of an unknown origin is detected on site, the US EPA, APHA or Australian Standard Methods should be used for the analysis of the contaminants listed in Table I (imported fill).</p>				