Framework for Managing Contaminated Land and Potentially Contaminated Land for Council owned Land

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Glossary

Key Terms	Definition
ABC	Ambient Background Concentration
ACM	Asbestos Containing Materials
ADWG	Australian Drinking Water Guideline
AS	Australian Standard
ANZG	Australian and New Zealand Guidelines for Fresh and Maine Water Quality
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CoPC	Chemical of Potential Concern
CSM	Conceptual Site Model
DELWP	Department of Environment, Land, Water and Planning
DSI	Detailed Site Investigation
EAO	Environmental Audit Overlay
EIL	Ecological Investigation Level
EPA	Victorian Environment Protection Authority
ERS	Environmental Reference Standard
ESL	Ecological Screening Level
GED	General Environmental Duty
GQRUZ	Groundwater Quality Restricted Use Zone
HIL	Health Investigation Level
HSL	Health Screening Level
ISL	Investigation and Screening Level
IWRG	Industrial Waste Resource Guidelines
NAPL	Non-aqueous phase liquid
NATA	National Association of Testing Authorities
NEPM (ASC)	National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1), 11 April 2013
OCP	Organochlorine Pesticides
OPP	Organophosphorus Pesticides
PAH	Polycyclic Aromatic Hydrocarbons

PFAS	Per- and Polyfluoryalkyl Substances
PPE	Personal Protective Equipment
PCB	Polychlorinated Bi-phenyls
PRSA	Preliminary Risk Screen Assessment
PSI	Preliminary Site Investigation
TRH	Total Recoverable Hydrocarbons
VAGO	Victorian Auditor-General's Office

1.0 Introduction

This document outlines the Framework for Managing Contaminated Land and Potentially Contaminated Land in the City of Casey (the Framework).

The Framework has been prepared to allow City of Casey to undertake an assessment of the potential for land contamination at Council owned land. It is understood that this assessment will be used by City of Casey to compile a database/register of land assessed to be contaminated or potentially contaminated that can be used by Council officers for decision making.

The development of the database/register is supported by the Victorian Auditor-General's Report "Managing Contaminated Sites" (Victorian Auditor-Generals Office [VAGO], 2011). This report highlights the importance of councils having complete and accurate information that identifies the known extent of potentially contaminated land across the whole municipality. In addition, the Report recommends that councils should:

- Develop systems to capture ongoing site conditions to inform their compliance monitoring activities around the development, management and clean-up of contaminated sites.
- Develop compliance monitoring program and enforcement processes, consistent with better practice, and perform these activities on a routine basis.
- Assess the level of expertise and financial resources required to accurately manage and clean up high-risk sites.

1.1 Scope of framework

This Framework includes the following:

- A flowchart for managing contaminated land.
- A summary of the legal framework for managing contaminated land in Victoria, including a description of the Environment Protection Act 2017 (the Act), the Environment Protection Regulations 2021 (the Regulations) and the Environmental Reference Standard (the ERS).
- A summary of the duties to manage contaminated land under the Act, including the General Environmental Duty (GED).
- A summary of the primary guidance documents for the assessment of contaminated land in Victoria. This includes the National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1), 11 April 2013 (the NEPM (ASC), which is the overarching guidance document for the assessment of contaminated land in Australia.
- A summary of the process for identifying whether land is potentially contaminated or contaminated.
- Guidance for managing contaminated land.
- A summary of the process for identifying whether land is potentially contaminated or contaminated.
- Guidance for managing contaminated land.

2.0 Flowchart for managing contaminated land

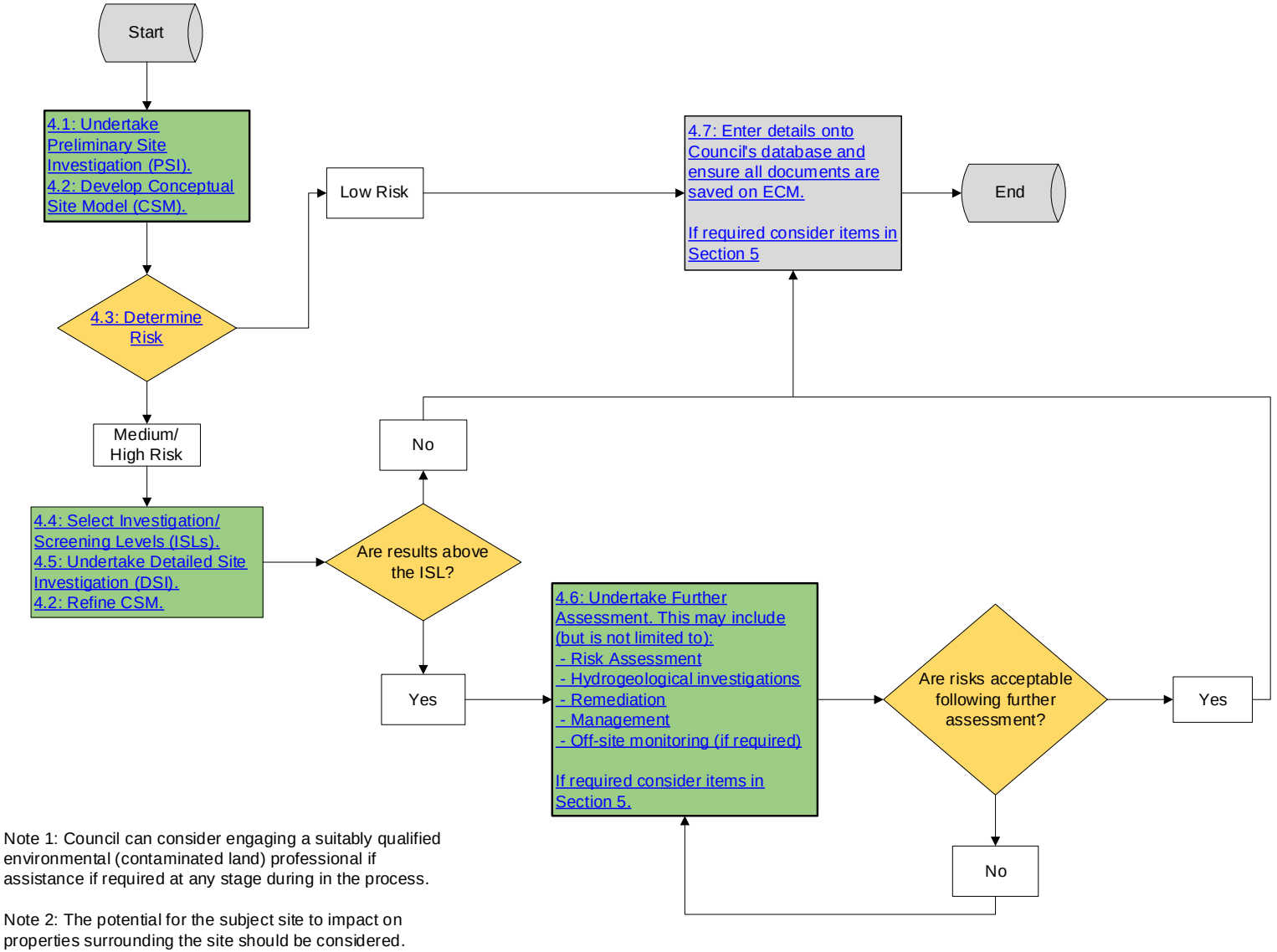
Determining whether land is contaminated, and if so, the extent of contamination and whether it will adversely affect human and ecological receptors, is normally undertaken in a step by step process that involves the following:

- Identification of whether the land is potentially contaminated. This is called a Preliminary Site Investigation (or PSI). Further information on this step is provided in **Section** Error! Reference source not found.
- Development of a Conceptual Site Model (CSM) which describes our understanding of which chemicals (or contaminants) we are concerned about, where they might be present in the environment, how they might have got there, and how they may affect human and ecological receptors. Receptors both at the site, and at properties adjacent to the site should be assessed. Further information on this step is provided in **Section 4.2.**
- Determination of the site risk ranking (i.e. high, medium or low). Further information on this step is provided in **Section 4.3**. If a site is determined to be a medium or high risk then further assessment, including environmental sampling, is normally required.
- For medium and high risk sites, environmental sampling is undertaken to determine if chemicals are present in the land (i.e. in the soil, groundwater, surface water, vapour as applicable) and comparison of chemical concentrations to guidelines that indicate the "safe level". This is called a Detailed Site Investigation (or DSI) requires the comparison of chemical concentrations in environmental media to appropriate investigation and screening levels. Further information on selecting appropriate ISLs is provided in **Section 4.4** below. Further information on undertaking a DSI is provided in **Section 4.5**.
- If the adopted ISLs or "safe levels" are exceeded, further assessment may be required. This further assessment may include human health or ecological risk assessment, off-site monitoring, hydrogeological investigations and remediation and/or management. Further information on this step is provided in **Section 4.6.**
- At all times during the contaminated land management process, data management procedures should be followed to ensure information obtained is accessible to all relevant Council staff members. Data management procedures are outlined in **Section 4.7.**

Flowchart 1 (below) shows the main steps in the contaminated land assessment process. Each step in the process is numbered and the step described in the corresponding chapter of this document.

The legal framework and guidance available for assessing and managing contaminated or potentially contaminated land is described in **Section 3.0.** The legal framework includes three environmental duties - the General Environmental Duty (GED), the duty to manage and the duty to notify. Flowchart 1 primarily relates to the duty to manage, however the GED and duty to notify must also be considered during the application of the Flowchart.

In addition, there are several other things that should be considered during the management of contaminated land. These include applicable links with the environmental planning process including the need for Preliminary Risk Screen Assessments (PRSA) and Environmental Audits, risk communication and involving the community, the allocation of buffer distances, the need to seek external advice and health and safety considerations. Further information on each of these aspects is provided in **Section 5.0**. Procedures for review of the Framework are provided in **Section 6.0 .**



Flowchart 1 – Flowchart for contaminated land decision making. This Flowchart primarily relates to the duty to manage, however the duty to notify and the General Environmental Duty (GED) must also be considered at all times.

3.0 Legal framework for managing contaminated land

In Victoria, the environment is protected by the Environment Protection Act 2017 (the Act; as amended by the Environment Protection Amendment Act 2018), which came into effect on 1 July 2021. The assessment and management of contaminated and potentially contaminated land is undertaken in accordance with the Act and overseen by the government body set up to administer the Act – the Victorian Environment Protection Authority (the EPA).

The Act, and subordinate legislation the Environment Protection Regulations 2021 (the Regulations), define how EPA works with the community and industry to minimise risks to human health and the environment from pollution and waste. The Regulations support the objectives of the Act by providing clarity and further detail on how to fulfil the required obligations.

Section 35 of the Act defines land to be contaminated if:

…a waste, a chemical substance, or a prescribed substance is present on or under the surface of the land and the waste, chemical or prescribed substance –

a) is present at a concentration above the background level; and

b) creates a risk of harm to human health or the environment.

The background level for a given contaminant is the naturally occurring concentration of that substance in the vicinity unless EPA makes a determination for that contaminant or a process for deriving a background level. This means that the background level does not include man made sources of ambient contamination (also referred to as the ambient background concentration or ABC).

The meaning of land includes publicly or privately owned land and includes any buildings or other structures permanently affixed to the land, and groundwater.

Groundwater means any water contained in or occurring in a geological structure or formation or an artificial landfill below the surface of land.

The Act also:

- Introduces the Environmental Reference Standard (ERS).
- Provides for the environmental duties – a set of obligations on duty holders; the cornerstone of which is the General Environmental Duty (the GED).

The key guidance documents provided by EPA are identified in Section 7.0. More recent EPA publications, or more up to date versions of existing EPA publications may be available at Publications | Environment Protection Authority Victoria (epa.vic.gov.au).

EPA Publication 1753.2 provides a guide to the Environmental Protection Regulations.

The legal framework for the assessment and management of contaminated land and potentially contaminated land in Victoria is summarised in **Figure 1** and **Figure 2** below.

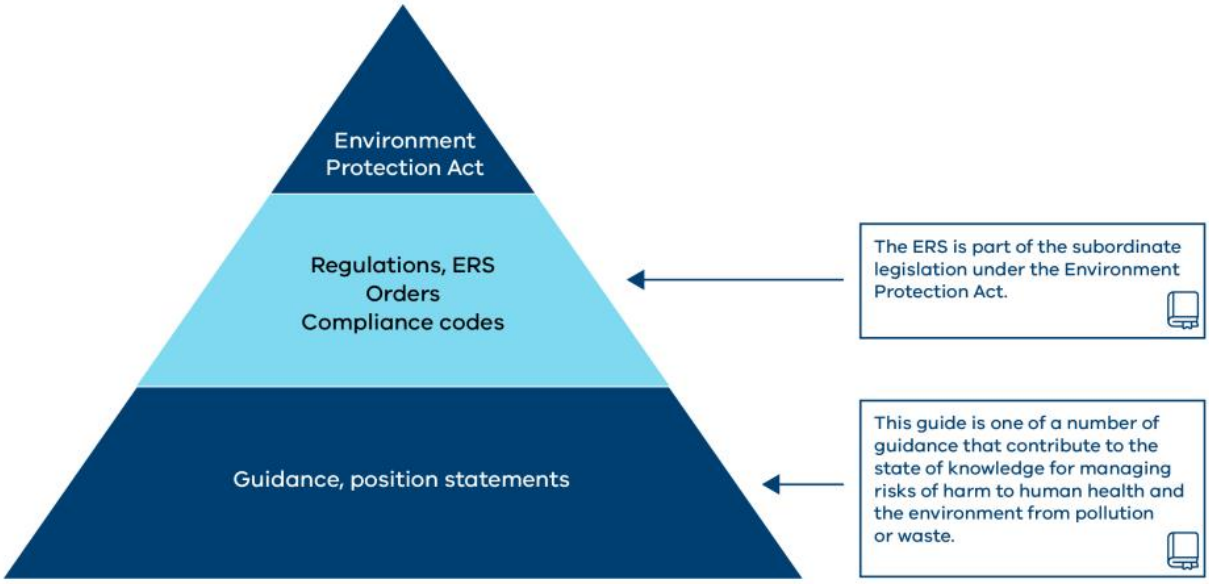


Figure 1 Hierarchy of Victorian Environmental Legislation and Guidance (from EPA Publication 1992)

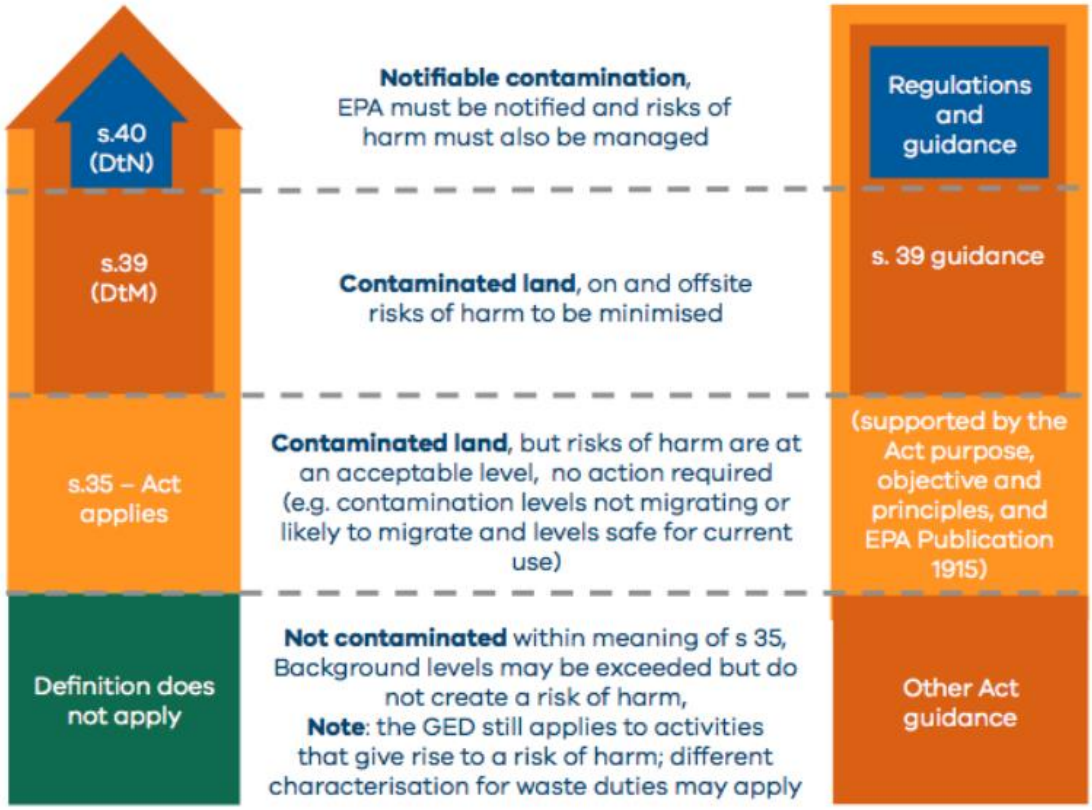
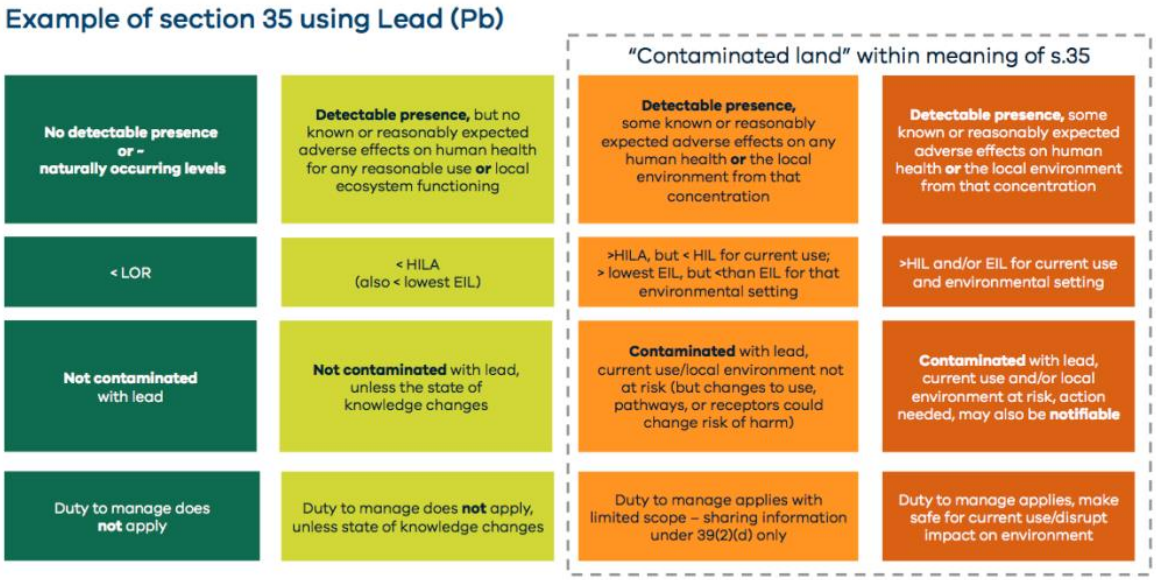


Figure 2 Confirming whether land is contaminated, and the required duties (from EPA Publication 1940)

Figure 3 provides an example of how to apply the Act using lead and the NEPM (ASC) as an example. Note that LOR = Limit of Reporting.



The legal

Figure 3 How to apply the Act, using lead and the NEPM (ASC) as an example (from EPA Publication 1940)

As mentioned above, three key environmental duties are provided for under the Act to address contaminated land risks:

- The GED.
- The duty to manage.
- The duty to notify.

The duty to manage and/or notify applies in addition to the GED. This means that a person must first consider how to comply with GED, given the activities they are proposing to engage in and the potential risk of harm to human health and the environment from these activities. Where a person has knowledge about the condition of their land, they also have a duty to manage any contamination that may be present. If the person subsequently becomes aware (or should reasonably have been aware) that the contamination is notifiable, then they have a duty to notify the contamination to EPA.

The duty holder is the person in management or control of land i.e. the person who can exercise power over land. This may include a person who holds legal interest in the land (e.g. owner, lease holder or committee of management), or a person who is granted access to and/or use of the land. More than one person can exercise control of land at a point in time. The scope of a person's duty is informed by what they know or ought to reasonable know about the presence of contamination on the site. This requires sharing information to continuously improve the available knowledge.

A duty holder is not expected to undertake an investigation solely for the purpose of determining if they have notifiable contamination. However, the accumulation of knowledge arising from their duty to manage may require them to notify the contamination to EPA. As knowledge of contamination changes, the level of expected action also changes.

In summary, as the varying states of contamination and corresponding duties are shown on Figure 4 below. These states can be described as follows:

- Potential contamination will require assessment.
- Known contamination will need to be managed.
- Notifiable contamination must be reported to EPA.

The duty to manage and notify contaminated land applies even if the person did not cause the contamination.

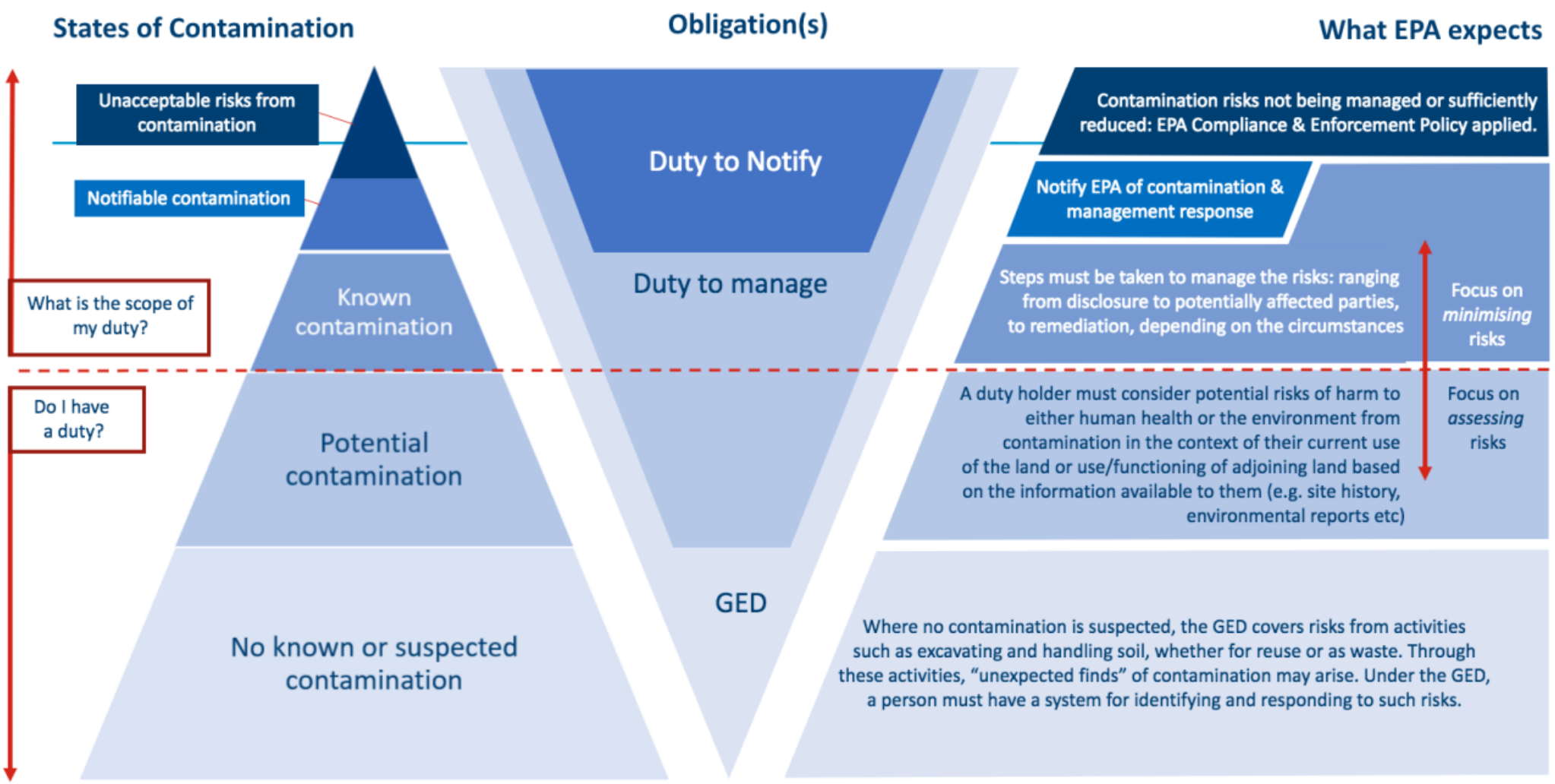


Figure 4 Contaminated land duties (from EPA Publication 1915

3.1 General environmental duty

The GED underlies the duty to manage and requires Victorians to understand and minimize their risk of harm to human health and the environment, from pollution and waste in accordance with the following definition:

> A person who is engaging in an activity that may give rise to risks of harm to human health or the environment from pollution or waste must minimize those risks, so far as reasonably practicable.

This could include activities that uncover contamination that was previously unknown or not detected e.g. during earthworks.

In addition, the GED does not rely on the definition of contaminated land to apply, as any risks from pollution or waste must be minimised under the GED, including risks of harm that are naturally occurring. This could include acid sulfate soils (when disturbed) or soil or groundwater with naturally elevated concentrations of potentially harmful chemical substances, where these chemicals may be transferred out of the area where they are naturally occurring.

The GED generally establishes the minimum requirements for conducting activities, except where other regulatory requirements are prescribed. The measures necessary to comply with GED will also change over time, as what is considered reasonably practicable changes.

EPA Publication 1741.1 provides further guidance for industry on GED. GED is also covered in many of the other EPA publications referenced in this Framework including Publication 1821.1.

3.2 Duty to Manage

Section 39 of the Act requires a person in management or control of contaminated land to minimise risks to harm to human health and the environment from the contaminated land so far as reasonably practicable. This requires the elimination of risks so far as reasonably practicable, and if this is not possible, the reduction of risks so far as reasonably practicable.

Managing contaminated land requires knowledge about the presence of contamination, which is often contained in environmental reports and site records. Further guidance on when it is reasonable to assume the presence of contamination, and the evidence that may indicate that land is contaminated, is provided in EPA Publications 1915, 1940 and 2010.

Where land is identified to be contaminated, EPA considers that the following 4 step risk mitigation process can be implemented:

» 1. Identify hazards.

» 2. Assess risks.

» 3. Implement risk control measures.

» 4. Review risk control measures.

Figure 5 below shows how these steps can be placed into the context of the contaminated land assessment process outlined in the NEPM (ASC). Further information to the contaminated land assessment process outlined in the NEPM (ASC) is provided in **Section 4.0.**

It is the obligation of the duty holder to understand their risks and the right approach to manage them. This may include seeking further advice where needed.

A guide to the duty to manage when assessing and controlling contaminated land risks can be found in EPA Publication 1977.

Further information on duty to manage is also provided in EPA Publication 1821.1 and 2010.

More general guidance on assessing and controlling risk can be found in EPA Publication 1695.1.

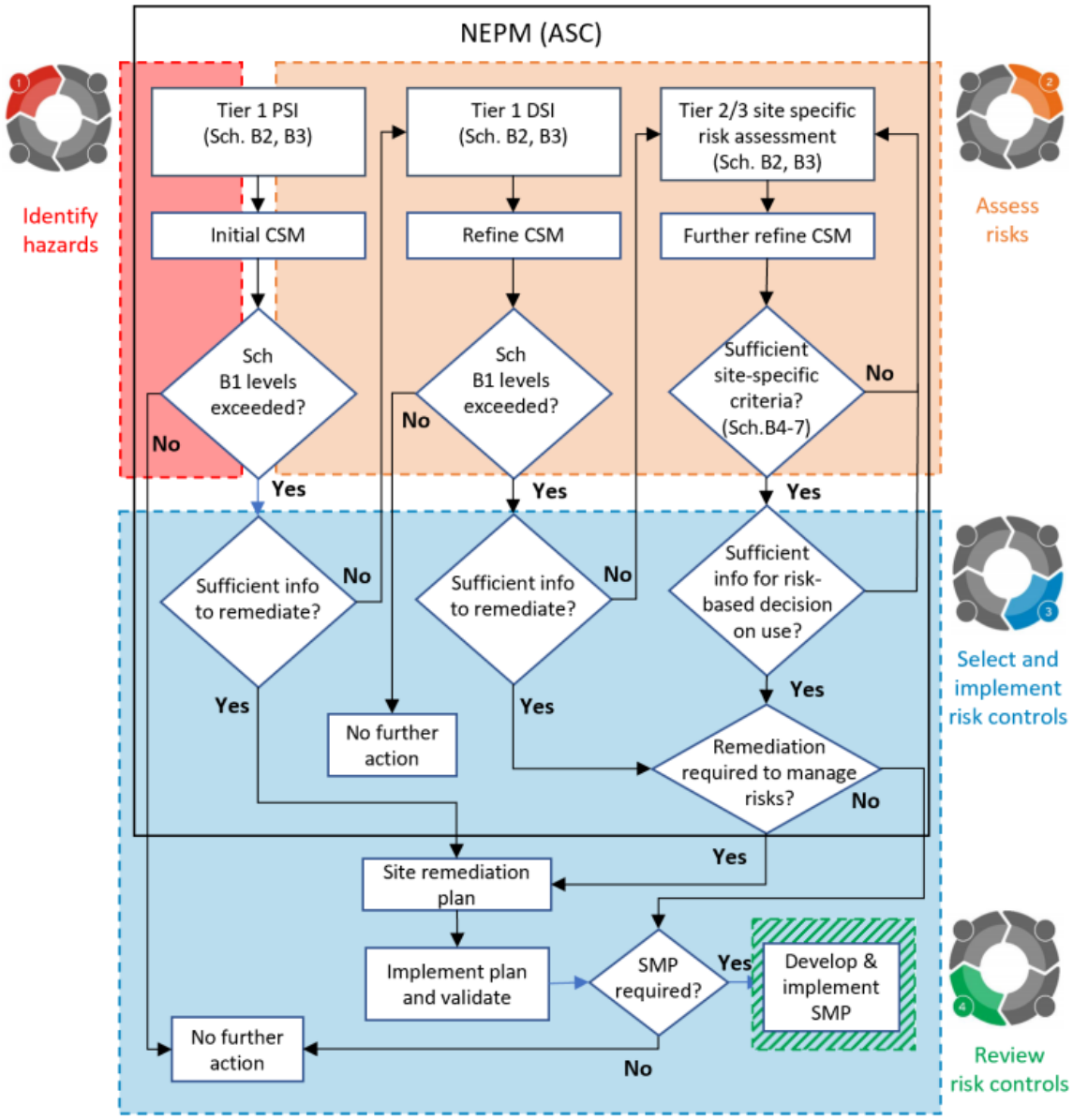


Figure 5 The duty to manage in the context of the guidance in the NEPM (ASC) (from EPA Publication 1977)

3.3 Duty to Notify

Where notifiable contamination is present, a person who manages or controls land has a duty to report that contamination to EPA when they are aware or should reasonably have been aware of the presence of the contamination. The Regulations identify the following broad areas of contamination that may be notifiable:

- Contaminated soil (including with friable asbestos) where a person may be exposed to the contamination.
- Soil contamination that is moving, has moved, or is likely to move onto adjacent land.
- Surface water and groundwater contamination where water is being used or may be used.
- Contamination of soil or groundwater that causes vapour intrusion.
- The presence of non-aqueous phase liquid (NAPL) in soil or groundwater.
- Contaminated soil sourced from that land that can be lawfully retained onsite.

The first five areas listed above are based on exposure pathways. The need to notify EPA of contamination for these exposure pathway areas requires both of the following:

- Contamination is present in excess of the investigation or guideline values set out in the NEPM (ASC), the Australian Drinking Water Guidelines (ADWG) of the Australian New Zealand Guidelines for Fresh and Marine Water (ANZG).
- An exposure pathway exists through which the contamination either exposes or is likely to expose a person to the contamination or is migrating or is likely to migrate from the land which the duty holder manages or controls.

A guide to the duty to notify can be found in EPA Publication 1821.1 and 2008.1. Further information on duty to notify is also provided in EPA Publication 2010.

3.4 Reasonably practicable

Reasonably practicable means that you must implement proportionate controls to mitigate or minimise the risk of harm. What is reasonably practicable can be determined by thinking about:

- the likelihood of those risks eventuating;
- the degree of harm that would result if those risks eventuated;
- what the person concerned knows, or ought reasonably to know, about the harm or risks of harm and any ways of eliminating or reducing those risks;
- the availability and suitability of ways to eliminate or reduce those risks; and
- the cost of eliminating or reducing those risks

The above factors are considered with reference to the ‘stage of knowledge’, which is the body of accepted knowledge that is known or ought to be reasonably known about the harm or risks of harm to human health and the environment, and the controls for eliminating or reducing those risks. Source of knowledge include business and industry knowledge (e.g. safety data sheets, standard operating procedures), regulatory and government agency knowledge (including that from EPA and WorkSafe) and independent organisations’ knowledge (e.g. information from Standards Australia and environmental engineers).

The state of knowledge will develop over time as new technology, systems and processes develop, or where there is an emerging risk.

Further information on what is considered reasonably practicable can be found in EPA Publication 1856. Two of the key flow charts from EPA Publication 1856 are reproduced as **Figure 6.**

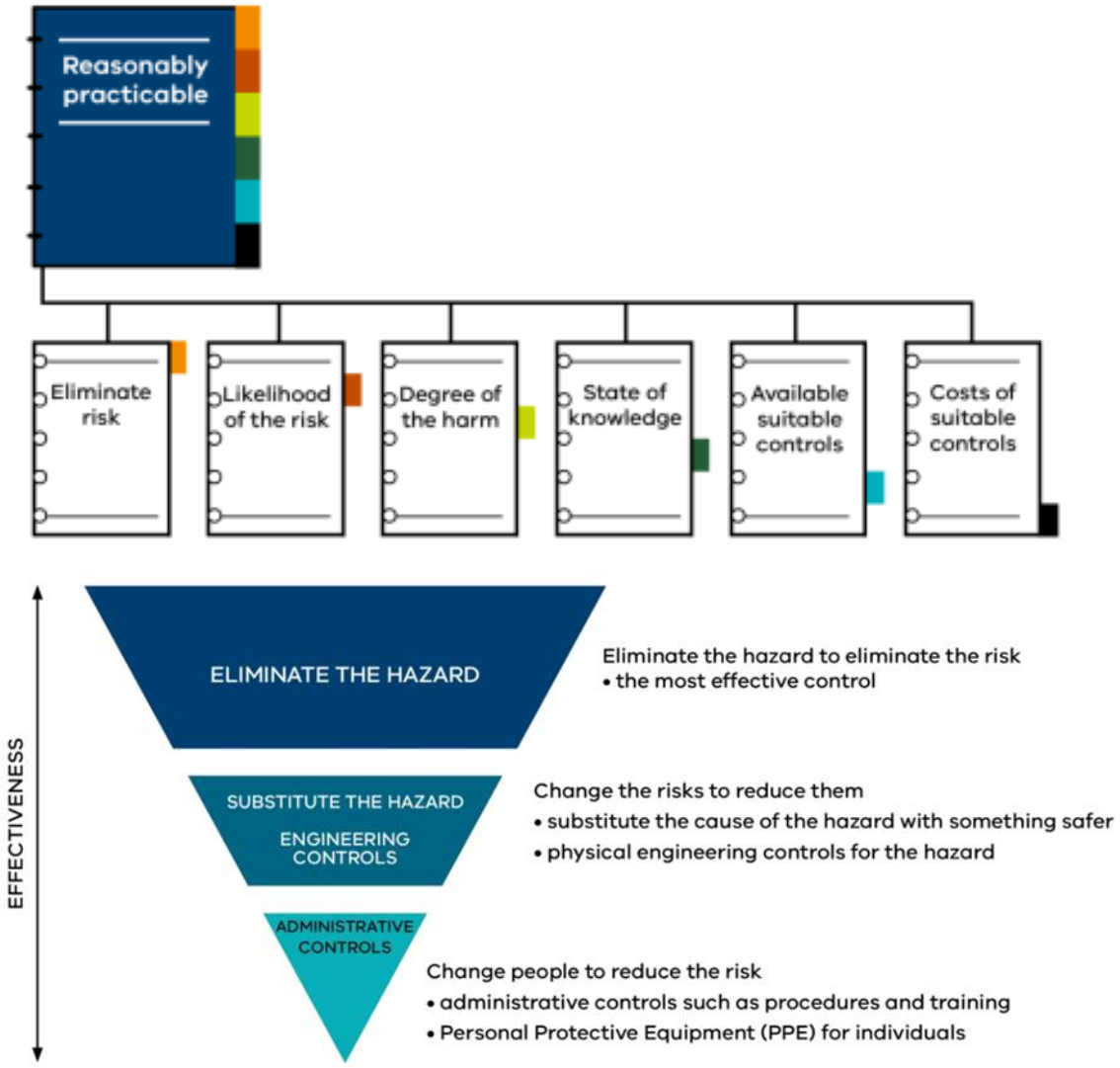


Figure 6 Determining what is reasonably practicable (from EPA Publication 1856)

3.5 The Environmental Reference Standards

The Environmental Reference Standards (ERS) replace the previous State Environment Protection Policies (the SEPP). The function of the ERS is to assess and report on environmental conditions in the whole or any part of Victoria. The ERS also forms part of the support material associated with establishing the state of knowledge, which means that it is a reference point which supports the GED. The ERS does not override the GED and do not indicate the levels up to which a person can lawfully pollute.

The ERS cover four environmental elements:

- Ambient air.
- Ambient sound.
- Land.
- Water (groundwater and surface water).

The ERS then specifies the environmental values, indicators, and methodology for monitoring and assessing the indicators, for each of the environmental elements:

- Environmental values are the desired outcome for human health and the environment.
- Indicators are the parameters or markers used to assess whether the environmental values are being achieved or maintained.

The process for implementing the process set out by the ERS is shown on Figure 7 below.

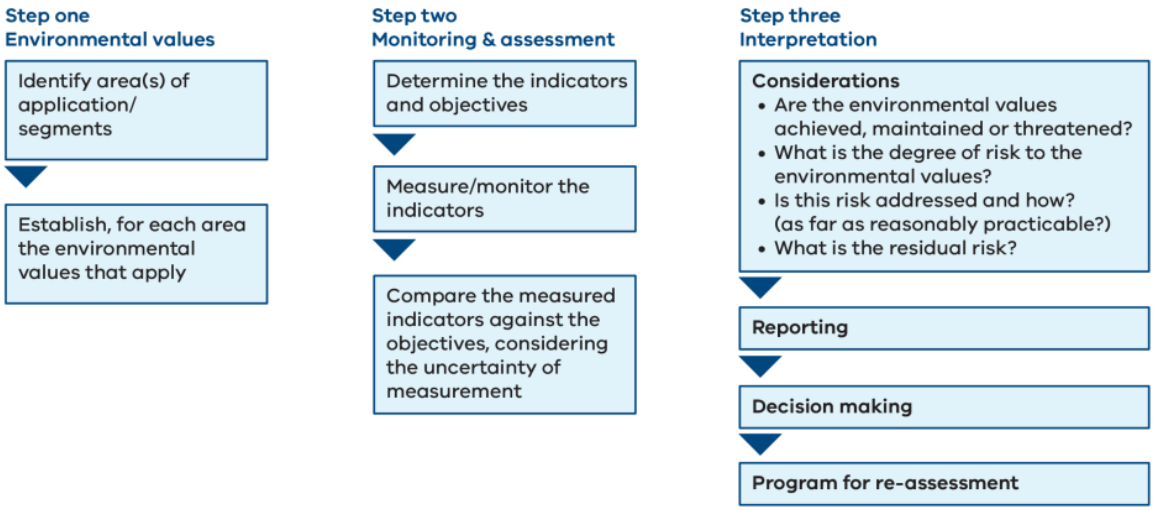


Figure 7 Implementing the process set out in the ERS (from EPA Publication 1992)

The environmental elements of land and water usually require consideration in contaminated land assessments.

The environmental values and indicators for land are reproduced in **Section 3.5.1** as an example.

The environmental values and indicators for groundwater and surface water are more complicated, and can be found in the ERS. The ERS also provides the full definition and details required for the assessment of each value and indicator.

A detailed guide to the ERS can be found in EPA Publication 1992.

3.5.1 Land

Table 4.1: Environmental values of the land environment

Column 1 Environmental value	Column 2 Description of environmental value
Land dependent ecosystems and species	Land quality that is suitable to protect soil health and the integrity and biodiversity of natural ecosystems, modified ecosystems and highly modified ecosystems
Human health	Land quality that is suitable for the specific land use and safe for the human use of that land
Buildings and structures	Land quality that is not corrosive to buildings, structures, property and materials
Aesthetics	Aesthetic issues do not adversely impact the use of land. Aesthetic issues include the quantity, type and distribution of foreign material or odours in relation to the specific land use and its sensitivity
Production of food, flora and fibre	Land quality that is suitable for the safe human consumption of food, flora and fibre and that does not adversely affect produce quality or yield

Table 4.2: Environmental values that apply to the land use categories

		Parks and reserves	Agricultural	Sensitive use		Recreation / Open space	Commercial	Industrial
				High density	*Other (lower density)*			
Land dependent ecosystems and species	Natural ecosystems	✓						
	Modified ecosystems	✓	✓		✓	✓		
	Highly modified ecosystems		✓	✓	✓	✓	✓	✓
Human health		✓	✓	✓	✓	✓	✓	✓
Buildings and structures		✓	✓	✓	✓	✓	✓	✓
Aesthetics		✓		✓	✓	✓	✓	
Production of food, flora and fibre		✓	✓		✓			

Table 4.3: Indicators and objectives for the land environment

Column 1 Environmental value	Column 2 Indicators	Column 3 Objectives
Land dependent ecosystems and species	Inorganic and organic contaminants set out in Appendix A of Schedule B2 of the NEPM (ASC) and any other contaminants present at the site as determined by the current use or site history assessed in accordance with the NEPM (ASC)	The objective for each indicator is the ecological investigation or screening level in the NEPM (ASC), unless – (a) there is no such investigation or screening level; or (b) due to site specific characteristics the more appropriate objective is: (i) the level derived using the risk assessment methodology described in the NEPM (ASC); or (ii) the background level determined in accordance with section 36 of the Act, in which case the objective for the indicator is (i) or (ii), as applicable.
Human health	Inorganic and organic contaminants set out in Appendix A of Schedule B2 of the NEPM (ASC), and any other contaminants present at the site as determined by the current use or site history assessed in accordance with the NEPM (ASC)	The objective for each indicator is the health investigation or screening level in the NEPM (ASC), unless – (a) there is no such investigation or screening level; or (b) due to site specific characteristics the more appropriate objective is: (i) the level derived using the risk assessment methodology described in the NEPM (ASC); or (ii) the background level determined in accordance with section 36 of the Act, in which case the objective for the indicator is (i) or (ii), as applicable.
Buildings and structures	pH, sulfate, chloride, redox potential, salinity or any chemical substance or waste that may have a detrimental impact on the structural integrity of buildings or other structures	Land that is not corrosive to or otherwise adversely affecting the integrity of structures or building materials
Aesthetics	Any chemical substance or waste that may be offensive to the senses	Land that is not offensive to the senses of human beings
Production of food, flora and fibre	Inorganic and organic contaminants set out in Appendix A of Schedule B2 of the NEPM (ASC) and any other contaminants present at the site as determined by the site history assessed in accordance with the NEPM (ASC)	The levels specified in the Food Standards Code detected in any food, flora or fibre produced at the site. Levels that do not adversely affect produce quality or yield

4.0 Managing contaminated land

Guidance for the assessment of compliance with the ERS is available in several documents which are identified in Section 7.0. More recent EPA publications, or more up to date versions of existing EPA publications, may be available at Publications | Environment Protection Authority Victoria (epa.vic.gov.au).

The key guidance document for the assessment of contaminated land is the NEPM (ASC). This document was first released in 1999, was amended in 2013 and provides guidance on aspects such as investigation levels for soil, soil vapour and groundwater, site characterization, risk assessment, community engagement and Environmental Auditing. The goal of the NEPM (ASC) is:

> *To establish a nationally consistent approach to the assessment of site contamination to ensure sound environmental management practices by the community which includes regulators, site assessors, environmental auditors, landowners, developers & industry.*

4.1 Preliminary Site Investigation

As noted above in **Section 2.0**, the first stage in a contaminated land assessment is to identify whether a site may be potentially contaminated. The NEPM (ASC) refers to this process as a preliminary site investigation (PSI).

There are several information sources available to identify if land may be potentially contaminated. EPA Publication 2010 provides a guide to activities and land uses with the potential to cause contamination, visual indicators of contamination and ways to identify if groundwater may be contaminated. The following information sources are listed in this publication:

- Victoria Unearthed (https://www.environment.vic.gov.au/sustainability/victoria-unearthed). This database includes the following datasets:
  - EPA Priority Sites Register.
  - EPA licensed sites
  - EPA Environmental Audits
  - EPA Groundwater Quality Restricted Use Zones (GQRUZ).
  - Victorian Landfill Register.
  - Victorian Planning Provisions Environmental Audit Overlays.
  - Historical business listings.
  - Victoria's Sands & McDougall business directory.
  - Note that information from 1 July 2021 is still be incorporated into Victoria Unearthed. This information is currently available on the EPA website.
- Landdata aerial photos (https://www.landata.vic.gov.au/).

A summary of other information sources that may be applicable to land in the City of Casey is provided in **Table 1** below. In addition, site walkovers and interviews with relevant council staff and/or tenants should be undertaken where possible. These activities may identify the presence of potentially contaminating infrastructure or material at a site or potentially contaminating activities that have been undertaken at a site historically. This information may not be able to be ascertained from a review of the information sources in **Table 1**.

Table 1 Summary of available information sources for preliminary site investigations

Resource	Use	Reference
Geological Survey of Victoria Map Sheets	Used to identify the site geology which may affect the depth to groundwater and the transport of contamination in the ground.	Available at: http://earthresources.efirst.com.au/categories.asp?cID=33&c=135910
Groundwater Resources Report	Used to identify the likely salinity of groundwater beneath the site and hence which beneficial uses of groundwater require protection at a site in accordance with the Groundwater SEPP.	Available at: http://www.depi.vic.gov.au/water/groundwater/groundwater-resource-reports
Visualising Victoria's Groundwater Database	Used to identify the presence of registered groundwater bores in the vicinity of a site. This may indicate groundwater in the area is being used (e.g. for domestic/stock, irrigation or industrial use) or groundwater investigation works have been previously undertaken in the area.	Available at: https://www.vvg.org.au/
Council Records	May identify permits previously issued for a site that provide information regarding the historical land uses.	Refer to relevant Council department.
Historical Society Enquiry	Used to identify historical site owners which may provide information regarding the historical land use.	Contact the applicable Historical Society. Fees may apply.
Water Authority Enquiry	Used to identify any current or historical trade waste agreements.	Contact the applicable Water Authority.
Energy Safe Victoria, Cathodic Protection Search	May identify certain underground services and sensitive assets including underground storage tanks, which are often protected against corrosion with the installation of a sacrificial anode known as cathodic protection.	Available at: Public registers and search functions – Energy Safe Victoria (esv.vic.gov.au)

4.1.1 Potentially contaminating land uses

AS4482.1 (2005) provides a list of land uses which are considered to be potentially contaminating and the associated main chemicals of potential concern (CoPC). Potentially contaminating land uses are also identified in EPA Publication 2010 and Planning Practice Note 30 Potentially Contaminated Land (July 2021) prepared by the Victorian Government Department of Environment, Land, Water and Planning (DELWP).

Table 2 below provides a collation of potentially contaminating land uses which may be present in the City of Casey, considering the recommendations of AS4481.2 (2005), EPA Publication 2010 and DELWP (2021) and the experience of Environmental Risk Sciences Pty Ltd. Potentially contaminating land-uses have been listed alphabetically, ranked as high, medium or low risk and the main CoPC have been listed. Recommendations for when a broad contaminant screen should be undertaken have also been provided.

The presence of imported fill has not been categorized as high, medium or low risk as the contamination status of imported fill cannot be determined until sampling and analysis has been undertaken. Based on experience it is possible for imported fill to present all three categories of risk depending on where it has been sourced. Hence, the presence of imported fill has been listed under “Other” in **Table 2** below. The exception is if inert wastes (e.g. metal fragments, brick, plastic etc.), odours or discoloration is reported in the fill - in this case the imported fill should be considered to have a “high” potential for contamination.

If the presence of Asbestos Containing Materials (ACM) is identified in the imported fill, the fill should be classed as contaminated/high risk.

Table 2 Summary of potentially contaminating land uses

Land use	Main chemicals of potential concern (CoPC)
High risk	
Agricultural activities e.g. market gardens, mushroom farm proposed to be used for continuing commercial agriculture	Pesticides (including OCPs and OPPs) and herbicides
Air strip/airport	Petroleum hydrocarbons, VOCs including chlorinated hydrocarbons, metals, PFAS Check for the presence of tanks, lines and bowsers used for plane re-fuelling Check for the presence of firefighting foam tanks or systems, the known former use of AFFF and/or the presence of historical firefighting (e.g. following incidents) and/or training areas.
Ammunition, explosives and fireworks production	Explosive objects – seek external advice
Asbestos production/disposal (including demolition of buildings if ACM is found to be present)	ACM
Biocides and fertiliser production	Nutrients, heavy metals, pesticides (including OCPs and OPPs) and herbicides
Boat docking area/slipway (boat repair)	Petroleum hydrocarbons, VOCs including chlorinated hydrocarbons, metals, antifoulants
Briquette, bitumen, cement, clay, glass and plaster production or processing[1]	Petroleum hydrocarbons
Chemical use and storage[1]	Chemicals of use, PFAS
Clandestine drug labs	Drugs of manufacture, solvents, petroleum hydrocarbons, metals – seek external advice
Compost manufacture[1]	Microbial hazards – seek external advice
Dry cleaning[1]	VOCs including chlorinated hydrocarbons
Electricity generation	PCBs, heavy metals, solvents
Gun club	Lead
Industrial gases production/gasworks	Petroleum hydrocarbons, ammonia, nitrate, cyanide, phenols, metals, PAHs
Intensive livestock agriculture including abattoirs and cattle feedlots	Buried wastes, nutrients, ammonia, acids / alkalis Pesticides (including OCPs and OPPs) and herbicides, metals (low levels associated with effluent disposal areas)
Landfill/quarry (filled) [1]	Buried wastes, PFAS, landfill gas (methane)
Leather production, tanning and dressing[1]	Heavy metals, petroleum hydrocarbons, ammonia, nitrate, phenols, formaldehyde
Manufacturing (including textiles, metal products, chemicals/formaldehyde, inks, cosmetics, paints, pharmaceuticals, resins, rubber and soaps/surfactants, paper and paper products)[1]	Specific to the type of industry, however, the following may be present: Petroleum hydrocarbons, VOCs including chlorinated hydrocarbons, heavy metals, acids/alkalis, phenols, acrylates, phthalates, fluoride, cyanide, sulfates, phosphates
Metal treatment, refining or smelting[1]	Heavy metals, petroleum hydrocarbons, VOCs including chlorinated hydrocarbons, acids/alkalis, PFAS
Panel beating	Petroleum hydrocarbons, VOCs including chlorinated hydrocarbons, heavy metals
Petroleum refinery	Petroleum hydrocarbons, lead, phenols, PFAS
Printing, rendering, coating and/or casing[1]	Specific to processes (including waste disposal practices) undertaken, however, the following may be present: Petroleum hydrocarbons, VOCs including chlorinated hydrocarbons, metals
Railway yard[1]	Heavy metals, pesticides (including OCPs and OPPs) and herbicides, PCBs, PAHs, ACM
Service stations, depots and automotive repair	Petroleum hydrocarbons, VOCs including chlorinated hydrocarbons, lead, phenols, PFAS (for depots)
Solid or liquid waste treatment including waste transfer station, recycling centre and sewage treatment plant[1]	Buried wastes, heavy metals, fluoride, microbial hazards, PFAS

Land use	Main chemicals of potential concern (CoPC)
Soil conditioning or blending (soil remediation and treatment)[1]	Acids/alkalis, VOCs including chlorinated hydrocarbons, chemicals used for treatment and chemicals present in soil being treated, PFAS
Stock dipping	Arsenic, pesticides (including OCPs and OPPs) and herbicides
Timber treatment and preservation	Heavy metals, pesticides (including OCPs and OPPs) and herbicides, ammonia, PAHs, phenols
Underground storage tanks or underground liquid transfer infrastructure (e.g. drains)[1, 2]	Chemicals associated with materials stored or transferred. Commonly includes petroleum hydrocarbons however may include solvents or acids/alkalis or other chemicals associated with site use
Medium Risk	
Agricultural activities (where the site is proposed for future non-agricultural uses) (low intensive livestock, large scale agriculture/cropping, market gardens, mushroom farm)	Pesticides (including OCPs and OPPs) and herbicides
Nursery and soil conditioning facilities (i.e. addition of nutrients)	Nutrients (nitrate, nitrite, ammonia, phosphates)
Poultry farming and processing	Buried wastes, nutrients, heavy metals, petroleum hydrocarbons, microbial hazards
Production and processing of food and beverages (e.g. brewery/distillery, bakery/flour mill, maltworks, milk products, seafood, smallgoods, tobacco / cigarettes)[1]	Specific to processes (including waste disposal practices) undertaken, however, the following may be present: Petroleum hydrocarbons, acids / alkalis Pesticides (including OCPs and OPPs) and herbicides, nutrients, heavy metals, microbial hazards (effluent disposal areas).
Septic system	Nutrients (nitrate, nitrite, ammonia, phosphates), microbial hazards
Timber storage	Heavy metals, pesticides (including OCPs and OPPs) and herbicides, ammonia, PAHs, phenols
Vehicle stores/depot (no above or below ground storage tanks)	Petroleum hydrocarbons
Low Risk	
Animal husbandry/keeping other than boarding (e.g. kennels, stables)	None
Car wash/car park	None
General warehousing (no above or below ground storage tanks)	None
Laundry (no dry cleaning)	None
Quarry (non-filled)	None
Other	
Imported fill[1]	Risk categorisation depends on contamination reported. CoPCs may include heavy metals, OCPs, PCBs, TRH, PAHs and ACM

Notes for Table 2:
1 = Broad contaminant screen recommended for selected samples (e.g. 10-20%).
AFFF = Aqueous film forming foams.
ACM = Asbestos Containing Material, PCBs = Polychlorinated biphenyls.
BTEX = Benzene, Toluene, Ethylbenzene and Xylenes
Chlorinated Hydrocarbons = a screen for volatile organic compounds with chlorine e.g. Trichloroethene (TCE), Tetrachloroethene (PCE), Dischloroethene (DCE), Dichloroethana (DCA), Trichloroethane (TCA) etc.
OCPs = Organochlorine Pesticides
OPPs = Organophosphorous Pesticides
PAH = Polycyclic Aromatic Hydrocarbons
Petroleum Hydrocarbons = TRH, BTEX and PAH.
PFAS = Per- and poly fluoroalkyl substances
TRH = Total Recoverable Hydrocarbons
VOC = Volatile Organic Compound

4.2 Developing a Conceptual Site Model

If the PSI indicates that the site is, or may be contaminated, the next stage in a contaminated land assessment is the development of a conceptual site model (CSM). A CSM is a representation of site-related information regarding contamination sources and receptors, and exposure pathways between those sources and receptors. The development of a CSM provides the framework for identifying how the site became contaminated and how potential receptors may be exposed to the contamination.

The development of a CSM is a dynamic process and it is important that all the information and data from each stage of an assessment is reviewed to refine the CSM and inform subsequent decisions. An initial CSM should be constructed from the results of the PSI and used to identify data gaps and inform a decision on whether a detailed site investigation (DSI) is required. If a DSI is undertaken, the CSM should then be updated with the results of the DSI and any further assessment. The essential elements of a CSM are:

- Known and potential sources of contamination and CoPCs.
- Potentially affected media (soil, sediment, groundwater, surface water, soil vapour).
- Characteristics of potentially affected media which may affect the fate and transport of the contaminants.
- Human and ecological receptors.
- Potential and complete exposure pathways.

A summary of the main potential exposure pathways and receptors for a contaminated site are listed in **Table 3** below.

Table 3 Potential exposure pathways and receptors for a contaminated site

Potential exposure pathways	Potential receptors
- **Soil** (transport of contaminants through the soil above groundwater) - **Groundwater** (movement of contaminants with groundwater) - **Vapour** (transport of contaminants in vapour upwards through the soil profile and accumulation within overlying enclosed spaces) - **Underground services** (underground services have the potential to transmit contaminants given that they are usually backfilled with gravel which has a higher permeability than the surrounding soil)	- Ingestion of surface soil (residents and site users) - Ingestion of sub-surface soil by site users (construction and intrusive maintenance workers) - Human contact with surface soils (residents and site users) - Human contact with sub-surface soils (construction and intrusive maintenance workers) - Plant uptake through garden cultivation in surface and sub-surface soils and subsequent ingestion through consumption of the garden produce (this can be a key pathway for metals and PFAS) - Inhalation of airborne dusts by site users. - Off-site transport of airborne dusts and inhalation by off-site users resulting from on-site construction activity/disturbance of surface soils - Vapour impact (indoor) to site users by volatilisation from site soils or groundwater - Vapour impact to users of adjacent sites (indoor and outdoor) by volatilisation from site groundwater. - Users of extracted groundwater - Contact of plants and soil fauna with the contaminated soil or groundwater - Contact of organisms in off-site ecosystems (i.e. surface water bodies), with contaminated groundwater at locations where it may discharge

Typically, the CSM should be presented in written format and illustrated with suitable graphics and flow diagrams. The pictorial CSM for a standard residential land use setting (i.e. Health Investigation Level 'A') from the ASC NEPM is shown below.

RECEPTORS	EXPOSURE PATHWAYS	
A Adult residents B Child residents (0 - 6 years)	1 Indoor inhalation of vapours derived from shallow soil 2 Outdoor inhalation of vapours derived from shallow soil 3 Incidental ingestion of surface soil and dust particulates 4 Dermal contact with surface soil and dust particulates 5 Indoor inhalation of dust particulates	6 Outdoor inhalation of dust particulates 7 Consumption of home-grown produce 8 Consumption of soil adhering to home-grown produce

It is important to note that if the exposure pathway between a contamination source/contaminated media and a receptor is incomplete (i.e. there is not a mechanism by which a person or organism can come into contact with the contaminated media) then there is no risk to the receptor from the contamination (e.g. metal contamination at depth where people cannot come into contact). Hence, development of a CSM can help to identify which receptors and exposure pathways are of concern given the contamination at a site. This can then allow available resources to be distributed appropriately.

4.3 Determining site risk

Following completion of the PSI and development of a CSM, a site risk ranking can be determined based on the proposed use of the site.

The risk ranking matrix, based on the recommendation of Planning Practice Note 30 (DELWP 2021) and the experience of Environmental Risk Sciences Pty Ltd, is provided in **Table 4** below.

Table 4 Risk ranking matrix

Potential for Contamination[1]	Proposed use of site			
	Residential or sensitive use[2]	Commercial agricultural	Commercial or industrial	No change in land use
High	High	High	Medium	Medium
Medium	Medium	Medium	Low	Low
Low	Low	Low	Low	Low

Notes:
1 = As per Table 3 above.
2 = Includes re-development for child care center, kindergarten/pre-school, primary school, secondary school and/or children's playground, even if ancillary to another use.

Each site can be initially categorised as high, medium or low risk based on existing information. The categorization of each site can then be reviewed as new information about the site becomes available.

For example, a site used as a car wash/car park may initially be classified as 'low' risk however reclassified as 'high' risk following the identification of underground storage tanks at the site. Or, a property used previously for timber treatment and proposed to be developed for commercial/industrial use may be initially classified as 'medium' risk. If the property is later proposed to be developed for a child care center, the site would need to be re-classified as 'high' risk.

4.4 Selection of investigation and screening levels

If the site is determined to have a medium or high risk, further investigation that may include a Detailed Site Assessment (DSI) is required.

Once collected, results for chemicals in environmental media will need to be compared to appropriate investigation and screening levels (ISL) to protect the receptors and environmental pathways identified in the development of the SCM.

The NEPM (ASC) provides investigation and screening levels to assess whether concentrations of chemicals detected in environmental media (e.g. soil, groundwater and vapour) represent contamination (as defined by the ERS).

The types of ISLs provided in the NEPM (ASC) are summarized in **Table 5** below. Extracts from Schedule B1 of the NEPM (ASC), with the available ISLs, are provided in **Appendix A**.

It is noted that these investigation and screening levels are not applicable for soil that is proposed to be disposed of off-site to landfill. For this purpose, the upper limits for Fill Material or Category A to D industrial waste provided in EPA Publication 1828.2 should be used.

ISL for PFAS are not available in the NEPM (ASC) can be found in the PFAS National Environmental Management Plan (the PFAS NEMP) (Available at: PFAS National Environmental Management Plan | Environment Protection Authority Victoria (epa.vic.gov.au))

Table 5 Summary of investigation and screening levels in the NEPM (ASC)

Investigation/Screening Level	Details	NEPM (ASC) Reference
Ecological Investigation Levels (EILs) and Ecological Screening Levels (ESLs)	Available for selected metals and organic substances (EILs) and selected petroleum hydrocarbon compounds including Total Recoverable Hydrocarbon (TRH) fractions (ESLs). Used to assess the risk to terrestrial ecosystems, depend on land use scenarios and generally apply to top 2 m of soil at finished ground levels (root/habitation zone). Measurement of soil physicochemical properties (e.g. % iron, pH, cation exchange capacity [CEC]) is required to determine site-specific EILs. Background concentrations of contaminants should also be considered.	EILs: Table 1B(1) to Table 1B(5) ESLs: Table 1B(6)
Health-based Investigation Levels (HILs) and Health Screening Levels (HSLs)	Available for a broad range of metals and organic substances (HILs) and petroleum hydrocarbons and asbestos (HSLs). Used to assess the risk to human health depending on the land use – land use scenarios include standard residential (exposure setting A), residential with minimal soil access (exposure setting B), public open space (exposure setting C) and commercial / industrial (exposure setting D). HIL or HSL selected is also dependent on depth of contamination and for HSLs, geology / soil type.	HILs: Table 1A(1) HSLs: Table 1A (3) to Table 1A(5)
Management Limits	Available for petroleum hydrocarbon compounds in soil. Are applied following assessment of human health & ecological risks & risks to groundwater. Based on policy considerations due to nature and properties of petroleum hydrocarbons (e.g. formation of LNAPL, fire and explosive hazards, effects on buried infrastructure).	Table 1B(7)
Groundwater Investigation Levels (GIL)	Available for a broad range of organic and inorganic substances. Used to assess the potential risk to surface water bodies following the discharge of groundwater or to human health following extraction or vapour intrusion.	Table 1C
Interim Soil Vapour Health Investigation Levels (Interim HILs)	Available for five volatile organic chlorinated compounds in vapour. Used to assess the potential risk to human health following vapour intrusion.	Table 1A(2)

With respect to the application of the ISLs, the NEPM (ASC) notes that:

> *Investigation and screening levels are not clean-up or response levels nor are they desirable soil quality criteria. Investigation and screening levels are intended for assessing existing contamination and to trigger consideration of an appropriate site-specific risk-based approach or appropriate risk management options when they are exceeded. The use of these levels in regulating emissions and application of wastes to soil is inappropriate."*
> *No single summary statistic will fully characterise a site and appropriate consideration of relevant statistical measurements should be used in the data evaluation process….*

It is also noted that there are some discrepancies between the different guidance documents listed in this Framework, due to the revision of the guidance documents at different times. In the instance where City of Casey is unsure of which guidance document is most appropriate for a site, advice should be sought from EPA and/or a suitably qualified environmental (contaminated land) professional.

4.5 Detailed site investigation (environmental sampling)

Following the selection of ISL, a comprehensive contaminated land assessment can be undertaken to determine whether concentrations of chemicals at the site exceed the adopted ISL. This will inform a decision as to whether the contamination is acceptable to remain at the site based, or whether further action is required.

This further assessment is called a DSI and comprises sampling of the environmental media that is thought to be contaminated. This may include sampling of soil, groundwater, soil gas, landfill gas and/or sediments in appropriate target locations or in an approximate grid pattern across the site in accordance with AS4482.1 (2005). Table 2 from AS4482.1 (2005), which specifies the minimum sampling points required for a site of a certain area, is reproduced as Table 6 below. Table 6 applies to the investigation of the site. Guidance for the sampling of soils ex-situ (e.g. in a stockpile) is provided in Table 4 of Schedule B2 of the ASC NEPM and this table is reproduced as Table 7 below.

Table 6 Minimum sampling points required by AS4482.1 (2005)

Area of site (m^2)	Number of sampling points recommended
500	5
1 000	6
2 000	7
3 000	9
4 000	11
5 000	13
6 000	15
7 000	17
8 000 plus	19 plus one location per 1 000 m^2

Table 7 Minimum number of samples for ex-situ soils (NEPM [ASC])

Stockpile volume (m^3)	Number of samples
>75	3
75 - <100	4
100 - <125	5
125 - <150	6
150 - <175	7
175 - <200	8
>200	1:25

Following environmental sampling, the following works are normally undertaken:

- Submission of environmental samples to a National Association of Testing Authorities (NATA) Accredited Laboratory for analysis for the CoPCs. If applicable, a broad contaminant screen should also be undertaken at this point.
- Review of received analytical results against investigation and screening levels including those presented in the NEPM (ASC).

4.6 Further assessment

In the instance where appropriate environmental investigations have been undertaken in accordance with the CSM, and concentrations of chemicals are below the ISLs, no further contaminated land assessment is required.

However, in the instance where ISLs are exceeded, further assessment may be required. This further assessment may include:

- Site-specific human health and/or ecological risk assessment (terms for risk assessments include RA; HHRA; ERA, HHERA, VIRA, VRA and DRA): this may include additional sampling and analysis for specific parameters relating to geology or chemical form, ecological surveys, vapour intrusion modelling, review of toxicity parameters, exposure assessment and completion of intake calculations. The aim of this process is to reduce uncertainty relating to the use of generic ISL and to determine if the identified impacts pose an unacceptable risk to human or ecological receptors.
- Off-site monitoring: this may include the installation of off-site sampling points to work out how far the contamination has travelled off-site and whether off-site receptors (e.g. potable water supplies, surface water bodies etc.) may be impacted by the contamination.
- Hydrogeological investigations: this may include the collection of hydrogeological parameters such as slug testing or the use of groundwater fate and transport modelling.to estimate whether concentrations of contaminants identified at the site may reach nearby receptors.
- Remediation and/or management of identified impacts: this may include the remediation of impacts (either insitu or exsitu) or the management of impacts through the placement of marker layers or barrier layers to prevent exposure to the contamination, or the implementation of management plans.

Further information on the above items is provided in the NEPM (ASC) and EPA Publications listed in this Framework (refer to **Section 7.0**).

Community consultation or the advice of a suitably qualified environmental (contaminated land) professional and/or Environmental Auditor may also be required and further information regarding these steps is provided in **Section 5.3** and Error! Reference source not found. below.

4.7 Data Management

The following data management procedures are recommended:

- Information obtained by Council during contaminated land investigations should be stored in a central database that is accessible to all relevant staff members.
- A unique site ID should be created for each site and **Table B1** and **B2** in **Appendix B** should be completed (as applicable), and then updated as new information is collected. Copies of all information reviewed (including search outputs) should be retained on file.
- If the City of Casey has engaged a suitably qualified environmental professional to undertake works (including DSI) at a site that includes the sampling of soil or groundwater, **Table B3** in **Appendix B** should be completed during review of the documentation provided. A checklist for reviewing soil vapour data (as sourced from Appendix L of CRC CARE [2013]) is also provided in **Appendix B.**

5.0 Other Considerations

This section describes some of the overarching processes that may need to be considered during the investigation and management of contamination land (i.e. **Sections 4.1** to **4.7** above).

These things include:

- The environmental planning process.
- Disposal of soils excavated from Council's lands and sediments/soils generated from Council's drainage maintenance works
- Risk communication and involving the community.
- Allocating buffer distances around contaminated land.
- Seeking external advice.
- Health and safety when dealing with contaminated land.

A summary of each of these items is provided in **Sections 5.1** to **5.7** below.

5.1 Links with the environmental planning process

Contaminated land assessments are often undertaken for due-diligence purposes prior to the acquisition or divestment of land. However, the requirement for a contaminated land assessment may also be triggered by the Victoria Planning Provisions. Planning Practice Note 30 (DELWP 2021) provides advice on land use planning and potentially contaminated land. The planning process may also trigger the requirement for a Preliminary Risk Screen Assessment (PRSA) or Statutory Environmental Audit. EPA provides further guidance on these processes, as outlined in the publications listed in **Section 7.0.**

5.2 Disposal of soil

Any soil to be stockpiled on Council land or sediments from Council's drainage maintenance works, which are to be disposed of, should be inspected for any suspected contamination. Should any contamination be suspected, further investigation must be undertaken. As a general quality assurance procedure, random sampling and testing of soils excavated from Council's lands and sediments/soils generated from Council's drainage maintenance works should be undertaken. It is recommended that a detailed procedure for this work should be developed in consultation with relevant Council officers.

5.3 Risk communication and involving the community

Schedule B8 of the ASC NEPM provides guidance on community engagement and risk communication noting that when well-managed, community engagement and risk communication can benefit the assessment and management of site contamination. Section 5.2 of Schedule B8 includes a list of communication DOs and DON'Ts and this list has been provided below.

	DO	DON'T
Abstractions	DO use examples, anecdotes and analogies to establish a common understanding	DON'T generalise too much or use hypothetical situations
Attacks	DO attack the issue	DON'T attack the person or organisation
Blame	DO take responsibility for your share of the problem	DON'T try to shift blame or responsibility to others
Clarity	DO ask whether you have made yourself clear	DON'T assume you have been understood
Guarantees	DO emphasise ongoing efforts and	DON'T say there are no guarantees
	achievements made and explain any limitations on the guarantee and why they exist	
Humour	DO use humour wisely — if used, direct it at yourself	DON'T use humour in relation to safety, health or environmental issues
Jargon	DO define all technical terms and acronyms (e.g. NATA)	DON'T use language that may not be understood by your audience
Length of presentation	DO limit presentation to 15 mins to allow for longer question & answer periods	DON'T ramble or fail to plan the time well
Money	DO refer to the importance you attach to health, safety and environmental issues; your moral obligation to protect public health and the environment outweighs financial considerations	DON'T refer to the amount of money spent as if it proved your concern
Negative allegations	DO refute allegations	DON'T repeat or refer to them
Negative words and phrases	DO use positive or neutral terms	DON'T minimise or trivialise the risk
Non-verbal messages	DO be sensitive to non-verbal messages you are communicating; make them consistent with what you are saying	DON'T allow your body language, your position in the room, or your dress to be inconsistent with your message
'Off the record'	DO assume everything you say and do is part of the public record	DON'T make side comments or 'confidential' remarks
Organisational identity	DO use personal pronouns (i.e. I, we)	DON'T take on the identity of a large organisation
Promises	DO promise only what you can deliver. Set and follow strict orders	DON'T make promises you can't keep or fail to follow up
Reliance on words	DO use visuals to emphasise key points	DON'T rely entirely on words
Risk comparisons	DO use comparisons, when asked, to help put risks in perspective	DON'T compare unrelated risks
Speculations	DO provide information on what is being done	DON'T speculate about worst-case scenarios
Technical details and debates	DO base your remarks on empathy, competence, honesty and dedication	DON'T provide too much detail or take part in protracted technical debates
Temper	DO remain calm. Use a question or allegation as a springboard to say something positive	DON'T let your feelings interfere with your ability to communicate positively

5.4 Allocating buffer distances around contaminated sites

If off-site properties may be impacted by a contaminated site, Council may choose to designate a buffer area that extends over these properties as well as the subject site.

Specific guidance for the implementation of buffer distances is not provided in the NEPM (ASC) and, as discussed above, the transport of contaminants at a site may be complex. Hence, the need for a buffer area around a contaminated site should be considered carefully on a site-specific basis when the site CSM has been established and enough information is available for the subject site to determine the CoPCs, the transport pathways for contamination (exposure pathways) and the off-site human and ecological receptors that may be affected by the CoPCs. This level of information will generally be available following completion of a DSI.

It is not recommended that buffer areas are applied around contaminated or potentially contaminated sites without a detailed assessment, as this may expose council to unacceptable levels of financial risk (including the need to contest objections at the Victoria Civil and Administrative Tribunal; VCAT) or cause un-necessary community concern.

If, following receipt of a DSI and detailed review of the CSM, Council considers that a buffer area is required around a contaminated site, the following guidance may assist in determining the buffer area:

- For contaminated sites, buffers are generally applied to title boundaries (i.e. they are not generally defined based on distance from the site). This is so controls can be implemented on a property by property basis.
- The application of buffer distances should err on the side of caution. In the instance where significant mobile contamination is identified, and complete exposure pathways have been identified, it would not be unreasonable to extend the buffer to one property beyond the property of concern around a contaminated site. This is especially important if groundwater use is known or suspected in the area in the area (e.g. use of groundwater for irrigation, stock watering or filling swimming pools).
- Under natural conditions, groundwater travels towards the nearest surface water body. Hence, determination of the nearest surface water body (e.g. during the PSI) can help to determine those properties that are down gradient from the contaminated site and may be impacted by groundwater contamination at the site.
- Vapour can travel upwards in any direction, hence, if soil vapour contamination has been identified at a site, buffer areas in all directions around the site should be considered. However, vapours from contaminated land (excluding landfills) do not generally travel significant distances vertically or horizontally i.e. they generally travel in the order of 10s of metres rather than 100s of metres away from the source. The exception is if a preferential pathway (e.g. an underground service) is present.

It is suggested that Council seek external advice from a suitably qualified (contaminated land) professional prior to the allocation of buffer areas around a contaminated site.

5.6 Seeking External Advice

City of Casey may need to seek external advice at one or more stages during the contaminated land assessment process. This may include when:

- It is unclear whether or not a site may be potentially contaminated from the site history information reviewed.
- Where the potential for contamination has been identified and City of Casey does not have the necessary in-house expertise to design/undertake DSI works.

- Where contamination has been identified and further assessment, remediation, risk assessment or management measures is, or may be, required.
- When the allocation of a buffer area around a contaminated site is being considered.

External advice should be sought from a suitably qualified environmental (contaminated land) professional. Although general guidance is provided in Schedule B9 of the ASC NEPM, there is no one formal accreditation process for contaminated land professionals in Victoria, however, Council may choose to refer to the member lists of the following organizations when choosing a suitably qualified environmental (contaminated land) professional:

- EPA List of Appointed Environmental Auditors – Contaminated Land.
- Australian Contaminated Land Consultants Association (ACLCA).
- Australian Land and Groundwater Association (ALGA).

The following certification schemes for contaminated land practitioners are currently available:

- Certified Environmental Practitioner (CEnvP) – Site Contamination.
- Certified Professional Soil Scientist (CPSS) Contaminated Site Assessment and Management.

With respect to the level of external advice sought, the following options are available to Council, and Council may choose which option is most appropriate:

- Council can engage a contaminated land consultant to undertaken assessment works or to peer review assessment works undertaken by Council.
- Council may request a PRSA or Statutory Environmental Audit be undertaken to confirm that the site in question is suitable for the proposed or existing land use.
- Council may request that a submitted report is peer reviewed and an opinion provided by an appointed Environmental Auditor in their capacity as a suitably qualified professional, outside of the Environmental Audit process. This may provide confidence that the requested person has the necessary level of expertise without the need to go through the Environmental Audit Process.
- Council may seek advice from EPA Victoria on 1300 372 842 (1300 EPA VIC).

In most instances it will be unnecessary for Council to have a PRSA or Statutory Environmental Audit completed prior to decision making, however, the need for this should be reviewed by Council on a case by case basis.

Legal advice should be sought if at any stage in the process Council is uncomfortable that the actions being proposed or implemented, or lack of action, could expose them to unacceptable levels of risk.

The environmental duties imposed by the Act should be considered throughout the contaminated land assessment and management process, as relevant to all Council owned and managed land.

5.7 Health and safety when dealing with contaminated land

It is critical that effective and appropriate health and safety procedures are implemented when dealing with contaminated and potentially contaminated land to protect site workers from contamination. Prior to any environmental sampling works at a contaminated or potentially contaminated site, Council should consider engaging a suitably qualified environmental professional so that an appropriate occupational health and safety plan can be prepared and implemented for the proposed works. Further, if any significant visual or olfactory evidence of contamination is identified during works (e.g. odours, visually stained soils, ACM or the presence of free phase hydrocarbon liquids, or workers start to feel unwell), works should cease and the site vacated until additional appropriate occupational health and safety controls can be implemented.

If Council workers are undertaking a site inspection or limited soil sampling at sites where significant contamination is not expected, health and safety practices should be adopted to

limit the potential for exposure to contamination. Generally speaking, exposure pathways to contaminants may include the following:

- Incidental ingestion of contaminated soil or groundwater.
- Inhalation of dust.
- Inhalation of vapours from soil or groundwater.
- Dermal (skin) contact with soil or groundwater.

Standard Personal Protective Equipment (PPE) commonly required at construction sites should be used at all times on a contaminated or potentially contaminated site. PPE should include:

- Gloves (if/when handling potentially contaminated soil). Many types of gloves are available and the length and material choice of glove will depend on the type of contamination present. Contaminated land professionals commonly use cut-resistant gloves (to protect against abrasion e.g. from inert waste in fill) with nitrile gloves over the top. However additional protection may be required if significant contamination is present, and external advice from a suitably qualified professional should be sought in these circumstances.
- Eye protection (especially if it is dusty on-site).
- High visibility clothing.
- Clothing with long sleeves and long pants.
- Steel capped boots.
- Hard hat and hearing protection (if plant or machinery is present on-site)

In addition:

- Good hygiene practices should be maintained during and after works (including practices like washing hands on leaving the site and before eating, drinking or toileting).
- PPE should be stored in a clean place to avoid contamination.
- PPE including clothing should be regularly cleaned, maintained and inspected to ensure it remains effective.
- Work clothing should be separated from general laundry.
- Gloves should be replaced regularly, and other equipment as required.
- The need for respiratory protection should be considered on a site-specific basis e.g. if odorous soils or high levels of volatile contaminants are expected or identified during works. External advice from a suitably qualified professional should be sought in these circumstances.

6.0 Review of the Framework

Review and amendment of this Framework should be undertaken:

- Following a change in the role and responsibility of Council with respect to contaminated land.
- Following the release of updated guidance documents relating to contaminated land. This may include new or updated legislation and/or key documents released by EPA.
- When there is a need to improve performance.

In the absence of any of the above, the Framework should be reviewed 6 months after implementation and every 4 years thereafter to ensure it continues to meet Council's requirements.

The Framework should be reviewed by both the Landfill and Planning departments with the assistance of a suitably qualified environmental (contaminated land) professional.

Following a significant change in the role and responsibilities of Council, review by City of Casey's legal advisor may also be prudent.

7.0 References

Legislation:

- Victorian Government, 2001. Direction No.1 – Potentially Contaminated Land. Available at: Planning and Environment Act 1987
- Victorian Government, 2017. Environment Protection Act 2017. Available at: Environment Protection Act 2017 (legislation.vic.gov.au).
- Victorian Government, 2018. Environment Protection Amendment Act 2018. Available at: Environment Protection Amendment Act 2018 (legislation.vic.gov.au).
- Victorian Government 2021, Environment Protection Regulations 2021. Available at: Environment Protection Regulations 2021 (legislation.vic.gov.au)
- Victorian Government 2021, Environmental Reference Standard. Available at: GG2021S245.pdf (gazette.vic.gov.au)

Australian Standards:

- Australian Standard AS 4482.1-2005 Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soil. Part 1: Non-volatile and Semi-volatile Compounds, Standards Australia 2005.
- Australian Standard AS 4482.2-1999 Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part 2: Volatile Substances, Standards Australia 1999.
- Australian Standard AS 2159-2009 Piling – Design and Installation, Standards Australia 2009.
- All available for purchase at: Home | Standards Australia

Overarching national guidance document for the assessment of contaminated land:

- National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1), April 2013 - the NEPM (ASC) (Available at: National Environment Protection (Assessment of Site Contamination) Measure | National Environment Protection Council (nepc.gov.au)):
    - Schedule B1, Investigation Levels for Soil and Groundwater
    - Schedule B2, Site Characterisation
    - Schedule B2, Laboratory Analysis of Potentially Contaminated Soil
    - Schedule B4, Site-Specific Health Risk Assessment Methodology
    - Schedule B5a, Ecological Risk Assessment
    - Schedule B5b, Methodology to Derive Ecological Investigation Levels in Contaminated Soils
    - Schedule B5c, Ecological Investigation Levels for Arsenic, Chromium (III), Copper, DDT, Lead, Naphthalene, Nickel and Zinc
    - Schedule B6, The Framework for Risk-Based Assessment of Groundwater Contamination
    - Schedule B7 and Appendices, Derivation of Health-Based Investigation Levels
    - Schedule B8, Community Engagement and Risk Communication
    - Schedule B9, Guideline on Competencies and Acceptance of Environmental Auditors and Related Professionals

EPA guidance on implementation, policy and risk:

- Publication 1553 (October 2013) – Implementing the National Environment Protection (Assessment of Contaminated Sites) Measure amendment 2013.
- Publication 1571.1 (October 2017) – Demonstrating Best Practice.
- Publication 1695.1 (August 2018) – Assessing and controlling risk: A guide for business.

- Publication 1741.1 (October 2020) – Industry guidance: supporting you to comply with the general environmental duty.
- Publication 1753.2 (May 2021) – Guide to the Environment Protection Regulations.
- Publication 1782.2 (June 2021) – Compliance and enforcement policy.
- Publication 1851.1 (November 2020) – Implementing the general environmental duty: A guide for licence holders.
- Publication 1856 (September 2020) – Reasonably practicable.
- Publication 1915 (February 2021) – Contaminated land policy.
- Publication 1940 (February 2021) – Contaminated land: understanding section 35 of the Environment Protection Act 2017.
- Publication 1977 (June 2021) – Assessing and controlling contaminated land risks: A guide to meeting the duty to manage for those in management or control of land.
- Publication 1992 (June 2021) – Guide to the Environmental Reference Standard.
- Publication 2008.1 (July 2021) – Notifiable contamination guideline – Duty to notify of contaminated land.
- Publication 2010 (July 2021) – Potentially contaminated land – A guide for business.

EPA guidance for Local Government:

- Publication 1671 (February 2018) – Local Council Self-Assessment Tool for Closed Landfill Environmental Risk.
- Publication 1821.1 (May 2021) – Local Government – Guide to preventing hard to people and the environment.
- Publication 1825.1 (June 2021) – Waste and recycling – Guide to preventing harm to people and the environment.

EPA guidance on soil sampling:

- Publication IWRG702 (June 2009) – Soil sampling.
- Publication 2033 (November 2021) – Background levels: Identifying naturally occurring chemical substances, method and approach.

EPA guidance on classification of soil for off-site disposal purposes:

- Publication 1827.2 (March 2021) – Waste classification assessment protocol.
- Publication 1828.2 (March 2021) – Waste disposal categories – characteristics and thresholds.
- Publication 1968.1 (August 2021) – Guide to classifying industrial waste.

EPA guidance on water sampling:

- Publication IWRG701 (June 2009) – Sampling and Analysis of Waters, Waste Waters, Soils and Wastes.
- Publication 668 (September 2006) – Hydrogeological Assessment (Groundwater Quality) Guidelines.
- Publication 669.1 (February 2022) – Groundwater sampling guidelines.

EPA guidance for Environmental Auditors:

- Publication 2001 (July 2021) – Guidance for the cleanup and management of contaminated groundwater.
- Publication 2009 (June 2021) - Information sheet for environmental audits and preliminary risk screen assessments (PRSAs)
- Publication 2021 (February 2022) – Guideline for conducting preliminary risk screen assessments.
- Publication 2022 (August 2021) – Environmental auditor guidelines – Provision of statements and reports for environmental audits and preliminary risk screen assessments.
- Publication 2041 (February 2022) – Guideline for conducting environmental audits.

EPA guidance on engaging consultants:

- Publication 1702 (June 2018) – Fact sheet: Engaging consultants.

Planning guidance:

- Planning Practice Note 30 (July 2021) – Potentially Contaminated Land (Available at: PPN30-Potentially-contaminated-land.pdf (planning.vic.gov.au)).

CRC CARE guidance:

- Technical Report No. 10 (September 2011) – Health screening levels for petroleum hydrocarbons in soil and groundwater.
- Technical Report No. 23 (July 2013) – Petroleum hydrocarbon vapour intrusion assessment: Australian guidance.
- All available at: Technical reports (crccare.com).

National guidance on PFAS:

- National Environmental Management Plan (the PFAS NEMP) (Available at: PFAS National Environmental Management Plan | Environment Protection Authority Victoria (epa.vic.gov.au))

8.0 Responsibilities

Who	What
Site Assessment and Environmental Remediation Team	Undertake assessments of the potential for land contamination of Council owned land.
Site Assessment and Environmental Remediation Team	Update Contaminated Land Assessment Register with updated information on land assessed to be contaminated or potentially contaminated that can be used by Council officers for decision making.
Site Assessment and Environmental Remediation Team	Ensure all depratments at Casey, who are directlu involved ith Council owned land, understand and implement the framework where appropriate.
Site Assessment and Environmental Remediation Team	Adhere to and keep updated on the legal framework for managing contaminated land in Victoria, including a description of the Environment Protection Act 2017 (the Act), the Environment Protection Regulations 2021 (the Regulations) and the Environmental Reference Standard (the ERS).

9.0 Relevant Forms

NA

10.0 Document History

Date approved	Change Type	Version	Next Review Date
29 Sep 2015	Document Created by Environmental Risk Sciences Pty Ltd	1.0	9 Aug 2024
9 Aug 2024	Update all sections of the Framework to align with new EPA legislation - *Victorian Government 2021, Environment Protection Regulations 2021*. Reformatted document and added formatting to align with all Casey documents. Updated formatting to ensure alignment with all City of Casey documents.	2.0	9 Aug 2028

Appendix A Investigation and screening levels

6 Tabulated investigation and screening levels

ROUNDING APPLIED TO INVESTIGATION AND SCREENING LEVELS

Tables 1A (HILs and interim HILs)

Rounded to 1 or 2 significant figures (see Schedule B7 Appendix C for details)

Tables 1A (HSLs) and 1B (EILs and ESLs) rounding rules

< 1	**to nearest 0.1**
1–<10	**to nearest whole number**
1–< 100	**to nearest 5**
100–<1,000	**to nearest 10**
1,000–<10,000	**to nearest 100**
≥10,000	**to nearest 1,000**

Numbers ending in '5' are rounded up, for example:

0.05 rounded to 0.1

1.5 rounded to 2

115 rounded to 120

Table 1A(1) Health investigation levels for soil contaminants

Chemical	Health-based investigation levels (mg/kg)			
	Residential[1] A	Residential[1] B	Recreational[1] C	Commercial/ industrial[1] D
Metals and Inorganics				
Arsenic[2]	100	500	300	3 000
Beryllium	60	90	90	500
Boron	4500	40 000	20 000	300 000
Cadmium	20	150	90	900
Chromium (VI)	100	500	300	3600
Cobalt	100	600	300	4000
Copper	6000	30 000	17 000	240 000
Lead[3]	300	1200	600	1 500
Manganese	3800	14 000	19 000	60 000
Mercury (inorganic)[5]	40	120	80	730
Methyl mercury[4]	10	30	13	180
Nickel	400	1200	1200	6 000
Selenium	200	1400	700	10 000
Zinc	7400	60 000	30 000	400 000
Cyanide (free)	250	300	240	1 500
Polycyclic Aromatic Hydrocarbons (PAHs)				
Carcinogenic PAHs (as BaP TEQ)[6]	3	4	3	40
Total PAHs[7]	300	400	300	4000
Phenols				
Phenol	3000	45 000	40 000	240 000
Pentachlorophenol	100	130	120	660
Cresols	400	4 700	4 000	25 000
Organochlorine Pesticides				
DDT+DDE+DDD	240	600	400	3600
Aldrin and dieldrin	6	10	10	45
Chlordane	50	90	70	530
Endosulfan	270	400	340	2000
Endrin	10	20	20	100
Heptachlor	6	10	10	50
HCB	10	15	10	80
Methoxychlor	300	500	400	2500
Mirex	10	20	20	100
Toxaphene	20	30	30	160
Herbicides				
2,4,5-T	600	900	800	5000
2,4-D	900	1600	1300	9000
MCPA	600	900	800	5000

Chemical	Health-based investigation levels (mg/kg)			
	Residential[1] A	Residential[1] B	Recreational[1] C	Commercial/ industrial[1] D
MCPB	600	900	800	5000
Mecoprop	600	900	800	5000
Picloram	4500	6600	5700	35000
Other Pesticides				
Atrazine	320	470	400	2500
Chlorpyrifos	160	340	250	2000
Bifenthrin	600	840	730	4500
Other Organics				
PCBs[8]	1	1	1	7
PBDE Flame Retardants (Br1–Br9)	1	2	2	10

Notes:

(1) Generic land uses are described in detail in Schedule B7 Section 3

HIL A – Residential with garden/accessible soil (home grown produce <10% fruit and vegetable intake (no poultry), also includes childcare centres, preschools and primary schools.

HIL B – Residential with minimal opportunities for soil access; includes dwellings with fully and permanently paved yard space such as high-rise buildings and apartments.

HIL C – Public open space such as parks, playgrounds, playing fields (e.g. ovals), secondary schools and footpaths. This does not include undeveloped public open space where the potential for exposure is lower and where a site-specific assessment may be more appropriate.

HIL D – Commercial/industrial, includes premises such as shops, offices, factories and industrial sites.

(2) Arsenic: HIL assumes 70% oral bioavailability. Site-specific bioavailability may be important and should be considered where appropriate (refer Schedule B7).

(3) Lead: HIL is based on blood lead models (IEUBK for HILs A, B and C and adult lead model for HIL D where 50% oral bioavailability has been considered. Site-specific bioavailability may be important and should be considered where appropriate.

(4) Methyl mercury: assessment of methyl mercury should only occur where there is evidence of its potential source. It may be associated with inorganic mercury and anaerobic microorganism activity in aquatic environments. In addition the reliability and quality of sampling/analysis should be considered.

(5) Elemental mercury: HIL does not address elemental mercury. A site-specific assessment should be considered if elemental mercury is present, or suspected to be present,

(6) Carcinogenic PAHs: HIL is based on the 8 carcinogenic PAHs and their TEFs (potency relative to B(a)P) adopted by CCME 2008 (refer Schedule B7). The B(a)P TEQ is calculated by multiplying the concentration of each carcinogenic PAH in the sample by its B(a)P TEF, given below, and summing these products.

PAH species	TEF	PAH species	TEF
Benzo(a)anthracene	0.1	Benzo(g,h,i)perylene	0.01
Benzo(a)pyrene	1	Chrysene	0.01
Benzo(b+j)fluoranthene	0.1	Dibenz(a,h)anthracene	1
Benzo(k)fluoranthene	0.1	Indeno(1,2,3-c,d)pyrene	0.1

Where the B(a)P occurs in bitumen fragments it is relatively immobile and does not represent a significant health risk.

(7) Total PAHs: HIL is based on the sum of the 16 PAHs most commonly reported for contaminated sites (WHO 1998). The application of the total PAH HIL should consider the presence of carcinogenic PAHs and naphthalene (the most volatile PAH). Carcinogenic PAHs reported in the total PAHs should meet the B(a)P TEQ HIL. Naphthalene reported in the total PAHs should meet the relevant HSL.

(8) PCBs: HIL relates to non-dioxin-like PCBs only. Where a PCB source is known, or suspected, to be present at a site, a site-specific assessment of exposure to all PCBs (including dioxin-like PCBs) should be undertaken.

Table 1A(2) Interim soil vapour health investigation levels for volatile organic chlorinated compounds

Chemical	Interim soil vapour HIL (mg/m^3)			
	Residential[1] A	Residential[1] B	Recreational[1] C	Commercial / Industrial[1] D
TCE	0.02	0.02	0.4	0.08
1,1,1-TCA	60	60	1200	230
PCE	2	2	40	8
cis-1,2-dichloroethene	0.08	0.08	2	0.3
Vinyl chloride	0.03	0.03	0.5	0.1

Notes:

1. Land use settings are equivalent to those described in Table 1A(1) Footnote 1 and Schedule B7, though secondary school buildings should be assessed using residential 'A/B' for vapour intrusion purposes.
2. Interim HILs for VOCCs are conservative soil vapour concentrations that can be adopted for the purpose of screening sites where further investigation is required on a site-specific basis. They are based on the potential for vapour intrusion using an indoor air-to-soil vapour attenuation factor of 0.1 and an outdoor air-to-soil vapour attenuation factor of 0.05.
3. Application of the interim HILs is based on a measurement of shallow (to 1 m depth) soil vapour (or deeper where the values are to be applied to a future building with a basement) or sub-slab soil vapour.
4. The applicability of the interim HILs needs to be further considered when used for other building types such as homes with a crawl-space and no slab, which may require site-specific assessment.
5. Use of the interim HILs requires comparison with data that has been collected using appropriate methods and meets appropriate data quality requirements.
6. Oral and dermal exposure should be considered on a site-specific basis where direct contact exposure is likely to occur.

Table 1A(3) Soil HSLs for vapour intrusion (mg/kg)

	HSL A & HSL B Low – high density residential				HSL C recreational / open space				HSL D Commercial / Industrial				
CHEMICAL	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4m**	**4 m+**	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m+**	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m+**	**Soil saturation concentration (Csat)**
SAND													
Toluene	160	220	310	540	NL	NL	NL	NL	NL	NL	NL	NL	560
Ethylbenzene	55	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	64
Xylenes	40	60	95	170	NL	NL	NL	NL	230	NL	NL	NL	300
Naphthalene	3	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	9
Benzene	0.5	0.5	0.5	0.5	NL	NL	NL	NL	3	3	3	3	360
F1[9]	45	70	110	200	NL	NL	NL	NL	260	370	630	NL	950
F2[10]	110	240	440	NL	NL	NL	NL	NL	NL	NL	NL	NL	560
SILT													
Toluene	390	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	640
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	69
Xylenes	95	210	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	330

	HSL A & HSL B Low – high density residential				HSL C recreational / open space				HSL D Commercial / Industrial				
Naphthalene	4	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	10
Benzene	0.6	0.7	1	2	NL	NL	NL	NL	4	4	6	10	440
F1[9]	40	65	100	190	NL	NL	NL	NL	250	360	590	NL	910
F2[10]	230	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	570
CLAY													
Toluene	480	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	630
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	68
Xylenes	110	310	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	330
Naphthalene	5	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	10
Benzene	0.7	1	2	3	NL	NL	NL	NL	4	6	9	20	430
F1[9]	50	90	150	290	NL	NL	NL	NL	310	480	NL	NL	850
F2[10]	280	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	560

Notes:

(1) Land use settings are equivalent to those described in Table 1A(1) Footnote 1 and Schedule B7. HSLs for vapour intrusion for high density residential assume residential occupation of the ground floor. If communal car parks or commercial properties occupy the ground floor, HSL D should be used,

(2) The key limitations of the HSLs should be referred to prior to application and are presented in Friebel and Nadebaum (2011b and 2011d).

(3) Detailed assumptions in the derivation of the HSLs and information on how to apply the HSLs are presented in Friebel and Nadebaum (2011a and 2011b).

(4) Soil HSLs for vapour inhalation incorporate an adjustment factor of 10 applied to the vapour phase partitioning to reflect the differences observed between theoretical estimates of soil vapour partitioning and field measurements. Refer Friebel & Nadebaum (2011a) for further information.

(5) The soil saturation concentration (Csat) is defined as the soil concentration at which the porewater phase cannot dissolve any more of an individual chemical. The soil vapour that is in equilibrium with the porewater will be at its maximum. If the derived soil HSL exceeds Csat, a soil vapour source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario. For these scenarios, no HSL is presented for these chemicals and the HSL is shown as 'not limiting' or 'NL'.

(6) The HSLs for TPH C_6-C_{10} in sandy soil are based on a finite source that depletes in less than seven years, and therefore consideration has been given to use of sub-chronic toxicity values. The >C_8-C_{10} aliphatic toxicity has been adjusted to represent sub-chronic exposure, resulting in higher HSLs than if based on chronic toxicity. For further information refer to Section 8.2 and Appendix J in Friebel and Nadebaum (2011a).

(7) The figures in the above table may be multiplied by a factor to account for biodegradation of vapour. A factor of 10 may apply for source depths from 2 m to <4 m or a factor of 100 for source depths of 4 m and deeper. To apply the attenuation factor for vapour degradation, a number of conditions must be satisfied. Firstly the maximum length of the shorter side of the concrete slab and surrounding pavement cannot exceed 15 m, as this would prevent oxygen penetrating to the centre of the slab. Secondly, measurement of oxygen in the subsurface is required to determine the potential for biodegradation. Oxygen must be confirmed to be present at >5% to use these factors.

(8) For soil texture classification undertaken in accord with AS 1726, the classifications of sand, silt and clay may be applied as coarse, fine with liquid limit <50% and fine with liquid limit>50% respectively, as the underlying properties to develop the HSLs may reasonably be selected to be similar. Where there is uncertainty, either a conservative approach may be adopted or laboratory analysis should be carried out.

(9) To obtain F1 subtract the sum of BTEX concentrations from the C_6-C_{10} fraction.

(10) To obtain F2 subtract naphthalene from the >C_{10}-C_{16} fraction.

Table 1A(4) Groundwater HSLs for vapour intrusion (mg/L)

	HSL A & HSL B Low – high density residential			HSL C recreational / open space			HSL D Commercial / industrial			
CHEMICAL	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**Solubility limit**
SAND										
Toluene	NL	NL	NL	NL	NL	NL	NL	NL	NL	61
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.9
Xylenes	NL	NL	NL	NL	NL	NL	NL	NL	NL	21
Naphthalene	NL	NL	NL	NL	NL	NL	NL	NL	NL	0.17
Benzene	0.8	0.8	0.9	NL	NL	NL	5	5	5	59
F1[7]	1	1	1	NL	NL	NL	6	6	7	9.0
F2[8]	1	1	1	NL	NL	NL	NL	NL	NL	3.0
SILT										
Toluene	NL	NL	NL	NL	NL	NL	NL	NL	NL	61
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.9
Xylenes	NL	NL	NL	NL	NL	NL	NL	NL	NL	21
Naphthalene	NL	NL	NL	NL	NL	NL	NL	NL	NL	0.17

	HSL A & HSL B Low – high density residential			HSL C recreational / open space			HSL D Commercial / industrial			
Benzene	4	5	5	NL	NL	NL	30	30	30	59
F1[7]	6	6	6	NL	NL	NL	NL	NL	NL	9.0
F2[8]	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.0
CLAY										
Toluene	NL	NL	NL	NL	NL	NL	NL	NL	NL	61
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.9
Xylenes	NL	NL	NL	NL	NL	NL	NL	NL	NL	21
Naphthalene	NL	NL	NL	NL	NL	NL	NL	NL	NL	0.17
Benzene	5	5	5	NL	NL	NL	30	30	35	59
F1[7]	NL	NL	NL	NL	NL	NL	NL	NL	NL	9.0
F2[8]	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.0

Notes:

(1) Land use settings are equivalent to those described in Table 1A(1) Footnote 1 and Schedule B7. HSLs for vapour intrusion for high density residential assume residential occupation of the ground floor. If communal car parks or commercial properties occupy the ground floor, HSL D should be used,

(2) The key limitations of the HSLs are presented in Friebel and Nadebaum (2011d) and should be referred to prior to application.

(3) Detailed assumptions in the derivation of the HSLs and information on the application of the HSLs are presented in Friebel and Nadebaum (2011a and 2011b).

(4) The solubility limit is defined as the groundwater concentration at which the water cannot dissolve any more of an individual chemical based on a petroleum mixture. The soil vapour that is in equilibrium with the groundwater will be at its maximum. If the derived groundwater HSL exceeds the water solubility limit, a soil vapour source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario. For these scenarios, no HSL is presented for these chemicals and the HSL is shown as 'not limiting' or 'NL'.

(5) The figures in the above table may be multiplied by a factor to account for biodegradation of vapour. A factor of 10 may apply for source depths from 2 m to <4 m or a factor of 100 for source depths of 4 m and deeper. To apply the attenuation factor for vapour degradation, a number of conditions must be satisfied. Firstly, the maximum length of the shorter side of the concrete slab and surrounding pavement cannot exceed 15 m, as this would prevent oxygen penetrating to the centre of the slab. Secondly, measurement of oxygen in the subsurface is required to determine the potential for biodegradation. Oxygen must be confirmed to be present at >5% to use these factors.

(6) For soil texture classification undertaken in accord with AS 1726, the classifications of sand, silt and clay may be applied as coarse, fine with liquid limit <50% and fine with liquid limit >50% respectively, as the underlying properties to develop the HSLs may reasonably be selected to be similar. Where there is uncertainty, either a conservative approach may be adopted or laboratory analysis should be carried out.

(7) To obtain F1 subtract the sum of BTEX concentrations from the C_6-C_{10} fraction.

(8) To obtain F2 subtract naphthalene from the >C_{10}-C_{16} fraction.

Table 1A(5) Soil vapour HSLs for vapour intrusion (mg/m³)

	HSL A & HSL B Low – high density residential					HSL C recreational / open space					HSL D Commercial / Industrial				
CHEMICAL	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**
SAND															
Toluene	1300	3800	7300	15 000	29 000	NL	NL	NL	NL	NL	4800	16 000	39 000	84 000	NL
Ethylbenzene	330	1100	2200	4300	8700	NL	NL	NL	NL	NL	1300	4600	11 000	25 000	53 000
Xylenes	220	750	1500	3000	6100	NL	NL	NL	NL	NL	840	3,200	8000	18 000	37 000
Naphthalene	0.8	3	6	10	25	410	NL	NL	NL	NL	3	15	35	75	150
Benzene	1	3	6	10	20	360	2400	4700	9500	19 000	4	10	30	65	130
F1[8]	180	640	1,300	2600	5300	86 000	NL	NL	NL	NL	680	2800	7000	15 000	32 000
F2[9]	130	560	1200	2400	4800	NL	NL	NL	NL	NL	500	2400	NL	NL	NL
SILT															
Toluene	1400	14 000	32 000	69 000	140 000	NL	NL	NL	NL	NL	5700	63 000	NL	NL	NL
Ethylbenzene	380	4200	9700	21 000	43 000	NL	NL	NL	NL	NL	1500	19 000	54 000	NL	NL
Xylenes	260	2900	6800	15 000	30 000	NL	NL	NL	NL	NL	1000	13 000	38 000	NL	NL
Naphthalene	0.9	10	25	60	120	NL	NL	NL	NL	NL	4	50	150	350	750
Benzene	1	10	25	55	110	1800	12 000	24 000	48 000	97 000	4	50	140	320	670
F1[8]	210	2600	6000	13 000	26 000	NL	NL	NL	NL	NL	850	11 000	33 000	77 000	160 000

	HSL A & HSL B Low – high density residential					HSL C recreational / open space					HSL D Commercial / Industrial				
F2[9]	160	2300	5400	NL	NL	NL	NL	NL	NL	NL	670	NL	NL	NL	NL
CLAY															
Toluene	1600	23 000	53 000	110 000	NL	NL	NL	NL	NL	NL	6500	100 000	NL	NL	NL
Ethylbenzene	420	6800	16 000	35 000	NL	NL	NL	NL	NL	NL	1800	31 000	NL	NL	NL
Xylenes	280	4800	11 000	24 000	50 000	NL	NL	NL	NL	NL	1200	21 000	NL	NL	NL
Naphthalene	1	20	45	95	200	NL	NL	NL	NL	NL	4	85	240	560	1200
Benzene	1	15	40	90	180	3000	20 000	40 000	81 000	160 000	5	80	230	530	1100
F1[8]	230	4200	9900	21 000	44 000	NL	NL	NL	NL	NL	1000	19 000	55 000	130 000	270 000
F2[9]	180	3,800	NL	NL	NL	NL	NL	NL	NL	NL	800	NL	NL	NL	NL

1. Land use settings are equivalent to those described in Table 1A(1) Footnote 1 and Schedule B7. HSLs for vapour intrusion for high density residential assume residential occupation of the ground floor. If communal car parks or commercial properties occupy the ground floor, HSL D should be used,
2. The key limitations of the HSLs should be referred to prior to application and are presented in Friebel and Nadebaum (2011b and 2011d).
3. Detailed assumptions in the derivation of the HSLs and information on how to apply the HSLs are presented in Friebel and Nadebaum (2011a and 2011b).
4. The maximum possible soil vapour concentrations have been calculated based on vapour pressures of the pure chemicals. Where soil vapour HSLs exceed these values a soil-specific source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario. For these scenarios, no HSL is presented for these chemicals and the HSL is shown as 'not limiting' or 'NL'.
5. Soil vapour HSLs should be compared with measurements taken as laterally close as possible to the soil or groundwater sources of vapour (i.e. within or above vapour sources). Consideration is required of where the sample is taken, the current condition of the site and the likely future condition of the site. Shallow gas measurements in open space (1ess than 1 m below ground surface) may be subject to influences of weather conditions and moisture.
6. The figures in the above table may be multiplied by a factor to account for biodegradation of vapour. A factor of 10 may apply for source depths from 2 m to <4 m or a factor of 100 for source depths of 4 m and deeper. To apply the attenuation factor for vapour degradation, a number of conditions must be satisfied. Firstly, the maximum length of the shorter side of the concrete slab and surrounding pavement cannot exceed 15 m, as this would prevent oxygen penetrating to the centre of the slab. Secondly, measurement of oxygen in the subsurface is required to determine the potential for biodegradation. Oxygen must be confirmed to be present at >5% to use these factors.
7. For soil texture classification undertaken in accord with AS 1726, the classifications of sand, silt and clay may be applied as coarse, fine with liquid limit <50% and fine with liquid limit >50% respectively as the underlying properties to develop the HSLs may reasonably be selected to be similar. Where there is uncertainty, either a conservative approach may be adopted or laboratory analysis should be carried out.
8. To obtain F1 subtract the sum of BTEX concentrations from the C_6-C_{10} fraction.

9. To obtain F2 subtract naphthalene from the $>C_{10}$-C_{16} fraction.

Table 1B(1) Soil-specific added contaminant limits for aged zinc in soil

Zn added contaminant limits (ACL, mg added contaminant/kg)						
Areas of ecological significance						
pH[a]	***CEC[b] ($cmol_c$/kg)***					
	5	***10***	***20***	***30***	***40***	***60***
4.0	15	20	20	20	20	20
4.5	20	25	25	25	25	25
5.0	30	40	40	40	40	40
5.5	40	60	60	60	60	60
6.0	50	90	90	90	90	90
6.5	50	90	130	130	130	130
7.0	50	90	150	190	190	190
7.5	50	90	150	210	260	280
Urban residential/public open space[1]						
pH[a]	***CEC[b] ($cmol_c$/kg)***					
	5	***10***	***20***	***30***	***40***	***60***
4.0	70	85	85	85	85	85
4.5	100	120	120	120	120	120
5.0	130	180	180	180	180	180
5.5	180	270	270	270	270	270
6.0	230	400	400	400	400	400
6.5	230	400	590	590	590	590
7.0	230	400	700	880	880	880
7.5	230	400	700	960	1200	1300
Commercial/industrial						
pH[a]	***CEC[b] ($cmol_c$/kg)***					
	5	***10***	***20***	***30***	***40***	***60***
4.0	110	130	130	130	130	130
4.5	150	190	190	190	190	190
5.0	210	290	290	290	290	290
5.5	280	420	420	420	420	420
6.0	360	620	620	620	620	620
6.5	360	620	920	920	920	920
7.0	360	620	1100	1400	1400	1400
7.5	360	620	1100	1500	1900	2000

1. Urban residential/public open space is broadly equivalent to the HIL A, HIL B and HIL C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. Aged values apply to contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
3. The EIL is calculated from summing the ACL and the ABC.

a = pH measured using the $CaCl_2$ method (Rayment & Higginson 1992).

b = CEC measured using the silver thiourea method (Chabra et al. 1972).

Table 1B(2) Soil-specific added contaminant limits for aged copper in soils

Cu added contaminant limits (ACL, mg added contaminant/kg)					
Areas of ecological significance					
CEC ($cmol_c/kg$)[a] based					
5	***10***	***20***	***30***	***40***	***60***
30	65	70	70	75	80
pH[b] based					
4.5	***5.5***	***6***	***6.5***	***7.5***	***8.0***
20	45	65	90	190	270
Urban residential/public open space[1]					
CEC ($cmol_c/kg$)[a] based					
5	***10***	***20***	***30***	***40***	***60***
95	190	210	220	220	230
pH[b] based					
4.5	***5.5***	***6***	***6.5***	***7.5***	***8.0***
60	130	190	280	560	800
Commercial/industrial					
CEC ($cmol_c/kg$)[a] based					
5	***10***	***20***	***30***	***40***	***60***
140	280	300	320	330	340
pH[b] based					
4.5	***5.5***	***6***	***6.5***	***7.5***	***8.0***
85	190	280	400	830	1200

Notes:

1. Urban residential/public open space is broadly equivalent to the HIL A, HIL B and HIL C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. The lower of the CEC or the pH-based ACLs for the land use and soil conditions is the ACL to be used.
3. Aged values apply to contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
4. The EIL is calculated from summing the ACL and the ABC.

a = CEC measured using the silver thiourea method (Chabra et al. 1972).

b = pH measured using the $CaCl_2$ method (Rayment & Higginson 1992).

Table 1B(3) Soil-specific added contaminant limits for aged chromium III and nickel in soil

CHEMICAL	Clay content (% clay)	Added contaminant limits (mg added contaminant/kg) for various land uses		
		Areas of ecological significance	Urban residential and public open space	Commercial and industrial
Chromium III	*1*	60	190	310
	2.5	80	250	420
	5	100	320	530
	≥10	130	400	660
Nickel	CEC[a] ($cmol_c/kg$)	Areas of ecological significance	Urban residential and public open space[1]	Commercial and industrial
	5	5	30	55
	10	30	170	290
	20	45	270	460
	30	60	350	600
	40	70	420	730
	60	95	560	960

Notes:

1. Urban residential/public open space is broadly equivalent to the HIL A, HIL B and HIL C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. Aged values apply to contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
3. The EIL is calculated from summing the ACL and the ABC.

a = CEC measured using the silver thiourea method (Chabra et al. 1972).

Table 1B(4) Generic added contaminant limits for lead in soils irrespective of their physicochemical properties

	Pb added contaminant limit (ACL, mg added contaminant/kg) for various land uses		
CHEMICAL	Areas of ecological significance	Urban residential and public open space[1]	Commercial and industrial
Lead	470	1100	1800

Notes:

1. Urban residential/public open space is broadly equivalent to the HIL A, HIL B and HIL C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. Aged values are applicable to lead contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
3. The EIL is calculated from summing the ACL and the ABC.

Table 1B(5) Generic EILs for aged As, fresh DDT and fresh naphthalene in soils irrespective of their physicochemical properties

	Ecological Investigation Levels (mg total contaminant/kg)		
CHEMICAL	**Areas of ecological significance**	**Urban residential and public open space[1]**	**Commercial and industrial**
Arsenic[2]	40	100	160
DDT[3]	3	180	640
Naphthalene[3]	10	170	370

Notes:

1. Urban residential/public open space is broadly equivalent to the HIL-A, HIL-B and HIL-C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. Aged values are applicable to arsenic contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
3. Insufficient data was available to calculate aged values for DDT and naphthalene, consequently the values for fresh contamination should be used.
4. Insufficient data was available to calculate ACLs for As, DDT and naphthalene. The EIL should be taken directly from Table 1B(5).

Table 1B(6) ESLs for TPH fractions F1 – F4, BTEX and benzo(a)pyrene in soil

CHEMICAL	Soil texture	ESLs (mg/kg dry soil)		
		Areas of ecological significance	Urban residential and public open space	Commercial and industrial
F1 C_6-C_{10}	*Coarse/ Fine*	125*	180*	215*
F2 >C_{10}-C_{16}		25*	120*	170*
F3 >C_{16}-C_{34}	*Coarse*	-	300	1700
	Fine	-	1300	2500
F4 >C_{34}-C_{40}	*Coarse*	-	2800	3300
	Fine	-	5600	6600
Benzene	*Coarse*	10	50	75
	Fine	10	65	95
Toluene	*Coarse*	10	85	135
	Fine	65	105	135
Ethylbenzene	*Coarse*	1.5	70	165
	Fine	40	125	185
Xylenes	*Coarse*	10	105	180
	Fine	1.6	45	95
Benzo(a)pyrene	*Coarse*	0.7	0.7	0.7
	Fine	0.7	0.7	0.7

Notes:

(1) ESLs are of low reliability except where indicated by * which indicates that the ESL is of moderate reliability.

(2) '-' indicates that insufficient data was available to derive a value.

(3) To obtain F1, subtract the sum of BTEX concentrations from C_6-C_{10} fraction and subtract naphthalene from >C_{10}-C_{16} to obtain F2.

Table 1 B(7) Management Limits for TPH fractions F1–F4 in soil

TPH fraction	Soil texture	Management Limits[1] (mg/kg dry soil)	
		Residential, parkland and public open space	Commercial and industrial
F1[2] C_6- C_{10}	*Coarse*	700	700
	Fine	800	800
F2[2] >C_{10}-C_{16}	*Coarse*	1000	1000
	Fine	1000	1000
F3 >C_{16}-C_{34}	*Coarse*	2500	3500
	Fine	3500	5000
F4 >C_{34}-C_{40}	*Coarse*	10 000	10 000
	Fine	10 000	10 000

[1] Management limits are applied after consideration of relevant ESLs and HSLs

[2] Separate management limits for BTEX and naphthalene are not available hence these should not be subtracted from the relevant fractions to obtain F1 and F2.

Table 1C Groundwater Investigation Levels (GILs)

Substance		Groundwater Investigation Levels		
		Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
		(µg/L)	(µg/L)	(mg/L)
Metals and Metalloids				
Aluminium, Al pH>6.5		55	-	-
Antimony		-	-	0.003
Arsenic		24 as As(III) 13 as As(V)	-	0.01
Barium		-	-	2
Beryllium		-	-	0.06
Boron		370[C]	-	4
Cadmium	H	0.2	0.7[D]	0.002
Chromium, Cr (III)	H	-	27	-
Chromium, Cr (VI)		1[C]	4.4	0.05
Cobalt		-	1	-
Copper	H	1.4	1.3	2
Iron, (Total)		-	-	-
Lead	H	3.4	4.4	0.01
Manganese		1900[C]	-	0.5
Mercury (Total)		0.06[D]	0.1[D]	0.001
Molybdenum		-	-	0.05
Nickel	H	11	7	0.02
Selenium (Total)		5[D]	-	0.01
Silver		0.05	1.4	0.1
Tributyl tin (as Sn)		-	0.006[C]	-
Tributyl tin oxide		-	-	0.001
Uranium		-	-	0.017
Vanadium		-	100	-
Zinc	H	8[C]	15[C]	-
Non-metallic Inorganics				
Ammonia[E] (as NH_3-N at pH 8)		900[C]	910	-
Bromate		-	-	0.02
Chloride		-	-	-
Cyanide (as un-ionised Cn)		7	4	0.08
Fluoride		-	-	1.5
Hydrogen sulphide (un-ionised H_2S measured as S)		1	-	-
Iodide		-	-	0.5

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Nitrate (as NO_3)	refer to guideline	refer to guideline	50
Nitrite (as NO_2)	refer to guideline	refer to guideline	3
Nitrogen	refer to guideline	refer to guideline	-
Phosphorus	refer to guideline	refer to guideline	-
Sulphate (as SO_4)	-	-	500
Organic alchohols/other organics			
Ethanol	1400	-	-
Ethylenediamine tetra-acetic acid (EDTA)	-	-	0.25
Formaldehyde	-	-	0.5
Nitrilotriacetic acid	-	-	0.2
Anilines			
Aniline	8	-	-
2,4-Dichloroaniline	7	-	-
3,4-Dichloroaniline	3	150	-
Chlorinated Alkanes			
Dichloromethane	-	-	0.004
Trichloromethane (chloroform)	-	-	0.003
Trihalomethanes (total)	-	-	0.25
Tetrachloromethane (carbon tetrachloride)	-	-	0.003
1,2-Dichloroethane	-	-	0.003
1,1,2-Trichloroethane	6500	1900	-
Hexachloroethane	290[D]	-	-
Chlorinated Alkenes			
Chloroethene (vinyl chloride)	-	-	0.0003
1,1-Dichloroethene	-	-	0.03
1,2-Dichoroethene	-	-	0.06
Tetrachloroethene (PCE) (Perchloroethene)	-	-	0.05
Chlorinated Benzenes			
Chlorobenzene	-	-	0.3
1,2- Dichlorobenzene	160	-	1.5
1,3- Dichlorobenzene	260	-	-

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
1,4- Dichlorobenzene	60	-	0.04
1,2,3- Trichlorobenzene	3[D]	-	0.03 for individual or total trichlorobenzenes
1,2,4- Trichlorobenzene	85[D]	20[D]	
1,3,5-Trichlorobenzene	-	-	
Polychlorinated Biphenyls (PCBs)			
Aroclor 1242	0.3[D]	-	-
Aroclor 1254	0.01[D]	-	-
Other Chlorinated Compounds			
Epichlorohydrin	-	-	0.1
Hexachlorobutadiene	-	-	0.0007
Monochloramine	-	-	3
Monocyclic Aromatic Hydrocarbons			
Benzene	950	500[C]	0.001
Toluene	-	-	0.8
Ethylbenzene	-	-	0.3
Xylenes	350 (as o-xylene) 200 (as p-xylene)	-	0.6
Styrene (Vinyl benzene)	-	-	0.03
Polycyclic Aromatic Hydrocarbons (PAHs)			
Naphthalene	16	50[C]	-
Benzo[a]pyrene	-	-	0.00001
Phenols			
Phenol	320	400	-
2-Chlorophenol	340[C]	-	0.3
4-Chlorophenol	220	-	-
2,4-Dichlorophenol	120	-	0.2
2,4,6-Trichlorophenol	3[D]	-	0.02
2,3,4,6-Tetrachlorophenol	10[D]	-	-
Pentachlorophenol	3.6[D]	11[D]	0.01
2,4-Dinitrophenol	45	-	-
Phthalates			
Dimethylphthalate	3700	-	-
Diethylphthalate	1000	-	-
Dibutylphthalate	10[D]	-	-
Di(2-ethylhexyl) phthalate	-	-	0.01

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Pesticides			
Acephate	-	-	0.008
Aldicarb	-	-	0.004
Aldrin plus Dieldrin	-	-	0.0003
Ametryn	-	-	0.07
Amitraz	-	-	0.009
Amitrole	-	-	0.0009
Asulam	-	-	0.07
Atrazine	13	-	0.02
Azinphos-methyl	-	-	0.03
Benomyl	-	-	0.09
Bentazone	-	-	0.4
Bioresmethrin	-	-	0.1
Bromacil	-	-	0.4
Bromoxynil	-	-	0.01
Captan	-	-	0.4
Carbaryl	-	-	0.03
Carbendazim (Thiophanate-methyl)	-	-	0.09
Carbofuran	0.06	-	0.01
Carboxin	-	-	0.3
Carfentrazone-ethyl	-	-	0.1
Chlorantraniliprole	-	-	6
Chlordane	0.03[D]	-	0.002
Chlorfenvinphos	-	-	0.002
Chlorothalonil	-	-	0.05
Chlorpyrifos	0.01[D]	0.009[D]	0.01
Chlorsulfuron	-	-	0.2
Clopyralid	-	-	2
Cyfluthrin, Beta-cyfluthrin	-	-	0.05
Cypermethrin isomers	-	-	0.2
Cyprodinil	-	-	0.09
1,3-Dichloropropene	-	-	0.1
2,2-DPA	-	-	0.5
2,4-D [2,4-dichlorophenoxy acetic acid]	280	-	0.03
DDT	0.006[D]	-	0.009
Deltramethrin	-	-	0.04

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Diazinon	0.01	-	0.004
Dicamba	-	-	0.1
Dichloroprop	-	-	0.1
Dichlorvos	-	-	0.005
Dicofol	-	-	0.004
Diclofop-methyl	-	-	0.005
Dieldrin plus Aldrin	-	-	0.0003
Diflubenzuron	-	-	0.07
Dimethoate	0.15	-	0.007
Diquat	1.4	-	0.007
Disulfoton	-	-	0.004
Diuron	-	-	0.02
Endosulfan	0.03[D]	0.005[D]	0.02
Endothal	-	-	0.1
Endrin	0.01[D]	0.004[D]	-
EPTC	-	-	0.3
Esfenvalerate	-	-	0.03
Ethion	-	-	0.004
Ethoprophos	-	-	0.001
Etridiazole	-	-	0.1
Fenamiphos	-	-	0.0005
Fenarimol	-	-	0.04
Fenitrothion	0.2	-	0.007
Fenthion	-	-	0.007
Fenvalerate	-	-	0.06
Fipronil	-	-	0.0007
Flamprop-methyl	-	-	0.004
Fluometuron	-	-	0.07
Fluproponate	-	-	0.009
Glyphosate	370	-	1
Haloxyfop	-	-	0.001
Heptachlor	0.01[D]	-	-
Heptachlor epoxide	-	-	0.0003
Hexazinone	-	-	0.4
Imazapyr	-	-	9
Iprodione	-	-	0.1
Lindane (γ-HCH)	0.2	-	0.01

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Malathion	0.05	-	0.07
Mancozeb (as ETU, ethylene thiourea)	-	-	0.009
MCPA	-	-	0.04
Metaldehyde	-	-	0.02
Metham (as methylisothiocyanate, MITC)	-	-	0.001
Methidathion	-	-	0.006
Methiocarb	-	-	0.007
Methomyl	3.5		0.02
Methyl bromide	-	-	0.001
Metiram (as ETU, ethylene thiourea)	-	-	0.009
Metolachlor/s–Metolachlor	-	-	0.30
Metribuzin	-	-	0.07
Metsulfuron-methyl	-	-	0.04
Mevinphos	-	-	0.006
Molinate	3.4	-	0.004
Napropamide	-	-	0.4
Nicarbazin	-	-	1
Norflurazon	-	-	0.05
Omethoate	-	-	0.001
Oryzalin	-	-	0.4
Oxamyl	-	-	0.007
Paraquat	-	-	0.02
Parathion	0.004[C]	-	0.02
Parathion methyl	-	-	0.0007
Pebulate	-	-	0.03
Pendimethalin	-	-	0.4
Pentachlorophenol	-	-	0.01
Permethrin	-	-	0.2
Picloram	-	-	0.30
Piperonyl butoxide	-	-	0.6
Pirimicarb	-	-	0.007
Pirimiphos methyl	-	-	0.09
Polihexanide	-	-	0.7
Profenofos	-	-	0.0003

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Propachlor	-	-	0.07
Propanil	-	-	0.7
Propargite	-	-	0.007
Proparzine	-	-	0.05
Propiconazole	-	-	0.1
Propyzamide	-	-	0.07
Pyrasulfatole	-	-	0.04
Pyrazophos	-	-	0.02
Pyroxsulam	-	-	4
Quintozene	-	-	0.03
Simazine	3.2	-	0.02
Spirotetramat	-	-	0.2
Sulprofos	-	-	0.01
2,4,5-T	36	-	0.1
Tebuthiuron	2.2	-	-
Temephos	-	0.05[D]	0.4
Terbacil	-	-	0.2
Terbufos	-	-	0.0009
Terbuthylazine	-	-	0.01
Terbutryn	-	-	0.4
Thiobencarb	2.8	-	0.04
Thiometon	-	-	0.004
Thiram	0.01	-	0.007
Toltrazuril	-	-	0.004
Toxafene	0.1 [D]	-	-
Triadimefon	-	-	0.09
Trichlorfon	-	-	0.007
Triclopyr	-	-	0.02
Trifluralin	2.6[D]	-	0.09
Vernolate	-	-	0.04
Surfactants			
Linear alkylbenzene sulfonates (LAS)	280	-	-
Alcohol ethoxylated sulfate (AES)	650	-	-
Alcohol ethoxylated surfactants (AE)	140	-	-

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)

A Investigation levels apply to typical slightly-moderately disturbed systems. See ANZECC & ARMCANZ (2000) for guidance on applying these levels to different ecosystem conditions.

B Investigation levels are taken from the health values of the Australian Drinking Water Guidelines (NHMRC 2011).

C Figure may not protect key species from chronic toxicity, refer to ANZECC & ARMCANZ (2000) for further guidance.

D Chemical for which possible bioaccumulation and secondary poisoning effects should be considered, refer to ANZECC & ARMCANZ (2000) for further guidance.

E For changes in GIL with pH refer to ANZECC & ARMCANZ (2000) for further guidance.

H Values have been calculated using a hardness of 30 mg/L $CaCO_3$ refer to ANZECC & ARMCANZ (2000) for further guidance on recalculating for site-specific hardness.

Table 2: Soil hazard categorisation thresholds

Category	Fill Material upper limits		Category C upper limits		Category B upper limits		
Contaminant concentration thresholds (dry weight)		TC0	ASLP1[1]	TC1	ASLP2[1]	TC2	
Units		(mg/kg)	(mg/L)	(mg/kg)	(mg/L)	(mg/kg)	
Inorganic species	**Inorganic species**		**Inorganic species**		**Inorganic species**		
Arsenic		20	0.7	500	2.8	2,000	
Cadmium		3	0.2	100	0.8	400	
Chromium (VI)		1	5	500	20	2,000	
Copper		100	200	5,000	800	20,000	
Lead		300	1	1,500	4	6,000	
Mercury		1	0.1	75	0.4	300	
Molybdenum		40	5	1,000	20	4,000	
Nickel		60	2	3,000	8	12,000	
Tin		50	-	500	-	-	
Selenium		10	1	50	4	200	
Silver		10	10	180	40	720	
Zinc		200	300	35,000	1,200	140,000	
Anions	**Anions**		**Anions**		**Anions**		
Cyanide		50	8	2,500	32	10,000	
Fluoride		450	150	10,000	600	40,000	
Organic species	**Organic species**		**Organic species**		**Organic species**		
Phenols (halogenated)[2]		1	2	10	8	320	
Phenols (non-halogenated)[3]		60	14	560	56	2,200	
Monocyclic aromatic hydrocarbons[4]		7	-	70	-	240	
Benzene		1	0.1	4	0.4	16	
Polycyclic aromatic hydrocarbons[5]		20	-	100	-	400	
Benzo(a)pyrene		1	0.001	5	0.004	20	
C6-C9 petroleum hydrocarbons		100	-	650	-	2,600	
C10-C36 petroleum hydrocarbons		1,000	-	10,000	-	40,000	
Polychlorinated biphenyls[6]		2	see note 6		see note 6		
Chlorinated hydrocarbons[7]		1					
Hexachlorobutadiene			0.07	2.8	0.28	11	
Vinyl chloride			0.03	1.2	0.12	4.8	
Other chlorinated hydrocarbons[8]			-	10	-	50	
Pesticides	**Pesticides**		**Pesticides**		**Pesticides**		
Organochlorine pesticides[9]		1					
Aldrin + dieldrin			0.03	1.2	0.12	4.8	
DDT + DDD + DDE			2	50	-	50	
Chlordane			0.1	4	0.4	16	
Heptachlor			0.03	1.2	0.12	4.8	
Other organochlorine pesticides[10]			-	10	-	50	

FILL MATERIAL | CATEGORY C CONTAMINATED SOIL | CATEGORY B CONTAMINATED SOIL | CATEGORY A CONTAMINATED SOIL

Notes

1. Australian Standard Leaching Procedure (acetate buffer) as specified in Australian Standards 4439.2 and 4439.3.
2. Total sum of 4-chloro-3-methylphenol, 2-chlorophenol, 2,4-dichlorophenol, 2,6-dichlorophenol, pentachlorophenol, 2,3,4,5-tetrachlorophenol, 2,3,4,6-tetrachlorophenol, 2,3,5,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.
3. Total sum of phenol, 2-methylphenol (o-cresol), 3-methylphenol (m-cresol), 4-methylphenol (p-cresol), 2,4-dimethylphenol, 2.4-dinitrophenol, 2-methyl-4,6-dinitrophenol, 2-nitrophenol, 4-nitrophenol, 2-cyclohexyl-4,6-dinitrophenol and dinoseb.
4. Total sum of benzene, toluene, ethyl benzene, xylenes (includes ortho, para and meta xylenes) and styrene.
5. Total sum of naphthalene, acenaphthylene, acenaphthene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluorene, fluoranthene, indeno(1,2,3-c,d)pyrene, phenanthrene and pyrene.
6. Soil containing polychlorinated biphenyls (PCBs) must be managed in accordance with the *Notifiable Chemical Order for Polychlorinated Biphenyls*. Industrial Waste Guidelines section *Polychlorinated Biphenyls (PCBs)* provides further information.
7. Total sum of carbon tetrachloride, chlorobenzene, chloroform, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, dichloromethane (methylene chloride), 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,2,4-trichlorobenzene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene, tetrachloroethene, vinyl chloride and hexachlorobutadiene.
8. Total sum of carbon tetrachloride, chlorobenzene, chloroform, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, dichloromethane (methylene chloride), 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,2,4-trichlorobenzene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene and tetrachloroethene.
9. Total sum of aldrin, hexachlorobenzene, alpha BHC, beta BHC, gamma BHC (lindane), delta BHC, chlordane, DDT, DDD, DDE, dieldrin, endrin, endrin aldehyde, heptachlor, heptachlor epoxide, methoxychlor and endosulfan (includes endosulfan I, endosulfan II and endosulfan sulphate).
10. Total sum of hexachlorobenzene(HCB), alpha BHC, beta BHC, gamma BHC (lindane), delta BHC, chlordane, endrin, endrin aldehyde, heptachlor, heptachlor epoxide, methoxychlor and endosulfan (includes endosulfan I, endosulfan II and endosulfan sulphate).

Appendix B Checklists

Table B1 Site summary

Item	Available Information
Site ID:	*e.g. 00112*
Address:	*e.g. 352 Princess Highway, Narre Warren 3805*
Title details:	*e.g. Lot 234 on Plan of Subdivision 456, Volume 787, Folio 254*
Site Area:	*e.g. 2 500 m^2*
Existing environmental reports:	*e.g. none or PSI, 10 June 2014, ref 217068*
Site owner:	*e.g. City of Casey, Westfield etc.*
Current site use:	*e.g. vacant, Council depot, shopping centre etc.*
Preliminary Site Investigation	
Date undertaken:	*e.g. 20 August 2015*
Undertaken by:	*e.g. City of Casey or External Consultant (add name)*
Information sources reviewed:	Refer to Table D2 below
Underground infrastructure identified on-site:	Yes/No. If yes, specify type and location *(e.g. 3 x USTs used for the storage of heating oil located in the northern corner of the site)*
Imported fill identified on-site:	Yes/No. If yes, indicate how this has been determine (*e.g. 3 x stockpiles of soil with inert waste including bricks and concrete located in western part of the site. Approximate volume of material is 40 m^3*)
Environmental Audit Report available:	Yes/No. If Yes, note CARMS reference number (*e.g. 78056-1)*
Site covered by EAO:	Yes/No.
Site within GQRUZ:	Yes/No.
Site inspection undertaken:	Yes/No. If yes, indicate date and person who inspected the site.
Photo of site available:	Yes/No. If yes, note where photographs are stored on the Council server. *e.g. folder ID "site 00112_photos_25 August 2015"*
Summary of historical site use:	*e.g. site was formerly used for agricultural purposes until it was acquired by Council in 1960 for use as a Council works depot*
Conceptual site model	
Source:	*e.g.1 underground storage tanks at former Council Works Deport*

Item	Available Information
	e.g.2 buried carcases at former Broiler farm
Affected media:	*e.g.1 soil, groundwater and soil vapour* *e.g.2 soil and groundwater*
Pathway:	*e.g.1 migration of petroleum hydrocarbons from UST through soil and into groundwater, migration of impacted groundwater to nearest surface water body, potential extraction of groundwater for use and vapour intrusion from impacted soil and groundwater into overlying spaces* *e.g.2 leakage of nutrients from carcases into groundwater, migration of impacted groundwater to nearest surface water body, potential extraction of groundwater for use, off gassing of odours from soil if soil is excavated*
Receptors:	*e.g. Properties surrounding the site (including potential extraction of groundwater for use), potential for vapour intrusion (example 1 only) and nearest surface water body*
Pictorial CSM prepared?	Yes/No. If yes, note where pictorial CSM is stored on the Council server. *e.g. folder ID "site 00112_CSM_25 August 2015"*
Site Risk Ranking	
Site Risk Ranking:	High Risk/Medium Risk/Low Risk
Environmental sampling required:	Yes/No.
Buffer required:	Yes/No. If yes, specify buffer area *e.g. one property to the north and south*
Detailed Site Investigation	
Date of DSI:	*e.g. 15 September 2015*
DSI undertaken by:	*e.g. Council or External Consultant (add name).* If DSI not undertaken by Council, complete Table D3.
Environmental media sampled:	*e.g. soil, groundwater, soil vapour*
Results of DSI:	*e.g. soil impacted with arsenic and lead, groundwater impacted with phenols*
Information/report location on server:	*e.g. "site 00112_DSI_15 September 2015"*
Peer review required:	Yes/No. If yes, indicate level of review required *(e.g. external consultant, person appointed as Environmental Audit, Statutory Environmental Audit).*
Peer review undertaken:	Yes/No. If yes, indicate date, who review was undertaken by and where the findings of the review are stored on the Council server. *e.g. folder ID "site 00112_DSI peer review_30 September 2015"*

Item	Available Information
Site re-categorisation:	High Risk/Medium Risk/Low Risk
Further work required:	Yes/No. If yes, provide details.

Table B2 Checklist – Review of PSI information sources

Source of Information	Reviewed (Y/N)?	Information/findings
Victoria Unearthed		
Geological Survey of Victoria Map Sheets		
Groundwater Resources Report		
Visualising Victoria's Groundwater Database		
Council Records		
Historical Society Enquiry		

Source of Information	Reviewed (Y/N)?	Information/findings
Historical Certificates of Title		
Water Authority Enquiry		
Energy Safe Victoria, Cathodic Protection Search		

Table B3. Checklist – Review of DSI report

Item	Completed (Y/N)?	Notes
All available sources of site history information reviewed		
CSM developed		
CoPCs identified based on historical and/or current land use		
Site geology and hydrogeology identified		
Nearest surface water body identified (distance and direction)		
Registered bores in the vicinity of the site identified		
Environmental media that requires sampling specified (with justification)		
Soil investigations		
Number of soil investigation locations installed in accordance with AS4482.1 (2005) for soils		
Grid and targeted soil sampling undertaken		
All potential point source of contamination targeted		
Natural soils intercepted during soil investigation and bores extent 0.5 m into natural soil		
Field screening equipment (e.g. Photoionisation (PID) detector) utilised		
Visual and/or olfactory evidence (or lack thereof) of contamination notes		
Samples with highest potential for contamination analysed		

Item	Completed (Y/N)?	Notes
Groundwater investigations		
Groundwater wells located in appropriate position (i.e. to target potential sources of contamination)		
Report indicates that groundwater has been checked for the presence of LNAPL		
Groundwater sampled via low flow (micropurge) sampling or adequate justification for alternative sampling techniques provided		
Wells gauged prior to sampling and surveyed to allow determination of groundwater flow direction (if 3 or more wells installed)		
Water quality meter used to collect groundwater quality parameters (dissolved oxygen, electrical conductivity, pH, redox and temperature), and parameters observed to stabilise prior to sample collection (note: applies to micropurge sampling only)		
Sample analysis		
Appropriate sample handling and preservation procedures utilised		
Analysis of samples undertaken for CoPCs (including broad contaminant screen if required)		
NATA-endorsed laboratory utilised and certificates of analysis provided for all samples		
Samples analysed within recommended holding times		
QA/QC procedures adopted		

Item	Completed (Y/N)?	Notes
Reporting		
Site plan with investigation locations provided		
Borelogs and/or groundwater sampling logs provided for all locations		
Assessment of adequacy of QA/QC procedures undertaken		
Analytical results compared to investigation and screening levels in the NEPM (ASC) and PFAS NEMP (if required) and any exceedances identified		
Statistical analysis undertaken (if appropriate and required)		
CSM reviewed and updated based on investigation results		
Assessment of land contamination against the ERS		
Recommendations provided		

APPENDIX L.

Checklist for Reporting Critical Aspects and Assessments Steps in PVI Assessment

Critical Issue and Assessment Steps	Relevant at Site (y/n)	Addressed in Report Section
Objectives of PVI assessment		
Determination of whether there is contamination present		
LNAPL		
Contaminated groundwater (dissolved phase)		
Contaminated soil		
Site ruled out from needing further assessment as no relevant contamination present at site		
Development of Sufficient CSM (meets minimum requirements from Table 1 of PVI guidance)		
Source of Contamination identified		
Nature and extent of contamination identified		
Geology described		
Hydrogeology described		
Zone of influence established		
Buildings and uses present		
Buildings and uses proposed		
Evaluation of whether short-term/acute risks are present		
Auditor/regulator notified of short-term/acute risks and rectification actions developed		
Contamination in direct contact with existing or proposed building foundations		
Review and use of HSLs – where applicable, are concentrations above HSLs?		
Review and use of screening distances – where applicable is the distance between contamination and receptors/building foundation greater than screening distances?		
Site ruled out from needing further assessment as vapour intrusion is not of significance as determined through appropriate use of HSLs or screening distances (unless preferential pathways present)		
Preferential pathways present		
Where contamination is in contact with foundations, modelling of indoor air concentrations from seepage indicates a potential risk		
Where contamination is not in contact with foundations, modelling of indoor air concentrations from groundwater using J&E (or equivalent) indicates a potential risk		
Collection of Vapour Data		
Soil gas samples taken to provide evidence of level of risk		
Soil gas samples collected from appropriate locations and depths		
Soil gas samples collected from representative conditions		
Soil gas samples collected in accordance with Box 5.4 of PVI guidance (also refer to **Appendix K**)		
Crawl space samples taken to provide evidence of level of risk		
Air samples collected from appropriate locations and over appropriate period of time		
Air samples collected in accordance with Box 5.5 of PVI guidance		
Indoor air samples taken to provide evidence of level of risk		
Air samples collected from appropriate locations and over appropriate period of time		

Critical Issue and Assessment Steps	Relevant at Site (y/n)	Addressed in Report Section
Air samples collected in accordance with Box 5.5 of PVI guidance		
Evaluation of vapour data		
Is the data of suitable quality to use in the assessment (QA/QC evaluation)		
Is there sufficient data for making robust conclusions		
Conclusions of PVI Assessment		

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City of Casey