Melbourne Metro Rail Project

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Contaminated Land and Spoil Management Impact Assessment

Melbourne Metro Rail Authority

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Glossary and Abbreviations

The following glossary of acronyms and terms are defined in the context of their use in this impact assessment report.

Acronym / Term	Definition
AASS	Actual acid sulfate soil - Acid Sulfate Soil producing sulfuric acid due to oxidation of sulfides.
AHD	Australian Height Datum
Alignment	The line or route that describes the linear infrastructure route as set out in the Concept Design. This includes both the vertical and horizontal route.
Alluvial	Referring to unconsolidated deposits of sediment (clay, silt, gravel, boulders) deposited by flowing water
Analyte	A chemical component that is the subject of chemical analysis
Anthropogenic	Association with human activities, as opposed to those occurring in biophysical environments without human influence
ANZECC	Australian and New Zealand Environment & Conservation Council
Aquifer	Rock or sediment in a formation that is saturated and sufficiently permeable to transmit economic quantities of water
Aquitard	A low permeability unit that can store groundwater and also transmit it slowly from one aquifer to another
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS	Australian Standard
ASLP	Australian Standard Leaching Procedure (as per Table 2 of EPA Publication IWRG 621)
ASR	Acid sulfate rock
ASS	Acid sulfate soil Any soil, sediment unconsolidated geological material or consolidated rock mass containing metal sulfides exceeding criteria published by the EPA in Publication 655.1 Acid Sulfate Soils & Rock 2009. (can also be used as a general term for AASS, PASS, and ASR)
AST	Aboveground Storage Tank
BTEX	Benzene, toluene, ethylbenzene, xylene
Categorisation	The process undertaken to gather the chemical information of soils and compare them against EPA disposal requirements outlined in EPA IWRG621.
Cavern	The caverns are excavated using the heading and bench method. This is a

Acronym / Term	Definition
	sequential technique, whereby the upper section is excavated first, followed by the middle section (bench) and finally the invert. Roadheaders have a boom-mounted cutting head, mounted on a crawler travelling track and are used as the primary excavation equipment.
CEMP	Construction Environment Management Plan – project wide document as opposed to the Spoil Management Plan (SMP) referred to in this document which would form part of the CEMP
Classification	EPA is the authority able to ‘classify’ soils as Prescribed Industrial Wastes for disposal
CIS	Coode Island Silt (a geological unit)
Clean fill	Uncontaminated material classified in accordance with the IWRG Regulations, specifically IWRG621 Soil Hazard Categorisation and Management 2010
Contractor	Construction Contractor
Cross passages	Transverse tunnels connecting the twin tunnels
CSM	Conceptual Site Model
Cut and Cover	A large cut-and-cover box is a common construction technique for underground railway stations. Cut-and-cover construction can be conducted through a top-down or bottom-up configuration.
CUTEP	Clean Up to the Extent Practicable
CQA	Construction quality assurance
DELWP	Department of Environment, Land, Water and Planning (State)
EC	Electrical Conductivity
Emergency access shaft	A vertical opening to grant access to the twin tunnels for emergency services personnel. These are spaced at appropriate intervals to meet safety requirements
EMP	Environmental Management Plan – used to denote an EPA-approved plan for management of acid sulfate materials at the disposal facility
EPA	Environment Protection Authority (Victoria)
FBS	Fishermans Bend Silt (a geological unit)
Fill or fill material	Lithological description of disturbed ground; material known to have been placed (or modified in some way) by man on the pre-existing natural land surface (including engineered fill). Not to be confused with clean fill which is used as an IWRG categorisation for the purposes of disposal and reflects the chemical makeup of the material
Golder	Golder Associates Pty Ltd
GQRUZ	Groundwater Quality Restricted Use Zone
Groundwater aggressivity	The potential for the chemistry of the groundwater to corrode and degrade

Acronym / Term	Definition
	construction materials such as steel and concrete
Hydraulic conductivity	A coefficient of proportionally describing the rate at which water can move through a permeable medium. Separated into directional components: horizontal hydraulic conductivity and vertical hydraulic conductivity
IWRG	Industrial Waste Resource Guidelines
LOR	Laboratory Limit of Reporting (synonymous with PQL)
Marsh gas	Naturally occurring gases, usually methane, carbon dioxide with traces of hydrogen sulphide
mbgl	Metres below ground level
Mined tunnel	See cavern
MM1	Melbourne Metro Stage 1 investigation conducted in 2010
NAPL	Non-Aqueous Phase Liquid (such as an oil)
NEPC	National Environment Protection Council – author of the NEPM
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NV	Newer Volcanics (a geological unit)
OH&S	Occupational Health and Safety
PAH	Polycyclic aromatic hydrocarbons
PASS	Potential acid sulfate soil Acid Sulfate Soil which has been oxygen deprived and therefore is not producing sulfuric acid (still contained within waterlogged soil). It has the potential to produce sulfuric acid
PCB	Polychlorinated biphenyl
PID	Photo-ionisation detector
PIW	Prescribed Industrial Waste – Categories A, B and C which may contain asbestos
PPE	Personal Protective Equipment
ppmV	Parts-per-million by Volume
PQL	Practical Quantitation Limit synonymous with Laboratory Limit of Reporting (LOR)
Precinct	For assessment purposes, the project boundary has been divided into precincts that have been defined based on the location of project components and required construction works, the potential impacts on local areas and the character of surrounding communities

Acronym / Term	Definition
Project boundary	The project boundary established for the project defines the area in which the project components would be contained
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
Retaining walls	When there are land constraints at a station site and the geology has low strength conditions to below formation level, earth retaining-structures in the form of piles or sheet pile walls are required to be constructed, prior to excavation. The earth-retaining structures can be designed to form the wall of the station structure
SEPP	State Environment Protection Policy
SKM	Sinclair Knight Merz (now Jacobs)
SMP	Spoil Management Plan to contain the following sub-plan: • Acid Sulfate Soil (ASS) and Acid Sulfate Rock (ASR) Spoil Management Plan
SRB	Sulfate reducing bacteria
SuRF ANZ	Sustainable Remediation Forum for Australia & New Zealand
Tanking	Construction process that seals structure from groundwater inflow
TC	Total Concentration (as per Table 2 of EPA Publication IWRG 621)
TDS	Total dissolved solids
TOC	Total organic carbon
TPH/TRH	Total petroleum hydrocarbons / total recoverable hydrocarbons
TBM	Tunnel boring machine
UST	Underground Storage Tank
VOCs	Volatile organic compounds
WASS	Waste Acid Sulfate Soil Comprises disturbed PASS, AASS and/or ASR classified in accordance with EPA Publication 655.1 Acid Sulfate Soils & Rock 2009

Executive Summary

This report provides an assessment of the contaminated land and spoil management related aspects associated with the construction and operation of Melbourne Metro. These include disturbance of actual and potential acid sulfate soil and rock, contaminated groundwater plumes and risks and impacts associated with handling and disposal of spoil. Related aspects, including surface water quality, waste groundwater disposal, transportation of spoil and changes in groundwater flow, are addressed in:

- Technical Appendix D *Transport*
- Technical Appendix H *Air Quality*
- Technical Appendix O *Groundwater*
- Technical Appendix U *Aquatic Ecology and River Health.*

Contaminated Land and Soil Management

The Melbourne Metro and associated infrastructure have the potential to disturb contaminated soil and groundwater. Most disturbed soils would be excavated and removed off site as spoil, but there is also the potential for infrastructure and construction works to impact potential acid sulfate soil and rock either in situ due to dewatering or ex situ due to excavation. There is also potential for sub-surface soil, groundwater and gas/vapour chemistry to impact on the durability of material aspects of the project. This could include degradation of below ground structures such as concrete or steel piles or rubberised seals, resulting in reduced life span of the material and the potential risk of ingress of groundwater, vapour or ground gases into structures. Relevant aspects of contaminated land and associated spoil management requiring consideration within the project boundary include:

- Excavation, handling, management and disposal of large volumes of spoil including clean fill, (uncontaminated non-acid forming soil or rock), contaminated Prescribed Industrial Waste and naturally occurring potential and actual acid sulfate rock which is prevalent along the entire length of the project boundary
- Naturally occurring potential acid sulfate soil associated with specific geological units such as the Coode Island Silt that may become oxidised during construction (due to either excavation or dewatering). These geological units are most likely to be found at western portal, Arden station, and tunnels between CBD South and Domain stations (including the Yarra River crossing).

Interception of contaminated soil, groundwater and/or vapour in the immediate vicinity of the project boundary during construction leading to potential exposure risks to workers and the environment. The MMRA Spoil Management hierarchy provides an outline of how the spoil should be managed, as follows:

- **Avoidance.** There is limited scope for avoidance other than minimising the volume of materials to be excavated, employment of vertical retaining walls rather than benching, etc
- **Re-use/recycling/recovery**. There is no obvious re-use option for this material on-site and the spoil would therefore have to be removed off site for re-use or managed as a waste
- **Treatment at off-site facility/containment**. Natural acid sulfate soil and rock would be managed in accordance with EPA guidelines on Acid Sulfate Soil and Rock with the off-site management in accordance with the Industrial Waste Management Policy (Waste Acid Sulfate Soils). Prevention of acid sulfate soil oxidation is the preferred management option

- **Disposal at landfill or licenced facility**. Excavated spoil may also have elevated concentrations of contaminants or asbestos due to historic land use activities. These wastes should be separated as far as reasonably practicable into the following waste streams:
  - Categories A, B and C waste would be disposed of at facilities licenced to accept the waste or to a treatment facility (Category A) that can reduce the concentrations of the contaminant prior to disposal.
  - Spoil with asbestos-containing materials would be managed in accordance with WorkSafe OH&S regulations and EPA's Asbestos Transport and Disposal (which may also be Category A, B or C as above).

Methodology

The methodology for the contaminated land and spoil management assessment included:

- Review of relevant previous studies and other available information, including relevant historical information and Environment Protection Authority (EPA) audits
- Review of relevant legislation and guidelines
- Review of project specific investigation results (soil, sediment, rock, groundwater and vapour) conducted between 2010 and 2015 and interpretation of site investigation data
- Site inspections of the study area
- Development of Conceptual Site Models (CSMs) to identify the linkages between sources of contamination, pathways of exposure and likely receptors that may be impacted by contamination. CSMs were prepared for each of the three common exposure scenarios – tunnels, portals (including the western turnback) and stations
- Completion of an initial risk assessment using all the information indicated above
- Assessment of impacts from the medium, high and very high initial risks, identification of proposed mitigation measures and recommended Environmental Performance Requirements.

Risk Assessment

A risk assessment process was adopted that identified potential construction and operational hazards, impact pathways, consequences of contaminated land and spoil management and likelihood of impacts. Risk to values was determined as the combination of consequence and likelihood. Where possible, mitigation measures and additional Environmental Performance Requirements were recommended to reduce risks to low or very low.

The environmental risk assessment considered the following potential risks to the environment associated with the disturbance of contaminated land, contaminated groundwater and acid sulfate soils and rock in the absence of mitigation measures:

- Spoil generation, handling, temporary stockpiling, transport and disposal. Inappropriate management of spoil has the potential to lead to adverse impacts on human health and the environment including serious injury to construction workers, moderate exposure to rail staff or commuters during operation and pollution of the environment. This could occur via:
  - Direct contact (inhalation, ingestion, dermal contact) with contaminants during construction
  - Inhalation and direct contact with vapours and contaminated groundwater entering below ground structures during operation
  - Inappropriate handling of spoil on-site due to volumes of spoil in excess of the project capacity to manage (for example, if transport of spoil is halted due to a road accident and spoil must be retained on-site). This could lead to releases of contaminated spoil (as dust or stormwater runoff) to adjacent land
  - Inappropriate disposal or re-use of contaminated spoil leading to pollution

– Identification, design and management of spoil at temporary stockpile areas/emergency spoil classification areas

- Permeation of groundwater contaminated with volatile organic compounds into Melbourne Metro structures and subsequent release of vapours
- Ground gases and vapours. Releases of methane (from natural soils) and other volatile organic compounds (as pollutants in soil)
- Materials durability. The potential impact on durability of building materials, including potential impact of acid sulfate soils. Aggressive ground conditions (such as elevated pH, chloride and sulfate in soil) can lead to durability issues
- Piling. Formation of pathways for contamination to migrate between aquifers, or formation of pathways for ground gases and vapours to migrate vertically
- Construction health and safety.

Tunnels Impact Assessment

Spoil Management

During tunnelling activities, impacts from disturbance of contaminated soil and acid sulfate rock would be related mostly to the handling, transport, re-use/disposal of the tunnel spoil. An estimated 613,000 m^3 of tunnel spoil would be generated. The majority of this would be natural soils and rock. Some of this material could be contaminated from crossing though contaminated groundwater plumes. A significant proportion (about 211,000 m^3) would be acid sulfate soil or rock. Category A, B or C Prescribed Industrial Waste is not anticipated to be generated during tunnelling and most spoil would therefore likely be categorised as either clean fill or acid sulfate soil and rock. Temporary stockpile areas are envisaged at Arden, Fawkner Park, Domain and western portal. If required, spoil would be staged through the temporary stockpile area in as short a time as practical to enable spoil categorisation. It is preferable to pre-categorize the spoil in-situ prior to excavation.

The Spoil Management Plan (SMP) would be developed by the Contractor and would identify methods to manage the excavation, on-site handling, transport, off-site treatment and disposal/re-use of spoil. A specific acid sulfate soil and rock management sub-plan would be prepared and approved by EPA to manage acid generating materials. Clean fill would likely be directed to off-site re-use, subject to finding a suitable site(s). Any acid sulfate soil and rock would be transported off-site to suitable facilities with an EPA-approved Environmental Management Plan (EMP) in place.

Groundwater Infiltration and Vapours

The tunnels would be designed so as to minimise groundwater inflow as far as reasonably practicable. Some groundwater inflow would occur and this is discussed in more detail in Technical Appendix O *Groundwater*. Impacts from vapours from water ingress could occur where the tunnels intercept plumes of groundwater contaminated with volatile organic compounds and semi volatile organic compounds. Further investigations would be required to fully address this risk, however the combination of structural concrete limiting groundwater permeation and tunnel ventilation diluting any vapours would reduce the residual risks to a low rating.

Ground Gases and Vapours

During tunnelling, pockets of methane may be encountered when passing through Moray Street Gravels and Coode Island Silt sediments. Tunnelling through contaminated groundwater plumes containing volatile organic compounds could also occur, particularly in the sections of tunnel between Arden and CBD North. In both cases, intercepting these pockets of gas or vapours could result in a short-term release of gas, generating odour. Further investigations would be required to fully assess this risk, however the use of earth-pressured tunnelling, plus work airspace monitoring and other management measures described in the *Safe Work Australia Guide for Tunnelling Work* (2013), would reduce the residual risk to a low rating.

Materials Durability

Site investigations have identified the presence of acid sulfate soil in Coode Island Silt south of the Yarra River. Disturbance of the Coode Island Silt has the potential to induce acidic conditions in the vicinity of the concrete lining of the tunnel. Tunnelling would be likely to exacerbate the chemical aggressiveness of the sediments and thus, impacts to building materials would require mitigation as described in *Australian Standard 2159-2009 Piling – Design and installation*. Mitigation measures applied in accordance with this standard would mitigate any risk to low.

Construction Safety and Other Environmental Hazards

All of the tunnelling would occur in natural soil and rock, however there is the potential for impacts on worker safety, and on parts of the environment, through the release of dust, odour and vapours. A variety of control measures are available to be used including ventilation, use of spraying to supress dusts, fitting air filters to machinery, provision of personal protective equipment and monitoring of air quality, which would mitigate any risk to a low rating.

Portals and Western Turnback Impact Assessment

Spoil Management

An estimated 104,200 m^3 of spoil would be generated during construction of the western and eastern portals. This spoil would include clean fill (77,000 m^3), contaminated soils (25,900 m^3) and acid sulfate soil (1,000 m^3) and would be disturbed through handling, transport and its re-use and/or disposal. Relatively small quantities of spoil are likely to be generated at the Western Turnback.

A Spoil Management Plan (SMP) would be prepared to manage all spoil generated by the project. The excavated material would be pre-categorised as far as reasonably practicable prior to construction, and would also be segregated at the point of generation as much as reasonably practicable prior to being moved off site. Spoil requiring further sampling would be staged through the temporary stockpile areas in as short a time as practical to allow it to be categorised. Clean fill would likely be directed to off-site re-use, subject to finding a suitable site(s). Any acid sulfate soil and rock (under an acid sulfate soil and rock sub-plan) would be transported off-site to suitable facilities with an EPA-approved environmental management plan in place.

Prescribed Industrial Waste generated at the western and eastern portals would be disposed of at one of the many facilities licenced to accept the waste or to a treatment facility that can reduce the concentrations of contaminant prior to disposal.

There remain potential impacts with the handling and transportation of the material to the final destination; this may affect the local community and users of nearby facilities and the general amenity of the transportation routes. Through the implementation of appropriate mitigation measures in the Spoil Management Plan, any risks associated with the transportation of spoil would be mitigated and reduced to low.

Groundwater Infiltration and Vapours

Both the western and eastern portals would be drained structures. Technical Appendix O *Groundwater* discusses this in more detail. Based on available analytical data, potential impacts from vapours associated with the contaminated groundwater are not considered significant enough to warrant further management.

Ground Gases and Vapours

The geological conditions and historic land uses at the western portal may generate hazardous ground gases and vapours which may impact on construction, however site investigations have indicated limited methane in the shallow soils in this area. This, combined with the mostly open nature of the construction, would limit the potential for gas to be generated and concentrated. Specific mitigation measures, if required, can be incorporated into the Remedial Options Assessment (ROA) Plan.

Given the historic land use at the eastern portal, ground gases and vapours are not considered likely to be an issue.

Materials Durability

A number of geological units including Coode Island Silts and Fishermans Bend Silts, Moray Street Gravels and Werribee Formation at the western portal and Brighton Group at the eastern portal are known to be potentially acid generating. Methane may also be generated or released during excavation at the western portal. Impacts to building materials would require mitigation as described in *Australian Standard 2159-2009 Piling – Design and installation*.

Piling

Piling would be required to construct the structures and to form the cutting leading to and at the western portal and possibly under a widened earth embankment near Kensington Road. Driven concrete or steel piling would disturb soil as it would extend through any surface layers of fill, the underlying alluvial sands, gravels and silts and into the Melbourne Formation. This disturbance may cause pathways allowing contamination to migrate from impacted to un-impacted strata or enable entrained gasses and vapours to be released. Impacts from piling risks would be mitigated through compliance with *Australian Standard 2159-2009 Piling – Design and installation*.

Construction Safety and Other Environmental Hazards

There is the potential for impacts on worker safety, and on parts of the environment through the release of dust, odour and vapours during excavations. A variety of control measures are available to be used including ventilation, use of spraying to supress dusts, fitting air filters to machinery, provision of personal protective equipment and monitoring of air quality which would mitigate the risks to low.

Stations Impact Assessment

Spoil Management

An estimated 1,316,300 m^3 of spoil would be generated during construction of the stations. This spoil would include clean fill (880,000 m^3), contaminated soils (107,300 m^3) and acid sulfate soil and rock (329,000 m^3) and would be disturbed through handling, transport and its re-use and/or disposal.

Impacts and mitigation would be similar to those described for the portals.

Groundwater Infiltration and Vapours

Groundwater dewatering would be required during construction of Parkville and both CBD stations. Technical Appendix O *Groundwater* considers mitigation and discharge in more detail. There is a known plume of solvent contaminated groundwater beneath a former brewery site near the CBD North station, which could migrate towards the station during construction and operation. Further site investigation to assess this risk is required; however, mitigation of this impact, if required, would be achieved through adoption of a monitoring plan and incorporation of vapour barriers into the design and construction.

Ground Gases and Vapours

The geological conditions and historic land uses at the Arden station may generate ground gases and vapours that may affect construction, as may the above-mentioned solvent plume near the CBD North station. Groundwater dewatering required for CBD North station may draw this plume towards the construction work sites. Further site investigation to assess this risk is required, however, mitigation of this impact, if required, would be achieved through adoption of a monitoring plan and incorporation of vapour barriers into the design and construction.

Ground gases and vapours are not considered likely to have a significant impact on construction or operation of the other stations. Specific mitigation measures, if required, can be incorporated into the ROA.

Materials Durability

Potentially aggressive ground conditions associated with Coode Island Silts and Fishermans Bend Silts are likely to be encountered at the Arden station. Methane may also be generated or released during excavation at the Arden station.

Construction Safety and Other Environmental Hazards

Construction activities and excavation of contaminated ground may lead to impact on worker safety and on parts of the environment including releases of air pollutants (dust, odour and vapours).

Impacts and mitigation would be similar to those described for the portals.

Environmental Performance Requirements

General Environmental Performance Requirements relating to regulatory requirements, policy, standards and best practice have been recommended covering:

- General spoil management and Prescribed Industrial Waste
- Acid sulfate soil and rock
- General contaminated land management
- Vapour ingress
- Durability
- Piling
- Health, safety and environmental protection.

Additional Environmental Performance Requirements have been recommended and are summarised in Table 0-1.

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Table 0-1 Environmental Performance Requirements

EPR No.	Environmental Performance Requirements
C1	Prior to construction of main works or shafts, prepare and implement a Spoil Management Plan (SMP) in accordance with MMRA's Spoil Management Strategy and relevant regulations, standards and best practice guidance. The SMP shall be developed in consultation with and to the satisfaction of the EPA. The SMP would include but is not limited to the following: • Applicable regulatory requirements • Identifying nature and extent of spoil (clean fill and contaminated spoil) across all precincts • Roles and responsibilities • Identification of management measures for handling and transport of spoil for the protection of health and the environment • Identification, design and development of specific environmental management plans for temporary stockpile areas • Identifying suitable sites for re-use, management or disposal of any spoil • Monitoring and reporting requirements • Identifying locations and extent of any Prescribed Industrial Waste and characterising Prescribed Industrial Waste spoil prior to excavation • Identifying suitable sites for disposal of any Prescribed Industrial Waste. The SMP shall include sub-plans as appropriate, including but not limited to an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan (Refer to C2).
C2	Prepare and implement an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan prior to construction of the project as a Sub-Plan of an overarching SMP in accordance with the Regulations, Standards and best practice guidance and to the satisfaction of EPA. This sub-plan would include the general requirements of the SMP and also: • Identifying locations and extent of any potential ASS/ASR • Characterising ASS/ASR spoil prior to excavation • Identification and implementation of measures to prevent oxidation of ASS/ASR wherever possible • Identifying suitable sites for re-use, management or disposal of any ASS/ASR.
C3	Prior to construction of main works or shafts, undertake a remedial options assessment (ROA) for contaminated land. The assessment must: • Consider the outcomes of further investigations • Interpret of groundwater permeation and VOC result • Present and take account of the outcomes of risk assessments

EPR No.	Environmental Performance Requirements
	• If required, identify remedial options in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA. If required, as an outcome of the ROA, prepare a remedial action plan and integrate the remediation approach into the design in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA.
C4	Prior to construction of main works or shafts commencing, prepare and implement a health, safety and environmental plan for the management of hazardous substances. The plan must include but not be limited to: • Consideration of the risks associated with exposure to hazardous substances for employees, visitors and general public • The identification of methods to control such exposure in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and the EPA • Method statements detailing monitoring and reporting.

1 Introduction

This report provides an assessment of contaminated land and spoil management on the Melbourne Metro. Related aspects, including environmental risk assessment, transportation of spoil, air quality, groundwater (changes in groundwater flow and dewatering) and surface water quality are addressed in:

- Technical Appendix D *Transport*
- Technical Appendix H *Air Quality*
- Technical Appendix O *Groundwater*
- Technical Appendix U *Aquatic Ecology and River Health.*

1.1 Project Description

The Melbourne Metro comprises two nine-kilometre-long rail tunnels from Kensington to South Yarra, travelling underneath Swanston Street in the Central Business District (CBD), as part of a new Sunbury to Cranbourne/Pakenham line form the new Sunshine-Dandenong Line. The alignment of Melbourne Metro is shown in Figure 1-1.

- The infrastructure to be constructed as part of Melbourne Metro broadly comprises:
- Twin nine-kilometre rail tunnels from Kensington to South Yarra connecting the Sunbury and Cranbourne/Pakenham railway lines (with the tunnels to be used by electric trains) lines to form the new Sunshine-Dandenong Line
- Rail tunnel portals (entrances) at Kensington and South Yarra
- New underground stations at Arden, Parkville, CBD North, CBD South and Domain with longer platforms to accommodate longer High Capacity Metro Trains (HCMTs). The stations at CBD North and CBD South would feature direct interchange with the existing Melbourne Central and Flinders Street Stations respectively
- Train/tram interchange at Domain station.

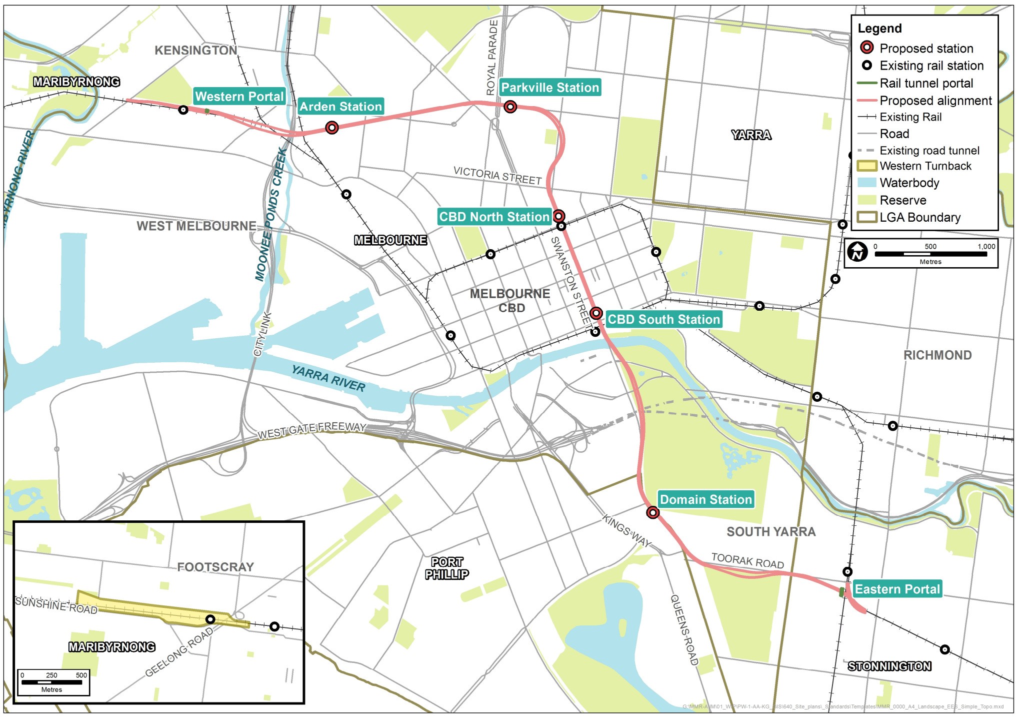

Figure 1-1 Map of the Melbourne Metro alignment and five stations

1.2 Project Precincts and Contaminated Land Areas of Interest

For assessment purposes, the project boundary has been divided into precincts as outlined below. The precincts have been defined based on the location of project components and required construction works, the potential impacts on local areas and the character of surrounding communities.

The precincts are:

- Precinct 1: Tunnels (outside other precincts)
- Precinct 2: Western Portal (Kensington)
- Precinct 3: Arden Station (including substations)
- Precinct 4: Parkville Station
- Precinct 5: CBD North Station
- Precinct 6: CBD South Station
- Precinct 7: Domain Station
- Precinct 8: Eastern Portal (South Yarra)
- Precinct 9: Western Turnback (West Footscray).

The nine precincts are shown in Figure 1-2.

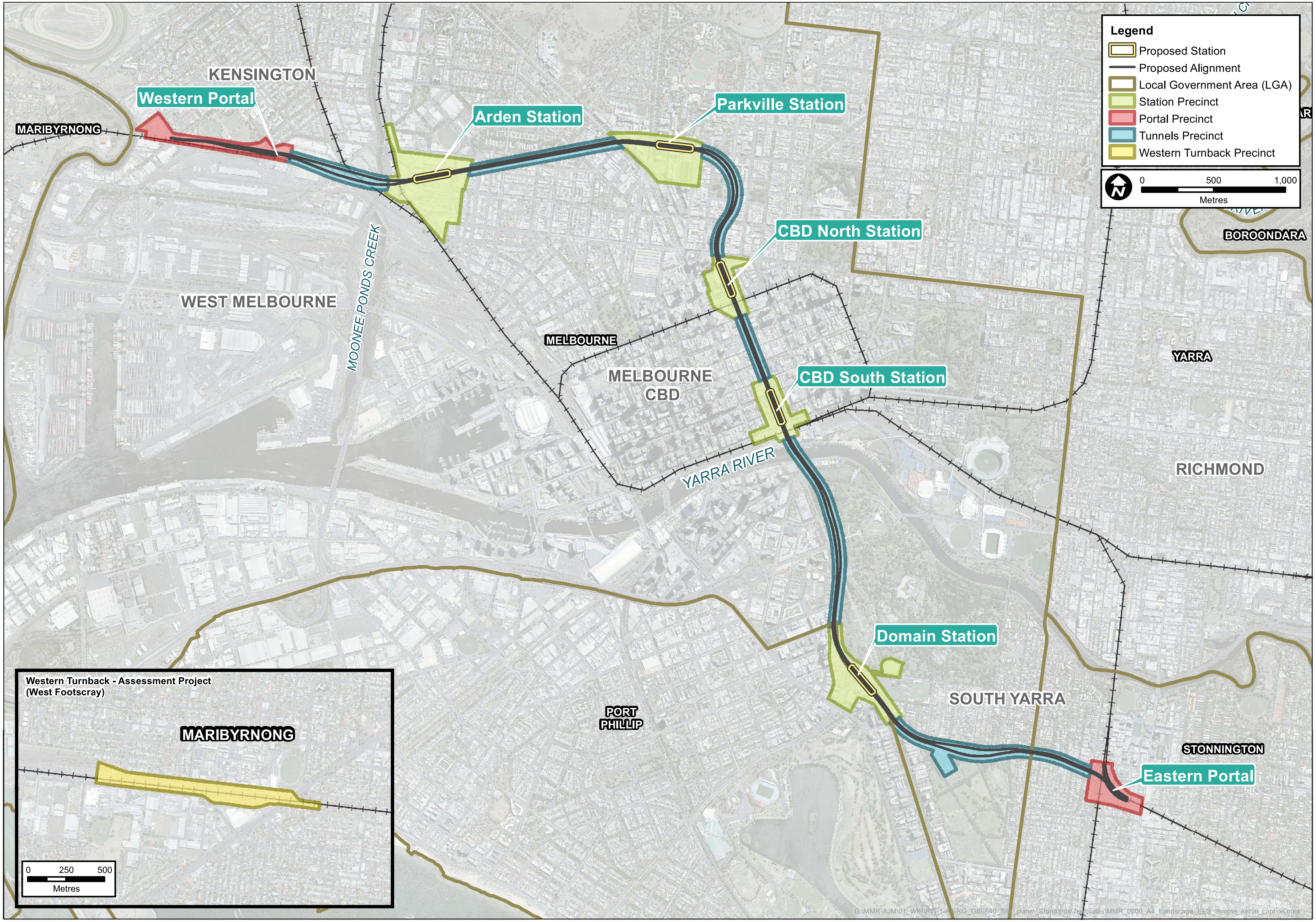

Figure 1-2 Melbourne Metro precincts

1.3 About this Report

This impact assessment addresses the following aspects of contamination within the project boundary during construction and operation:

- Contamination of soil, sediment and rock and the potential impacts upon the environment including human health and third party impacts associated with the movement of contamination both on site and beyond the project boundaries
- Naturally occurring, potentially acid-generating soil and rock
- Naturally occurring compounds such as trace elements and inorganics in soil, sediment and rock that may impact on human health or limit the re-use of otherwise non-contaminated spoil
- Man-made or naturally occurring contamination of groundwater that may impact on human health or and third parties associated with the movement of contamination both on-site or beyond the project boundaries.

The reports listed in Table 1-1 are of direct relevance to contaminated land and spoil management.

Table 1-1 Summary of relevant impact assessment reports

Specialist appendices to EES report	Relevance to contaminated land
Technical Appendix D ***Transport***	This report assesses the potential impacts of spoil transportation on the surrounding environment.
Technical Appendix H ***Air Quality***	This report assesses the potential impacts of dust, odour and vapour generation during construction and ongoing potential odour and vapour issues associated with contaminated groundwater during operations.
Technical Appendix O ***Groundwater***	This report assesses potential changes in the groundwater flow regime within the project boundary and potential on-going disposal of groundwater inflows to tunnels and station boxes during the operational phase of the project. The assessment provides an indication of likely movement of potential groundwater contamination plumes in the vicinity of the project boundary, which has allowed for an assessment of the potential impacts of these movements on construction workers and third parties.
Technical Appendix U ***Aquatic Ecology and River Health***	This report assesses the discharge of groundwater from construction and operation activities and provides an assessment of potential impacts of polluted soil, sediment, rock, stormwater or groundwater entering the aquatic ecosystem.
Map Book	Includes vertical and horizontal alignments for all aspects of the project.

For the purposes of this report, the precincts defined in the Concept Design have been divided into Tunnels (Section 7), Portals (Section 8) and Stations (Section 9), with the Western Turnback (Section 10) and Early Works (Section 11).

1.4 Contaminated Land

1.4.1 Background

This report focuses on the potential impacts of contaminated land on the environment during construction and operation of the Melbourne Metro. These are wide ranging and include potential impacts on the health of construction workers and nearby residents and land users, the quality of the land, surface water, groundwater and air and the impacts on durability of building materials.

Site contamination is a major environmental issue for Australia. Sites affected by contamination can pose potential threats to public health and the environment and can also have significant economic, legal and planning impacts. A general definition of contaminated land, as defined by the National Environment Protection Council is:

> *Contaminated land refers to soils and (in many instances) groundwater where the concentrations of hazardous chemicals exceed those specified in policies and regulations or are at such a concentration as to materially impact the development being proposed. Contamination occurs in a variety of forms, but mainly comprises inorganic compounds such as metals and asbestos and organic compounds such as petroleum hydrocarbons. Generally, contamination is caused by historic land use management practices, particularly those related to industrial processes, waste disposal and the storage and use of chemicals. However, there is also naturally occurring contamination, such as acid sulfate soils.*

The industrial and manufacturing heritage of Melbourne and Victoria, together with working practices which are not considered best practice by today's standards, has left a legacy of potentially contaminated sites. Sites which may be adversely affected include former factories, foundries, town gas plants, oil and chemical refineries, fuel depots, service stations and landfills.

A number of overarching principles can be applied to the management of contaminated sites:

- Precautionary Principle – relating to the application of measures even if some of the cause and effect harm relationships are not fully established
- Prevention – minimising the creation of additional contaminated sites
- Risk Management – directed assessment and management based on application of a risk management framework
- Options hierarchy – prioritising the treatment or on-site management to reduce risks
- Sustainability – contaminated land management with a view to achieving integrated environmental, economic and social outcomes.

1.4.2 Site Characterisation

Geoscience practices (such as contaminated land, hydrogeology, geology and environmental science) are far less exact than other engineering and science disciplines. These inherent uncertainties manifest themselves in the way this report has been structured and within the language used in it. Further limitations are provided in Section 4.3 and Section 4.4.

Adequate characterisation of the nature and extent of contamination along the route of Melbourne Metro is the foundation for appropriate assessment of impacts from disturbance of site contamination and also the appropriate classification of waste spoil. In this regard, the key guidance document is Volume 3 Schedule B2 of the National Environment Protection Measure (NEPC, 2013). This guideline provides information on the design and implementation of soil, groundwater and vapour sampling programs and the presentation of site assessment reports. Guidance is also provided on the minimum measures that should be adopted to ensure protection of the environment during site assessment.

The National Environment Protection Measure describes a typical sequence of activities:

- Determining what the objectives are
- Completing a review of available information (desktop study) and visiting the site to complete a site inspection
- Development of a conceptual site model and identification of any data gaps
- Development of data quality objectives for any further investigations and design of a sampling strategy and optimisation of a sampling and analysis quality plan
- Data collection involving fieldwork, sampling, monitoring, etc.

- Laboratory analysis, data review and interpretation (including risk assessment and iterative development of the conceptual site model)
- Reporting.

Golder Associates has completed the contaminated land site investigations for this project. A summary of these investigations is included in Appendix D of this report.

Every precinct along Melbourne Metro is different, and thus the scale of investigation effort, sample numbers, analytes of interest, and scope of risk assessment has varied. The following sections describe the investigations completed and identify the general level of confidence in the data.

1.4.3 Waste Categorisation and Management

Guidance on sampling soil to categorise as Prescribed Industrial Waste is given in the Industrial Waste Resource Guide 702, and waste categorisation (for EPA classification) is given in Industrial Waste Resource Guide 621. It is noted that it is the holder's responsibility to categorise waste and, based on the categorisation only, the EPA can classify waste soils for disposal. In the majority of instances of waste soil disposal, classification is agreed by the receiving EPA-licensed landfill prior to any disposal.

The waste categorisation procedure is summarised as:

- Understanding the source of waste (i.e. is the waste natural and of natural origin or not?)
- Observing the waste (how variable is the material? Does the soil contain fragments of waste materials?)
- Estimation of the total concentration of contaminants present in the waste soils as listed in Industrial Waste Resource Guide
- Estimation of the leachable concentrations of contaminants present in the soils listed in Industrial Waste Resource Guide
- Comparison of concentrations of contaminants in the waste soils with the lookup table in Industrial Waste Resource Guide 621 to determine the category of waste.

There are three categories of Prescribed Industrial Waste and one class of “Fill” as shown in Table 1-2.

Table 1-2 Summary of waste soil classification and management options

Waste soil categories	Description	Management options	Off-site disposal requirements
Category A **Highest class of Prescribed Industrial Waste**	Displays in Table 1 of any specific characteristics Industrial Waste Resource Guide 621 or any contaminant levels above TC2 or ASLP2 thresholds.	On-site remediation Offsite remediation Storage pending availability of treatment	No disposal to landfill EPA transport certificates must be used Vehicles must hold EPA permit (unless an exemption issued)
Category B	Contains contaminants greater than TC1, but below TC2 or greater than ASLP1 but below ASLP2 thresholds.	On-site remediation Off-site remediation Licensed facility	Disposal to a licensed facility EPA transport certificates must be used Vehicles must hold EPA permit (unless an exemption issued)
Category C **Lowest class of**	Contains contaminants greater than TC0, but below	On-site remediation Off-site remediation	Disposal to a licensed facility

Waste soil categories	Description	Management options	Off-site disposal requirements
Prescribed Industrial Waste	TC1 or ASLP1 thresholds.	Licensed facility	EPA transport certificates must be used Vehicles must hold EPA permit (unless an exemption issued)
Fill Material **(commonly referred to in industry as clean fill)**	Contains contaminant levels below the TC0 threshold Any soils (including clay, silt, and/or sand) from which any industrial waste has been removed as far as is practicable	NA	NA

Notes to table:

TC0, TC1, TC2 – Total concentrations indicating increasing threshold of contamination and assisting with waste classification. Described in Table 2 of Industrial Waste Resource Guide 621.

ASLP1, ASLP2 – Australian Standard leaching process indicating increased threshold of contaminant concentrations relating to assisting with waste classification. Described in Table 2 of Industrial Waste Resource Guide 621.

With large volumes of soils (greater than 2,500 m^3), the Industrial Waste Resource Guidelines recommend that one sample is taken every 250 m^3 (expressed as in situ volumes). If that density of sampling can be achieved, then the results can be interpreted statistically with the upper confidence limit of the mean of the results used in the waste classification assessment.

As described in the following sections, a large number of samples of fill and natural soils and rock have been taken. These have been used to assess the volumes and categorisation of the Prescribed Industrial Waste, acid sulfate rock and soil and clean fill.

Tunnelling and some deeper station box excavations would produce wastes almost entirely of natural origin. Some contaminants may be naturally elevated (such as fluoride in the Silurian Melbourne Formation and arsenic in the Brighton formation) however, this material may be appropriate for categorisation as clean fill subject to an EPA determination.

1.4.4 Relevance to Construction Projects

Contaminated land is a material consideration for land redevelopment and construction for the following reasons:

- Safety. Contaminated sites can be hazardous to worker health. Chemical exposure can be divided into acute (short term) and chronic (long term). Toxic effects vary widely from chemical to chemical, with some effects being temporary or reversible and others long term. The principal route of exposure is via inhalation, with construction workers also potentially at risk from direct or dermal contact. Other chemicals can have physical effects such as flammability. Contaminated land health and safety issues at construction sites are well recognised. Mitigation begins with effective planning, but requires training and compliance auditing.
- Bulk earthworks. Spoil generated by bulk earthworks during tunnelling and excavations of the station boxes, portals and decline structures requires consideration of the nature and extent of contamination to inform the waste classification which then influences how excess material can be managed, re-used or disposed. Linear infrastructure projects such as Melbourne Metro present additional logistical challenges

associated with the legislative restrictions around transfer, stockpiling and re-use of contaminated soil. The potential impacts of transportation of spoil on the environment are included in Technical Appendix D *Transport* and Technical Appendix H *Air Quality*.

- Aggressive ground and groundwater conditions. Certain chemicals or ground and groundwater conditions are incompatible with modern building materials (such as acidic conditions potentially present in Coode Island Silt). An understanding of aggressive ground conditions would be required in order to understand risks to the durability of building materials used during construction and long-term operation and also on the management and disposal of this material.
- Piling and deep excavation. If piles or deep excavations are planned (such as at the portal precincts), during the construction of embankments or as retaining walls for the station boxes, this may introduce pathways for contaminant migration or mobilisation.
- Contaminated groundwater and pollution. Understanding the nature and extent of any contaminated groundwater plumes is required in advance of any construction. Groundwater plumes may originate on the site or can migrate into the project boundary from off-site, resulting in contaminant migration and mobilisation. Groundwater flow and drawdown is addressed in Technical Appendix O *Groundwater*.
- Discharges. If groundwater needs to be controlled at construction work sites, the quality of the groundwater is a key parameter in determining how any discharges are to be managed on site. Discharge of groundwater from construction and operation activities is addressed in Technical Appendix O *Groundwater* and Technical Appendix U *Aquatic Ecology and River Health*.
- Ground gases and vapours. In a similar way to groundwater, any volatile contaminants (such as solvents) may also move from sources towards the surface or other sub-surface structures. If vapours accumulate, this could lead to risks associated with the accumulation of ground gases and vapours. Environmental impacts associated with dust generation are included in Technical Appendix H *Air Quality*.
- Monitoring. Monitoring is generally required to assess whether the baseline conditions are changing or behaving in the way predicted.
- Treatment or containment of soil and groundwater contamination. Depending on the nature and extent of residual or remaining contamination within the project boundary, specific remediation may be required. This could include techniques that would destroy or remove the contaminants (such as bioremediation) or techniques that may contain the contamination (such as cement stabilisation or capping).

1.4.5 Spoil Management and Site Remediation

1.4.5.1 Spoil Management

Appendix E of this report contains MMRA's Spoil Management Strategy.

In constructing the stations and tunnels, the project would displace large volumes of soil and rock. Collectively, this is termed 'spoil'. This spoil would require removal off-site as there are generally no on-site options for re-use and therefore the spoil would be classed as a waste. Management of the spoil would follow the waste hierarchy as described by the EPA with avoidance (i.e. minimising the volume of spoil generated where possible) being the most preferred option and disposal being the least. The waste hierarchy is one of the key principles of environment protection contained in the *Environment Protection Act 1970* with this principle reinforced in the SEPP (Prevention and Management of Contamination of Land) in selecting preferred approaches for the management of contaminated land and site clean-up. Additional information on the transportation of spoil, impacts on air quality or aquatic ecology can be found in Technical Appendix D *Transport*, Technical Appendix H *Air Quality* and Technical Appendix U *Aquatic Ecology and River Health* of the EES.

A Spoil Management Plan (SMP) would be required to manage and monitor spoil generation, handling, categorisation, storage and disposal. Included in this plan would be an Acid Sulfate Soil (ASS) Management Plan, Acid Sulfate Rock (ASR) Management Plan. Other aspects of contaminated land requiring management and monitoring would be included in the remedial options assessment (RAO) plan.

1.4.5.2 Re-use of Clean Fill

The EPA does not regulate the use of clean fill material (EPA publication 1438, 2012), but encourages re-use where possible. The EPA sets out the following responsibilities on the generator:

- Re-use must meet human health and ecological criteria
- Segregate and categorise the materials to ensure that the clean fill material is not contaminated
- Identify an appropriately approved receiving facility for the fill material
- Provide evidence to the receiving facility of the soil characterisation (e.g. site assessment and analytical data)
- Keep accurate records of soil removed from site and details of the receiving facility.

Soil meeting the description in Table 1-2 and with any elevated level of metals (such as arsenic) or other constituents that can be demonstrated to be of natural origin would also be considered to be fill material subject to an EPA determination. It must be demonstrated that the use would not affect the receiving environment. For instance, re-use of fill material having naturally elevated levels of metals or other contaminant may be appropriate at a receiving facility having a similar natural geological setting. Re-use options could include:

- Bulk infill used to rehabilitate the large number of quarries in the north-western and south-eastern metropolitan Melbourne areas
- Engineering fill for infrastructure projects
- Concrete, aggregate and brick production
- Daily cover or capping for landfill cells.

1.4.5.3 Disposal of Prescribed Industrial Waste

EPA requirements for Prescribed Industrial Waste soils are included in the Industrial Waste Resource Guidelines. While off-site disposal of the spoil to landfill would be considered the least desirable option, if no other viable on-site or off-site re-use options were identified, disposal of this spoil to landfill would be acceptable. The nature of Melbourne Metro is such that on-site re-use options are limited due to the built up nature of the alignment. Most environmental impacts of waste management and landfilling relate to the disposal of municipal putrescible waste, and thus disposing of a relatively small volume of contaminated soils (relative to the total volume of waste landfilled per annum) is unlikely to lead to a significant additional impact.

EPA's position is that waste soil should be treated as opposed to being landfilled, where feasible with an assessment of 'practicable accessibility' regarding the treatment of waste soil versus its disposal to landfill required to be undertaken. The EPA, in publication 1589 (EPA 2015), states that a contaminated soil producer must be able to demonstrate how it has assessed the practicable accessibility of treatment before it decides to consign the material to landfill for disposal or immobilisation. This assessment requires the consideration of a range of factors such as technical, financial and logistical. EPA further recognises that as of 2015, there are few facilities that can treat contaminated soils in Victoria and the few that are being planned are mainly focussing on the thermal treatment of organic contaminants in the soil.

Category A, B or C Prescribed Industrial Waste would be disposed of at facilities licenced to accept the waste or to a treatment facility that can reduce the concentrations of contaminant prior to disposal. There are currently 18 licenced landfills in the metropolitan Melbourne area – four of which (all in the north-west of the city) can accept Category C waste, with one (Lyndhurst) currently able to accept Category B waste. The north-west landfills currently all have significant capacity to take waste soils. In addition to this, the EPA has been collecting and reporting contaminated soil disposal statistics since 2000. Yearly disposal of contaminated soils range from 250,000 tonnes/year to 630,000 tonnes/year (the average is about 400,000 tonnes/year). Category A waste cannot be directly disposed of to landfill. If any Category A waste is encountered, then it would need to be sent to a waste treatment facility for treating to reduce the category from A to B, C or lower.

Asbestos-containing materials and asbestos fibres may be encountered in the fill material. Such soils would be managed in accordance with WorkSafe OHS regulations and EPA's Industrial Waste Resource Guidelines pertaining to asbestos. Landfills licensed to receive asbestos are listed on the EPA's website.

1.4.5.4 Disposal of Acid Sulfate Soils and Rock Waste

Waste acid sulfate soil and rock must be managed in accordance with the Waste Acid Sulfate Soils Industrial Waste Management Policy. Waste acid sulfate soil includes both acid sulfate soils such as the Coode Island Silt and acid sulfate rock such as the Silurian aged Melbourne Formation.

Whilst waste acid sulfate soil and rock could be managed on site (with treatment), this however, is considered unlikely owing to logistical constraints. Therefore any waste acid sulfate soil and rock would be required to be removed to an off-site facility. In this case, this offsite facility would be required to have an EPA-approved EMP.

There are a number of facilities in the metropolitan Melbourne area that could accept the type and quantity of waste acid sulfate soil that the Melbourne Metro may generate.

With respect to waste acid sulfate soil, there are four main options for managing and/or treating materials at the off-site waste management facility:

- Treat waste acid sulfate soil with limestone
- Inhibit oxidation of pyrite by underwater disposal
- Inhibit oxidation of pyrite by encapsulation within a water saturated engineered cover
- Prevent leaching of pyritic spoils by encapsulation within a long term containment system designed to limit infiltration.

1.4.5.5 Temporary Stockpile Areas

Stockpiling spoil is sometimes required should the characteristics of the spoil be unknown or the spoil cannot be removed off site for logistical reasons. The EPA does not generally consider stockpiling for any length of time is desirable, unless the material has a demonstrable re-use option on-site.

MMRA's Spoil Management Strategy (refer to Appendix E of this report) describes the approach to spoil management based around excavation and removal to an off-site location in an expeditious manner (a staged approach involving stockpiling prior to off-site re-use or disposal is not being planned). However, at each of the sites, temporary stockpile areas would be provided. It is envisaged that these would be located at all sites, with larger facilities at the western portal, Arden, and the southern TBM facility (Domain and Fawkner Park). Only a limited amount of spoil could be stored at these sites due to the space available and the ongoing site activities. EPA approvals would likely be required for these temporary stockpile areas.

1.4.5.6 Site Remediation

Where it does not pose an unacceptable risk to human health or the environment, contaminated soil adjacent to or below the alignment would be left in situ.

If land on and in the vicinity of the project boundary is determined to be contaminated and beneficial uses restricted, the land would require management to reduce the risks to an acceptable level. Various mitigation measures could be employed to reduce the risk posed by any residual contamination, such as engineering techniques to control exposure pathways to receptors (such as capping surface materials and providing vapour barriers to below ground structures). The National Environment Protection Measures state that the preferred order of options for management (site clean-up) are:

- On-site treatment of the soil so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level

- Off-site treatment of excavated soil after which, depending on the residual levels of contamination, the treated material is then returned to the site, removed to an approved waste disposal site or facility or taken to landfill.

It is noted that in addition to potential site remediation discussed above, some treatment of spoil would be required off-site prior to re-use or disposal. If, however, it is not possible for implementation of either of these options, then National Environment Protection Measure describes other options that should be considered including:

- Leaving contaminated material in situ, providing there is no immediate danger to the environment or community and the site has appropriate controls in place
- Isolating the soil by covering with a properly designed barrier
- Removing contaminated soil to an approved site or facility, followed where necessary by replacement with clean fill
- Where the assessment indicates remediation would have no net environmental benefit or would have a net adverse environmental effect, implementation of an appropriate management strategy
- Choosing a less sensitive land use to minimise the need for remedial works which may include partial remediation.

2 Scoping Requirements

2.1 Draft EES Objectives

The following draft EES evaluation objective (Table 2-1) is relevant to contaminated land and identifies the desired outcomes in the context of potential project effects. The draft EES evaluation objectives provide a framework to guide an integrated assessment of environmental effects of the project, in accordance with the *Ministerial guidelines for assessment of environmental effects under the Environment Effects Act 1978.*

Table 2-1 Hydrology, water quality and waste management draft EES evaluation objective

Draft EES evaluation objective	Key legislation
Hydrology, water quality and waste management: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	*Environment Protection Act 1970,* State Environment Protection Policies and guidelines

2.2 EES Scoping Requirements

The following extracts from the Scoping Requirements, issued by the Minister for Planning, are relevant to the hydrology, water quality and waste management draft evaluation objective.

Table 2-2 Hydrology, Water Quality and Waste Management Scoping Requirements

Aspect	Relevant response
Key Issues	• Potential for contaminated runoff or other water, including groundwater, to be discharged into surface waters or groundwater • Potential for disturbance of anthropogenic contaminated soil or groundwater or naturally occurring potential acid sulfate soils • Need to manage substantial quantities of material, in particular excavation and tunnelling spoil, including temporary stockpiling and transporting material away from works sites.
Priorities for characterising the existing environment	• Identify existing groundwater conditions and characteristics within the general area that might be affected by project works • Identify known contaminated sites and ground conditions which could indicate potential acid sulfate soils • Identify the volume and nature of project excavation spoil.
Design and mitigation measures	• Identify proposed design, management and mitigation measures to be used to protect surface water quality, especially during the construction phase, in the light of relevant SEPP objectives and other relevant standards and guidelines • Identify measures to protect groundwater and aquifers, including with respect to the potential effects of constructing and operating the tunnels and underground stations • Identify options for treating, re-using or disposing of excavation spoil, including both contaminated material (as relevant) and clean material, and the routes and destinations for spoil material to be transported away from the project works sites.

Aspect	Relevant response
Assessment of likely effects	• Assess potential for the project to cause short-term or longer-term changes to groundwater conditions, with particular regard to groundwater quality and beneficial uses • Assess potential for disturbance of contaminated soil, acid sulfate soils or contaminated groundwater to affect users or environmental values • Assess potential for treatment of contaminated material to enable it to be re-used or recycled rather than disposed of • Assess potential for project re-use or other economically viable re-use of project excavation spoil.
Approach to manage performance	• Describe principles to be adopted for setting programs for monitoring groundwater quality • Describe principles to be adopted for monitoring management of spoil and identifying previously unknown sources of contamination • Describe principles to be adopted for developing contingency measures to be implemented if unexpected adverse effects are identified.

3 Legislation, Policy and Guidelines

In Victoria, the legal and regulatory obligations, policies and guidance relating to contaminated land can be found in the following:

- The *Environment Protection Act 1970*, which is administered by the EPA. The *Environment Protection Act 1970* makes provisions with respect to the powers, duties, and functions of the EPA and the protection of the environment. The Act:
  - provides the basis for the various State Environment Protection Policies (SEPPs). SEPPs contain fixed and ambient standards which are directed to maintaining and protecting ‘beneficial uses’ of the environment as it relates to land, groundwater and surface water.
  - regulates the discharge or emission of waste to water, land or air through works approvals and licences. It also specifically controls the emission of noise and the disposal and transportation of waste.
  - provides for environmental audits to provide an authoritative opinion on risks to the environment posed by certain potentially contaminating activities or conditions, and the suitability of potentially contaminated land for future use. The audit process forms an integral part of the land use planning and approval processes.
  - includes provision for an Industrial Waste Management Policy (IWMP) that provides Victoria’s framework for the management of waste (industrial and hazardous).
- The Environment Protection (Industrial Waste Resource) Regulations, 2009, which include the following relevant policies and guidelines:
  - Industrial Waste Management Policy (Waste Acid Sulfate Soils). Any entity receiving waste contaminated acid sulfate soil must, in addition to complying with the requirements of the Environment Protection (Prescribed Waste) Regulations 1998, prepare and implement an environmental management plan in accordance with this policy. The policy includes management measures and requirements for re-use and disposal of acid sulfate soils.
  - The Industrial Waste Resource Guidelines (IWRGs) – Provide a framework for the classification and disposal of contaminated soils.
- The *Occupational Health and Safety Act 2004*, which is administered by WorkSafe Victoria. Employers, including Principal Contractors, have general duties under this Act to provide a safe and healthy working environment for workers, any contractors that they hire and others living, working or passing nearby.
- The *Planning and Environment Act 1987*. The Ministerial Direction No. 1 and the Planning Practice Note on Potentially Contaminated Land requires responsible planning authorities to satisfy themselves that the environmental conditions of land proposed to be used for a sensitive use, agriculture or public open space are, or would be, suitable for that use. This is generally achieved through the completion of an environmental site assessment and audit process.

Supporting the Acts and policies are a range of standards and guidelines. These together provide an approach to best practice in undertaking the investigation and management of potentially contaminated land. A key document includes the National Environment Protection (Assessment of Site Contamination) Measure, which was updated in 2013 and has been adopted as an amendment to the SEPP (Prevention and Management of Contamination of Land).

Appendix A provides a summary of the relevant primary legislation that applies to the project as well as the implications, required approvals and interdependencies and information requirements associated with obtaining approvals. Section 1.4 provides further detail on the relevant policy and technical aspects of contaminated land and spoil management.

4 Methodology

4.1 General Approach

The methods used in this impact assessment follow guidance set out in:

- The Review of Scoping Requirements for Melbourne Metro
- The National Environment Protection (Assessment of Site Contamination) Measure as amended in 2013. This approach is summarised in Figure 4-1.

A phased approach to assess impacts from contaminated land and acid sulfate soils has been adopted as follows:

- Phase 1 – Baseline Assessment
- Phase 2 – Risk Assessment
- Phase 3 – Impact Assessment
- Phase 4 – Performance measures.

Phase 1 and Phase 2 follow the general approach recommended in current best practice guidance for contaminated land assessment (NEPM). Phase 3 and Phase 4 follow general methods for completion of Environment Effects Statement and the scoping requirements of Melbourne Metro.

Golder Associates was responsible for the completion of geotechnical, hydrological and contaminated land investigation works and the findings of these works are included in a series of summary reports. Golder Associates' contaminated land summary report is included as Appendix D of this report.

The relationship between the EES Specialist Reports and the supporting Golder Associates' EES Summary Reports is shown in Table 4-1.

Table 4-1 Summary of investigations stages associated with Melbourne Metro by associated discipline

		EES Specialist Reports			
		Ground movement and Land Stability	**Future Development Loading**	**Groundwater**	**Contaminated Land and Spoil Management**
Golder Associates EES Summary Report	**Ground *Movement Assessment***	✓			
	Interpreted *Geological Setting*	✓	✓	✓	✓
	Interpreted *Hydrogeological Setting*			✓	✓
	Regional Groundwater Numerical Modelling			✓	
	Contaminated Land Assessment			✓	✓

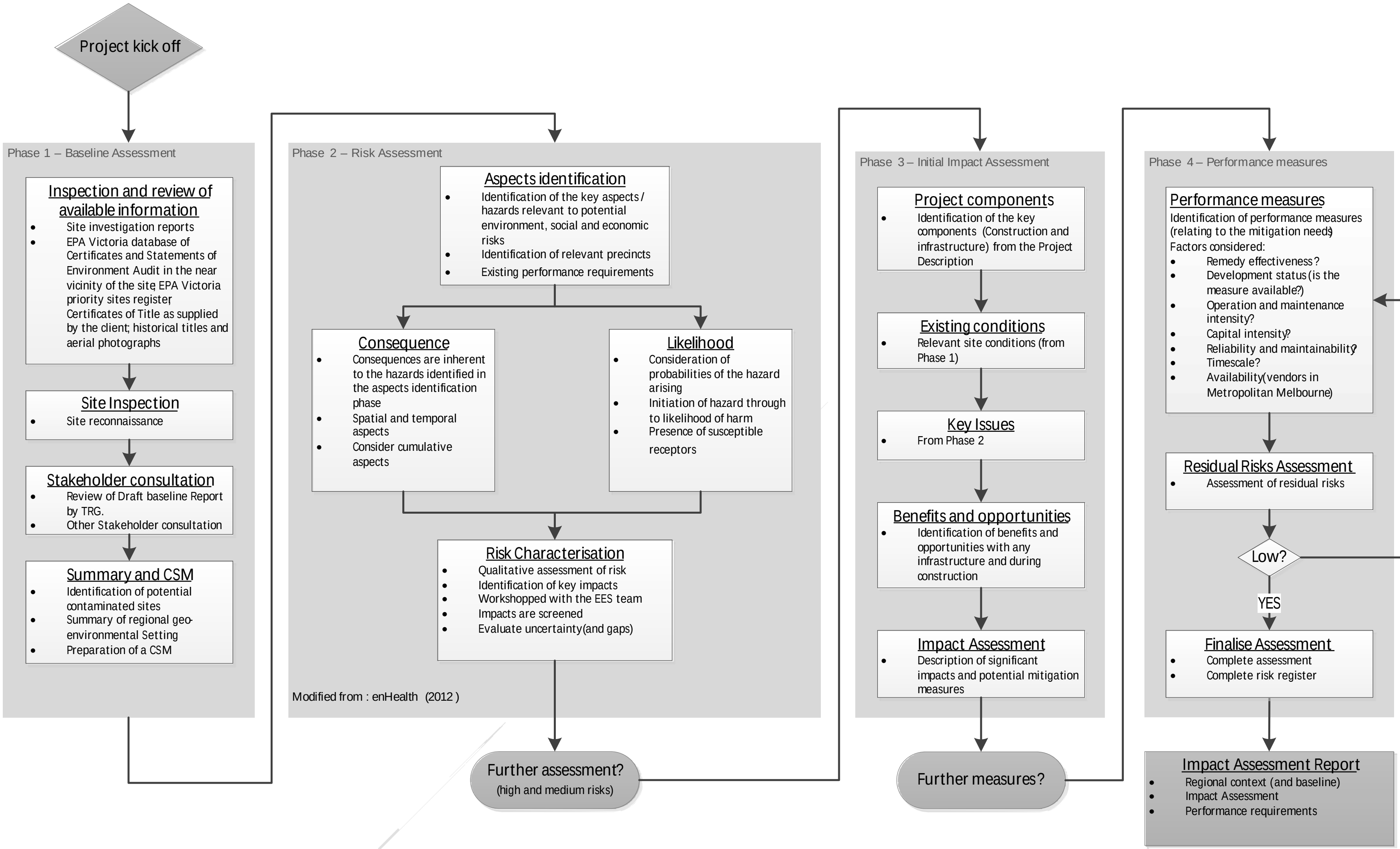

Figure 4-1 Summary of methodology

4.2 Method

4.2.1 Phase 1 – Baseline Assessment

4.2.1.1 Site Investigation Information

A number of site investigations have been conducted specifically for the Melbourne Metro. These investigations are summarised in Appendix C, Table C-1 of this report, which provides detail on the 120 boreholes which have been drilled within the project boundary.

4.2.1.2 Other Information

In addition to information provided by Golder Associates (Appendix D of this report), further information relating to environmental audit sites and EPA Registered Priority Sites along the alignment was also reviewed.

4.2.1.3 Site Inspections

On the 6 and 7 May 2015 a walk over of the project boundary was conducted by two experienced AJM-JV land contaminated land staff. The objective was to observe current land use practices. The inspection was conducted from publicly accessible places to observe areas of potential contamination and inform this study.

4.2.2 Stakeholder Engagement

As part of this assessment, the following specific engagement with stakeholders was undertaken, as shown in Table 4-2.

Table 4-2 Summary of stakeholder engagement

Activity	When	Attendees	Matters discussed/ issues raised
Meeting with WorkSafe Victoria	19 May 2015	MMRA, AJM-JV, WorkSafe Victoria	Introduction to the project. Discussion regarding health and safety aspects of the project. Request for provision of any relevant information on dangerous/hazardous goods stored in the vicinity of the project boundary. WorkSafe Victoria, Manager, Dangerous Goods & Occupational Hygiene (0412 259 368). Contacts for electrical assets from AJM-JV, Yarra Trams, MTM and Energy Safe Victoria. AJM-JV was seeking access to any contamination registers (bulk fuel storage/hazardous materials etc. along the alignment)
Teleconference with EPA	28 October 2015	MMRA, AJM-JV, EPA	Discussion about EPA comments on contaminated land report from TRG meeting.
Teleconference with EPA	30 October 2015	MMRA, AJM-JV, EPA	Discussion about EPA comments on contaminated land report from TRG meeting.

In addition to this specific engagement, general engagement and consultation with the community was also conducted as part of this assessment. Written feedback was obtained through feedback forms and the online engagement platform, and face-to-face consultation occurred at the drop-in sessions (refer to Technical Appendix C *Community and Stakeholder Feedback Summary Report* for further information). Although the community was given the opportunity to offer feedback in regards to contaminated land, no comments were provided or concerns identified.

4.2.2.1 Conceptual Site Model

The National Environment Protection Measure notes that '*A conceptual site model is a representation of site-related information regarding contamination sources, receptors and exposure pathways between those sources and receptors*.' The National Environment Protection Measure considers that the development of a conceptual site model is an essential element of all contaminated land assessments.

Three framework conceptual site models were developed covering the main construction and infrastructure aspects of Melbourne Metro, namely:

- Tunnels
- Above ground running track and decline structures – Portals
- Stations.

The framework conceptual site models are described in Section 5.5.

4.2.3 Phase 2 - Risk assessment

4.2.3.1 Overview

An Environmental Risk Assessment has been completed for impacts of Melbourne Metro in relation to contaminated land and acid sulfate soils considerations. The risk-based approach is integral to the EES as required by Section 2.2 of the Scoping Requirements for the EES. The risk assessment was used to prioritise potential impacts for further consideration.

Importantly, an environmental risk is different from an environmental impact. Risk is a function of the likelihood of an adverse event occurring and the consequence of the event, whereas, impact relates to the outcome of an action in relation to values of a resource or sensitivity of a receptor. Benefits are considered in impact assessment but not in risk assessment. An impact assessment must be informed by a risk assessment so that the level of action to manage an impact relates to the likelihood of an adverse impact occurring.

The overall risk assessment process adopted was based on Australian Standard 31000:2009 pertaining to Risk Management principles and guidelines, as illustrated in Figure 4-2.

The following tasks were undertaken to determine the impact pathways and assess the risks:

- Setting of the context for the environmental risk assessment
- Development of consequence and likelihood frameworks and the risk assessment matrix
- Review of project description and identification of impact assessment pathways by specialists in each relevant discipline area
- Allocation of consequence and likelihood categories and determination of preliminary initial risks
- Workshops with specialist team members from related discipline areas and focussing on very high, high and moderate initial risks to ensure a consistent approach to risk assessment and to identify possible interactions between discipline areas
- Follow-up liaison with specialist team members and consolidation of the risk register.

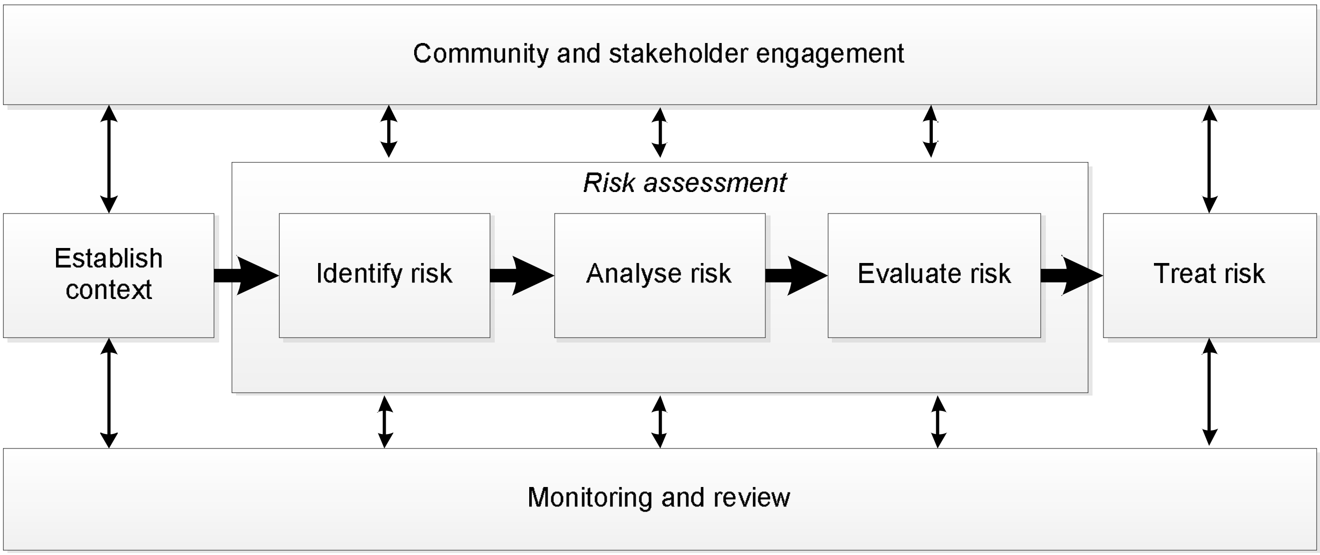

Figure 4-2 Overview of AS/NZS ISO 31000-2009 risk process

4.2.3.2 Context

Technical Appendix B *Environmental Risk Assessment* of the EES provides an overall context for the risk assessment and a specific context for each specialist study. The context describes the setting for evaluation of risks arising from Melbourne Metro. The specific context for the contaminated land and spoil management impact assessment follows:

> *With around 180 years of urban development and redevelopment and a wide variety of past and current land uses, many of which would have had the potential to cause contamination of the land and/or groundwater, the Melbourne Metro study area is either known to contain or has the potential to contain contamination of various types. Parts of the project area also contain soil or rock which is known to form acid when exposed to oxygen following excavation. The Melbourne Metro therefore has the potential to disturb contaminated land, groundwater, and acid sulfate soil and rock. The scope of this component of the assessment includes risks associated with transport and disposal of solid wastes from excavation works, including potentially contaminated materials and acid sulfate soils and rock.*
>
> *The proponent would manage potential disposal of contaminated soils and acid sulfate soils and rock in accordance with a Spoil Management Strategy and relevant statutory requirements including the SEPP (Prevention and Management of Contaminated Land), SEPP (Groundwaters of Victoria) and Industrial Waste Management Policy (Waste Acid Sulfate Soils).*

The likelihood rating criteria used in the risk assessment by all specialists is shown in Table 4-3.

Table 4-3 Likelihood rating criteria

Level	Description
Rare	The event is very unlikely to occur but may occur in exceptional circumstances.
Unlikely	The event may occur under unusual circumstances but is not expected.
Possible	The event may occur once within a five-year timeframe.
Likely	The event is likely to occur several times within a five-year timeframe.
Almost Certain	The event is almost certain to occur one or more times a year.

The consequence criteria framework used is shown in Table 4-4.

Table 4-4 Consequence framework

Level	Qualitative description of biophysical/ environmental consequence	Qualitative description of socio-economic consequence
Negligible	No detectable change in a local environmental setting.	No detectable impact on economic, cultural, recreational, aesthetic or social values.
Minor	Short-term, reversible changes, within natural variability range, in a local environmental setting.	Short-term, localised impact on economic, cultural, recreational, aesthetic or social values.
Moderate	Long-term but limited changes to local environmental setting that are able to be managed.	Significant and/or long-term change in quality of economic, cultural, recreational, aesthetic or social values in local setting. Limited impacts at regional level.
Major	Long-term, significant changes resulting in risks to human health and/or the environment beyond the local environmental setting.	Significant, long-term change in quality of economic, cultural, recreational, aesthetic or social values at local, regional and State levels. Limited impacts at national level.
Severe	Irreversible, significant changes resulting in widespread risks to human health and/or the environment at a regional scale or broader.	Significant, permanent impact on regional economy and/or irreversible changes to cultural, recreational, aesthetic or social values at regional, State and national levels.

The consequence rating criteria used in the risk assessment specifically for the contaminated land impact assessment is shown in Table 4-6.

The environmental risk assessment matrix (Table 4-5) used by all specialists to determine levels of risk from the likelihood and consequence ratings is shown below. Following consideration of potential risk, those with very high, high and medium were considered further in the impact assessment. Risk categories of low and very low were not considered further.

Table 4-5 Risk matrix

		Consequence rating				
		Negligible	Minor	Moderate	Major	Severe
Likelihood rating	**Rare**	Very Low	Very Low	Low	Medium	Medium
	Unlikely	Very Low	Low	Low	Medium	High
	Possible	Low	Low	Medium	High	High
	Likely	Low	Medium	Medium	High	Very High
	Almost Certain	Low	Medium	High	Very High	Very High

Section 6 provides a summary of the contaminated land and waste management risks assessed as part of the EES.

Table 4-6 Consequence rating criteria[1]

Level of consequence	Contaminated land consequence criteria	Spoil consequence criteria
Negligible	No disturbance of contaminated soils, acid sulfate soils/rock, or contaminated groundwater. Or Contamination levels are above background but below ecological investigation levels.	No increase over the calculated or expected total volumes of waste. No change in the calculated or expected waste classification.
Minor	Potential disturbance of small volumes of contaminated soil able to be contained and treated on-site and/or disposed of as clean fill or Category C waste with no risk to human health and/or the environment. Or Potential disturbance of small volumes of acid sulfate soils able to be contained and treated on-site and/or disposed of as prescribed waste with and EPA approved Environmental Management Plan (here referred to as an acid sulfate soil and rock management plan) and no risk to human health and/or the environment. Or Small volumes of contaminated groundwater that can be readily treated and or disposed of to sewer under a trade waste agreement. Or Contamination levels exceed Health Investigation Levels (HILs) or EILs as defined by the National Environment Protection Measure 2013. Or Minor impacts on Client's ability to manage the environment in a sustainable manner.	Small volumes of Prescribed Industrial Waste over the calculated or expected total volumes of waste = <1,000 $m^{3.}$ OR Small reclassification to a more hazardous waste classification (<10% of the volume) Small volumes acid sulfate soils / rock over the calculated or expected total volumes = <199 $m^{3.}$

[1] Based on the Standard, the Contamination Risk Assessment Tool (CRAT)[1] developed by the Department of Defence

Level of consequence	Contaminated land consequence criteria	Spoil consequence criteria
	Or Poses aesthetic impacts as defined in the SEPP (Prevention and Management of Contaminated Land).	
Moderate	Potential disturbance of moderate volumes of contaminated soil, able to be contained and treated on-site and/or disposed as prescribed waste and that can be managed locally with limited risk to human health and/or environment. Or Potential disturbance of moderate volumes of acid sulfate soil able to be contained and treated on-site and/or disposed as prescribed waste with no risk to human health and/or environment. Or Contamination levels exceed site specific risk based investigation levels developed in accordance with National Environment Protection Measure or other guidelines. Or Possible impact on Client's ability to manage the environment in a sustainable manner.	Moderate volumes Prescribed Industrial Waste over the calculated or expected total volumes of waste = >1,000 m^3 <10,000 $m^{3.}$ OR Moderate reclassification to a more hazardous waste classification (>11% to <30% of the volume) Moderate volumes of acid sulfate soils / rock over the calculated or expected total volumes = >200 m^3 <1,999 $m^{3.}$
Major	Potential disturbance of large volumes of contaminated soil resulting in risks to human health and/or environment across and outside the project boundary. Or Disturbance of large volumes of acid sulfate soil resulting in localised (across the project boundary) risks to human health and/or environment. Or Users of the site exposed to a hazard that results in major or permanent adverse health effects	Large volumes Prescribed Industrial Waste over the calculated or expected total volumes of waste = >10,000 m^3<20,000 $m^{3.}$ OR Significant reclassification to a more hazardous waste classification (>31% to <50% of the volume) Large volumes of acid sulfate soils / rock over the calculated or expected total volumes = >2,000 m^3 <9,999 $m^{3.}$

Level of consequence	Contaminated land consequence criteria	Spoil consequence criteria
	Or Impact on Client's ability to manage the environment in a sustainable manner.	
Severe	Potential disturbance of very large volumes of contaminated soil resulting in widespread irreversible risks to human health and/or environment. Or Disturbance of very large volumes of acid sulfate soil resulting in widespread (outside the project boundary) risks to human health and/or environment. Or Irreversible and extensive damage is caused to the environment. Or Users of the site exposed to a severe, adverse long-term health impact or life-threatening hazard that may result in acute toxicity to receptors (as defined in the National Environment Protection Measures). Or Contamination levels constitute an Imminent environmental hazard in accordance with EPA Environmental auditing as per Publication 759.2. Or Severe impact on Client's ability to manage the environment in a sustainable manner.	Very large volumes of Prescribed Industrial Waste over the calculated or expected total volumes of waste = >20,000 $m^{3.}$ OR Extensive reclassification of the waste to a more hazardous waste classification (>50% of the volume) Very large volumes of acid sulfate soils / rock over the calculated or expected total volumes = >10,000 $m^{3.}$

4.2.4 Phase 3 – Impact Assessment

An impact assessment was completed for each precinct. Each impact assessment comprised the following steps:

- Identification of relevant project components such as infrastructure and construction methods – Relevant components of the Concept Design were used to inform this aspect
- Summary of existing conditions – Key precinct specific information on potential sources of contamination, site-specific data were summarised from the existing conditions sections of this impact assessment
- Identification of key issues following the risk assessment
- Consideration of benefits and opportunities
- Impact assessment.

4.2.5 Phase 4 – Performance Measures

If the impact assessment demonstrates there are unacceptable impacts to be managed, then further mitigation (or performance) measures need to be identified. This phase identifies what management or remediation is feasible. The key objective is to identify performance measures that would reduce the residual risks to low.

During this phase, the following general factors were considered:

- Remedy effectiveness (can the performance measure manage the risks from contaminated land, acid sulfate soil and rock?)
- Development status (is the measure available or is the measure in development?)
- Operation and maintenance intensity (does the measure require long-term maintenance?)
- Capital intensity (does the measure require an initial capital outlay?)
- Reliability and maintainability (how reliably is the measure?)
- Timescale (can the measure achieve the objective within the timeframe of the project?)
- Availability (how practical is the measure? Are their vendors in metropolitan Melbourne that can adopt the measure?).

If the measure does not reduce the impacts to low then the measures are revisited. Otherwise the impacts are satisfactory and the assessment report can be completed.

4.3 Assumptions

Assumptions made during the completion of the baseline and impact assessment are summarised in Table 4-7.

Table 4-7 Assumptions

	Assumptions
Land contamination	This impact assessment relies on a compilation of background information of relevance to soil and groundwater contamination and potential acid sulfate soils and rock across the study area.
	This report incorporates information supplied by Golder Associates and from Aurecon (as set out in Appendix D of this report). AJM-JV has assumed that the information provided to date is accurate and correct.
	The report is limited to consideration of the project boundary defined in Section 1.1. If the alignment changes significantly, there is potential for different ground conditions to be encountered, and as such, the findings might need to be re-visited.
	The site walkover was conducted on public property only. Therefore, some areas within the project boundary were not accessible, such as private property, publicly-owned (VicTrack) land (e.g. Arden station precinct) and active rail land (western and eastern portals).
	Only EPA Environmental Audit reports and priority sites within one(1) km of the project boundary as shown in Section 1.1 of this report were reviewed. It should also be noted that given the extent of the project boundary, it is likely that new audit sites would become available after completion of this report.

4.4 Limitations

The following limitations apply to the information provided in this report:

- The interpretation of sub-surface conditions and the nature and extent of contamination in this study is based on field observations and chemical analytical data from widely-spaced sampling locations. It is possible that contamination exists in areas that were not investigated, sampled or analysed
- This impact assessment is based on conditions that existed at the time the assessment was completed. Its findings and conclusions may be affected by the passage of time, by man-made events such as construction on or adjacent to the project area and by new releases of hazardous substances
- The interpretation of sub-surface conditions are based on field observations and chemical analytical data from the sample design applied to this work. Site investigations identify sub-surface conditions only at those points where sub-surface tests were conducted or samples were taken
- The results presented in this report are also subject to those limitations described in Golder Associates' report presented in Appendix D of this report.

5 Regional Context

5.1 Melbourne Metro Features

Section 1.2 of this report identifies the precincts within the project boundary. These precincts are reflective of the fact that, for many of the impact assessments, potential environmental and social impacts are most likely to be experienced at the station and portal locations where significant ground disturbance is expected. Rather than focus on these precincts, the contaminated land impact assessment has considered the following four areas of interest:

- Tunnels – defined as comprising the various lengths of tunnel that connect the stations and portals
- Portals – the above ground sections and decline structures at the western and eastern portals
- Stations – includes all the five stations
- Turnback – the Western Turnback located at West Footscray.

The precinct and investigation locations areas are described further in Table C-**0-** in Appendix C.

5.2 Current and Historic Land Uses

The existing conditions sections within in each area of interest (Sections 7 to 11) summarise key current and historic land uses for each area of interest. In some areas of interest, swamp land has historically has been reclaimed or stabilised to facilitate development. The use of fill material of unknown origin and quality to infill these swamp areas may have led to soil or groundwater contamination and this has been highlighted in the relevant precincts.

Current and historic land uses are summarised in Appendix D of this report and to the extent possible have been confirmed following site inspections conducted by AJM-JV in May 2015.

5.3 General Environmental Setting

5.3.1 Ecological Significance

The groundwater-dependant ecosystems (GDEs) along the alignment are focused on the major surface water bodies. This is further discussed in Technical Appendix O *Groundwater* and Technical Appendix U *Aquatic Ecology and River Health*. It is noted that ecosystems along the majority of the alignment are highly modified (in accordance with the SEPP (Prevention and Management of Contamination of Land)) due to at least 150 years of European occupation. Industrial development in Melbourne has historically been focussed along waterways where there was easy access for the transportation of materials and products, a ready supply of water and an ability to dispose of wastes in the river or creek.

5.3.2 Landscape, Topography and Drainage

The elevation of the surface sections of the Melbourne Metro alignment range from 4 m AHD to 37 m AHD. The topography in the vicinity of the western portal is generally flat, with the existing rail embankment forming the main topographic relief in the area. As the project boundary extends eastward, the topography starts to rise after the Arden station and reaches a topographic high point at Leicester Street to the east of the Parkville station, before sloping down through the CBD towards the Yarra River.

The project boundary to the south-west of the Yarra River towards the Domain station is again relatively flat with an average elevation of 10 m AHD. Between the Domain station and the eastern portal, the topography rises within Fawkner Park and, after a high point of approximately 30 m AHD at Walsh Street, slopes down towards the eastern portal in South Yarra.

The topography of the area influences the movement of surface water and the extent to which contamination of surface waters might occur. In addition, low-lying water-logged areas are known to have the potential to produce swamp deposits that may become acid generating when disturbed and exposed to oxidising conditions.

5.3.3 Geology and Hydrogeology

The geology of the study area has been described in detail in Technical Appendix O *Groundwater* and relies on the 3D geological model of the project area prepared by Golder Associates based on specific project information as well as previous studies that they have completed in the area. The cross sections produced by Golder Associates (see Appendix D of this report) based on this model have been used in this impact assessment to form precinct-specific hydrogeological conceptualisations.

The geology of Melbourne consists of Silurian bedrock overlain by Tertiary and Quaternary sediments and basalts. The Silurian bedrock in the area is the Melbourne Formation and consists of mudstone, sandstone and siltstone that has been folded, faulted and intruded with dykes, sills and granite bodies. These rocks have been weathered to varying depths, with fresh rock sometimes existing within the shallow profile, whereas in other areas bedrock is weathered to depths of up to 60 m (Hancock, 1992).

The Melbourne Formation is overlain by Tertiary sediments and volcanics, including lake and swamp deposits (Werribee Formation), basalt flows and ash (Older Volcanics), marine sediments within eroded valleys (the Newport Formation) and sandy material (Brighton Group). Between the Maribyrnong River and Moonee Ponds Creek, the Werribee Formation and Older Volcanics are present, while at the southern end of the alignment near the eastern portal the Brighton Group is located.

A series of sea level fluctuations in the Quaternary period then deposited gravels, sands, silts and clays over the Silurian and Tertiary units. These sediments cover much of Port Melbourne and South Melbourne and underlie the areas surrounding the Yarra River, the Maribyrnong River and the Moonee Ponds Creek. These sediments are often referred to as the Yarra Delta Sediments (Neilson, 1992) and consist of (from youngest to olderst) Port Melbourne Sands, Coode Island Silt, Jolimont Clay, Newer Volcanics, Fishermans Bend Silt and Moray Street Gravels.

Golder Associates has also identified recent Silt, Holocene Alluvium, Pleistocene Alluvium and Early Pleistocene Colluvial and Alluvial Sediments, which vary in age and are described and included in Appendix C Table C-2 of this report, and the outcropping geology is shown on Figure 1 in Appendix A of this report. The Fishermans Bend Silt and Coode Island Silt act as confining layers to the other sediments in the palaeovalleys. The confined units below the Fishermans Bend Silt (Moray Street Gravels, Quaternary Fluvial Sediments and Lower Newer Volcanics Flow) are likely to have some degree of hydraulic connectivity. There may also be hydraulic connectivity between these units and the overlying Holocene Alluvium where the inferred overlying Holocene Alluvium valley intersects the older Jolimont Clay.

Table C-**0-2** in Appendix C of this report shows the main geological units in the project area, their occurrence, description and hydrogeological classification. While the tunnels alignment does not necessarily intersect all of these geological formations, they may still be connected hydraulically to the tunnels and are therefore important in terms of inflows and drawdown.

More discussion on the geological units that are present and likely to be excavated is included within the existing conditions sections of each area of interest (Sections 7 to 11).

Table C-0-3 and Table C-**0-4** in Appendix C of this report show the units present and the groundwater segment recorded within each of the precincts. The groundwater segments are based on the total dissolved solid concentrations where Segment A groundwater is the freshest water and is suitable for potable water supply (drinking water) and Segment D is salty water with limited beneficial uses.

The segments of groundwater as defined by SEPP (Groundwaters of Victoria) are outlined in Table 3.2 of the SEPP. The total dissolved solid concentrations (in mg/L) indicated are based on project-specific data summarised in Technical Appendix O *Groundwater*. Where an aquifer is likely to be present but there is no project-specific groundwater quality data available, the field has been marked with an 'X'. Figure 2 in Appendix B of this report provides an overview of water table salinity across the project boundary; comprising of shading corresponding to groundwater salinity ranges published by VicMap and total dissolved solids measured at boreholes. It is expected that greater delineation of total dissolved solids would be achieved with additional groundwater data produced as the project progresses, those data would be considered as available to confirm the groundwater segments indicated.

5.3.3.1 Groundwater Elevation and Flows

There are currently 70 project-specific groundwater monitoring bores within the project boundary. A summary of bore locations and groundwater level monitoring undertaken to date is provided in Technical Appendix O *Groundwater*.

The boreholes were designed to assess conditions at the tunnel depths and have not been designed to (necessarily) measure the water table. Therefore, it is not always clear whether the water table or a potentiometric surface is being measured. For the purpose of this report, it is assumed that the water table and the potentiometric surfaces of most aquifers are very similar.

The highest groundwater elevations within the project boundary occur in the Parkville area at 25 m AHD and the lowest groundwater levels occur in the area of the CityLink tunnels at around -10 m AHD. In most cases, the groundwater level would be above the tunnel depth however, in some areas, the measured groundwater level would be below the tunnels. In the wider Melbourne Metro study area, the highest groundwater levels are in the north and northeast with groundwater flow generally south and south-west towards the Yarra River and Port Phillip Bay (see Figure 3 in Appendix D of this report).

The regional flow is impacted by local influences such as the Moonee Ponds Creek, North Yarra and South Yarra main sewers, the City Loop tunnels and the CityLink tunnels. Figure 3 in Appendix B shows most recent water level monitoring results for each bore within the project boundary. The water table level is below 0 m AHD:

- In the west of the project boundary near the western portal and Arden station, where the North Yarra Main Sewer is lowering groundwater
- In the south-west of the project boundary near Domain, where the South Yarra Main Sewer is lowering groundwater
- In the CBD, where the City Loop tunnels are lowering groundwater
- To the south of the Yarra River, where the CityLink tunnels are lowering groundwater.

The highest groundwater levels are associated with higher topographic areas and areas of groundwater recharge such as the Royal Botanic Gardens. The lowest groundwater elevations coincide with the previously mentioned groundwater sinks (i.e. North and South Yarra Main Sewers, the City Loop tunnels and the CityLink tunnels) as well as deep basements within the CBD and Southbank.

More information on groundwater elevation and flow within the project area can be found in Technical Appendix O *Groundwater*.

5.3.3.2 Groundwater Use

The majority of registered groundwater bores within the project area were drilled for investigation or monitoring purposes. There are 25 bores within the vicinity of the project boundary that are registered as stock and domestic or groundwater use. Further discussion on groundwater use can be found in Technical Appendix O *Groundwater*.

5.3.3.3 Hydrology

The following surface water bodies are located in the vicinity of the study area (Figure 3 in Appendix A of this report):

- The Maribyrnong River is located at the western end of the western portal. It is anticipated that the river would not be crossed as part of the project. However, the river would require protection during the construction due to its proximity to works.
- The Moonee Ponds Creek is located between the western portal and Arden station. The Concept Design shows that the tunnels would be driven under the creek thus protecting it. However, the Arden station would involve large-scale earth works and as such, extensive protection of the creek would be required to protect against any potential environmental impacts associated with the construction works.
- The Yarra River is located immediately south of CBD South station between the CBD South and Domain Stations precincts. The Yarra River is both a potential source and receptor of water-borne contamination and would require management during the construction phase of the project.

5.4 Site Conditions

Soil, sediment and groundwater sampling locations reviewed as part of this assessment are shown in Appendix D of this report.

5.4.1 Soils

The soils of the Melbourne region vary widely according to the underlying geology, biological processes and modifications made by human occupation. Soils can be divided into natural soils reflective of the underlying geology and fill, which can be associated with a number of man-made processes.

Soil disturbance, and exporting and importing of soil materials have been common in many parts of the built up area of Melbourne.

5.4.1.1 Natural Soils

Table 5-1 summarises the typical soil types generated on top of the major outcropping geological units near the project boundary.

Table 5-1 Summary of typical Melbourne soil types

Major geological units	Typical soil type
Yarra Delta Sediments including Coode Island Silt (Qhi), Holocene Alluvium (Qha), Jolimont Clay (Qpj), Pleistocene Alluvium (Qpa), Fishermans Bend Silt Upper & Lower (Qpfu & Qpfl), Moray Street Gravels (Qpg), Early Pleistocene Colluvial and Alluvial Sediments (Qpc)	Dark loams, clays, local sands. These soils have developed on the flood plains and swampy areas of Melbourne. They consist of dark loams, clays and sands. Sand and clay content vary depending upon position and level on the floodplain.
Newer Volcanics (Qvn)	Shallow dark and reddish brown heavy clays with a thin loamy topsoil. Outcrops of basalt rock are common and basalt floaters occur extensively. Brown loams over clay. Basaltic clay has a large shrink-swell capacity which can cause cracks in walls and pavements.
Brighton Group (Tpb)	Deep sands free of lime. These are deep grey brown sands over yellow grey, frequently with a layer of dark brown hard cemented sand ('coffee rock'). They occur in the sand-

Major geological units	Typical soil type
	dune areas from Black Rock to Brighton, and along the coast of Port Phillip Bay (Domain to South Yarra).
Older Volcanics (Tov)	Brown loams over clay. Grey brown friable loam topsoil materials overly well-structured yellow red mottled clay subsoils.
Melbourne Formation (Sud)	Light grey loams over clay. The topsoil overlies a compact yellow brown mottled clay subsoil.

5.4.1.2 Fill

The entire project boundary is located within the urbanised area of Melbourne. Human occupation has altered the natural soil profile significantly either by placing material on top of the existing soil profile or excavation (or reworking) of in situ soils and deposition of imported material.

Fill material can have a number of sources including:

- The importation of materials from known or unknown sources – historically, large areas of Melbourne have been infilled with imported materials to reclaim swamp land or improve the geotechnical properties of sites. This material is often sourced from large industrial sites such as gas works, incinerators and foundries where solid wastes are generated in the form of slag and ash or from council depots where solid wastes from building and road demolitions are stored and re-used.
- The Melbourne area historically had a large number of quarries and pits, which have subsequently been filled with wastes including putrescible matter (such as household organic wastes), solid inert materials (such as building demolition waste), industrial wastes (both solids and liquids) and soils.
- In areas where buildings and structures were erected prior to the 1990s, there would be potential for asbestos-containing materials (such as asbestos-cement sheeting) to have been used. Due to significant changes in land use within the study area, many buildings containing asbestos have been demolished. Often demolition waste is retained on-site and used as fill. Therefore, asbestos containing fill would be expected at various locations within the project boundary. This is discussed in Sections 7 to 11.

Project-specific soil quality investigations have generally focused on near surface fill material which has the highest potential to be contaminated due to past or present land uses, or underlying shallow natural soils that may have been impacted by surface activities or shallow contaminated groundwater.

5.4.1.3 Acid Sulfate Soils and Rock

In addition to soil analyses conducted to assess disposal options and assess risk to human health and the environment, Melbourne Metro investigations have tested fill, river sediments and natural soils and rock for acid generation potential and corrosion (See Appendix D of this report for details of acid sulfate soil and rock analytical methods).

For the purposes of management and disposal of potentially acid-forming materials associated with the Melbourne Metro, the difference between acid sulfate soil and acid sulfate rock is marginal. For the purposes of this study, all geological units except the Melbourne Formation are considered a ‘soil’ when excavated, while spoil generated from the Melbourne Formation is considered a ‘rock’.

Acid sulfate soil or rock are soils, sediment or rocks that contain elevated concentrations of iron sulfides. Acid sulfate soils can be found as coastal acid sulfate soils, inland acid sulfate soils (associated with dry land salinity) and as monosulphidic black ooze. Acid sulfate soils can be present in the form of:

- Potential acid sulfate soils. These are generally soils that contain sulphidic materials that have not been oxidised but that would generate acidity if oxidised. Undisturbed potential acid sulfate soils has a pH around neutral

- Actual acid sulfate soils. These soils have already become acidified are a result of inorganic sulfide oxidation. Typically, the formation of actual acid sulfate soils results from the disturbance of potential acid sulfate soils.

Potential impacts of acidification from acid sulfate soils and rock are:

- Mobilisation of metals (especially aluminium, iron and manganese) and other potentially toxic contaminants that could cause adverse effects to terrestrial and aquatic flora and fauna.
- Corrosion of concrete structures and services.
- Degradation of aquatic ecosystems.
- Loss of soil structure.

A review of various sources of information on potential acid sulfate soils and acid sulfate rock along the alignment was conducted (see Appendix D of this report) and noted the potential for acid-generating materials at the following locations or associated with the following geological units:

- Coode Island Silt
  - Western portal precinct. This is consistent with local geology that includes Yarra Delta Sediments including Coode Island Silt, which are known to have potential acid sulfate properties.
  - Tunnels: CBD South station to Domain station. The tunnelling activities beneath the Yarra River area would also be likely to encounter Coode Island Silt.
- Melbourne Formation Siltstones
  - Most of the route through North Melbourne, Carlton and the CBD.

It is noted that while acid testing of Brighton Group sands and clays through the South Melbourne and South Yarra areas has not reported AASS or PASS, the depositional history of this Formation (some swamp deposits are included in the Brighton Group Formation) makes it possible that these sediments may generate acid at some locations. Testing by Golder Associates has noted that some fill material may also generate acid.

Acid leaching tests on Melbourne Formation rock cores were conducted (Appendix D of this report) to assess the potential for short to long-term acid generation. These static and kinetic tests, along with standard acid sulfate rock tests, indicate that moderately-weathered to fresh Melbourne Formation rock has the potential to generate acid when oxidised.

Therefore, spoil generated from the construction intersecting these geological formations has the potential to oxidise on exposure to air and generate acid sulfate impacts to surrounding land and aquatic environments from run-off, and so create management requirements for re-use and off-site disposal.

Temporary dewatering of the Melbourne Formation may occur during construction. This could cause the consequential oxidation of this material in the vicinity of the portals and stations. The groundwater impact assessment shows that groundwater drawdown and subsequent potential in situ oxidation of acid sulfate soils and acid sulfate rock would be unlikely to be realised due to the measures to be put in place to limit drawdown. Refer to Technical Appendix O *Groundwater* for further information.

Figure 4 in Appendix B and Table C-**0-5** in Appendix C of this report summarises the geological units likely to be potentially acid sulfate soils and acid sulfate rock potential based on project specific information of this report shows potential acid generating formations.

5.4.2 Groundwater

Seventy project-specific groundwater monitoring bores have been drilled and installed across the project alignment. Further details on the groundwater investigations and results of the sampling can be found in Technical Appendix O *Groundwater*.

Additional groundwater bores are currently being planned and drilled. Some of these bores would be installed to assess groundwater contamination. Table **5-2** provides a summary of the groundwater-sampling programs undertaken to date.

Table 5-2 Summary of groundwater sampling program undertaken

Bores	Sampling	Dates
MM1-BH001-4, 6-10, 12, 13, 15-18, 20	Samples using micropurge low flow sampling.	June - July 2010
GA11-BH002, 3, 5, 7, 8, 17, 19, 26, 27	Bailer samples of field parameters.	February 2012
GA11-BH020-25	Samples using micropurge low flow sampling.	January 2013
GA11-BH001, 9, 11, 13, 14, 18, 31, 41	Samples using micropurge low flow sampling.	July – August 2013
GA15-BH001-3, 5, 7-10, 12, 18, 19, 21, 110, 112, 27, 28, 120, 121	Samples using micropurge low flow sampling.	July – September 2015

5.4.2.1 Groundwater Quality

This section sets out the regional groundwater quality context based on groundwater samples taken within the project boundary. The existing conditions assessment identifies potential sources of contamination based on available data (e.g. EPA audit sites) is described in detail in Sections 7 to 11 for each of the precincts.

Full groundwater sampling results are included in Technical Appendix O *Groundwater*. Groundwater contamination may be encountered during construction via shallow groundwater, groundwater inflows or dewatering and long-term operation has the potential to mobilise and transport contaminants near the project boundary. Both of these risks may affect groundwater users, the health and safety of construction workers, groundwater disposal options and potentially, other drained structures in the area (e.g. basements).

The project boundary traverses two main hydrogeological settings:

- Complex sequence of fluvial/swamp delta sediments at the Maribyrnong River, Moonee Ponds Creek and Yarra River
- Simpler sequences of more massive older non-marine and marine sediments/rock and volcanics found in all other areas of the project boundary.

Groundwater quality is first discussed in terms of salinity (concentration of total dissolved solids) as this is the basis on which the SEPP (Groundwaters of Victoria) attributes groundwater beneficial uses (such as drinking water supply, irrigation and stock watering uses) that require protection.

As shown in Figure 2 in Appendix B of this report, the salinity of the water table tends to increase near the Maribyrnong River, Moonee Ponds Creek and Yarra River. It is noted that all of these waterbodies are saline and tidal.

5.4.2.2 Known Groundwater Contamination

Groundwater contamination near the project boundary has the potential to impact on the project as follows:

- Risks to workers during construction
- Risk to users of the rail infrastructure during normal operations
- Risk to the environment during construction and operation due to movement of plumes either to the infrastructure or under third party properties. This may result in the reduction of beneficial uses of groundwater (including extraction), the degradation of buildings and structures due to aggressive

groundwater conditions and the intrusion of vapours associated with the plume into buildings and structures.

Project-specific groundwater quality data is discussed in detail in Technical Appendix O *Groundwater*.

It is noted that the bores installed within the project boundary have generally been designed to monitor the groundwater at the depth of the tunnels and not potential contamination. Technical Appendix O *Groundwater* identifies that the following bores contained organic components:

- GA11-BH002 and GA11-BH007 in the western portal
- GA11-BH014 in the tunnels between the Parkville and CBD North stations
- GA11-BH041 in the tunnels between the CBD South and Domain stations
- GA11-BH022 and GA11-BH023 in the tunnels between Domain and the eastern portal
- MM1-BH002 in the Arden station precinct
- MM1-BH010 in the tunnels between Parkville and CBD North stations
- MM1-BH012 in the tunnels between CBD North and CBD South stations
- MM1-BH020 in the Domain station precinct
- GA15-BH001 and GA15-BH003 in the tunnels between the western portal and Arden station
- GA15-BH007 in the CBD North station precinct
- GA15-BH021 and GA15-BH110 in the CBD South station precinct.

The groundwater impact assessment shows that all hypothetical indoor air concentrations (due to volatilisation from groundwater and vapour intrusion into buildings) are below acceptable conservative (residential) indoor air concentrations (Technical Appendix O *Groundwater*).

5.4.2.3 Groundwater Quality Restricted Use Zones

A Groundwater Quality Restricted Use Zone is an area in which the EPA has determined that groundwater contamination is present that precludes one or more of the beneficial uses that would otherwise apply to the groundwater.

Twenty-eight EPA Groundwater Quality Restricted Use Zones were identified within approximately one (1) km of the project boundary, the majority of which do not extend beyond the boundaries of the audit site. Only two EPA Groundwater Quality Restricted Use Zones are within the project boundary. Contaminated groundwater from these sites may migrate towards tunnels or excavations if the groundwater flow regime is altered during construction and through ongoing operation.

A conservative approach has been adopted for construction-related groundwater draw down zones (see Technical Appendix O *Groundwater*). This assumes that groundwater from all the Groundwater Quality Restricted Use Zones may be mobilised and either migrate under third party properties or impact on construction along the alignment itself.

Additional information on audit sites and Groundwater Quality Restricted Use Zones can be found in Appendix D of this report and is discussed further in Sections 7 to 11.

5.4.2.4 Inflow Volumes and Disposal

During construction of temporarily or permanently drained structures (such as stations, portals and mined/bored tunnels), groundwater dewatering via active extraction and/or passive inflows (leakage into a structure located below the water table) is expected to generate volumes of groundwater of varying quality that would require disposal. Technical Appendix O *Groundwater* assumes there would be no net inflows into below ground structures during the operational phase of the project.

Technical Appendix O *Groundwater* and Technical Appendix U *Aquatic Ecology and River Health* provide more detail of the likely volumes that would be generated and potential disposal options.

5.4.3 Ground Gases and Vapours

For the purposes of this report, ground gases are defined as gases such as methane, carbon dioxide and hydrogen sulfide that can arise naturally from biodegradation of organic materials in soils and sediments. Vapours are defined as chemicals that are volatile in nature and are typically from man-made sources such as petroleum hydrocarbons and solvents.

5.4.3.1 Ground Gases

Natural swamp sediments such as Coode Island Silt, which contain high amounts of degrading organic matter, can naturally generate gases such as methane, hydrogen sulfide and carbon dioxide. While left undisturbed and in situ, these ground gases do not pose a risk to human health or the environment. However, if disturbed, these gases could either migrate to enclosed spaces or be released via piling or excavation thus presenting a potential explosive or asphyxiation risk.

Site investigations have been completed on the organic-rich Coode Island Silt at the western portal, Arden station and the Yarra River crossing (refer to Appendix D of this report). Limited testing to date indicates that there are minor amounts of methane in shallow sediments in the vicinity of the western portal to Arden station and some methane likely to be present in the vicinity of the Yarra River crossing.

The formation of gas within these sediments has occurred over a long period via microbiological and geological processes. These tend to limit the ongoing production of methane to low levels and as such, the levels of gas produced are unlikely to pose a risk to human health and the environment.

5.4.3.2 Vapours

Disturbance of ground and groundwater conditions during construction could cause vapours associated with petroleum hydrocarbon and solvent contamination in soils or groundwater to migrate towards features within the project boundary. These vapours may contain volatile organic compounds and if present could impact on air quality around the construction work site. If the volatile organic compounds are below ground, construction activity may deflect or modify existing vapour migration routes and thus wider consideration/impacts (sub-surface impacts) may need to be considered.

Volatile organic compounds along and near the project boundary are typically sourced from historic land use practices where contaminant such as fuels and solvents have been released into soil and groundwater. There are many potential sources of vapours in the vicinity of the project boundary, however, site investigations (as reported in Appendix D of this report) have confirmed limited volatile organic compounds in the shallow soils and groundwater at various locations along the project boundary. Specific results are discussed in Sections 7 to 11.

5.4.4 Durability

There are no comprehensive guidelines in Australia to enable assessment of the impact of soil or groundwater contaminants on buildings and structures (and by extension, building materials). *Australian Standard 2159-2009 Piling – Design and installation* provides for the construction of concrete and steel piles in-ground that may be aggressive. This Standard states:

> *'contamination by the tipping of mineral and domestic waste or by spillage from mining, processing or manufacturing industries presents special durability risks due to the presence of certain aggressive acids (both organic and inorganic), salts and solvents, which can chemically attack steel. In the absence of site-specific chemical information, the exposure condition should be assessed as 'severe' for domestic refuse tips and 'very severe' for industrial/mining waste tips.'*

The principal hazards which may affect durability of materials includes:

- Aggressive ground conditions and chemicals
- Acid sulfate soils (a special case of the above)
- Combustible fills and other materials
- Vapours and ground gases.

The following sections discuss each of these hazards, providing some introductory background and then a commentary on the conditions anticipated or found along the route.

5.4.4.1 Aggressive Ground Conditions – Inorganics

Acidity and salinity are the two most widely understood corrosive agents to buildings and structures in soil and groundwater.

Corrosive conditions can also arise from:

- Chlorides, sulfates, sulfides, acidic and alkaline conditions, phenols, coal tars and organic solvents
- The potential for chemical attack also depends on general soil and groundwater conditions such as pH, REDOX/reduction potential, soil permeability and biological activity.

The presence of these conditions or chemicals is more likely if man-made fill is present, however natural soils and rock can also generate these conditions.

As discussed previously, AS2159-2009 provides guidance with respect to construction of concrete and steel piles in ground that may be aggressive, with this typically relating to selecting resistant concrete mixes, concrete placing in relation to reinforcement, casting or pouring methods and sequencing.

The condition of the groundwater has the potential to impact on the structural integrity and lifespan of materials used to construct the tunnels and stations. The majority of the TBM-constructed tunnels and at least a portion of each station would be expected to be exposed to groundwater. In addition, piles and supporting structures may also be in contact with groundwater. Potential impacts on material structural durability may arise due to:

- Elevated concentrations of total dissolved solids, chloride, sulfate and some metals (iron)
- Water hardness
- Reducing in situ redox conditions
- Presence of sulfate-reducing bacteria.

To assess the magnitude of potential impacts from the above impacts, the following guidelines can be used:

- *Australian Standard 2159-2009 Piling – Design and installation* – pH, chloride and sulfate
- Langelier Index and Ryznar Stability Index (indicators of water ability to dissolve or deposit calcium carbonate).

Existing chemical data with respect to corrosion risk from groundwater is summarised in the relevant subsections in Sections 7 to 11. Active sulfate reduction in sub-surface soils and sediments under certain conditions can result in enhanced corrosion of steel; enhanced corrosion by sulfate-reducing bacteria (SRBs) is recognised in the footnote of Table 6.5.2 (C) of *Australian Standard 2159-2009 Piling – Design and installation*. The standard notes 'Where high levels of sulfates exist (>1,000 ppm), sulfate-reducing bacteria may be present and active, sometimes leading to microbiologically induced corrosion. With microbiologically induced corrosion, whilst corrosion rates can be significant, the factors that govern them are not definitively understood. In very general terms, both the geochemical conditions of the sub-surface and the presence, activity and type of sulfate-reducing bacteria are the two main factors.

Abundant sulfate-reducing bacteria was noted in:

- Western portal (Kensington)
- Tunnel – western portal to Arden station
- Tunnel – CBD South station to Domain station
- Domain station.

These high-sulfate-reducing bacteria-abundant zones generally overlap precincts already identified as having potentially aggressive or acid sulfate soil risks.

As noted above, high sulfate concentrations and low pH can generate corrosive conditions for concrete and steel structures. Therefore, the presence of acid sulfate soils or rock could potentially impact on the durability of in-ground structures. Design of any structures would need to take into account potential aggressive ground conditions in accordance with *Australian Standard 2159-2009 Piling – Design and installation*.

5.4.4.2 Aggressive Ground Conditions – Organics

The presence of organic compounds such as petroleum hydrocarbons and chlorinated hydrocarbons in soil and groundwater has the potential to impact on construction materials and consequently reduce the durability of project infrastructure.

Section 5.4.4 above has identified inorganic parameters that may corrode cement and steel. The presence of organic and petroleum compounds, particularly in groundwater, in the vicinity of the project boundary would require detailed assessment of chemical reactions between groundwater and infrastructure components such as PVC pipes, rubber and plasticised seals (e.g. tunnel gaskets) and cements and other petroleum based materials.

It is noted that ground gases and vapours could also present a durability risk due to the potential for atmospheric condensation of petroleum hydrocarbon vapours coming into contact with petroleum-based materials.

5.4.4.3 Combustible Fill and Other Materials

Combustible materials, such as domestic refuse, coal/colliery spoil, tyres, timber, sawdust, sewage sludge, plastics and other industrial waste and natural geological units such as peat and coal seams, if ignited, can lead to subterranean fires. Combustion can result in adverse impacts on the performance and durability of construction materials and can also lead to environmental contamination and hazards to human health.

With respect to the Melbourne Metro, there have been no specific investigations into this risk. However, a qualitative assessment has been conducted. Based on the historic land uses and the location of the project boundary, no locations have been identified where these conditions are likely to prevail.

5.5 Conceptual Site Models

5.5.1 General

A conceptual site model is a fundamental requirement in the assessment of impacts from contaminated land and groundwater. This requirement is clearly set out in the National Environment Protection Measure. The conceptual site model serves as a platform to enable understanding of the potential risks and impacts and serves as a focus to consider mitigation and performance requirements.

Three conceptual site models have been developed covering potential impacts on the main construction and infrastructure aspects of Melbourne Metro:

- Conceptual site model 1 – Tunnels
- Conceptual site model 2 – portals and western turnback – above ground running track and decline structures

- Conceptual site model 3 — Stations.

Each conceptual site model is made up of three elements: potential sources, pathways and receptors. With Melbourne Metro the sources can be natural, such as acid sulfate soils, or it can be associated with former industrial activity and associated contamination. Receptors can include construction workers, members of the public during construction, maintenance workers during operations, the environment, groundwater, surface water and building materials. A pathway can be direct (such as construction workers touching contaminated soil) or indirect (such as contaminant migration in groundwater to a river). Only if all three of these elements are present can a potential impact develop.

Much of what is covered in this section informs the risk assessment in Section 6.

For context in respect to relevant SEPP, and further to Figures 5-1, 5-2 and 5-3, a conservative assessment of beneficial uses protected by the SEPP (Prevention and Management of Contamination of Land) and SEPP (Groundwater of Victoria) relevant to potential impacts are summarised in the Table 5-3).

Table 5-3 Assessment of beneficial uses

SEPP	Protected beneficial uses
SEPP (Groundwater of Victoria), conservatively adopting Segment B based on groundwater total dissolved solid data in Table C-**0-4** in Appendix C of this report.	• Maintenance of Ecosystems • Potable Mineral Water Supply • Agriculture, Parks and Gardens • Stock Watering • Industrial Use • Primary Contact Recreation • Buildings and Structures.
SEPP (Prevention and Management of Contamination of Land), conservatively adopting sensitive land use (excluding food production).	• Maintenance of ecosystems – modified ecosystems • Human health • Buildings and structures • Aesthetics.

5.5.2 Conceptual Site Model 1 – Tunnels

Tunnels would be entirely subterranean formed within natural rock and soil. Most of the tunnelling would be completed within saturated strata. It is unlikely that historically infilled land would be encountered. The conceptual site model is described in Table **5-4**.

Table 5-4 Conceptual Site Model - Tunnels

Aspect	Description
Sources	Potential sources of contamination are: • Natural acid sulfate soils predominantly from Coode Island Silt • Natural marsh gas from Coode Island Silt. Marsh gas is predominantly methane with hydrogen sulfide. Methane is potentially flammable • Natural potential acid sulfate rock – acid sulfate rock (Fresh Melbourne Formation – at depth) • Deeper groundwater-borne contamination from sources above the tunnel or contamination plumes originating from adjacent land. Contaminants (if present) would be variable and may comprise soluble contaminants and free phase hydrocarbons.

Aspect	Description
	All tunnelled materials would be removed as spoil. Tunnelling methods would limit disturbance of the surrounding ground and groundwater, although some aeration of the acidic material may be possible.
Pathways	With marsh gas, the key pathways relate to advective and diffusive flow from methane-rich sources or strata in the Coode Island Silt towards either the atmosphere or the tunnel air space. With the tunnels structure, migration would be limited by the concrete liner. If methane enters the tunnels, it would be significantly diluted by ventilation in the tunnels and by the action of trains moving through the tunnels. If gas reaches the atmosphere, it would be significantly diluted. A similar process would be likely for vapours from contaminated land or groundwater. With groundwater, key pathways would be percolation and leaching with the soil/rock mass. Contaminants would tend to migrate with the direction of groundwater flow, however may be subject to retardation, dilution and dispersion. Some organic contaminants within the project boundary, if they are in sufficiently high concentrations, could form non-aqueous phase liquids. Non-aqueous phase liquids can either float (such as oils) or sink (such as some chlorinated solvents). Groundwater flow paths have the potential to be modified by the tunnelling methods and is discussed further in Technical Appendix O *Groundwater*. Groundwater (and any contamination) that is adjacent to the tunnel wall lining may seep through into the tunnels where the water may collect. Groundwater seeping through into the tunnels would be collected in sumps and discharged in accordance with an EPA approved management and disposal plan. If such drainage is contaminated with volatile organic compounds, they may then partition into the tunnels atmosphere.
Receptors	Whilst a number of human and environmental receptors could be impacted (as per Figure 5-1), the key receptors are more likely to be: • Maintenance workers during routine maintenance work • Tunnel lining and other structures (with respect to aggressive groundwater conditions).
Complete linkages	Figure 5-1 shows the complete impact linkages. The relevance of these to the individual tunnel segments discussed in Section 7.

5.5.3 Conceptual Site Model 2 – Portals and Turnback (Above Ground Running Track and Decline Structures)

The main above ground sections of the Melbourne Metro would be at either end (Kensington and South Yarra) and at the western turnback. In Kensington, new railway tracks are to be located within existing railway land on an embankment before entering a decline structure. This decline structure would initially be a cutting before entering a short cut-and-cover section terminating at the western portal. The eastern portal is similar to the above, although covers a shorter length and the decline structure emerges between existing running lines at South Yarra. The western turnback is to be constructed largely within existing rail land and entail minor surface earthworks relating to platform construction and rail re-alignments.

In Kensington, excavations would predominantly be in Coode Island Silt, whilst in South Yarra excavations would be in the Brighton Group and in fill and basalt at the western turnback. Groundwater and historically infilled land would be encountered at all locations. The conceptual site model is described in Table 5 – 5.

Table 5-5 Conceptual Site Model – Portals and Turnback

Aspect	Description
Sources	Potential sources of contamination are: • Natural acid sulfate soils (predominantly Coode Island Silt in Kensington) • Natural marsh gas from the Coode Island Silt. Marsh gas is predominantly methane with hydrogen sulfide. Methane is potentially flammable • Historically infilled ground containing a variety of contaminants • Shallow groundwater-borne contamination from sources at the site. Contaminants would be variable with soluble and free phase contaminants likely. Off-site sources of contaminated groundwater are also possible. The embankment in Kensington would likely be piled. All excavated materials would be removed as waste. Excavation and piling methods may disturb the surrounding ground and groundwater. Aeration of the potential acid sulfate soils in the west would be likely.
Pathways	Key pathways would be direct contact of construction materials with surrounding historically infilled ground, formation of pathways via piling or deep excavations, percolation and leaching within the soil/rock mass and pressure driven (advective) migration of marsh gas. Construction and maintenance workers could come into direct contact with contamination in historic infilled ground. This material could also be in direct contact with building materials for the decline structures and thus would potentially impact on the durability of building materials. Some residual soils may be retained and thus could be available for transfer into flora and fauna. With marsh gas, the key pathways relate to advective and diffusive flow from methane-rich sources or strata in the Coode Island Silt towards either the atmosphere or the tunnel air space. Most of the decline structure would be open to the atmosphere and thus accumulation within enclosed spaces is not likely. During construction, ground gases may be released, but these events would be transient. If methane enters the cut-and-cover section, it would be significantly diluted by tunnel ventilation and the action of train movements through the tunnels. If gas reaches the atmosphere, it would be significantly diluted by wind dispersion. A similar process is likely for vapours from contaminated land or groundwater. If contaminants are mobilised into groundwater during either piling or construction of the decline structures, they would tend to migrate with the direction of groundwater flow, however may be subject to retardation, dilution and dispersion. Some organic contaminants within the project boundary, if they are in sufficiently high concentrations, could form non-aqueous phase liquids. Groundwater flow paths may be modified by the construction methods, as discussed in Technical Appendix O *Groundwater*. Groundwater (and any contamination) that is adjacent to the decline wall lining may seep through into the structure where the water may collect. Any water seeping through into the tunnels would be collected in sumps and discharged in accordance with an EPA-approved management and disposal plan.
Receptors	Whilst a number of human and environmental receptors could be impacted (as per Figure 5-1), the key receptors are more likely to be: • Maintenance workers during routine maintenance work • Tunnel lining and other structures (with respect to aggressive groundwater conditions). • Groundwater.
Complete linkages	Figure 5-2 shows the complete impact linkages. The relevance of these to the western portal, eastern portal and the western turnback are considered in Section 8 (Portals) and Section 10 (Turnback).

5.5.4 Conceptual Site Model 3 – Stations

Most stations would be constructed through the surface historic infilled material, natural soil and rock. All share similar general construction features. The key potentially contaminated material would be the historic infilling and this is most apparent at the Arden station where considerable thicknesses may be present. The Arden precinct also has Coode Island Silt below the fill. The other stations would have a variable, but in the main thin, layer of historic infill overlying either Brighton Group or Melbourne Formation siltstones. It is noted that CBD South and CBD North stations would be constructed using a cavern method which would not entail the excavation of surface materials. However, these stations would also have cut-and-cover sections at entry and exist points where fill (if present) would be excavated.

Groundwater would likely be encountered in all stations, requiring dewatering during the construction phase. Further discussion on expected dewatering volumes is included in Technical Appendix O *Groundwater*.

The conceptual site model is described in Table 5-6.

Table 5-6 Conceptual Site Model – Portals and Turnback

Aspect	Description
Sources	Potential sources of contamination are: • Natural acid sulfate soils (Coode Island Silt at Arden) • Natural marsh gas from the Coode Island Silt. Marsh gas is predominantly methane with hydrogen sulfide. Methane is potentially flammable • Historically infilled ground containing a variety of contaminants • Shallow groundwater-borne contamination from sources near the stations. Contaminants would be variable with soluble and free phase contaminants likely. Off-site contaminated groundwater plumes are likely – mainly at the Arden and CBD North stations. Extensive dewatering may pull off-site plumes towards the stations. All excavated materials would be removed as waste. Excavation methods may disturb the surrounding ground and groundwater. Aeration of the potential acid sulfate soils in the Arden precinct would be likely
Pathways	The pathways for this conceptual site model would be the same as conceptual site model 2 (Section 5.5.3).
Receptors	Whilst a number of human and environmental receptors could be impacted (as per Figure 5-1), the key receptors are more likely to be: • Construction workers • Maintenance workers during routine maintenance work • Station box retaining walls and other structures • Groundwater. Receptors identified may also be relevant where temporary placement of spoil is required, such as the Emergency Spoil Categorisation Area at Arden, and would be considered.
Complete linkages	Figure 5-3 shows the complete impact linkages. The relevance of these to the individual stations are discussed in Section 9.

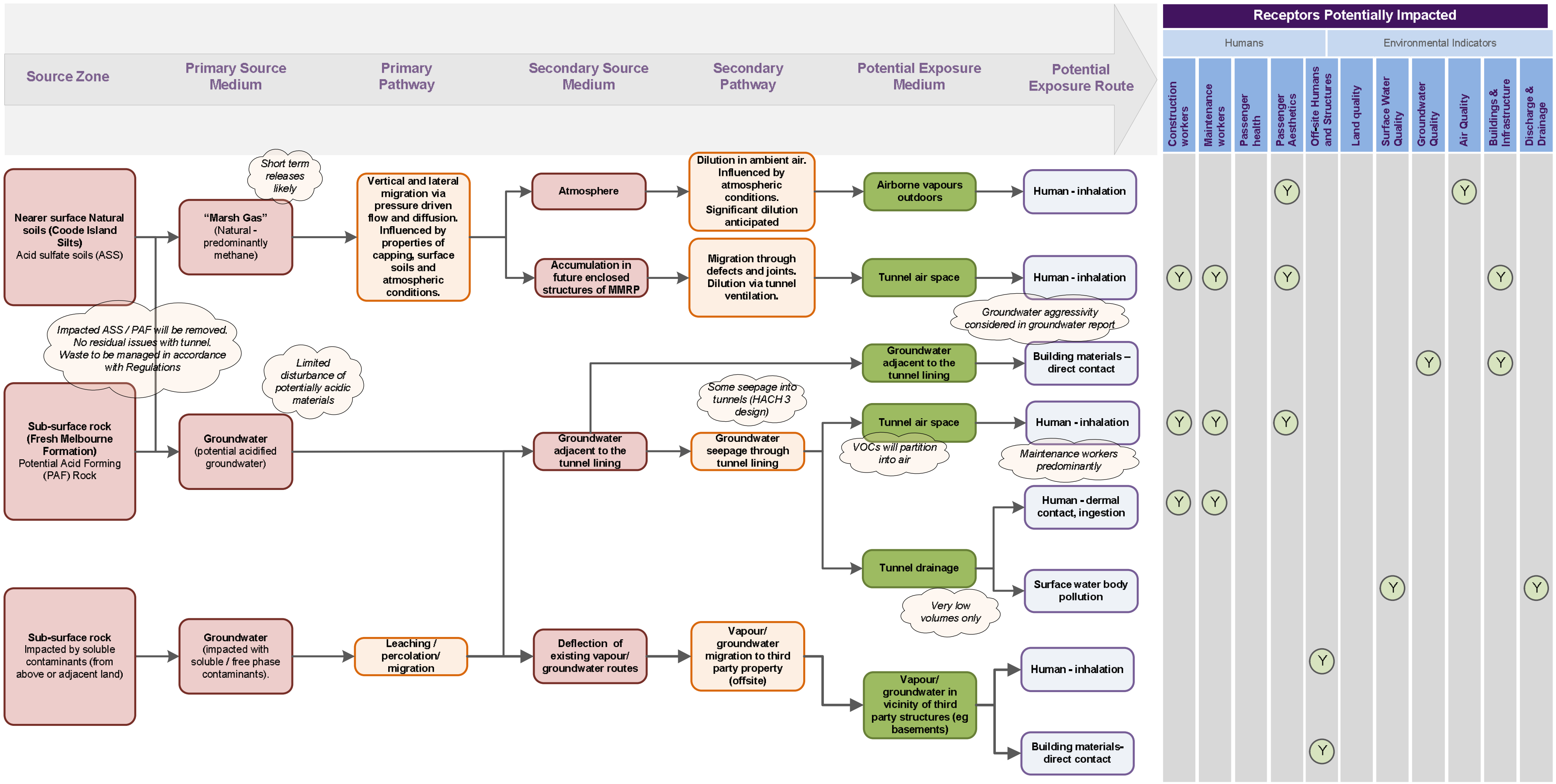

Figure 5-1 Generic conceptual site model 1 – Tunnels

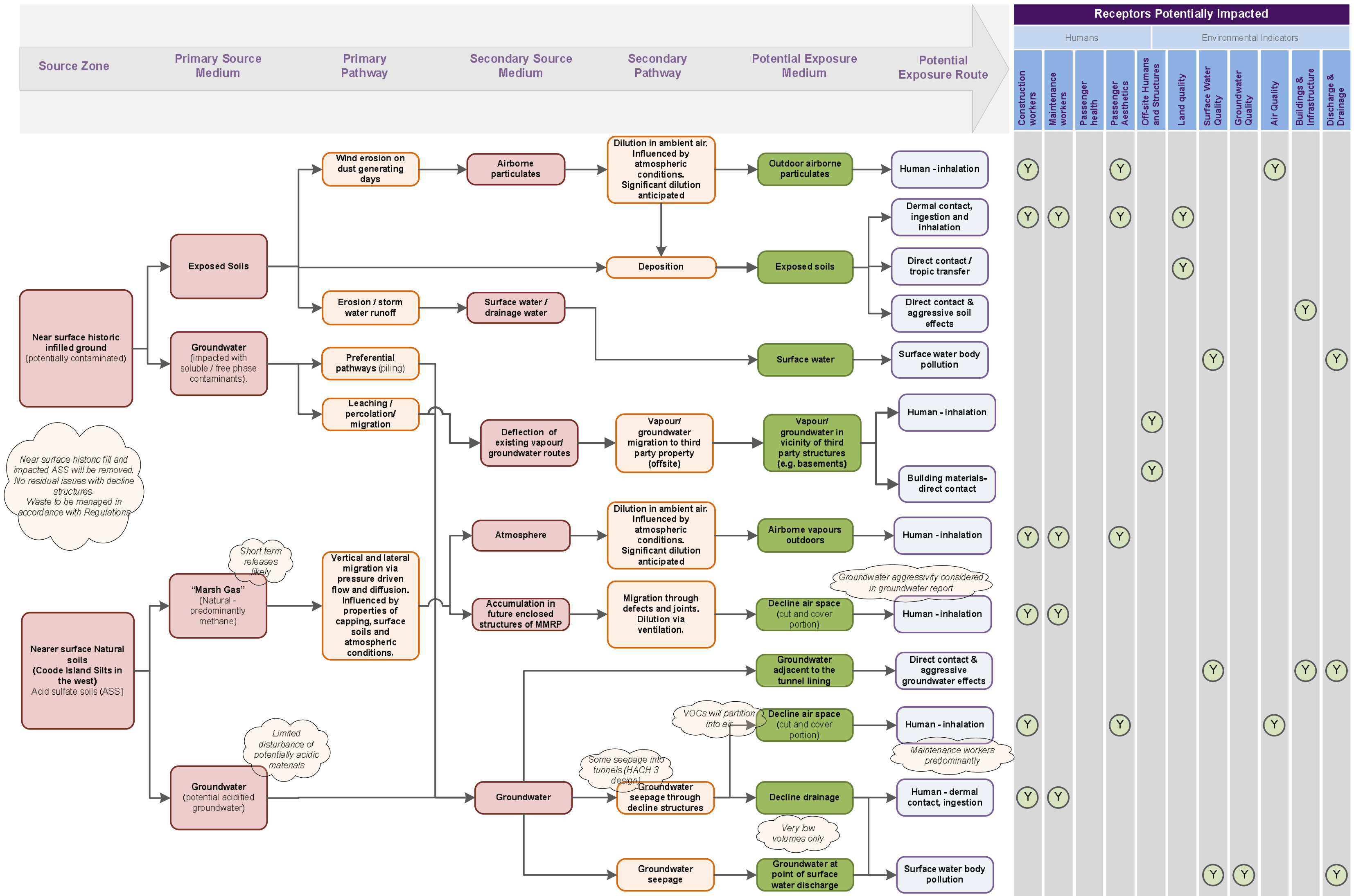

Figure 5-2 Generic conceptual site model 2 – Portals and turnback

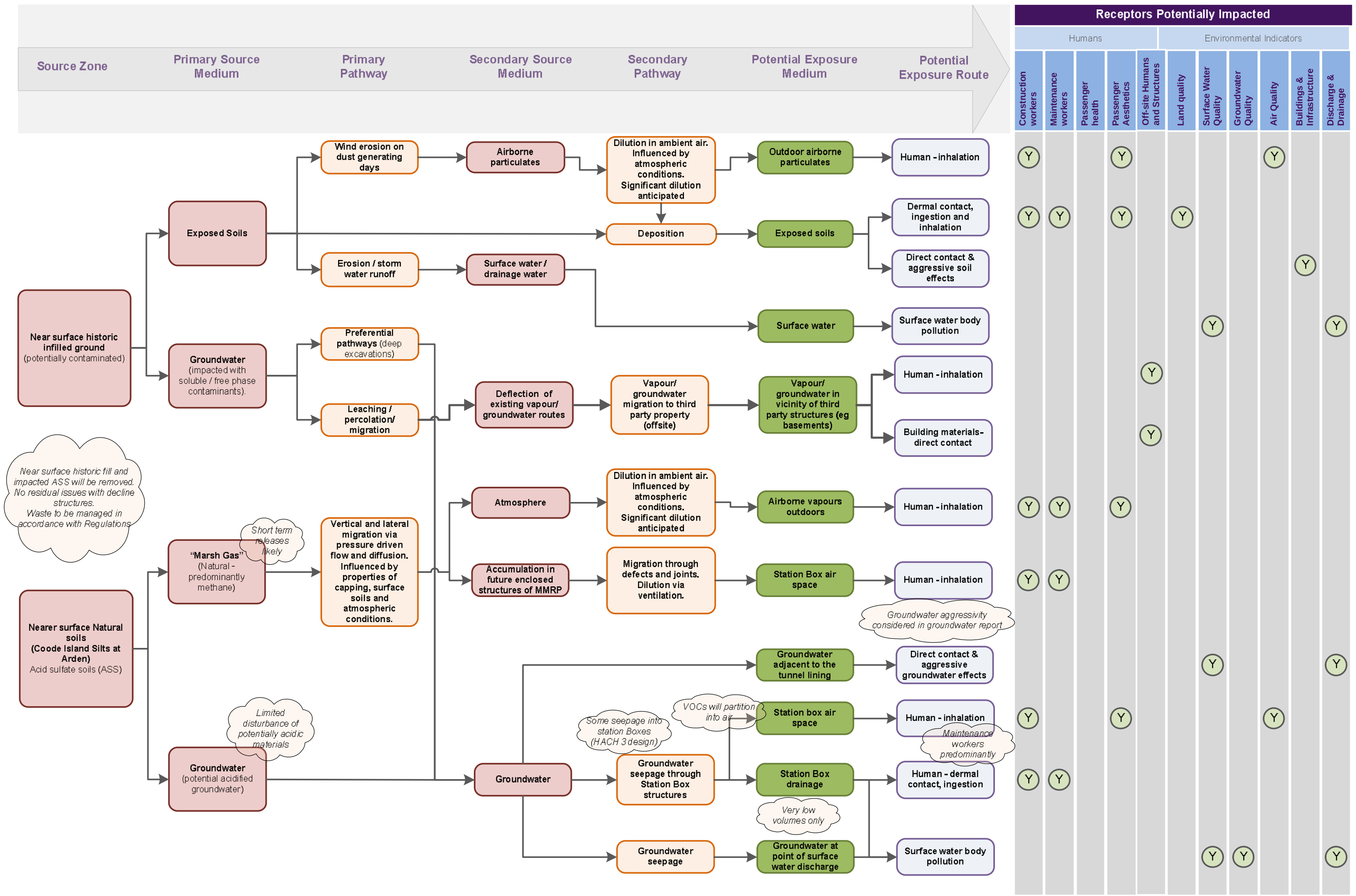

Figure 5-3 Generic conceptual site model 3 – Stations

5.6 Data Quality Assessment

5.6.1 Site Investigation Locations

Table C-1 in Appendix C of this report summarises the borehole locations and samples taken per precinct.

As discussed in Sections 3 and 4, various guidance documents such as the Industrial Waste Resource Guidelines, Industrial Waste Management Policies, National Environment Protection Measures and Australian Standards, set out data requirements relating to the type and number of samples required based on either the size of the area under investigation or the volume of material to be disturbed/removed.

Due to the nature of Melbourne Metro, the density of sampling required by these publications cannot be achieved practically due to limited access to sampling locations at many sites. Therefore, the dataset is augmented with data from other sources such as historic land uses, Groundwater Quality Restricted Use Zones and audit information and professional knowledge of the area.

For the purposes of this impact assessment, AJM-JV considers the dataset to be adequate to assess the potential impacts of the project on the environment.

5.6.2 Sampling and Contaminated Investigations

Planning and implementing contaminated land investigation in Victoria is guided by two main documents:

- Australian Standard 4482.1-2005 Guide to the sampling and investigation of potentially contaminated soil – Part 1: non-volatile and semi-volatile substances
- National Environment Protection Measure (NEPM 2013) Schedule B2 Guidance on Site Characterisation.

These documents both describe sampling strategies that can be adopted to assess the nature and extent of contamination. The common strategies adopted include systematic, judgemental, stratified and targeting sampling, with the approach taken based on the level of knowledge of the site by the assessor, the conceptual site model and the potential complexity of the contamination.

To date, investigations completed for the project have been judgemental in nature where site investigation efforts have been purpose driven; based on knowledge of the site either from the site history or on an earlier phase(s) of site investigation; and focussed on known or potentially contaminated areas identified from investigations and professional judgement. This form of judgemental sampling is commonly used during concept phases of projects. Additional investigation along the alignment would be required by the contractor prior to construction to infill data gaps in the existing investigation program (see Section 5.6.5 below).

Throughout the project-specific investigation stages, SAQPs and Data Quality Objectives (DQOs) have been prepared (by Golder Associates) and reviewed by the AJM-JV for consistency and appropriateness.

These documents include DQOs including field and laboratory quality assurance and quality control (QA and QC) procedures to ensure:

- An appropriate sampling program is implemented to achieve the DQOs of the investigation
- Collection, storage, handling, transportation and analysis of appropriate (to the objectives of the investigation) and representative samples (and relevant quality control samples) is completed
- Field recording of sample collection, decontamination procedures and equipment calibration is conducted to provide confidence in the sample representativeness and integrity
- Appropriate quality control samples are taken in the field (field QC samples) and instituted in the laboratory (laboratory QC samples)
- The quality control results comply with the relevant data quality standards in Australian Standard 4482.1-2005.

5.6.3 Sampling and Waste Categorisation

Categorisation of spoil is required by the EPA once:

- Spoil is to be taken off-site for re-use, treatment or disposal
- Spoil is to be retained on-site for the purposes of re-use or encapsulation.

EPA Publication IWRG 702 – *Soil sampling* provides information relating to the most suitable patterns for sampling and the number of samples to be taken to ensure the appropriate hazard categorisation is applied to soils being moved off-site for re-use, treatment or disposal. Essentially, it provides the minimum sampling density required for off-site disposal of spoil while EPA Publication IWRG 621 – *Soil hazard categorisation and management* includes the chemical threshold limits by which the spoil is categorised as either clean fill (uncontaminated) or Category A (most contaminated Prescribed Industrial Waste) to Category C (least contaminated Prescribed Industrial Waste). This categorisation and subsequent classification by EPA determines where the Prescribed Industrial Waste can be disposed of. As a general indicator, a minimum one sample is required for each 250 m^3 to be disposed of.

The waste categorisation described in this impact assessment has been completed with the available sample results. An indication of the confidence in the data can be made using the following:

- High confidence – greater than one (1) sample in 250 m^3 (compliance with Industrial Waste Resource Guidelines sampling density)
- Medium confidence – between 1 in 250 m^3 and 1 in 1,000 m^3 (partial compliance with the Industrial Waste Resource Guidelines sample density)
- Low confidence – less than 1 in 1,000 m^3 (poor compliance with the Industrial Waste Resource Guidelines sampling density).

As noted in Industrial Waste Resource Guideline 702, '*The appropriate sampling rate can be reduced* ….'. Scenarios that may result in reduced sampling would typically be found when sampling natural soils. Lower sampling density can provide the required data quality objectives to enable waste categorisation as the natural soils would be more homogeneous and also the contaminant concentrations would likely be lower (and mostly much lower) than the Category C, B and A thresholds (i.e. more likely to be clean fill).

5.6.4 Uncertainty Assessment

Due to the long and varied nature of land uses, the linear nature of Melbourne Metro and the current early phase in the planning and concept design, various assumptions and an acceptance of some uncertainties are required in assessing the information used in this impact assessment. These assumptions and the uncertainties are discussed below.

- Sources of information – completeness and currency

  The data used in this assessment comes from a variety of sources and investigations spanning a number of years. Some of these are from the public domain and were prepared by third parties for non-Melbourne Metro purposes. Melbourne Metro has been conducting a project-wide site investigation and this was planned specifically to provide information for this impact assessment and to complete the Concept Design. These investigations are ongoing at the time of writing this report. Other investigations have also been completed by the Victorian Government considering earlier stages in the planning of Melbourne Metro.

  All usable site investigation data over the period of these investigations have been used, with each investigation adding further detail to the conceptual site models developed. Thus, the initial conceptual models based on generic and publicly available information have been refreshed regularly as more current and specific information is planned and obtained. This process would continue throughout the life of this project.

- Density of sampling

  The density of sampling at each of the precincts noted in this section is variable. Some soil units have been targeted for more sampling than others, whilst other soil units have been characterised by relatively few samples. Sufficient sampling has been undertaken to identify the contaminants of concern and potential risks to human health and the environment. The IWRG guidelines on sampling requirements for waste generally require about one sample every 250 m^3 of waste; insufficient samples have been taken with respect to this requirement. The impact assessment has been prepared with the project at Concept Design stage and in that regard, an indicative or preliminary waste classification is possible. The assessment has taken the conservative approach of considering that a proportion of the total volume of historically infilled material would be Category B and A wastes. As described in Appendix D, the contaminant profile and preliminary results (and in particular the leaching test results) suggests that any Category B and A wastes would be strong candidates for reclassification to Category C (or as clean fill).

- Data quality

  Specific data quality aspects of the recent investigations are described in Golder Associates' Contaminated Land Assessment – EES Summary Report (Appendix D of this report) and have been further considered based on the following aspects of the work completed to date:

  – Preliminary investigation (desktop study)
  – Completeness of field works planned
  – Investigation coverage and sample density
  – Field work and sampling processes
  – Laboratory analysis.

  Overall, data quality over the various stages and phases of work is good to very good.

- Conclusions

  The dataset comprised of sufficient sampling and analysis to allow development of a conceptual site model, and assess impacts and required mitigation measures in respect to soil contamination and spoil characterisation.

  Further sampling would be required by the contractor in order to finalise specific designs and management plans. The requirement for this sampling would be a performance requirement. Specific sample analysis quality plans) as per the NEPM (2013) would be requested for approval in advance of any site work commencing. A summary of these further requirements are described in Section 5.6.5.

5.6.5 Consideration of Uncertainty Within the Risk Register for Impact Assessment

As noted above, there remains some uncertainty in the information and data used within this assessment. This uncertainty is a significant factor in determining the initial risk ranking within the risk register (Section 6), and in many cases, this uncertainty has resulted in the initial risks being factored to a higher level than if there was less uncertainty. This is a conservative, but appropriate approach at this stage in the project lifecycle.

When considering waste classification, compliance with sampling density set out in EPA Publication IWRG 702 is the main factor when determining confidence in the waste classification. As confidence goes down and uncertainty increases, to compensate, more conservative assessments of the data is required. For example, with a small sample set, waste classification is determined based on the maximum result, whereas with larger sample sizes, the average[2] can be used.

[2] Or more accurately a 95% upper confidence limit on the average

Within this assessment, because a relative small number of samples have been taken, the initial risk rating assumes that waste volumes might be higher than expected or calculated, or might have a higher volume of waste reclassified to a more hazardous category (see Table 4-3 and Table 4-6). This impacts on both the consequence and likelihood parameters and the resultant risk would be higher than if a larger number of samples were taken.

With contaminated land and spoil management, further investigation and assessment is the key factor in addressing impacts and reducing risks from contaminated land. Mitigation measures have been proposed to meet the recommended Environmental Performance Requirements, with the mitigation measures generally requiring further assessment in the first instance. Depending on the impact being considered and the initial risks, reducing uncertainty can result in either or both the consequence and likelihood parameters to be re-evaluated.

5.6.6 Further Site Characterisation and Assessment

Further assessment of ground conditions has been mentioned on a number of occasions in this report. This requirement for additional accumulating data is normal in contaminated land projects and is reflective of the current Concept Design stage of the project.

To recap, the following broad stages of site characterisation have been completed, are currently ongoing or would be anticipated:

- Stage 1 – completed in 2011
- Stage 2 – completed in 2012 (and refreshed in 2015)
- Stage 3 – the Concept Design bores – completed in 2015 (this, together with the previous stages, is the database on which the EES is based)
- Stage 4 – the Procurement Bores. Currently being undertaken and would be completed in time to be included in the tender documents
- Further anticipated investigations
  - Contractor-specific requirements to support their tender design
  - Pre-construction, to comply with regulatory requirements for spoil waste categorisation
  - During construction, it t is anticipated that data gathering (and monitoring) would be ongoing during the span of the project
  - Post construction. Some long-term monitoring may be needed depending on construction-specific aspects.

The various needs for further investigation are contained in the recommended Environmental Performance Requirements.

6 Risk Assessment

Table 6-1 presents the contaminated land and waste management risks associated with the project, on a precinct basis. The environmental risk assessment methodology is outlined in Section 4.2.2.

Existing performance requirements were identified to inform the assessment of initial risk ratings. These existing performance requirements are based on standard requirements that are typically incorporated into construction contracts for rail projects.

Risk assessments help decide whether contamination may present a problem. This is generally completed using a combination of document review and site investigation, together with an understanding of the scope of the project. As discussed in Section 5.6, there are some limitations in the site investigation data which is reflective of the project's current conceptual stage. This is offset to a degree by comprehensive background information within and close to the project boundary. However, because of the relative uncertainty in the data with respect to characterising the nature of contamination, a precautionary approach has been adopted where initial risk ranking parameters have been conservatively allocated, resulting in a higher initial risk level. A similar approach was adopted by Golder Associates in calculating spoil volumes and providing a preliminary waste categorisation (See Appendix D of this report).

As a result of the risk assessment, project-specific performance requirements (recommended Environmental Performance Requirements) have been proposed to reduce risks and hence determine the Residual Risk Rating. The recommended Environmental Performance Requirements are outlined in the following sections of the impact assessment and collated in Table 12-1, Table 12-2 and Table 12-3. All recommended Environmental Performance Requirements are incorporated into the Environmental Management Framework for the project (Chapter 23 of the EES).

In contaminated risk assessments, consequence would typically be linked to an inherent hazardous property of the source of the chemical of interest (or the waste categorisation), together with extent of contamination and volume of the waste, and this would not normally change. Likelihood is linked more to exposure (for example, contaminant migration, hydrogeological setting at the site, characteristics of the sensitive receptors) and this tends to be a variable. As noted above, the initial risk parameter settings have been influenced by uncertainty in the current knowledge at the site.

Adopting performance measures could influence both the consequence and likelihood parameters. As the risk assessment has erred on the side of caution, further investigations would tend to decrease the extent of contamination or decrease the waste categorisation and thus consequences reduce. Further understanding of the hydrogeological setting and/or adoption of engineering mitigation or management practices or clarification of waste disposal locations would all tend to reduce or eliminate exposure or reduce the uncertainty and thus reduce the likelihood.

For further details refer to Technical Appendix B *Environmental Risk Assessment Report* of the EES which includes the full Risk Register, with existing performance requirements and recommended Environmental Performance Requirements assigned to each risk.

Table 6-1 Risk register for impact assessment

Impact pathway			Initial risk			Residual risk			Risk no.
Category	Event	Precinct	C	L	Risk	C	L	Risk	
Bulk earthworks and spoil management	Increased volumes and / or incorrect classification of 'Clean Fill' leading to inappropriate re-use.	All tunnels	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL001
Bulk earthworks and spoil management	Increased volumes of natural acid sulfate soils (Coode Island Silts and Brighton Group), requiring management / off-site disposal.	CBD South station to Domain station	Major	Possible	High	Moderate	Unlikely	Low	#CL002
Bulk earthworks and spoil management	Increased volumes and / or incorrect classification of natural potential acid sulfate rock, requiring management / off-site disposal.	Parkville station to CBD North station, CBD North station to CBD South station, CBD South station to Domain station	Major	Possible	High	Moderate	Unlikely	Low	#CL005
Bulk earthworks and spoil management	Increased volumes and / or incorrect classification of natural potential acid sulfate rock, requiring management / off-site disposal.	Western portal to Arden station	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL006
Contaminated land management	If groundwater is contaminated with VOCs, inflows may result in raised levels of vapours in the tunnel atmosphere resulting in increased impact on human health	Parkville station to CBD North station	Moderate	Possible	Medium	Minor	Rare	Very Low	#CL008
Groundwater inflow and vapour impact	Disturbance of ground gases and migration and accumulation in tunnels	Western portal to Arden station, CBD South station to Domain station	Moderate	Possible	Medium	Minor	Unlikely	Low	#CL010
Below ground structures	Impact on durability of building and construction materials	Western portal to Arden station, CBD South station to Domain station	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL013

Impact pathway			Initial risk			Residual risk			Risk no.
Category	Event	Precinct	C	L	Risk	C	L	Risk	
Construction safety hazards	Potential impact to worker safety	All tunnels	Major	Possible	High	Moderate	Unlikely	Low	#CL015
Bulk earthworks and spoil management	Increased volumes and / or incorrect classification of 'Clean Fill' leading to inappropriate re-use.	Eastern portal, Western portal	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL016
Bulk earthworks and spoil management	Increased volumes of natural acid sulfate soils (Coode Island Silts and Brighton Group), requiring management / off-site disposal.	Eastern portal	Major	Possible	High	Moderate	Unlikely	Low	#CL018
Bulk earthworks and spoil management	Inappropriate handling, stockpiling and/or treatment of contaminated spoil may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Category C or fill.	Eastern portal	Major	Possible	High	Moderate	Unlikely	Low	#CL021
Bulk earthworks and spoil management	Inappropriate handling, stockpiling and/or treatment of contaminated spoil may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Category C or fill.	Western portal	Major	Possible	High	Moderate	Unlikely	Low	#CL022
Bulk earthworks and spoil management	Inappropriate handling, stockpiling and/or treatment of contaminated spoil may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Category C or fill.	Western Turnback	Major	Possible	High	Moderate	Unlikely	Low	#CL023

Impact pathway			Initial risk			Residual risk			Risk no.
Category	Event	Precinct	C	L	Risk	C	L	Risk	
Bulk earthworks and spoil management	Inappropriate handling, stockpiling and/or treatment of asbestos containing materials may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Category C or fill.	Eastern portal	Major	Possible	High	Moderate	Unlikely	Low	#CL024
Bulk earthworks and spoil management	Inappropriate handling, stockpiling and/or treatment of asbestos containing materials may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Category C or fill.	Western portal	Major	Possible	High	Moderate	Unlikely	Low	#CL025
Bulk earthworks and spoil management	Inappropriate handling, stockpiling and/or treatment of asbestos containing materials may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Category C or fill.	Western Turnback	Major	Possible	High	Moderate	Unlikely	Low	#CL026
Groundwater inflow and vapour impact	If groundwater is contaminated with VOCs, inflows may result in raised levels of vapours in the tunnel atmosphere resulting in increased impact on human health	Eastern portal	Moderate	Likely	Medium	Moderate	Unlikely	Low	#CL027
Below ground structures	Disturbance of ground gases and migration and accumulation in tunnels	Eastern portal	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL030
Below ground structures	Disturbance of vapours and migration and accumulation in tunnels	Eastern portal	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL033

Impact pathway			Initial risk			Residual risk			Risk no.
Category	Event	Precinct	C	L	Risk	C	L	Risk	
Below ground structures	Impact on durability of building and construction materials	Eastern portal	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL036
Piling and retaining walls	Piling may disturb ground and cause the formation of pathways for contamination to migrate from impacted strata to un-impacted strata or may enable entrained gasses and vapours to be released.	Eastern portal	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL039
Piling and retaining walls	Piling may disturb ground and cause the formation of pathways for contamination to migrate from impacted strata to un-impacted strata or may enable entrained gasses and vapours to be released.	Western portal	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL040
Construction safety hazards	Potential impact to worker safety	Eastern portal, Western portal, Western Turnback	Major	Possible	High	Moderate	Unlikely	Low	#CL042
Bulk earthworks and spoil management	Increased volumes and / or incorrect classification of 'Clean Fill' leading to inappropriate re-use.	All stations	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL043
Bulk earthworks and spoil management	Increased volumes of natural acid sulfate soils (Coode Island Silts and Brighton Group), requiring management / off-site disposal.	Arden	Major	Possible	High	Moderate	Unlikely	Low	#CL044
Bulk earthworks and spoil management	Increased volumes and / or incorrect classification of natural potential acid sulfate rock, requiring management / off-site disposal.	Parkville, CBD North, CBD South	Major	Possible	High	Moderate	Unlikely	Low	#CL046

Impact pathway			Initial risk			Residual risk			Risk no.
Category	Event	Precinct	C	L	Risk	C	L	Risk	
Bulk earthworks and spoil management	Inappropriate handling, stockpiling and/or treatment of contaminated spoil may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Category C or fill.	All stations.	Major	Possible	High	Moderate	Unlikely	Low	#CL048
Bulk earthworks and spoil management	Inappropriate handling, stockpiling and/or treatment of asbestos containing materials may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Category C or fill.	All stations	Major	Possible	High	Moderate	Unlikely	Low	#CL049
Groundwater inflow and vapour impact	If groundwater is contaminated with VOCs, inflows may result in raised levels of vapours in the tunnel atmosphere resulting in increased impact on human health	CBD North, Domain.	Moderate	Likely	Medium	Moderate	Unlikely	Low	#CL050
Below ground structures	Disturbance of ground gases and migration and accumulation in tunnels	Arden,	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL052
Below ground structures	Disturbance of vapours and migration and accumulation in tunnels	Arden, Parkville, CBD North,	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL054
Below ground structures	Impact on durability of building and construction materials	Arden	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL056

Impact pathway			Initial risk			Residual risk			Risk no.
Category	Event	Precinct	C	L	Risk	C	L	Risk	
Piling and retaining walls	Piling may disturb ground and cause the formation of pathways for contamination to migrate from impacted strata to un-impacted strata or may enable entrained gasses and vapours to be released.	All stations	Moderate	Possible	Medium	Moderate	Unlikely	Low	#CL058
Construction safety hazards	Potential impact to worker safety	All stations	Major	Possible	High	Moderate	Unlikely	Low	#CL059

7 Precinct 1 – Tunnels

This section describes the project components, existing conditions, key issues, benefits and opportunities, and findings of the impact assessment for the tunnels component of the Concept Design and alternative design options.

7.1 Project Components

The following infrastructure is relevant for this assessment in the Tunnels precinct:

- Two nine kilometre long tunnels
- Twenty three tunnel cross passages (emergency cross passages between the two tunnels at various locations, provided in line with the fire and life safety requirements at a maximum spacing of 350 m)
- Emergency access shafts.

7.1.1 Construction

Construction aspects for the tunnels are summarised in Table **7-1**.

Table 7-1 Summary of construction details

Location	Construction – Concept Design	Construction – Alternative Design Option
Western portal to Arden station	TBMs would excavate from Arden station to the western portal, where they would be retrieved. Tunnels would pass under the Upfield Line.	None
Arden station to Parkville station	TBMs (one for each tunnel) would then be relaunched to excavate from Arden station to CBD North station, passing through the previously excavated station box at Parkville.	None
Parkville station to CBD North station	TBMs (one for each tunnel) would then be relaunched to excavate from Arden station to CBD North station, passing through the previously excavated station box at Parkville.	None
CBD North station to CBD South station	Mined tunnels would be excavated using road headers.	None
CBD South station to Domain station	TBMs would excavate from Fawkner Park to the southern end of Domain station, where they would be retrieved and relaunched from the northern end of Domain station to CBD South station.	Emergency access shaft at Linlithgow Avenue - Located in Tom's Block (Option 3), between Linlithgow Avenue and St Kilda Road. Tunnels alignment going under City Link tunnels.
Domain station to eastern portal	TBMs would excavate from Fawkner Park to the eastern portal where they would be retrieved and then relaunched from Fawkner Park to the southern end of Domain. The Fawkner Park construction work site would have area of 19,800 m^2, and include a TBM launch site and other construction related activities such as material laydown,	Emergency access shaft at Fawkner Park (Option 2) – Utilising the location of the potential Fawkner Park TBM launch site.

Location	Construction – Concept Design	Construction – Alternative Design Option
	equipment storage and maintenance, site office, amenities and spoil loading facilities.	

The tunnel spoil would likely be handled at the locations where the TBMs are launched and retrieved (western portal, Arden, CBD North, CBD South, Fawkner Park and Domain (refer to the EES Map Book for locations). These facilities would be configured to handle spoil and to allow trucks entry and egress. Smaller temporary stockpiling areas would be located at each construction work site.

Tunnelling activities would produce a waste stream of wet rock cuttings (spoil) and/or a slurry. This material would require separation into solids and wastewater prior to disposal. Disposal of wastewater to sewer is proposed and would result in no impacts on waterways (Technical Appendix O *Groundwater)*.

7.2 Existing Conditions

7.2.1 Land Uses

The current and historic land uses above the tunnels are highly variable. Some of the key potentially contaminating land uses are summarised in Table **7-2.**

Table 7-2 Summary of main land uses across the tunnel portions of the route

Location	Notable land use
Western portal to Arden station	Historically reclaimed low lying marshy ground with a wide variety of historical land uses. The tunnel alignment goes below the West Melbourne Terminal Station and a number of transportation and freight businesses, workshops and light industrial facilities.
Arden station to Parkville station	Mix of light industrial land uses (such as foundries, car repair), commercial land uses (including petrol stations) and residential.
Parkville station to CBD North station	Historically the location of a number of industrial and commercial concerns including a former brewery and a former petrol station on corner of Swanston and Pelham Streets. These sites are both potential sources of contamination that has polluted the groundwater with chlorinated solvents and petroleum hydrocarbons respectively.
CBD North station to CBD South station (including temporary shaft)	The alignment runs below Swanston Street. There is a mix of commercial and residential land uses adjacent to the alignment.
CBD South station to Domain station	Predominantly below old public parkland/recreational areas. Land near the Yarra River has been historically infilled. Land to the south (near Domain) has had a variety of historical industrial and commercial land uses.
Domain station to eastern portal (including Fawkner Park shaft)	Predominantly below old public parkland/recreational areas. Land to the north is predominantly residential with some historical industrial and commercial land uses. Beyond Punt Road, the Melbourne Metro would run below Toorak Road, before passing below more residential and commercial land.

A review of relevant historic and current land use data within 200 m and 500 m radius respectively of the project alignment) was conducted to gain further information on potential contamination. In total 55 audit sites (including 11 Groundwater Quality Restricted Use Zones and one Clean Up to the Extent Practicable determination) were identified and are summarised in Appendix D. All Groundwater Quality Restricted Use Zones except two are located off the alignment and are discussed in Technical Appendix O *Groundwater*. The relevant audit sites and associated Groundwater Quality Restricted Use Zones which are located along the tunnel alignment are:

- A former service station site located on alignment at the corner of Pelham and Swanston Streets in Carlton (EPA reference number CARMS 48717-2)
- Former brewery located on alignment at the corner of Victoria and Swanston Streets in Melbourne (EPA reference number CARMS 64057-7)

7.2.2 Contamination and Acid Sulfate Soil and Rock

7.2.2.1 General

While the majority of the material to be tunnelled would be natural soil and rock, potential contaminated land and spoil management issues could arise from:

- The presence of acid sulfate soils from shallower sediments and acid sulfate rock from deeper Melbourne Formation Silurian siltstones.
- Contaminated groundwater plumes may intermingle with the rock.
- Natural soils and rocks still need to be assessed for the nature and extent of contamination so disposal and/or re-use options can be considered.

7.2.2.2 Nature and Extent of Contamination and Acid Generating Materials

Soil and groundwater information is summarised in Appendix D (soil) of this report and Technical Appendix O *Groundwater* with a summary of groundwater contamination in Table C-**0-6** and Table C-**0-7**. The following provides a summary of the contamination profile at each tunnel sub-precinct against relevant contaminated land and groundwater quality objectives and the waste categorisation guidelines:

- Western portal to Arden station

  Six environmental bores were drilled between 2010 and 2015. No soils from around the tunnel depths were submitted for laboratory analysis, but other natural shallower soils indicated raised levels of nickel such that these would classify soils as Category C for disposal purposes. The raised nickel concentrations are thought to be natural and could be reclassified as clean fill subject to further investigation. One sample also returned a Category C classification for benzo(a)pyrene.

  Analysis reported potential acid sulfate soil and rock in shallow Coode Island Silt sediments, Werribee Formation sediments and deeper fresh Melbourne Formation rock (Appendix D of this report).

  Groundwater samples were collected from the Quaternary Fluvial Sediments in three wells constructed at depths of between 17 and 20 m below ground level (mbgl). Groundwater from this aquifer did not report any hydrocarbons above groundwater quality objevtives. A number of heavy metals (arsenic, boron, chromium, cobalt, iron, manganese, nickel, selenium) and ammonia were reported above groundwater quality objectives. Total dissolved solid concentrations ranged between 28,000 and 38,000mg/L. Two monitoring wells were installed in the Werribee Formation at depths of 23.8, 23 mbgl total depth and one monitoring well was installed to 28 mbgl in the Melbourne Formation. Groundwater quality in these aquifers appeared to be similar to the overlying Quaternary Fluvial Sediments with no hydrocarbons reported above the groundwater quality objectives, but with some metals above groundwater quality objectives. Total dissolved solid concentrations were 22,000, 44,000 and 25,000 mg/L respectively. Petroleum hydrocarbons were reported at concentration above drinking water guidelines in GA11-BH007 which was screened in the Werribee Formation.

- Arden station to Parkville station

  No bores are located directly within the project boundary.

  Testing reported potential acid sulfate soil in Werribee Formation sediments and acid sulfate rock in deep fresh Melbourne Formation rock (Appendix D of this report).

  Four bores were drilled between 2010 and 2015 all on slightly different alignment to the current and three were converted to monitoring wells. pH and sulphur testing was conducted on two rock samples. No other soil/rock testing was conducted. A limited number of groundwater samples were taken from the Melbourne Formation. Slightly raised levels of some metals were noted in the groundwater. No hydrocarbons were detected.

- Parkville station to CBD North station

  Two bores were drilled outside the project boundary. One sample from soil/rock was analysed for a limited range of contaminants and all were below their respective detection limits. A limited number of groundwater samples were taken from the Melbourne Formation. Slightly raised levels of some metals were noted in the groundwater. 1,1-dichloroethene was above the drinking water quality objective in a groundwater sample from MM-BH010 with cis-1,2 dichloroethene and pentachloroethene all above their respective Laboratory Limit of Reporting in a groundwater sample from GA11-BH014.

  Testing reported potential acid sulfate rock in deep fresh Melbourne Formation rock (Appendix D of this report).

- CBD North station to CBD South station

  Two bores were drilled. One sample from soil/rock was analysed for a limited range of contaminants and all were below detection limit. Only one groundwater sample was taken from the Melbourne Formation. Some metals and toluene were noted in the groundwater above respective Laboratory Limit of Reporting.

  Testing reported potential acid sulfate rock (Melbourne Formation rock), however, it is unlikely that tunnelling would progress to this depth (Appendix D of this report).

- CBD South station to Domain station

  Thirty-one bores were drilled and 45 samples of fill and 81 samples of natural soils were tested. Only one sample of soil/rock from the tunnel equivalent depth was analysed for a limited range of contaminants. No raised levels of contaminants were noted relevant to soil quality objectives.

  Testing reported potential acid sulfate soil and rock in shallow Yarra Delta sediments (including Coode Island Silt sediments), Brighton Group sediments and deeper fresh Melbourne Formation rock (Appendix D of this report).

  Samples of groundwater were collected from monitoring wells installed in the Moray Street Gravels, Fishermens Bend Silt, Coode Island Silt, the Holocene Alluvium and Melbourne Formation aquifers. Groundwater quality near the Yarra River had raised levels of ammonia, slightly raised levels of metals and petroleum hydrocarbons noted in one sample from the Moray Street Gravels. Fluoride was noted at high concentrations in the samples from the Melbourne Formation. Well GA11-BH041 (screened in the Moray Street Gravels) reported a petroleum hydrocarbon concentration above the drinking water quality objective.

  The potential presence of methane, petroleum hydrocarbons and chlorinated solvents was investigated using a membrane interface probe in Elizabeth Street Gardens. This indicated the presence of petroleum hydrocarbons and chlorinated solvents associated with shallow groundwater (above the tunnel alignment), with methane found naturally in the sediments.

- Domain station to eastern portal

  Four bores were drilled. No soil or rock samples were taken. Three groundwater samples were taken, all from the Melbourne Formation. Slightly raised levels of some metals were noted in the groundwater. Benzene, and methyl ethyl ketone were noted in the groundwater above respective Laboratory Limit of Reporting.

  Testing reported potential acid sulfate soil in Brighton Group sediments and acid sulfate rock in deep fresh Melbourne Formation rock (Appendix D of this report).

  Review of the limited data taken from natural soils showed the majority of samples classified as clean fill with some Category C waste. The Category C waste was identified in a number of samples by raised levels of fluoride, arsenic and nickel. These analytes detected as elevated concentrations may be determined to be naturally occurring (and thus this may be reclassified as clean fill).

  With respect to groundwater impacts, the limited data suggests groundwater quality is variable and further investigation would be required. Well GA11-BH022 reported benzene above the drinking water guideline and MEK above Laboratory Limit of Reporting but below guideline. Well GA11-BH023 reported 1,2,4-trimethylbenzene, total xylenes, petroleum hydrocarbons above Laboratory Limit of Reporting but below guideline concentrations. Both these wells were screened in the Melbourne Formation.

7.2.2.3 Waste Categorisation and Volumes

The approximate volumes of spoil material and potential acid generating material in each of the tunnel sectors are discussed in Section 7.5. These volumes are based on calculations completed by Golder Associates which are included in Appendix D of this report.

Technical Appendix O *Groundwater* provides further information on groundwater volumes, management and disposal options.

7.2.2.4 Management of Groundwater: Corrosion

As outlined in Section 5, groundwater quality may impact on various aspects of the project. Technical Appendix O *Groundwater* and Technical Appendix U *Aquatic Ecology and River Health* provide further information on water quality and groundwater extraction. Groundwater results were reviewed against various corrosion criteria and concluded that high concentrations of chloride ions, sulfate and sulfate-reducing bacteria may indicate corrosive groundwater conditions at: Tunnel (Western Portal – Arden station), Tunnel (CBD South station – Domain station) and Tunnel (Domain station – eastern portal). Table C-**0-8** in Appendix C provides a summary of the results with respect to corrosion.

7.3 Key Issues

The key issues associated with the project relating to contamination that could arise are identified in Table 7-3.

Table 7-3 Key issues associated with the Tunnels

Concept Design	Issue	Risk no.
Construction of tunnels	Bulk earthworks and spoil generated during tunnelling construction works	CL001, CL002, CL005, CL006
	Groundwater inflow and vapour impacts during construction and operation	CL008
	Ground gases (methane) encountered during tunnelling and accumulation in tunnel structures	CL010

Concept Design	Issue	Risk no.
	Durability following construction	CL013
	Construction safety and environmental pollution.	CL015

7.4 Benefits and Opportunities

The opportunities relating to contaminated land and spoil management associated with the tunnels relate to the re-use of non-acid sulfate rock material. Table **7-4** provides the benefits and opportunities at the portals.

Table 7-4 Benefits and opportunities associated with the Concept Design and alternative design option

Concept Design	Benefits	Opportunities
Construction of the Tunnels	Tunnelling would generate a large amount of spoil that would require off-site disposal or re-use. Almost all the spoil would be natural rock, although a portion would be potential acid sulfate rock. The acid sulfate rock material would require further management at the site of disposal.	All the non-acid sulfate rock material can be disposed of as clean fill and can be re-used in accordance with current regulatory standards. This could include using at sites that require infilling.

7.5 Impact Assessment

7.5.1 Potential Impacts

The following draft EES evaluation objective and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 7-5 Draft EES Evaluation Objectives and Assessment Criteria

Draft EES evaluation objective	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Minimise risks associated with disturbance, transport and disposal of solid wastes from excavation works, including potentially contaminated materials and acid sulfate soils.

Completion of the risk assessment (Section 6 of this report) identified the key issues as noted in Section 7.3. These potential impacts are considered in more detail in the following sections.

7.5.2 Spoil Management Impacts

7.5.2.1 General

Around 613,000 m^3 of spoil would be generated throughout the tunnelling phases of the works. This spoil can be broadly categorised as:

- Clean fill – suitable for re-use **(Risk #CL001)**
- Acid sulfate soil – requiring management and off-site disposal **(Risk #CL002)**

- Acid sulfate rock – requiring management and off-site disposal **(Risks #CL004** and **#CL005)**.

The key impact relates to consequential impacts resulting from either underestimating the volumes of spoil and/or incorrectly classifying the spoil. Additional impacts relating to tunnel spoil handling and transport are considered elsewhere (in Technical Appendix D *Transport* and Technical Appendix H *Air Quality*).

7.5.2.2 Clean Fill

Of the total spoil volume, an estimated 392,000 m^3 would be natural soils and rock with this material having limited contamination or acid generating potential. Any contaminants present in this material are likely to be naturally elevated with this material classified as clean fill in accordance with EPA soil hazard categorisation and management. There is no obvious re-use option for this material on-site, thus requiring removal off-site where re-use options may be considered further. There are many re-use options for clean fill (Section 1.4.5.2). The potential impacts are related then to erroneous categorisation of the spoil such that material is then not suitable for the re-use location used (this could be due to materials or chemical properties for example).

An initial medium risk has been allocated to **Risk #CL001** with this reflecting some current uncertainties in waste classification, but mainly reflects the large volumes of materials that would be generated.

7.5.2.3 Acid Sulfate Soil

Approximately 12,000 m^3 Coode Island Silt would require excavation along the tunnel alignment with the majority between CBD South station and Domain station – below the Yarra River **(Risk #CL002)**. A small amount of acid sulfate soil would be generated between the western portal and Arden station (not assigned a risk number.). This material has potential to generate acid and required management as acid sulfate soil in accordance with EPA guidelines on Acid Sulfate Soil and Rock and the Industrial Waste Management Policy (Waste Acid Sulfate Soils). There are many re-use options for acid sulfate soil (Section 1.4.5.4), but any off-site disposal facility would need to comply with the EPA guidelines on Acid Sulfate Soil and Rock. The potential impacts are related then to erroneous categorisation of the spoil or an underestimate of the volumes such that acid sulfate material is not managed appropriately with consequential environmental impacts.

An initial high risk has been allocated to **Risk #CL002** with this reflecting current uncertainty in both waste classification and the estimate of the volume of material and potential consequences of inappropriate handling and disposal of this material. Further mitigation measures (described below) to meet the recommended Environmental Performance Requirements (Section 7.6.2) would be required to reduce this impact to low.

7.5.2.4 Acid Sulfate Rock

Fresh to slightly weathered Melbourne Formation siltstones and sandstones would be likely to be encountered along the entire tunnelling alignment with the exception of Arden station to Parkville station. A total volume of around 209,000 m^3 of potential acid sulfate rock would be excavated from the tunnels with the bulk (about 197,000 m^3) from Arden station through to Domain **(Risk #CL005)** and a smaller proportion (12,000 m^3) from the western portal through to Arden **(Risk #CL006)**. This material is likely to be classified as potential acid sulfate rock. There are many re-use options for acid sulfate rock (Section 1.4.5.4), but any off-site disposal facility would need to comply with the EPA requirements outlined in EPA guidelines on Acid Sulfate Soil and Rock. The potential impacts are related then to erroneous categorisation of the spoil or an underestimate of the volumes such that acid sulfate material is not managed appropriately with consequential environmental impacts.

An initial high risk has been allocated to **Risk #CL005** (as for **Risk #CL002**) and medium risk for **Risk #CL006** (as for **Risk #CL002**, but with smaller likely volumes). Proposed mitigation measures and recommended Environmental Performance Requirements have been identified below to reduce these impacts to low and these are described in Section 7.6.2.

7.5.2.5 Spoil Management Mitigation

Reusing spoil on-site is unrealistic. Potential impacts with respect to the off-site re-use, management or disposal of tunnel spoil would arise from either underestimating the volumes of spoil and/or incorrectly classifying the spoil. This would be managed by the contractor by compliance with the SEPPs and a number of EPA guidelines on waste categorisation and the management of waste acid sulfate soils and rocks. Recommended Environmental Performance Requirements have been recommended (Section 7.6.2) requiring the contractor to complete further site investigation, waste categorisation, identification of suitable re-use or disposal facilities and identification of a suitable spoil handling methodology. Further information on uncertainties and further site characterisation can be found in Sections 5.6.4 and 5.6.6 respectively

With actual and potential acid sulfate soil and rock, prevention of acid sulfate soil oxidation is the preferred management option. Any off-site facility accepting the acid sulfate soil would need to have an EPA-approved EMP in place (for further details see Section 1.4.5.4 and the Spoil Management Strategy in Appendix E of this report). There is currently significant capacity within metropolitan Melbourne for receiving acid sulfate soils and rock in accordance with the regulations.

As noted in Section 1.4.5.5, the tunnel spoil would likely be handled at the locations where the TBMs or road headers are launched and retrieved (western portal, Arden, CBD North, CBD South, Fawkner Park and Domain; refer to the EES Map Book for locations). Smaller temporary stockpiling areas would be located at each work site. Given that there would be limited room to stockpile material during construction, with the temporary stockpile areas envisaged to only be used for unexpected materials, further testing by the contractor may be required to determine the final characterisation of the fill in accordance with EPA regulations and guidelines.

Mitigation measures would therefore comprise the following general aspects:

- The collection of additional data (samples) in accordance with EPA IWRG702 and IWRG621 in order to allow for the appropriate in situ categorisation of spoil prior to excavation. The collection and analysis of samples would reduce the level of uncertainty around spoil quality and quantity at the point of generation and allow for forward planning of management and disposal options
- Engagement with EPA licensed waste disposal and soil treatment facility operators located within a feasible distance from the CBD to identify potential Prescribed Industrial Waste disposal and/or treatment sites
- Provide requirements for work site monitoring, material (spoil) tracking, work site environmental management, identify roles and responsibilities and provide contingency measures to account for:
  - larger than anticipated volumes or levels of contamination
  - transport to the wrong disposal/treatment facility
  - delay in removal of spoil from site (for example, truck breakdown)
  - emergency measures in the case of a spill or release (or any other unexpected event).

Adopting appropriate mitigation measures such as those described above and meeting the recommended Environmental Performance Requirements outlined in Section 7.6.2 would enable the contractor to reduce residual impacts relating to bulk earthworks **(Risks #CL001, #CL002, #CL005** and **#CL006)** to low.

There remain potential impacts associated with the handling and transportation of the material to the final destination; this may affect the local community and users of nearby facilities and the general amenity of the transport routes. These impacts are discussed further in Technical Appendix D *Transport* and Technical Appendix H *Air Quality*.

7.5.3 Contaminated Land Management Impacts

7.5.3.1 General

This section considers impacts from:

- Groundwater inflow and vapour impacts
- Ground gases encountered during tunnelling and accumulation in tunnel structures
- Durability

Mitigation measures are described for each of the above and then an overarching mitigation approach is outlined.

7.5.3.2 Groundwater Inflow and Vapour Impacts (Construction and Operation)

The tunnels would be constructed through water-saturated soils and rocks. During construction, with the exception of the mined tunnel between CBD North and CBD South, inflows would be very small and drawdown inflows around the tunnels would be minor. Once operational, the tunnels would have a very small amount of leakage (See Technical Appendix O *Groundwater*).

Should potentially contaminated groundwater ingress into the tunnels, short-term release of vapours and consequential odour generation and associated health and safety issues could be encountered.

There are numerous potential sources of volatile organic compound contaminated groundwater near the project boundary (Section 7.2.1). These sources would be from historic releases of contaminants into groundwater and could be sourced on and adjacent to the project boundary. Petroleum hydrocarbons (such as from petrol filling stations) or solvents (such as from a former brewery site near CBD North) are the most likely source.

<u>Source</u>

Site investigations have confirmed low levels of volatile organic compounds in groundwater in the Parkville to CBD North segment (chlorinated hydrocarbons including trichloroethylene [TCE] and perchloroethylene [PCE] and near Fawkner Park (benzene and methyl ethyl ketone [MEK]). Further site investigation is required to confirm the nature and extent of contamination.

<u>Pathway</u>

The method of tunnelling (mainly earth pressured) and provision of air ventilation would mitigate any risks during construction. Low permeability mass concrete tunnel linings would limit groundwater ingress. Tunnel joints would be sealed with proprietary elastomer seals, but some leakage is anticipated with this via any defects or joints. Any groundwater permeation or ingress would pool and then drain at the base of the tunnels. The large surface area within the tunnels, together with dilution resulting from ventilation and air movement from train movements, would likely result in significant dilution and attenuation of any vapours. Resultant vapour concentrations are likely to be low.

<u>Receptors</u>

Site construction and maintenance workers and members of the public could potentially be exposed. Maintenance workers are the most likely sensitive receptor as they would potentially be present in tunnels to carry out works out with normal operational periods when the tunnel air would be relatively stagnant (and hence the normal ventilation and dilution seen with operational tunnels would be less). Risks to other receptors are considered low or very low.

<u>Impact linkage</u>

A potential impact linkage between source, pathway and receptor has been identified for Parkville to CBD North segment and near Fawkner Park (Domain station to eastern portal). These two segments of the tunnel have been assigned an initial medium risk **(Risk #CL008)** and further proposed mitigation measures and recommended Environmental Performance Requirements have been identified (Section 7.6.3).

Mitigation measures

Guidance on assessing risks and devising mitigation measures from groundwater ingress and vapour accumulation in structures can be found in CRC CARE (2013).

Restricting groundwater inflow coupled with ventilation would provide the mitigation. Structural concrete would provide all or most of the protection measures recommended, but some groundwater would leak into the tunnels. Natural or forced ventilation and compliance with Australian Standards would provide mitigation to risks from vapour accumulation from any vapours originating from contaminated groundwater. Further investigations would be required by the contractor in order to assess this and whether additional ventilation and / or tanking would be needed.

Summary

Adopting appropriate mitigation measures such as those described above and meeting the recommended Environmental Performance Requirements (Section 7.6.3) would enable the contractor to reduce residual impacts relating to groundwater inflow **(Risks #CL008)** to low.

7.5.3.3 Ground Gases Encountered During Tunnelling and Accumulation in Tunnel Structures

As discussed in Section 5, these naturally occurring sources of hazardous ground gases are generated due to natural biological activity within the sediments and would be trapped in soil pores due to limited diffusion transport. Alluvial or sediment-rich areas can be characterised as being low emission sources, where the concentrations may be high but the release is in general very low. Disturbance of ground gases during construction may result in a short-term release of gas and consequential odour generation and associated health and safety issues.

In the longer term and relating to operational impacts, using terminology adopted by British Standard 8485:2015, hazardous gases from natural alluvial soils and silts would be low hazard potential or very low hazard potential.

Source

Tunnelling through the Coode Island Silt (and potentially other swamp deposit) sediments between the western portal and Arden station and in the vicinity of the Yarra River (CBD South station to Domain) has the potential to disturb ground gases such as methane and hydrogen sulfide. Tunnelling could also deflect or modify existing gas migration routes (for example, piling through pockets of marsh gas in the Coode Island Silt) and consequently wider consideration/impacts may need to be considered. Site investigations carried out to date have confirmed limited methane in the shallow Coode Island Silt at the western portal and Arden station, with some methane likely to be present in the vicinity of the Yarra River (CBD South station to Domain).

Pathway

The pathway of exposure would be from mass release of entrained gases from the sediments into the air space around the TBM.

Receptor

Receptors would be the construction workers involved in tunnelling.

Impact linkage

A potential impact linkage between source, pathway and receptor has been identified. Impacts relate to potential flammability and or asphyxiating properties of methane and an initial medium risk has been allocated to **Risk #CL010**. Proposed mitigation measures and recommended Environmental Performance Requirements have been identified (Section 7.6.3).

Mitigation measures

Guidance on assessing risks and devising mitigation measures from gas accumulation in structures can be found in NSW EPA Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases (2012), which refers to a number of UK guidance documents (such as British Standard 8485:2015). Structural concrete would provide all or most of the protection measures recommended in BS 8485:2015, although further measures could include incorporation of pressure relief blankets or strips around any structural concrete. These blankets could be made of higher permeability materials or could be a geocomposite and would terminate in a venting system external to the structure. Further investigations would be required by the contractor in order to develop appropriate remedial plans.

Summary

Adopting appropriate mitigation measures such as those set out above and meeting the associated recommended Environmental Performance Requirements (Section 7.6.3) would enable the contractor to reduce residual impacts relating to ground gases **(Risks #CL010)** to low.

7.5.3.4 Durability

Durable materials generally have less environmental impact than materials that may need to be replaced or repaired. In the context of contaminated land, durability of materials used for construction relates mainly to resistance of sulfate and chloride attack and acidic conditions. Other chemicals (such as solvents and oils) could also cause material durability issues particularly with plastics and rubbers, although concentrations would have to be very high and these conditions are not expected for any of the tunnel segments with the possible exception of the tunnel sections near CBD North (where a plume of trichloroethylene is known to be present). Other factors can influence contamination related durability such as groundwater flow and whether the materials are permanently wet or go through wet and dry cycling.

Source

Site investigations (see Section 7.2.2) have identified the presence of potentially corrosive groundwater (chloride and sulfates) in the western portal to Arden and CBD South to Domain (south of the Yarra River) linked to natural acid sulphate soils found predominantly in quaternary fluvial sediments and Moray Street Gravels respectively. Whilst disturbance of the sediments may introduce oxygen and thus may begin to acidify the soils/rock in direct contact with concrete lining of the tunnel, the extent of disturbance is not considered significant.

In addition to the potential acid sulphate soils located at western portal to Arden and CBD South to Domain tunnel segments, raised levels of chlorinated solvents (and petroleum hydrocarbons) are known to be present between Parkville and CBD North stations just north of the CBD North station.

Further site investigation is required to confirm the nature and extent of contamination.

Pathway

The main pathway is direct contact with aggressive ground or groundwater conditions formed as a result of disturbance and introduction of oxygen.

Receptor

The key receptors are concrete tunnel lining and other constituent materials. Degradation of these materials could lead to loss of structural integrity or serviceability and possibly threaten health and safety.

Impact linkage

A potential impact linkage between source, pathway and receptor has been identified for the above tunnel segments. These two segments of the tunnel have been assigned an initial medium risk **(Risk #CL013)** and further proposed mitigation measures and recommended Environmental Performance Requirements have been identified (Section 7.6.3).

Mitigation measures

Guidance available on contaminated land related durability of building materials is limited. *Australian Standard 2159-2009 Piling – Design and installation* covers the basic aspects of building materials corrosion assessment. Further investigations would be required to assess the risks and identify protective or mitigation measures. Routine mitigation measures could include adding corrosion inhibitors, cathodic protection, cement replacements, reinforcement surface sealants singly or in combination, whilst considering servicing and maintenance.

Summary

Adopting appropriate mitigation measures such as those set out in Section 7.6.3 and meeting the associated recommended Environmental Performance Requirements would enable the contractor to reduce residual impacts relating to durability **(Risks #CL013)** to low.

7.5.3.5 Mitigation Measures

Specific mitigation measures are described in the sections above, covering the particular contaminated land aspects or risk. The following general mitigation framework is as follows:

- The collection of additional data (samples) in accordance with NEPM, AS4482.1 and AS4482.2 and EPA Publications 668 and 840.1 (the cleanup and management of polluted groundwater) in order to appropriately characterise the nature and extent of contamination to allow for the appropriate design and mitigation measures to be put in place prior to excavation.
- The collection and analysis of samples would reduce the level of uncertainty around contaminant nature and extent and be used to conduct a human health or environmental risk assessment if required
- Based on additional sampling and risk assessment results, remediation may be required. This may be in the form of treatment of materials to reduce the level of contamination (such as in situ chemical or physical treatment of contaminants) or engineering or design controls to reduce the exposure pathway (such as vapour barriers)

7.5.4 Construction Safety and Environmental Pollution (Construction)

Construction activities and tunnelling through contaminated ground may lead to impact on worker safety and potential impact on segments of the environment including releases of air pollutants (dust, odour and vapours). All of the tunnelling would be completed through natural soils and rocks, however hazardous contaminants may be encountered from:

- The mechanical process of tunnelling
- Be produced in situ (e.g. exhaust ground gases from internal combustion engines, welding or shotcreting) or from blasting activity
- Be introduced into the tunnels from the external environment (such as when tunnelling through portions of the project boundary impacts with contaminated groundwater – such as the sections between CBD North and Arden).

Mitigation

With respect to health and safety, consideration of risks from chemical exposure and risk mitigation may include the following:

- Identification of chemicals or other hazardous substances in the work space (directly or indirectly)
- Assess risks
- Determine how to prevent or control exposure
- Ensure controls measures are used
- Monitor exposure
- Undertake appropriate health surveillance
- Prepare plans and procedures to deal with emergencies and accidents
- Ensure employees are properly informed, trained and supervised

Summary

Potential health and safety and environmental impacts are possible for all tunnel segments and these have been assigned an initial high risk **(Risk #CL015)**. Mitigation measures have been described and Further Environmental Performance Requirements have been recommended in Section 7.6.4 and in conclusion, adopting the mitigation measures recommended and appropriate environmental protection requirements would enable the contractor to reduce residual impact relating to contaminated ground and groundwater health safety and environmental pollution issues to low.

7.6 Environmental Performance Requirements

7.6.1 General

Environmental Performance Requirements have been recommended for all the medium and above impacts described in Section 7.5. Three categories of Environmental Performance Requirements have been recommended:

- Spoil management
- Contaminated land management
- Health and safety and environmental management.

These three aspects are described below.

7.6.2 Spoil Management

Recommend Environmental Performance Requirements for spoil management from tunnels **(Risks #CL001, #CL002, #CL005** and **#CL006)** can be found below, with additional recommended Environmental Performance Requirements included in Table **7-6.**

General **(all risks)**

- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 2009. Environmental Protection (Industrial Waste Resource) Regulations 2009. SR No. 77/2009
- EPA Victoria 2009. Solid industrial waste hazard categorisation and management. Publication IWRG631
- EPA Victoria 2009. Sampling and analysis of waters, wastewaters, soils and wastes. Publication IWRG701

- EPA Victoria 2009. Soil sampling. Publication IWRG702
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480.

Acid sulfate soil and rock **(Risks #CL002, #CL005** and **#CL006)**

- EPA Victoria 2009. Acid sulfate soil and rock. Publication 655.1
- State of Victoria 1999. State Environmental Protection Policy, Industrial Waste Management Policy (Waste Acid Sulfate Soils) No S125, Gazette 18/09/1999

Table 7-6: Additional Environmental Performance Requirements – Spoil Management - Tunnels

EPR No.	Environmental Performance Requirements	Risk No.
C1	Prior to construction of main works or shafts, prepare and implement a Spoil Management Plan (SMP) in accordance with MMRA's Spoil Management Strategy and relevant regulations, standards and best practice guidance. The SMP shall be developed in consultation with and to the satisfaction of the EPA. The SMP would include but is not limited to the following: • Applicable regulatory requirements • Identifying nature and extent of spoil (clean fill and contaminated spoil) across all precincts • Roles and responsibilities • Identification of management measures for handling and transport of spoil for the protection of health and the environment • Identification, design and development of specific environmental management plans for temporary stockpile areas • Identifying suitable sites for re-use, management or disposal of any spoil • Monitoring and reporting requirements. • Identifying locations and extent of any Prescribed Industrial Waste and characterising Prescribed Industrial Waste spoil prior to excavation • Identifying suitable sites for disposal of any Prescribed Industrial Waste. The SMP shall include sub-plans as appropriate, including but not limited to an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan (Refer to C2)	CL001
C2	Prepare and implement an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan prior to construction of the project as a Sub-Plan of an overarching SMP in accordance with the Regulations, Standards and best practice guidance and to the satisfaction of EPA. This sub-plan would include the general requirements of the SMP and also: • Identifying locations and extent of any potential ASS/ASR • Characterising ASS/ASR spoil prior to excavation • Identification and implementation of measures to prevent oxidation of ASS/ASR wherever possible • Identifying suitable sites for re-use, management or disposal of any ASS/ASR.	CL002, CL005 CL006

7.6.3 Contaminated Land Management

Recommended Environmental Performance Requirements for contaminated land management during tunnel construction **(Risks #CL008, #CL010** and **#CL013)** can be found below, with additional recommended Environmental Performance Requirements shown in Table 7-7.

General **(All)**

- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 1997. State Environmental Protection Policy (Groundwaters of Victoria), Victoria Government Gazette No S160.
- EPA Victoria 2014. The cleanup and management of polluted groundwater. EPA Publication 840.
- National Environment Protection Council (NEPC), 2013. National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended. Schedule A: Recommended General Process for Assessment of Site Contamination, Canberra, A.C.T.: National Environment Protection Council Service Corporation.

For vapour ingress **(#CL008)**:

- State of Victoria 2001. State Environment Protection Policy (Air Quality Management) No. S240
- NSW EPA 2012. Guidelines for the Assessment and management of Sites Impacted by Hazardous Gases
- CRC CARE 2013. Petroleum hydrocarbon vapour intrusion assessment: Australian guidance, CRC CARE Technical Report no. 23, CRC for Contamination Assessment and Remediation of the Environment, Adelaide, Australia
- British Standards Institute 2015. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS8485:2015, BSI Standards Ltd, UK.

For ground gases **(#CL010)**:

- British Standards Institute 2013. Guidance on investigations for Ground gas – permanent gases and Volatile Organic Compounds (VOCs). BS8576:2013. BSI Standards Ltd, UK.
- British Standards Institute 2015. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS8485:2015, BSI Standards Ltd, UK.

For durability **(#CL013)**:

- *Australian Standard 2159-2009 Piling – Design and installation*
- Environment Agency (2005). Assessment and Management of Risks to Buildings, Building Materials and Services from Land Contamination. R&D Technical Report P5-035/TR/01
- Environment Agency (2000). Risks of Contaminated Land to Buildings, Building Materials and services. R&D Technical Report P331. Available from The R&D Dissemination Centre, WRc Plc, Swindon, Wiltshire.

Table 7-7: Additional Environmental Performance Requirements – Contaminated Land Management - Tunnels

EPR No.	Environmental Performance Requirements	Risk no.
C3	Prior to construction of main works or shafts, undertake a remedial options assessment (ROA) for contaminated land. The assessment must: • Consider the outcomes of further investigations • Interpret of groundwater permeation and VOC result	CL008 CL010 CL013

EPR No.	Environmental Performance Requirements	Risk no.
	• Present and take account of the outcomes of risk assessments If required, • Identify remedial options in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA. If required, as an outcome of the ROA, prepare a remedial action plan and integrate the remediation approach into the design in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA.	

7.6.4 Construction Safety Hazards and Environmental Pollution (Construction)

Recommended Environmental Performance Requirements for contaminated land management during tunnel construction **(Risks #CL015)** can be found below, with additional recommended Environmental Performance Requirements shown in Table **7-8.**

- WorkSafe 2005. Contaminated Construction Site – Industry Standard
- WorkSafe (2013). Guide For Tunnelling Work.
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480.

Table 7-8: Additional Environmental Performance Requirements – Health, Safety and Environmental Management- Tunnels

EPR No.	Environmental Performance Requirements	Risk No.
C4	Prior to construction of main works or shafts commencing, prepare and implement a health, safety and environmental plan for the management of hazardous substances. The plan must include but not be limited to: • Consideration of the risks associated with exposure to hazardous substances for employees, visitors and general public • The identification of methods to control such exposure in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and the EPA. • Method statements detailing monitoring and reporting	CL015

8 Western and Eastern Portals

This section describes the project components, existing conditions, key issues, benefits and opportunities, and findings of the impact assessment for the portals component of the Concept Design and alternative design options.

8.1 Project Components

8.1.1 Infrastructure

A summary of infrastructure can be found in Table **8-1.**

Table 8-1 Summary of infrastructure details

Location	Infrastructure – Concept Design	Infrastructure – Alternative Design Option
Western Portal	50 Lloyd Street Business Estate TBM retrieval box and a shorter decline structure. The Melbourne Metro tracks would connect to the existing rail network between the Maribyrnong River and adjacent to the South Kensington station. The portal works for the Concept Design would include: • Turnout of the rail lines east of the Maribyrnong River to connect the existing surface level Sunbury line tracks to the new Melbourne Metro tracks • Lowering of the existing Sunbury line tracks for a distance of approximately 250 m. This is required to accommodate the connection between the Sunbury line tracks and future Melbourne Metro tracks, as the crossovers between the new Melbourne Metro tracks and the existing Sunbury line tracks would need to be set at a lower level • Removal of the crossovers between the Sunbury line track and the Werribee line track • Twin track decline structure and retaining wall along Childers Street to carry the Melbourne Metro tracks from embankment level to below ground, 3.0 % gradient in the decline structure • Twin track cut-and-cover tunnel from the decline structure to the tunnels entrance (i.e. tunnels precinct) • The interface with the TBM-driven tunnels occurs adjacent to the railway reserve on the east side of Tennyson Street in the 50 Lloyd Street Business Estate • The Concept Design includes an emergency relief facility/TBM retrieval box located adjacent to the railway reserve on the eastern side of Tennyson Street in the 50 Lloyd Street Business Estate.	Kensington Road bridge and TBM retrieval box opposite the pavilion on Childers Street with a longer decline
Eastern Portal	The eastern portal precinct would connect the twin tunnels to the existing Dandenong rail corridor just west of Chapel Street. The portal includes the approach to the tunnel and the tunnel works that connect to the tunnel precinct. The Concept Design includes a cut-and-cover structure (under the Sandringham line, Frankston line and freight and	

Location	Infrastructure – Concept Design	Infrastructure – Alternative Design Option
	regional line) and a decline structure (open to air) which brings the Melbourne Metro tracks to the same vertical level as the existing rail corridor and construction (reinstatement) of the William Street bridge. William Street bridge, South Yarra Siding Reserve, Osborne Street Reserve and Lovers Walk would be impacted during construction and re-instated following construction.	

As discussed in Section 1.4.5.5, the spoil would be handled at construction sites at Arden, Domain and Fawkner Park and western portal (refer to the EES Map Book for locations). These facilities would be configured to handle spoil and to allow trucks entry and egress. Smaller temporary stockpiling areas would be located at each construction work site.

8.1.2 Construction

A summary of infrastructure can be found in Table **8-2**.

Table 8-2 Summary of construction details

Location	Construction – Concept Design
Western Portal	• Main construction activities at the site would be: • Establishment of construction work sites • Construction of a piled structure to the east end of the skate park in the J.J. Holland Park • Construction of decline structure to the centre of South Kensington station • Cut-and-cover tunnel construction to the east end of Childers Street, including an area of excavation of approx. 5,300 m2 • Construction of services and relief shaft in the west corner of the 50 Lloyd Street Business Estate • Tunnel excavation and TBM retrieval (with the TBM driving first to the western portal from Arden station before being retrieved and relaunched from Arden station for the second drive to CBD North station) • Track works and installation of rail systems • A major construction work site located at 1-39 Hobsons Road to support activities at the western portal. This site would be used for site offices and facilities, laydown areas and materials and equipment storage.
Eastern Portal	Main construction activities at the site would be: • Establishment of construction work sites • Demolition of William Street bridge • Cut-and-cover excavation of the tunnel box, including an excavation area of approximately 720 m2 • Widening of the existing rail corridor and construction of retaining walls • Construction of ventilation shaft, emergency access shaft and substation in Osborne Street Reserve • Retrieval of the TBM from Osborne Street and the adjoining rail reserve • Track works and installation of rail systems • Reinstatement of William Street bridge

Location	Construction – Concept Design
	• Reinstatement of South Yarra Siding Reserve and Lovers Walk. The South Yarra Siding Reserve and Osborne Street Reserve, generally bordered by William Street to the east and Osborne Street to the west, would be occupied as major sites for the eastern portal construction. This area would house site offices, amenities, and materials laydown and equipment storage. An area in Osborne Street to the south of the portal site would also be required for materials laydown and manoeuvring of equipment.

Dewatering activities may be required at the portals during construction. Further discussion on management and disposal of groundwater can be found in Technical Appendix O *Groundwater*.

8.2 Existing Conditions

8.2.1 Land Uses

The current and historic land uses in the vicinity of the portals are mixed. Some of the key potentially contaminating land uses are summarised in Table 8-3.

Table 8-3 Summary of main land uses in the vicinity of the portals

Location	Notable land use
Western Portal	The Western Portal precinct currently runs alongside existing railway land to the south with mixed land use (such as light to heavy industrial, residential and open parkland) to the immediate north. Historically the land was reclaimed from low-lying marshlands the late 1800s. A number of potentially contaminative land uses have been identified at and near the site including: • Historic heavy industrial uses such as abattoirs, soap and candle works, manure and bone works, Kensington Glue Works, Gillespies Flour Mills and Kimptons Flour Mills, Allied Mills • Rail and port facilities and rail and dock freight facilities.
Eastern Portal	The Eastern Portal precinct is generally bound to the west by Osborne Street, to the north by Toorak Road, to the south by Arthur Street and to the east by Chapel Street, with the majority of surface excavation works along the existing Sandringham and Frankston and Pakenham/Cranbourne lines and South Yarra Siding Reserve. The area is currently characterised by a mixture of commercial and residential properties with the South Yarra Siding Reserve used as public open space. A number of potentially contaminative historic land uses have been identified at and near the site including: • Historic heavy industrial uses such as garbage incinerator including petrol bowsers and underground service tanks, auto repair workshops, drycleaner • Rail lines and facilities.

A review of relevant historic and current land use data within 200 m and 500 m radius respectively of the portals was conducted to gain further information on potential contamination. One audit site was identified in the vicinity of the western portal and 37 audit sites were identified in the vicinity of the eastern portal (see Appendix D of this report). All reviewed Groundwater Quality Restricted Use Zones are located outside the alignment and are discussed in more detail in the groundwater impact assessment.

8.2.2 Contamination and Acid Sulfate Soil and Rock

8.2.2.1 General

Construction of the western portal would entail piling and excavation to facilitate the lowering of the Sunbury line, twin track decline and retaining wall along Childers Street and twin track cut-and-cover tunnel from the decline structure to bored tunnel entrance. Therefore, the majority of material that would be excavated would be shallow fill and geological units such as Coode Island Silt and Older Volcanics basalt.

The eastern portal would connect the two tunnels to the existing Dandenong rail corridor just west of Chapel Street. The portal includes a cut-and-cover structure under the Sandringham, Frankston, freight and regional lines. A decline structure to bring the Melbourne Metro tracks to the same level as the existing rail corridor (which would potentially include piling for a retaining structure), turnout tracks, widening and realignment of the existing Cranbourne/Pakenham and Frankston lines, a TBM retrieval box, ventilation/emergency access shafts and underground substation. There is also potential for grout injection to improve ground conditions along the approach to the TBM retrieval box (between Davis Avenue and Osborne Street). Technical Appendix U *Aquatic Ecology and River Health* discussed the potential environmental impacts associated with grouting in more detail. Therefore, the majority of material that would be excavated would be shallow fill and from the Brighton Group sands and Melbourne Formation rock.

Construction of the western and eastern portals would entail piling, grouting and excavation of surface fill materials as well as natural soils and rock at depth. As a result, potential contaminated land, groundwater and spoil management issues could arise from:

- Contaminated fill material and contaminated shallow natural material
- Contaminated groundwater plumes intermingling with the rock
- The presence of acid sulfate soils particularly associated with the Coode Island Silt at the western portal and the Melbourne Formation at the eastern portal.

8.2.2.2 Contamination and Acid Sulfate Soil and Rock

Soil and groundwater information is summarised in Appendix D (soil) of this report and Technical Appendix O *Groundwater* with a summary of groundwater contamination in Table C-**0-9** in Appendix C of this report. The following provides a summary of the contamination profile at each portal against relevant contaminated land and groundwater assessment quality objectives and the waste categorisation guidelines:

<u>Western Portal</u>

Ten environmental bores were drilled within the precinct boundaries between 2010 and 2015. Fifteen samples of fill and 24 samples of underlying natural soils or rock were analysed. Soil analytical results were screened against current contaminated land quality objectives and the EPA's waste categorisation guidelines.

The fill materials to be excavated during construction are variable in both composition and contaminant profile containing a variety of waste materials, which is typical of fill found across Melbourne. All results were less than the human health soil quality objectives with the exception of two samples from each of GA11-BHE001 and GA11-BHE003, which reported elevated polycyclic aromatic hydrocarbons or PAHs (TEQs). These four samples were all collected from fill material at depths of between 1.5 and 2.4 mbgl (GA11-BHE001) and 0.6 and 1.1 mbgl (GA11-BHE003). Six samples (three from GA11-BHE001 and two from GA11-BHE003) exceeded the Urban residential and Public Open Space/Commercial-Industrial ecological use quality objectives for benzo(a)pyrene. All exceedances of soil quality objectives were reported in fill samples at depths of less than 2.5m bgl.

The analytical results were screened against the Industrial Waste Resource Guidelines. A point-by-point comparison of samples taken from the natural soil samples would be clean fill. Seven samples would be Category C (based on heavy metal concentrations of one or more of arsenic, chromium, copper, lead, mercury, nickel, tin and zinc) in GA11-BHE001, GA11-BHE003 and GA11-BHE005. Two samples would be Category B due to elevated concentrations of benzo(a)pyrene (in GA11-BHE001 and GA11-BHE003) and one sample would be Category A also due to benzo(a)pyrene (in GA11-BHE003). It is likely that the bulk of the spoil generated from excavations in the natural soils and rock would be classed as 'Clean Fill'.

Given that the approximate fill volume is 18,000 m^3 and 15 samples have been taken, this gives an approximate fill sampling ratio of 1 sample per 1,100 m^3 and an overall relative low classification confidence (See Section 5.6.3).

Testing reported potential acid sulfate soil and rock in shallow Coode Island Silt sediments, Werribee Formation sediments and deeper fresh Melbourne Formation rock (Appendix D of this report).

Five groundwater monitoring wells have been installed within the western portal precinct, four in the Older Volcanics (maximum depth of 21 mbgl) and one in the Moray Street Gravels (maximum depth of 23 mbgl). In 2013, the depth to groundwater in these wells is generally shallow (between 2.8 and 8.8 mbgl); however it is noted that this is based on old data and conditions may have changed since 2013.

Shallow groundwater is likely to be intercepted during most of the excavation work within this precinct. Technical Appendix O *Groundwater* summarises groundwater quality data above various relevant guidelines.

Total dissolved solid concentrations were lowest in the shallow Older Volcanics, ranging from 2,100 to 7,900 mg/L while a total dissolved solid concentration of 29,800 mg/L was reported in the Moray Street Gravels. Ammonia, iron, manganese were elevated above groundwater quality objective in all bores with boron, molybdenum, nickel also high in the Older Volcanics. Petroleum hydrocarbon concentrations above the drinking water quality objective were noted in a sample from GA11-BH002.

Given the surrounding land uses, poor quality groundwater may be encountered. Dewatering and discharge of groundwater during construction and possibly more in the long term would require further consideration and design (refer to Technical Appendix O *Groundwate*r for more detail).

Eastern Portal

Four environmental bores were drilled within the precinct boundaries between 2010 and 2015. Five samples of fill and three samples of underlying natural soils or rock were analysed. Soil analytical results were screened against current contaminated land assessment soil quality objectives (National Environment Protection Measure) and EPA waste categorisation guidelines.

The fill materials to be excavated during construction (as for the Western Portal) variable and typical of fill found across Melbourne. All samples taken were less than the soil quality objectives for human health with the exception of one fill sample (GA11-BHE033 at 0.9-1 mbgl) which reported elevated PAHs (TEQs) above HIL B – residential. Four fill samples (three from GA11-BHE033 and one from GA11-BHE034) exceeded the ecological soil quality objective for Public Open Space/Commercial-Industrial for benzo(a)pyrene. Three samples reported elevated arsenic concentrations above ecological soil quality objective for Public Open Space/Commercial-Industrial; one in fill (GA11-BHE033 at 0.9 to 1 mblg) and two in natural (GA11-BHE033 at 1.9 to 2 mblg and GA11-BHE034 at 2 to 2.1 mbgl). It is likely that these elevated arsenic concentrations are reflective of natural conditions (as raised levels within the Brighton Group) or the use of arsenical pesticides (which were commonly used on railway land).

The analytical results were screened against the Industrial Waste Resource Guidelines. A point-by-point comparison of samples taken from fill material shows that all soil samples would be Category C (with the exception of one sample which was clean fill) based on arsenic concentrations. Given that the approximate fill volume is 7,900 m^3 and 5 samples have been taken, this gives an approximate fill sampling ratio of 1 sample per 1,600 m^3 and an overall relative low classification confidence (See Section 5.6.3).

Testing reported potential acid sulfate soil and rock in Brighton Group sediments and deeper fresh Melbourne Formation rock (however, it is unlikely that excavation would reach fresh Melbourne Formation).

Based on data collected in 2013, two groundwater wells have been installed within the eastern portal precinct, both in the Melbourne Formation at a maximum depth of 20 mbgl. The depth to groundwater in these wells is generally shallow; between 3.8 and 6 mbgl, however it is noted that this is based on old data and conditions may have changed since 2013.

The shallow groundwater is likely to be intercepted during most of the excavation work within this precinct. Technical Appendix O *Groundwate*r summarises groundwater quality data above various relevant guidelines. Total dissolved solid concentrations ranged between 5,000 and 6,000 mg/L. No groundwater samples reported hydrocarbons above groundwater quality objectives. Reportable levels of petroleum hydrocarbons were noted in one well (GA11-BH024), although it should be noted that GA11-BH025 was not tested for hydrocarbons. Both wells reported ammonia, iron and manganese concentrations above drinking water quality objectives.

Given the surrounding land uses, poor quality groundwater may be encountered. Dewatering and discharge of groundwater during construction and possibly more long term would need further consideration and design.

The Coode Island Silt at the western portal is known to contain raised levels of sulfates and is defined as acid sulfate soil. Sediments (inferred to be Coode Island Silt) were tested from GA11-BHE001, 2 and 3 at depths of 2.5 to 4.5 mbgl and reported the presence of either actual acid sulfate soil or potential acid sulfate soil.

To date, no soil or rock from the eastern portal has been tested for potential acid generation, however based on the geology, there is potential here for acid sulfate soils.

8.2.2.3 Waste Categorisation and Volumes

The approximate volumes of Category A, B and C waste material and potential acid generating material at the portal areas are presented in Section 8.5.1. These volumes are based on calculations in Appendix E of this report and further information on this is included in Appendix D of this report.

With respect to groundwater impacts, the limited data suggests groundwater quality is variable. Technical Appendix O *Groundwater* provides further information on groundwater volumes, management, and disposal options.

8.2.2.4 Management of Groundwater: Corrosion

As outlined in Section 5, groundwater quality could impact on various aspects of the project. Technical Appendix O *Groundwater* and Technical Appendix U *Aquatic Ecology and River Health* provide further information on water quality and groundwater extraction. The groundwater results have been reviewed against various corrosion criteria and concluded that high concentrations of sulfate and sulfate-reducing bacteria may indicate corrosive groundwater conditions at the western portal. Limited corrosion parameters have been collected at eastern portal.

Table C.**0-10** in Appendix C of this report provides a summary of the results with respect to corrosion.

8.3 Key Issues

The key issues associated with the project relating to contamination that could arise are identified in Table **8-4** and Table 8-5.

Table 8-4 Key issues associated with Western Portal

Concept Design	Issue	Risk no.
Western Portal Construction of the decline structure to the centre of South Kensington station Cut-and-cover tunnel construction to east end of Childers Street	Bulk earthworks and spoil generated during excavation construction works	CL016, CL018, CL021, CL024
	Groundwater inflow and vapour impacts during construction and operation	CL027
	Ground gases (methane) encountered during excavation construction works and accumulation in tunnel structures	CL030
	Vapours encountered during excavation construction works and accumulation in tunnel structures	CL033
	Durability issues and impacts on building materials following construction	CL036
	Piling and potential formation of contaminant migration pathways	CL039
	Construction safety and environmental pollution.	CL042

Table 8-5 Key issues associated with Eastern Portal

Concept Design	Issue	Risk No.
Eastern Portal Construction of the incline structure in the rail reserve between Osborne Street and the existing Sandringham line	Bulk earthworks and spoil generated during excavation construction works	CL016, CL022, CL025
	Piling and potential formation of contaminant migration pathways	CL040
	Construction safety and environmental pollution.	CL042

8.4 Benefits and Opportunities

Table 8-6 provides the benefits and opportunities associated with contaminated land and spoil management at the portals.

Table 8-6 Benefits and opportunities associated with the Concept Design

Concept Design	Benefits	Opportunities
Western Portal Construction of the decline structure to the centre of South Kensington station Cut-and-cover tunnel construction to east end of Childers Street	Excavation of materials would remove potentially contaminated soils from construction footprint (and in particular at the eastern portal/South Yarra Siding Reserve). Depending on the nature of contamination and the waste classification, the potentially contaminated spoil could be disposed of safely to a suitable waste management facility or re-used in accordance with current regulatory standards. Project spoil, for example, could be re-used at South Yarra	Further site investigation required for completion of this project would provide information about the nature and extent of contamination, the ground conditions and the disposition and quality of the groundwater. Making this information publicly available may be of benefit to any future development of the area.

Concept Design	Benefits	Opportunities
Eastern Portal Construction of the incline structure in the rail reserve between Osborne Street and the existing Sandringham line	Siding Reserve. Further investigations in advance of construction would enable decisions to be made to maximise potential re-use options and minimise ultimate disposal. Excavation of the contaminated soils would also: • provide a higher level of certainty that the contamination would not pose a hazard in the future (as the contamination has been removed) • provide a higher level of certainty that regulatory buy in and approval would be met • be completed in a short time frame • be completed using practical civil engineering methods • minimise long-term liabilities (as the sources have been removed) • avoid long-term monitoring. Residual contamination (if any) at the site would be characterised. This would inform a remedial options assessment (ROA) for the precinct. Future users, maintenance workers, etc. would be able to reference this ROA in order to safely execute any maintenance works that are planned.	

8.5 Impact Assessment

8.5.1 Potential Impacts

The following draft EES evaluation objective and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 8-7 Draft EES Evaluation objectives and assessment criteria

Draft EES evaluation objective	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Minimise risks associated with disturbance, transport and disposal of solid wastes from excavation works, including potentially contaminated materials and acid sulfate soils.

Completion of the risk assessment (Section 6 of this report) identified the key issues as noted in Section 8.3. These potential impacts are considered in more detail in the following sections.

8.5.2 Spoil Management Impacts

8.5.2.1 General

Around 104,000 m^3 of spoil would be generated throughout the construction phases of the works from both portals.

Western Portal

Bulk earthworks at the western portal would generate an estimated 57,000 m^3 of spoil material. About 39,000 m3 of this would be natural material comprising about 1,000 m^3 potential acid sulfate soil (from Coode Island Silt). Around 18,000 m^3 of the total material is more than likely to be Prescribed Industrial Waste as this material potentially contains contamination and asbestos. A large proportion (38,000 m^3) would likely be categorised as clean fill.

Eastern Portal

Bulk earthworks at the eastern portal would generate approximately 47,000 m^3 of spoil material the bulk of this would be natural material comprising the sands, silts and clays of the Brighton Group and is likely classified as clean fill. Brighton Group is a potential acid sulfate soil, although site investigations (refer to Appendix D of this report) do not identify any potential acid sulfate soil and have thus not included any acid sulfate soil in the volume estimate. Around 7,900 m^3 of the total material would be fill and on excavation more than likely to be Prescribed Industrial Wastes as this material potentially contains contamination and asbestos.

This spoil can be broadly categorised as:

- Clean fill – suitable for re-use **(Risk #CL016)**
- Acid sulfate soil – requiring management and off-site disposal **(Risk #CL018)**
- Prescribed Industrial Waste – requiring management and off-site disposal **(Risk #CL021** and **#CL022)**
- Prescribed Industrial Waste incorporating asbestos – requiring management and off-site disposal **(Risk #CL024** and **#CL025).**

The key impact relates to consequential impacts resulting from either underestimating the volumes of spoil and/or incorrectly classifying the spoil. Additional impacts relating to tunnel spoil handling and transport are considered elsewhere (in Technical Appendix D *Transport* and Technical Appendix H *Air Quality*).

8.5.2.2 Clean Fill

An estimated 77,000 m^3 of natural soils and rock would be generated during excavation with this material having limited contamination or acid generating potential. Impacts are as per Tunnels (7.5.2).

An initial medium risk has been allocated to **Risk #CL016**. Further Environmental Performance Requirements are recommended to reduce this impact to low and these are described in Section 8.6.2.

8.5.2.3 Acid Sulfate Soil

A small amount (approximately 1,000 m^3) Coode Island Silt would require excavation during the excavation of the western portal. Impacts are as per Tunnels (Section 7.5.2).

An initial high risk has been allocated to **Risk #CL018**. Further Environmental Performance Requirements are recommended to reduce this impact to low.

8.5.2.4 Prescribed Industrial Waste

About 18,000 m^3 and 7,900 m^3 of Prescribed Industrial Waste would be excavated at the western and eastern portals respectively.

Based on preliminary site investigation data, about 70 per cent of the material would be Category C waste with some Category B and A waste anticipated. There are many disposal options for Prescribed Industrial Wastes (Section 1.4.5.3). The potential impacts are related then to erroneous categorisation of the waste or an underestimate of the volumes such that Prescribed Industrial Waste is not managed appropriately with consequential environmental impacts. The Prescribed Industrial Waste is more than likely to contain asbestos.

An initial high risk has been allocated to **Risks #CL021, #CL022, #CL024** and **#CL025**. Proposed mitigation measures and recommended Environmental Performance Requirements have been identified to reduce these impacts to low.

8.5.2.5 Mitigation measures

With the possible exception of the eastern portal, there is no obvious re-use option for the clean fill on-site and therefore this spoil would have to be removed off-site. Impacts and associated strategies for dealing with the clean fill and acid sulfate soil and rock spoil has been described in the impact assessment for the Tunnels (Section 7.5.2).

The anticipated volumes of Prescribed Industrial Waste are relatively small compared to the total spoil generated during the project. Current information summarised in the Spoil Management Strategy in Appendix E of this report. There is known capacity in metropolitan Melbourne for receiving Prescribed Industrial Waste within the greater Melbourne conurbation thereby minimising the impacts arising from the creation of new sites or intensifying the use (see Section 1.4.5). As noted above, fill materials may be contaminated with asbestos. Such soils would be managed in accordance with WorkSafe OHS regulations and EPA's asbestos transport and disposal. The contractor would develop appropriate mitigation measures in accordance with WorkSafe Victoria's requirements.

Mitigation measures would be managed by the contractor by compliance with the SEPPs and a number of EPA guidelines on waste categorisation and the management of waste. Recommended Environmental Performance Requirements have been identified (Section 7.6.2) requiring the contractor to complete further site investigation, waste categorisation, identification of suitable re-use or disposal facilities and identification of a suitable spoil handling methodology. Further information on uncertainties and further site characterisation can be found in Sections 5.6.4 and 5.6.5 respectively.

As noted in Section 1.4.5, temporary stockpile areas would be identified at both the western and eastern portals. Potential environmental impacts and recommended Environmental Performance Requirements are described in Section 8.6. Given the limited room to stockpile material during construction, the temporary stockpile areas are envisaged only to be used for unexpected materials.

Mitigation measures for spoil and acid sulfate soil and rock are described previously in Section 7.5.2.

Adopting appropriate mitigation measures such as those described above and meeting the recommended Environmental Performance Requirements outlined in Section 8.6.2 would enable the contractor to reduce residual impacts relating to bulk earthworks **(Risks #CL021, #CL022, #CL024** and **#CL025)** to low.

There remain potential impacts with the handling and transportation of the material to the final destination; this may affect the local community and users of nearby facilities and the general amenity of the transportation routes (Refer to Technical Appendix D *Transport* and Technical Appendix H *Air Quality*).

8.5.3 Contaminated Land Management Impacts

8.5.3.1 General

This section considers impacts from:

- Groundwater inflow and vapour impacts
- Ground gases encountered during tunnelling and accumulation in tunnel structures
- Durability.

Proposed mitigation measures are described for each of the above and then an overarching mitigation approach is outlined.

8.5.3.2 Groundwater Inflow and Vapour Impacts (Construction and Operation)

Groundwater inflows into portal structures can occur during both construction and operation (Refer to Technical Appendix O *Groundwater*). The volume of inflow depends on the extent to whether construction methods would be drained or undrained and which the structures are made watertight (i.e. tanked). During construction, inflows are expected to be very small and drawdown inflows around the tunnels would be minor. The portals would be open to the atmosphere and thus rainfall would enter (Refer to Technical Appendix O *Groundwater*).

An assessment of risks, impacts and strategies for mitigations are similar to those described for the tunnels sections from Parkville to CBD North (Section 7.5.3.2). A potential impact linkage between source, pathway and receptor has been identified for the Western portal only as petroleum hydrocarbons were detected in groundwater (Section 8.2.2.2) **(Risk #CL027)** and further proposed mitigation measures and recommended to meet the recommended Environmental Performance Requirement (Section 8.6.3). Adoption of these would enable the contractor to reduce residual impacts relating to groundwater inflow **(Risk #CL027)** to low.

8.5.3.3 Ground Gases Encountered During Excavation of the Portal Structures

Disturbance of ground and groundwater during construction may release ground gases such as methane and hydrogen sulfide from naturally occurring Coode Island Silt found at the western portal. These naturally occurring sources of hazardous ground gases are generated historically and would be trapped in soil pores due to limited diffusion transport. Experience tells that construction work sites in organic sediments can be characterised as being low emission sources, where the concentrations may be high, but the release is in general is very low.

An assessment of risks impacts and strategies for mitigations are similar to those described for the tunnels sections south of the Yarra River (Section 7.5.3.3).

A potential impact linkage between source, pathway and receptor has been identified for the Western Portal only as the portal would be excavated through the Coode Island Silt and an initial medium risk has been allocated **(Risk #CL030)**. Proposed mitigation measures to meet the recommended Environmental Performance Requirements have been identified (Section 8.6.3). Adopting these would enable the contractor to reduce residual impacts relating to ground gases **(Risk #CL030)** to low.

8.5.3.4 Vapours Encountered During Excavation of the Portal Structures

Disturbance of ground and groundwater conditions during construction may cause vapours such as petroleum and solvents to migrate towards features on the alignment. Construction activities could impact on air quality around the construction work site. If the volatile organic compounds are below ground, construction activity may deflect or modify existing vapour migration routes and thus wider consideration/impacts (sub-surface impacts) may need to be considered.

The mostly open aspect of the construction (i.e. a cut-and-cover decline structure) would limit potential impacts and specific mitigation is unlikely to be required in the longer term and relating to operational impacts.

Source

Excavation into the fill materials at the western and eastern portals has the potential to disturb contamination and release volatile organic compounds. The sources of volatile organic compounds would be from historic releases of contaminants and could be sourced on and adjacent to the proposed project boundary. Oils or solvents are the most likely source. Site investigations (refer to Appendix D of this report) have confirmed limited volatile organic compounds in the shallow soils at the portals.

Pathway

The pathway of exposure would be from mass release and/or slow permeation of entrained vapours from the Fill into the air space in the excavations.

Receptor

Receptors would be the construction workers.

Impact linkage

A potential impact linkage between source, pathway and receptor has been identified. During construction, volatile organic compounds could be encountered as diffuse contamination or as hot spots. Diffuse contamination could result in a slow release of volatile organic compounds whilst more rapid sudden releases could occur with hot spots. This could occur anywhere within the western portal and may result in short term or more chronic health effects, odour generation and associated health and safety issues. If the monitored air quality deteriorates to below safe work standards, work could be temporarily suspended. Specific mitigation measures can be incorporated into the Contaminated Land Management Plan (and associated sub-plans). Effects are likely to be transient.

Impacts relate to potential toxicity of volatile organic compounds and an and an initial medium risk has been allocated **(Risk #CL033)** at the western portal only.

Mitigation measures

Proposed mitigation measures are similar to those described in (Section 7.5.3.3).

Summary

Recommended Environmental performance Requirements and proposed mitigation measures and have been identified (Section 8.6.3). Adopting these would enable the contractor to reduce residual impacts relating to ground gases **(Risk #CL033)** to low.

8.5.3.5 Durability

Site investigations have identified raised levels of chlorides and sulfates at the western portal and sulfates at eastern portal. This is linked to the presence of acid sulfate soils in Coode Island Silt at the western portal and Brighton Group clays at the eastern portal. Disturbance of the Coode Island Silt could introduce oxygen and thus may begin to acidify the sediments in direct contact with retaining wall structures or mass concrete used in the decline structures. Further site investigation is required to confirm the nature and extent of contamination.

An assessment of risks impacts and strategies for mitigations are similar to those described for the tunnels sections south of the Yarra River (Section 7.5.3.4). A potential impact linkage between source, pathway and receptor has been identified for the western portal only and this has been given an initial medium risk **(Risk #CL036)**.

Proposed mitigation measures to meet the recommended Environmental Performance Requirements have been identified (Section 8.5.3.7). Adopting these mitigation measures and meeting associated recommended Environmental Performance Requirements would enable the contractor to reduce residual impacts relating to durability **(Risk #CL036)** to low.

8.5.3.6 Piling and Retaining Walls

Piling at the western and eastern portals would disturb the soils and potentially cause the formation of pathways for contamination to migrate from impacted strata to un-impacted strata or may enable entrained gasses and vapours to be released. Piles are likely to extend through any fill, shallow soils and into either the Melbourne Formation (at the western portal) or Brighton Group (at the eastern portal). Piles could be impacted by aggressive ground conditions; see Section 5.4.4.2 above.

Piling methods are unknown, however for this impact assessment a non-displacement or bored pile is assumed. This method involves drilling out a core of soil and replacing it with a pile formed by casting in situ concrete around a reinforced cage. Of the possible environmental impact scenarios associated with piling, the key environmental impact would be related to the formation of preferential pathways through an aquitard to allow potential contamination of an aquifer.

Addition of grout or other cementitious materials into the ground during construction and potential impact on groundwater and surface is considered further in Technical Appendix U *Aquatic Ecology and River Health.*

<u>Source</u>

Site investigations have identified contaminated fill at both the western portal and eastern portals. Further site investigation is required to confirm the nature and extent of contamination.

<u>Pathway</u>

The groundwater table is relatively shallow and likely to be intersected by piles, with the piles breaching a potential aquitard at the western portal. Piling would create pathways for contaminant migration. Once the pile is formed and the soils re-form around the pile then the likelihood of pathway formation would recede.

<u>Receptor</u>

Aside for the piles themselves (which are considered in the durability assessment above), the key receptor is the groundwater.

<u>Impact linkage</u>

A potential impact linkage between source, pathway and receptor has been identified for the portals and this has been given an initial medium risk **(Risk #CL039** and **#CL040)**.

<u>Mitigation measures</u>

Australian Standard 2159-2009 Piling – Design and installation provides some limited guidance on piling requirements and acid sulfate soils and contaminated land. Guidance available on piling in contaminated land can be found in Environment Agency (2001) Piling and Penetrative Ground Improvement methods on Land Affected by Contamination: Guidance on Pollution Prevention. Environment Agency National Groundwater and Contaminated Land Centre report NC/99/73.

Further investigations in advance of the works can establish if the contamination in the fill is mobile or not. If mobile contaminants are detected, further consideration of the removal/remediation of the fill in advance of piling should be made, thus removing potential sources of contamination. Alternate piling methods may also need to be considered.

Summary

Adopting appropriate mitigation measures set out above and meeting the associated recommended Environmental Performance Requirements Section 8.6.3 would enable the contractor to reduce residual impacts relating to piling **(Risk #CL039** and **#CL040)** to low.

8.5.3.7 Mitigation Measures

Specific mitigation measures are described in the sections above, covering the particular contaminated land aspects or risk. The general mitigation framework is described as for the tunnels in Section 7.5.3.5.

8.5.4 Construction Safety and Environmental Pollution (Construction)

Construction activities and excavation of contaminated ground may lead to impact on worker safety, potential impact on segments of the environment including releases of air pollutants (dust, odour and vapours), spills and contamination control relating to dangerous goods (such as fuels).

8.5.4.1 Exposure to Contamination – Worker Health and Safety

Many contaminants in soils, groundwater and soil gas are potentially hazardous. Workers may be exposed by direct contact with soils, or indirectly by breathing vapours. Typical construction activities can lead to a higher potential risk of exposure than from other work activities. If concentrations are high enough, acute effects can be apparent.

8.5.4.2 Releases of Air pollutants

Excavation works at the portals have the potential to lead to the generation of dust, odours or vapours. Works would be carried out in such a way that emissions to air of dust and pollutants including odours are limited and that best practicable means are employed to avoid the creation of a dust, odour or vapour nuisances.

8.5.4.3 Spills and Contamination Control

The contractor would employ best practicable means to complete the works in such a way as to avoid pollution incidents. However, should any occur, procedures and measures would be implemented to contain and limit the effects as far as reasonably practicable. The contractor would ensure the correct storage, handling, use, and disposal of any potentially hazardous materials in accordance with the relevant EPA guidance notes.

Construction activity may produce some wastewater. This would arise from:

- decontamination of vehicles or equipment
- spillage of oil or fuel.

8.5.4.4 Conclusion

Potential health and safety and environmental impacts are possible for the portals and these have been assigned an initial high risk **(Risk #CL042)**. Mitigation is as described previously in Section 7.5.4

Further Environmental Performance Requirements have been recommended in Section 8.6.4 and in conclusion, adopting the mitigation measures recommended and appropriate environmental protection requirements would enable the contractor to reduce residual impact relating to contaminated ground and groundwater health safety and environmental pollution issues to low.

8.6 Environmental Performance Requirements

8.6.1 General

Environmental Performance Requirements have been recommended for all the medium and above impacts described in Section 8.5. Three categories of recommended Environmental Performance Requirements have been identified:

- Spoil management
- Contaminated land management
- Health and safety and environmental management.

These three aspects are described below.

8.6.2 Spoil Management

Recommended Environmental Performance Requirements for spoil management from portals **(Risks #CL016, #CL018, #CL021, #CL022, #CL024** and **#CL025)** can be found below, with additional recommended Environmental Performance Requirements included in Table 8-8.

General **(all risks)**

- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 2009. Environmental Protection (Industrial Waste Resource) Regulations 2009. SR No. 77/2009
- EPA Victoria 2009. Solid industrial waste hazard categorisation and management. Publication IWRG631
- EPA Victoria 2009. Sampling and analysis of waters, wastewaters, soils and wastes. Publication IWRG701
- EPA Victoria 2009. Soil sampling. Publication IWRG702
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480
- WorkSafe Victoria 2010. Guidance Note Asbestos-contaminated soil
- EPA Victoria 2009. Asbestos transport and disposal. Publication IWRG611.1

Acid sulfate soil and rock **(Risks #CL018)**

- EPA Victoria 2009. Acid sulfate soil and rock. Publication 655.1
- State of Victoria 1999. State Environmental Protection Policy, Industrial Waste Management Policy (Waste Acid Sulfate Soils) No S125, Gazette 18/09/1999.

Table 8-8: Additional Environmental Performance Requirements – Spoil Management - Tunnels

EPR No.	Environmental Performance Requirements	Risk no.
C1	Prior to construction of main works or shafts, prepare and implement a Spoil Management Plan (SMP) in accordance with MMRA's Spoil Management Strategy and relevant regulations, standards and best practice guidance. The SMP shall be developed in consultation with and to the satisfaction of the EPA. The SMP would include but is not limited to the following: • Applicable regulatory requirements • Identifying nature and extent of spoil (clean fill and contaminated spoil) across all precincts	CL016 CL021 CL022 CL024 CL025

EPR No.	Environmental Performance Requirements	Risk no.
	• Roles and responsibilities • Identification of management measures for handling and transport of spoil for the protection of health and the environment • Identification, design and development of specific environmental management plans for temporary stockpile areas • Identifying suitable sites for re-use, management or disposal of any spoil • Monitoring and reporting requirements. • Identifying locations and extent of any Prescribed Industrial Waste and characterising Prescribed Industrial Waste spoil prior to excavation • Identifying suitable sites for disposal of any Prescribed Industrial Waste. • The SMP shall include sub-plans as appropriate, including but not limited to an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan (Refer to C2)	
C2	Prepare and implement an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan prior to construction of the project as a Sub-Plan of an overarching SMP in accordance with the Regulations, Standards and best practice guidance and to the satisfaction of EPA. This sub-plan would include the general requirements of the SMP and also: • Identifying locations and extent of any potential ASS/ASR • Characterising ASS/ASR spoil prior to excavation • Identification and implementation of measures to prevent oxidation of ASS/ASR wherever possible • Identifying suitable sites for re-use, management or disposal of any ASS/ASR.	CL018

8.6.3 Contaminated land management

Recommended Environmental Performance Requirements for contaminated land management during tunnel construction **(Risks #CL027, #CL030, #CL033, #CL036, #CL039** and **#CL040)** can be found below, with additional recommended Environmental Performance Requirements shown in Table **8-9.**

General **(All)**

- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 1997. State Environmental Protection Policy (Groundwaters of Victoria), Victoria Government Gazette No S160.
- EPA Victoria 2014. The cleanup and management of polluted groundwater. EPA Publication 840.
- National Environment Protection Council (NEPC), 2013. National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended. Schedule A: Recommended General Process for Assessment of Site Contamination, Canberra, A.C.T.: National Environment Protection Council Service Corporation.

For vapour ingress (**#CL027** and **#CL033)**:

- State of Victoria 2001. State Environment Protection Policy (Air Quality Management) No. S240
- NSW EPA 2012. Guidelines for the Assessment and management of Sites Impacted by Hazardous Gases

- CRC CARE 2013. Petroleum hydrocarbon vapour intrusion assessment: Australian guidance, CRC CARE Technical Report no. 23, CRC for Contamination Assessment and Remediation of the Environment, Adelaide, Australia
- British Standards Institute 2015. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS8485:2015, BSI Standards Ltd, UK.

For ground gases (**#CL030)**:

- British Standards Institute 2013. Guidance on investigations for Ground gas – permanent gases and Volatile Organic Compounds (VOCs). BS8576:2013. BSI Standards Ltd, UK.
- British Standards Institute 2015. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS8485:2015, BSI Standards Ltd, UK.

For durability **(#CL036)**:

- *Australian Standard 2159-2009 Piling – Design and installation*
- Environment Agency (2005). Assessment and Management of Risks to Buildings, Building Materials and Services from Land Contamination. R&D Technical Report P5-035/TR/01
- Environment Agency (2000). Risks of Contaminated Land to Buildings, Building Materials and services. R&D Technical Report P331. Available from The R&D Dissemination Centre, WRc Plc, Swindon, Wiltshire.

For piling **(#CL039)**

- *Australian Standard 2159-2009 Piling – Design and installation*
- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 1997. State Environmental Protection Policy (Groundwaters of Victoria), Victoria Government Gazette No S160.
- EPA Victoria 2014. The cleanup and management of polluted groundwater. EPA Publication 840.1
- Environment Agency (2001) Piling and Penetrative Ground Improvement methods on Land Affected by Contamination: Guidance on Pollution Prevention. Environment Agency National Groundwater and Contaminated Land Centre report NC/99/73.

Table 8-9: Additional Environmental Performance Requirements – Contaminated Land Management - Tunnels

EPR No.	Environmental Performance Requirements	Risk No.
C3	Prior to construction of main works or shafts, undertake a remedial options assessment (ROA) for contaminated land. The assessment must: • Consider the outcomes of further investigations • Interpret of groundwater permeation and VOC result • Present and take account of the outcomes of risk assessments • If required, identify remedial options in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA. If required, as an outcome of the ROA, prepare a remedial action plan and integrate the remediation approach into the design in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA.	CL027 CL030 CL033 CL036 CL039 CL040

8.6.4 Construction Safety Hazards and Environmental Pollution (Construction)

Recommended Environmental Performance Requirements for contaminated land management during tunnel construction **(Risks #CL042)** can be found below, with additional recommended Environmental Performance Requirements shown in Table **8-10**.

- WorkSafe 2005. Contaminated Construction Site – Industry Standard
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480.

Table 8-10: Additional Environmental Performance Requirements – Health, Safety and Environmental Management- Tunnels

EPR No.	Environmental Performance Requirements	Risk no.
C4	Prior to construction of main works or shafts commencing, prepare and implement a health, safety and environmental plan for the management of hazardous substances. The plan must include but not be limited to: • Consideration of the risks associated with exposure to hazardous substances for employees, visitors and general public • The identification of methods to control such exposure in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and the EPA. • Method statements detailing monitoring and reporting	#CL042

9 Stations

This section describes the project components, existing conditions, key issues, benefits and opportunities, and findings of the impact assessment for the stations component of the Concept Design and alternative design options.

9.1 Project Components

9.1.1 Infrastructure

Stations are to be constructed at Arden, Parkville, CBD North, CBD South and Domain. With the exception off Arden, the stations would be located below existing road and transport infrastructure. The Arden station is located in publicly owned (VicTrack) land currently used for industrial purposes.

9.1.2 Construction

A summary of construction activities is identified in Table **9-1**.

Table 9-1 Summary of construction methods at the stations

Location	Construction	Implications
Arden station	Cut-and-cover. Includes piling and grouting. Substation construction	Both surface material and natural material at depth would be excavated.
Parkville station	Cut-and-cover. Includes piling and grouting.	Both surface material and natural material at depth would be excavated.
CBD North station	Cavern and some excavation from the ground surface. Includes piling and grouting.	Majority of material to be excavated would be natural at depth, however some surface material would be excavated for shafts and entry/exit points.
CBD South station	Cavern and some excavation from the ground surface. Includes piling and grouting.	Majority of material to be excavated would be natural at depth, however some surface material would be excavated for shafts and entry/exit points.
Domain station	Cut-and-cover. Includes piling and grouting.	Both surface material and natural material at depth would be excavated.

For the construction of a new electrical substation in the vicinity of Arden station/western portal, there are currently four options:

- Concept Design Option 1: A ~3,000 m^2 site north of Arden Street, between City Link to the west and Langford Street to the east. Includes underground cabling from the West Melbourne Terminal Station to the substation (~250m) and from the substation to the station box (~320 m)
- Concept Design Option 2: Co-location at Melbourne Metro Trains' Melbourne Traction Substation. Includes underground cabling from the West Melbourne Terminal Station to the substation (~210 m) and from the substation to the station box (~190 m)

- Concept Design Option 3: Southern section of the Arden precinct, between rail to the west and Laurens Street to the east. Includes underground cabling from the West Melbourne Terminal Station to the substation (~600m) and from the substation to the station box (~250 m)
- Concept Design Option 4: A ~3,000 m^2 site located to the north of the western portal (option 4) at the existing 50 Lloyd Street Business Estate. Includes underground cabling from the West Melbourne Terminal Station to the substation and from the substation to the western portal.

Excavation spoil would likely be handled at the locations where the TBMs are launched and retrieved (western portal, Arden, CBD North, CBD South, Fawkner Park and Domain (refer to the EES Map Book for locations). These facilities would be configured to handle spoil and to allow trucks entry and egress. Smaller temporary stockpiling areas would be located at each construction work site.

9.2 Existing Conditions

9.2.1 Land Use

The current and historic land uses in the vicinity of the stations are highly variable. Some of the key potentially contaminating land uses are summarised in Table 9-2.

Table 9-2 Summary of main land uses at the station precincts

Location	Notable land use
Arden station	Arden station is wholly located within publicly owned (VicTrack) land at Arden. The precinct land is currently used for a variety of light to heavy industrial activities and some commercial businesses. To the north and east of the precinct, mixed land uses prevail (including commercial, residential and open parkland). Historically, the land was reclaimed from low-lying marsh lands in the late 1800s. A number of potentially contaminative land uses have been identified at and near the site including: • Historic heavy industrial uses such as workshops, rail yards, concrete production, timber storage, grain/stock feed storage, numerous USTs, triple interceptor traps, washbays and ASTs, flour mills, biscuit factories • Rail and port facilities rail and dock freight facilities • Surrounding historic heavy industrial uses such as North Melbourne Gasworks (a gas holder plant), numerous underground storage tanks, triple interceptor traps, washbays and above ground storage tanks (ASTs), asphalt plant, workshops, garage and fuel merchants. Land uses affecting the substation sites include the following: • Langford Street Site: Assessment Option 1: A ~3,000 m2 site north of Arden Street, between City Link to the west and Langford Street to the east. Includes underground cabling from the West Melbourne Transmission Station to the substation (~250 m) and from the substation to the station box (~320 m) – EPA Audit CARMs 33298-4 – Realignment of Mooney Ponds Creek: various phases in 1885, 1930, 1945 – Tile Factory – Transportation warehousing (including two ASTs) – Wool Traders – A variety of smaller industrial / commercial facilities The majority of the site is covered by fill used for the rail sidings and to build up the ground level above the Mooney Creek flood plain. Fill is likely to be heterogeneous with a mixture of sands, silts, clays and gravels as well as brick, glass, concrete, pipes, coke, ash, plastic, slag, domestic waste (plastic bags and organics) and crushed rock ballast. Fill is underlain by alluvial deposits of clays, silts and some

Location	Notable land use
	sands with some shelly layers that may be indicative of the Coode Island Silt. Groundwater was encountered at less than 2 m below surface with salinity of approximately 3,000 mg/L TDS with potential localised groundwater flow towards Moonee Ponds Creek. Fill contaminated with heavy metals (arsenic, copper, lead, mercury, zinc) and petroleum hydrocarbons • Metro Trains Melbourne Traction Substation site: Alternative Design Option 2: Co-location at Metro Trains Melbourne Traction Substation. Includes underground cabling from the West Melbourne Terminal Station to the substation (~210 m) and from the substation to the station box (~190 m) Existing substation • Laurens Street Site: Alternative Design Option 3: Southern section of the Arden precinct, between rail to the west and Laurens Street to the east. Includes underground cabling from the West Melbourne Transmission Station to the substation (~600m) and from the substation to the station box (~250 m) Currently used by USG Boral (plastering supply), Irwin Stockfeeds (animal feed store), Z Transport Group and Central Cleaning Supplies • 50 Lloyd Street Business Estate: Alternative Design Option 4: A ~3000 m2 site located to the north of the western portal (option 4) at the existing 50 Lloyd Street Business Estate. Includes underground cabling from the West Melbourne Transmission Station to the substation and from the substation to the western portal.
Parkville station	Land in this precinct is currently used for a variety of health and educational services including the University of Melbourne to the immediate north of the precinct and the Royal Melbourne Hospital to the north-west of the precinct. To the south and east of the precinct, mixed land uses prevail (including commercial, residential and open parkland). A number of potentially contaminative land uses have been identified at and near the site. Historically the area has been the site of the hay and pig markets as well as various industrial activities including galvanised iron and timber merchants, furniture manufacture and farrier. The University of Melbourne has been on the north side of Grattan Street since the mid-1850s. South of the station box, historic mixed land uses prevail including galvanised iron and timber merchants, farrier and furniture manufacturing, engineers, motor body builder, medical practitioners, plumbing supplies store, wheelwright/blacksmith from 1869; Royal and Company axle market, metal foundry, furnace, service station, Austral auto repairs service station, commercial, warehousing, school.
CBD North station	Land in this precinct is currently used for a variety of commercial, educational and residential uses as well as transport structures such as Melbourne Central station and associated City Loop tunnels, and numerous tram routes running along Swanston, Victoria and LaTrobe Streets. Historically the area has included industrial and commercial activities such as factories (clothing, jam, tobacco, bicycle), saw mills, timber yards, lead works (shot tower), foundries, as well as the former Melbourne Hospital (on the corner of Lonsdale and Swanston Streets).
CBD South station	Land in this precinct is currently used for a variety of commercial, educational and residential uses as well as transport structures such as Flinders Street Station and numerous tram routes running along Swanston, Collins and Flinders Streets. Historically the area has included industrial and commercial activities such as warehouses and clothing factories and printers. Due to the proximity to the Yarra River, it is likely that reclaimed swamp (or riverbank) land is also present.

Location	Notable land use
Domain station	Land in this precinct is currently used for a variety of commercial, recreational and residential uses as well as transport structures such as Domain tram interchange. Historically the area was a swampy plain that may have undergone some land reclamation works. In addition to this the area has hosted various commercial/industrial activities include petrol stations and drycleaners.

A review of EPA audit and Groundwater Quality Restricted Use Zones within 200 m and 500 m radius respectively of the stations was conducted to gain further information of historic land uses and contamination. In total, 20 audit sites (including three Groundwater Quality Restricted Use Zones and one clean up to the extent practicable determination) were identified. This information has been summarised in Appendix D of this report. All reviewed Groundwater Quality Restricted Use Zones are located off the alignment and are discussed in Technical Appendix O *Groundwater*.

9.2.2 Contamination and Acid Sulfate Soil and Rock

9.2.2.1 General

Potential contaminated land, groundwater and spoil management issues could arise from:

- Contaminated fill material and contaminated shallow natural material
- Contaminated groundwater plumes intermingling with the rock
- The presence of acid sulfate soil particularly associated with the Coode Island Silt, Brighton Group and Melbourne Formation
- The presence of acid sulfate rock particularly associated with the Melbourne Formation.

Contaminated groundwater plumes could intermingle with some of the deeper constructions particularly during construction dewatering. Fill and natural soils and rocks still need to be assessed for the nature and extent of contamination so disposal and/or re-use options can be considered in detail.

9.2.2.2 Contamination and Acid Sulfate Soil and Rock

Soil, vapour and groundwater information is summarised in Appendix D of this report and Technical Appendix O *Groundw*ater and a summary of groundwater results is included in Table C-**0-11** and Table C-**0-12** in Appendix C of this report. The following provides a summary of the contamination profile at each station precinct against relevant contaminated land and groundwater assessment quality objectives and also the EPA's waste classification guidelines.

<u>Arden station:</u>

Fourteen environmental bores were drilled between 2010 and 2015 within the Arden station precinct with a total of 99 soil samples tested. Thirty-seven samples of the fill and 62 samples of underlying natural soils or rock were analysed. Soil analytical results were screened against current contaminated land assessment quality objectives and also the EPA's waste soil categorisation guidelines. Most of the samples taken were located on the original west–east orientation of the station box within the precinct. Since the investigations have been completed, the orientation of the Arden station box has been realigned in a south-west to north-east direction. Whilst the new station box is very close to the original orientation, no specific investigation data currently exists on this new orientation. Recognising this limitation, the remainder of the assessment for Arden is based on the original orientation information. Extrapolation across the wider Arden precinct is considered valid because:

- The land use in general terms has remained similar and hence the contamination profile has remained similar

- The geological setting is the same.

The fill materials that would be excavated for the Concept Design are very highly variable in both composition and contaminant profile containing a variety of waste materials – typical of fill found across Melbourne. All samples taken were less than the screening quality objectives for human health with the exception of three samples from GA11-BHE007 (at 0.25 to 0/35 mbgl), GA11-BHE010 (at 0.2 to 0.3 mbgl) and GA15-BH005 (at 0.5 to 0.6 mbgl), which reported elevated PAHs (TEQs) above HIL B – residential. These three samples were all collected from fill material at depths of between 0.2 to 0.6 mbgl. Ten samples of fill exceeded the urban residential and public open space/commercial-industrial ecological quality objectives for elevated benzo(a)pyrene concentrations and four samples of petroleum hydrocarbons. All exceedances of criteria were reported in fill samples at depths of less than 1.5 mbgl.

The analytical results were screened against the IWRG guidelines. A point-by-point comparison of 62 samples taken from natural soils shows that all natural soil samples would be clean fill with the exception of 11 samples that would be classified as Category C based on elevated concentrations of arsenic, mercury and nickel. Twenty-three fill samples out of a total of 37 samples would be Category C based on heavy metal concentrations of one or more of arsenic, chromium, lead, nickel, tin and zinc and benzo(a)pyrene. Two samples would be Category B due to elevated concentrations of benzo(a)pyrene (in GA11-BHE010and GA15-BH005) and one sample would be Category A also due to an elevated concentration of benzo(a)pyrene (in GA11-BHE007). It is likely that the bulk of the spoil generated from excavations in the natural soils and rock would be classed as clean fill. Given that the preliminary volume estimate of Prescribed Industrial Waste (Categories C, B and A) is 32,000 m^3 and 37 samples have been taken, this gives an approximate fill sampling ratio of 1 sample per 870 m^3 and an overall relative medium classification confidence (see Section 5.6.3).

The Coode Island Silt at Arden is known to contain raised levels of sulfates and is defined as acid sulfate soil. Sediment samples (inferred to be Coode Island Silt) from nine locations were tested at Arden Station from GA11-BHE005 to GA11-BHE011 at depths of 0.5 to 4.75 mbgl and reported the presence of either actual acid sulfate soil or potential acid sulfate soil.

The Coode Island Silt may also be a source of ground gases and vapours. Three boreholes (GA15-BH004 to GA15-BH006) were tested for vapours using the Geoprobe Membrane Interface Probe (MIP) system which uses sensors to detect volatile organic compounds and soil electrical conductivity at depth in the sub-surface. Only GA15-BH005 reported a FID response between 2.6 and 3.0 mbgl which may indicate the presence of methane. The GA15-BH005 borehole log indicates that the geology at this depth corresponds to the top of the Coode Island Silt. It is noted that TPH C10 to C36 concentrations of 270 mg/kg and 480 mg/kg at 0.15-0.25 and 0.5-0.6 mbgl respectively in the laboratory reports were not detected by the MIP system.

Shallow groundwater has the potential to be intercepted during most of the excavation work within this precinct. Groundwater quality data above various relevant guidelines is summarised in Technical Appendix O Groundwater. Five groundwater wells were installed in the precinct – three in the Fishermens Bend Silt and one each in the Werribee Formation and Coode Island Silt. The depth to groundwater in these wells is generally shallow (between 4 and 7.3 mbgl), however some of these levels were recorded in 2010 and 2013 and conditions may have changed. Heavy metals, metalloids, cyanide, fluoride, nitrite and ammonia were elevated in one or more of the wells. Five of the wells were tested for hydrocarbons and reported all results either below the laboratory limit of reporting or below the guidelines. Petroleum hydrocarbons were detected above the laboratory limit of reporting in samples from MM1-BH002 and GA11-BH009. Given the surrounding land use, poor quality groundwater may be encountered. Dewatering, treatment and discharge of groundwater during construction and possibly more long term would need further consideration and design.

Parkville station

Six environmental bores were drilled between 2010 and 2015 with a total of 18 soil samples tested. Ten samples of the fill and eight samples of underlying natural soils or rock were analysed. Soil analytical results were screened against current contaminated land assessment quality objectives and also the waste soil categorisation guidelines.

Parkville station is to be constructed using a cut and cover method. Near surface fill materials that would be excavated for the Concept Design are very highly variable in both composition and contaminant profile containing a variety of waste materials – typical of fill found across Melbourne. All samples taken were less than the soil quality objectives for human health with the exception of one fill sample from GA11-BHE012 (at 0.1 to 0.2 mbgl) which reported elevated PAHs (TEQs) above HIL B – residential. Four samples of fill exceeded the urban residential and public open space/commercial-industrial ecological quality objectives for benzo(a)pyrene . All exceedances of criteria were reported in fill samples at depths of less than 2 mbgl.

The analytical results were also screened against the Industrial Waste Resource Guidelines on a point-by-point basis. All natural soil samples would be clean fill with the exception of two samples that would be classified as Category C based on elevated concentrations of arsenic, nickel and fluoride. Seven fill samples out of a total of 10 samples would be Category C based on heavy metal concentrations of one or more of arsenic, mercury, nickel and zinc and benzo(a)pyrene. It is likely that the bulk of the spoil generated from excavations in the natural soils and rock would be classed as clean fill.

Given that the approximate Prescribed Industrial Waste (Categories C, B and A) volume is 25,100 m^3 and 10 samples have been taken, this gives an approximate fill sampling ratio of 1 sample per 2,500 m^3 and an overall relative low classification confidence (See Section 5.6.3).

No samples from the Parkville station precinct have been tested for acid sulfate soil and acid rock potential. However, based on the known geology of the area and the depth of the station it is likely that fresh Melbourne Formation interbedded siltstone and sandstone would be encountered during construction. Testing of the Melbourne Formation rock at other points within the project boundary indicate that below about 25 mbgl the Melbourne Formation becomes fresh and the sulfidic minerals (such as pyrites) contained in the rock have the potential to mobilise if exposed to oxidising conditions. The Concept Design indicates the station box would be constructed at maximum depth of between approximately 22 to 27 mbgl. and therefore fresh Melbourne Formation spoil is likely to be generated and require management in relation to acid generation.

The Parkville station box is to be constructed using a cut-and-cover method which would likely induce dewatering and drawdown of the groundwater level in the area. Two groundwater monitoring wells were installed in the precinct in the Melbourne Formation in 2010. The depth to groundwater in these wells is unknown but expected to be generally shallow with this shallow groundwater likely to be intercepted during most of the excavation work within this precinct.

Technical Appendix O *Groundwater* summarises groundwater quality data above various relevant guidelines. Iron and total dissolved solids (salinity) were elevated in both wells above drinking water guidelines. These monitoring wells were not tested for organics such as petroleum hydrocarbons or heavy metals.

Given the surrounding land use, poor quality groundwater may be encountered. Dewatering and discharge of groundwater during construction and possibly more long term would need further consideration and design.

CBD North station

Thirteen environmental bores were drilled between 2010 and 2015 with a total of 75 soil samples tested. Thirty-three samples of the fill and 42 samples of underlying natural soils or rock were analysed. Soil analytical results were screened against current contaminated land quality objectives and also the EPA's waste soil categorisation guidelines.

CBD North station is to be constructed using a cavern method with cut-and-cover entrances at Franklin and La Trobe Streets and therefore fill materials at these locations would be excavated. No laboratory results of soil samples reported concentrations above human health or ecological soil quality objectives. Fill material at 0.25-0.35 mbgl at GA15-BH008 reported a benzene concentration of 0.6 mg/kg, which exceeds the soil quality objective for residential vapour intrusion (HSL B guideline). This appears a relatively isolated result as the sample form 0.5-0.6 mbgl below had undetectable benzene.

Raised levels of PAHs (TEQs) in comparison with the soil quality objective HIL B were detected in samples from GA15-BH009A at 0.1mbgl. This result was not replicated in a deeper 1 mbgl sample which returned a result below the laboratory limit of reporting. The benzo(a)pyrene concentration in the 0.1 mbgl sample was also greater that the Urban residential and public open space/Commercial-Industrial ecological soil quality objective. No other samples reported concentrations above the human health and ecological quality objectives.

The analytical results were screened against the IWRG guidelines. A point-by-point comparison showed that the majority of fill material at CBD North is classified as either clean fill or Category C Prescribed Industrial Waste based on elevated heavy metal concentrations (arsenic, lead, mercury, tin). Two fill samples are classified as Category B due to elevated benzo(a)pyrene (GA15-BH009A at 0.1 mbgl) and tin (GA11-BHE16 at 1.2 to 1.35 mbgl). Sample GA15-BH009A is from 0.1 mbgl might reflect bitumen inclusions from road base material. GA11-BHE16 at 1.2 mbgl was logged as fill (siltstone rocks, cobbles with clay matrix) with no obvious man-made source of elevated tin concentration. Five natural soil samples reported arsenic concentrations that put them into Category C and one sample noted fluoride concentration at Category C levels. All these samples were from depths of less than 3.2 mbgl.

Given that the approximate Prescribed Industrial Waste (Categories C, B and A) volume is 16,000 m^3 and 33 samples have been taken, this gives an approximate fill sampling ratio of 1 sample per 490 m^3 and an overall relative medium classification confidence (See Section 5.6.3).

Samples from within the CBD North station precinct (36 samples from six locations) have been tested for acid sulfate soil and rock potential. Five samples from two locations (GA15-BH010 and BH012) indicated acid sulfate potential at depths of between 15 and 40 mbgl in Melbourne Formation rock.

Shallow groundwater is likely to be intercepted during most of the excavation work within this precinct. Technical Appendix O *Groundwater* summarises groundwater quality data above various relevant guidelines. Six groundwater monitoring wells have been installed within the CBD North precinct in 2015, all in the Melbourne Formation at a maximum depth of 26 mbgl. The depth to groundwater in these wells ranges from 3.8 to 22 mbgl based on water levels taken in July and August 2015. Total dissolved solids concentrations ranged between 1,400 and 8,000 mg/L. No groundwater samples reported organics such as hydrocarbons above groundwater quality objectives. GA15-BH007 reported concentrations of TPH C9-C36 above drinking water quality objectives and this monitoring well also reported of toluene, chloroform and phenol however all these were below the relevant groundwater quality objctives.

One or more wells reported ammonia, magnesium, sodium and chloride concentrations above drinking water guidelines. Given the surrounding land uses, poor quality groundwater may be encountered. Dewatering, treatment and discharge of groundwater during construction and possibly more long term would need further consideration and design.

<u>CBD South station</u>

Eleven environmental bores were drilled within the precinct boundaries between 2010 and 2015 and twenty samples of fill and 18 samples of underlying natural soils or rock were analysed. Soil analytical results were screened against current soil quality objectives assessment and EPA waste categorisation guidelines.

CBD South station would in resemble CBD North and the shallow fill materials excavated for the Concept Design would be very variable in both composition and contaminant profile containing a variety of waste materials – typical of fill found across Melbourne.

Laboratory results indicated raised levels of PAHs (TEQs) above residential soil quality objectives (HIL B) reported in fill samples from GA11-BHE22, GA15-BH019, GA15-BH021A, GA15-BH112, with one fill sample from GA11-BHE22 at 0.8 to 0.9 mbgl above commercial/industrial soil quality objectives (HIL D) for PAHs (TEQs). Petroleum hydrocarbons and benzo(a)pyrene concentrations above in five fill samples from GA11-BHE22 between 0.3 and 0.9 mbgl, GA15-BH019 at 1 mbgl and GA15-BH112 from 0.1 to 0.5 mbgl.

In natural soils, benzo(a)pyrene concentrations above urban residential and public open space/commercial industrial ecological quality objectives in nine fill samples from GA11-BHE20 between 0.8 to 0.9 mbgl, GA11-BHE22 between 0.3 and 0.9 mbgl, GA15-BH019 at 0.5 to 1.5 mbgl, GA15-BH021A between 0.5 to 0.7 mbgl, GA15-BH112 from 0.1 to 0.5 mbgl. No natural samples reported hydrocarbon concentrations above laboratory limits of reporting.

The analytical results were screened against the Industrial Waste Resource Guidelines. A point-by-point comparison of samples taken from fill material shows that all except one sample of natural material would be clean fill (GA15-BH018 at 0.18 to 0.23mbgl reported elevated nickel which classified it as Category C). Twelve out of the 20 fill samples are classified as Category C based on elevated metals (arsenic, copper, lead, mercury, tin and vanadium). GA15-BH112 at 0.5 mbgl reported elevated benzo(a)pyrene and total PAHs. Given that the approximate Prescribed Industrial Waste (Category C, B and A) volume is 13,100 m^3 and 20 samples have been taken, this gives an approximate fill sampling ratio of 1 sample per 660 m^3 and an overall relative medium classification confidence (See Section 5.6.3).

Potential for acid generation was tested at four locations at CBD South with acid sulfate potential indicated at two locations in Melbourne Formation at depth of between 17 and 28 mbgl.

Shallow groundwater is likely to be intercepted during most of the excavation work within this precinct. Technical Appendix O *Groundwater* summarises groundwater quality data above various relevant guidelines. Six groundwater monitoring wells were installed at the CBD South precinct, all in the Melbourne Formation at maximum depths between 15 and 41 mbgl. The depth to groundwater in these wells is generally shallow; between 6 and 25 mbgl, but this is based on relatively old measurements (2013). Total dissolved solids concentrations ranged between 1,500 and 5,300 mg/L.No groundwater samples reported hydrocarbons above groundwater quality objectives. Petroleum hydrocarbons were above drinking water quality objectives from GA15-BH021. It is further noted that MM1-BH013, GA15-BH018 and GA15-BH019 were not tested for hydrocarbons.

One or more wells reported ammonia, sodium, chloride, magnesium, fluoride, cyanide, arsenic, iron, manganese, molybdenum, nickel and selenium above drinking water guidelines. Given the surrounding land uses, poor quality groundwater may be encountered. Dewatering, treatment and discharge of groundwater during construction and possibly more long term would need further consideration and design.

<u>Domain station</u>

Twelve environmental bores were drilled within the precinct boundaries between 2010 and 2015. Fourteen samples of fill and 48 samples of underlying natural soils or rock were analysed. Soil analytical results were screened against current soil quality objectives and also the waste soil categorisation guidelines.

The fill materials that would be excavated for the Concept Design are very variable in both composition and contaminant profile containing a variety of waste materials – typical of fill found across Melbourne.

All fill samples (except two) reported benzo(a)pyrene and calculated PAHs (TEQs) above both residential and industrial soil quality health objectives. Three samples reported petroleum hydrocarbon concentrations above vapour intrusion soil quality objectives for a residential setting (HSL B). All exceedances were in fill above 1mbgl. Only three natural samples reported benzo(a)pyrene above urban residential and public open space/commercial industrial ecological quality objectives with these at shallow depths of less than 1.2 mbgl. Seven samples of natural material also reported elevated arsenic concentrations above urban residential and public open space/commercial industrial ecological quality objectives generally at depth of greater than 1 mbgl.

The analytical results were screened against the IWRG guidelines. A point-by-point comparison of samples taken from fill material shows that elevated metals (arsenic, copper, lead, mercury, nickel, zinc) and petroleum hydrocarbons were reported in most fill samples above the Category C threshold. Five samples reported benzo(a)pyrene and/or PAHs above the Category B threshold and six above Category A threshold. A total of 17 natural samples reported chemicals above the Category C threshold; fourteen based on elevated arsenic, one based on chromium and two based on benzo(a)pyrene. Given that the approximate Prescribed Industrial Waste (Categories C, B and A) volume is 21,100 m^3 and 14 samples have been taken, this gives an approximate fill sampling ratio of 1 sample per 1,500 m^3 and an overall relative low classification confidence (See Section 5.6.3).

The potential for acid generation was tested at eight locations on either fill or shallow Brighton Group sediments at depths of less than 1.5 mbgl. Four locations (two testing fill and two testing Brighton Group) reported potential for acid generation in field tests but not in laboratory tests. It is noted that construction of the Domain station box would entail the cut-and-cover excavation of fill, Brighton Group and Melbourne Formation material and that no Melbourne Formation material has been tested within the precinct for acid generation.

Shallow groundwater is likely to be intercepted during most of the excavation work within this precinct with Domain station box is to be constructed using a cut-and-cover method which would likely induce dewatering and drawdown of the groundwater level in the area. Technical Appendix O *Groundwater* summarises groundwater quality data above various relevant guidelines.

Seven groundwater monitoring wells have been installed within the precinct. Six monitoring wells are installed in the Melbourne Formation (at depths of 14 to 35 mbgl) and one in the Brighton Group (installed at approximately 9 mbgl). The depth to groundwater in these wells varied from 11.7 to 12.7 mbgl in the Melbourne Formation well and 8 mbgl in well installed in the Brighton Group. This is however based on relatively old data (2012-2013).

Total dissolved solids concentrations ranged between 1,600 and 10,000 mg/L in the Melbourne Formation and 1,500 mg/L in the Brighton Group. Petroleum hydrocarbons were detected in MM1-BH020, and chloroform was reported in GA11-BH026. It is noted that GA11-BH027 was not tested for hydrocarbons. One or more of the wells reported metal (arsenic, iron, manganese, molybdenum, nickel, selenium) and inorganic (ammonia, fluoride, sulfate, chloride, magnesium, sodium) concentrations above various guideline values. Given the surrounding land uses, poor quality groundwater may be encountered. Dewatering, treatment and discharge of groundwater during construction and possibly more long term would need further consideration and design.

9.2.2.3 Waste Volumes and Classification

The approximate volumes of Categories A, B and C waste material and potential acid generating material in the station precincts are presented in Section 9.5. These volumes are based on Golder Associates calculations and further information on this is included in Appendix D of this report.

Technical Appendix O *Groundwater* provides further information on groundwater volumes, management, and disposal options.

9.2.2.4 Management of Groundwater: Corrosion

As outlined in Section 5, groundwater quality may impact on various aspects of the project.

Technical Appendix O *Groundwater* and Technical Appendix U *Aquatic Ecology and River Health* provide further detail around specifics of water quality and groundwater extraction. Groundwater results have been reviewed against various corrosion criteria and concluded high concentrations of chloride ions, sulfate and sulfate reducing bacteria may indicate corrosive groundwater conditions at Arden station.

Table C-**0-13** Appendix C provides a summary of results with respect to corrosion.

9.3 Key Issues

The key issues associated with the Concept Design relating to contamination that could arise are identified in Table **9-3** to Table **9-7**.

Table 9-3 Key issues associated with the Arden

Concept Design	Issues	Risk no.
Construction of stations – Arden	Bulk earthworks and spoil generated during excavation construction works	CL043, CL044, CL048, CL049
	Ground gases (methane) encountered during excavation construction works and accumulation in tunnel structures	CL052
	Vapours encountered during excavation construction works and accumulation in tunnel structures	CL054
	Durability issues and impacts on building materials following construction	CL056
	Piling and potential formation of contaminant migration pathways	CL058
	Construction safety and environmental pollution.	CL059

Table 9-4 Key issues associated with the Parkville

Concept Design	Issues	Risk no.
Construction of stations – Parkville	Bulk earthworks and spoil generated during excavation construction works	CL043, CL046, CL048, CL049
	Vapours encountered during excavation construction works and accumulation in tunnel structures	CL054
	Piling and potential formation of contaminant migration pathways	CL058
	Construction safety and environmental pollution.	CL059

Table 9-5 Key issues associated with CBD North

Concept Design	Issues	Risk no.
Construction of stations – CBD North	Bulk earthworks and spoil generated during excavation construction works	CL043, CL046, CL048, CL049
	Groundwater inflow and vapour impacts during construction and operation	CL050
	Vapours encountered during excavation construction works and accumulation in tunnel structures	CL054

Concept Design	Issues	Risk no.
	Piling and potential formation of contaminant migration pathways	CL058
	Construction safety and environmental pollution.	CL059

Table 9-6 Key issues associated with the CBD South

Concept Design	Issues	Risk no.
Construction of stations – CBD South	Bulk earthworks and spoil generated during excavation construction works	CL043, CL046, CL048, CL049
	Piling and potential formation of contaminant migration pathways	CL058
	Construction safety and environmental pollution.	CL059

Table 9-7 Key issues associated with Domain

Concept Design	Issues	Risk no.
Construction of stations – Domain	Bulk earthworks and spoil generated during excavation construction works	CL043, CL048, CL049
	Groundwater inflow and vapour impacts during construction and operation	CL050
	Piling and potential formation of contaminant migration pathways	CL058
	Construction safety and environmental pollution.	CL059

9.4 Benefits and Opportunities

Table **9-8** provides the benefits and opportunities relating to contaminated land and spoil management associated with the stations components of the project.

Table 9-8 Benefits and opportunities associated with Concept Design and alternative design option

Concept Design	Benefits	Opportunities
Construction of the cut-and-cover stations: • Arden station • Parkville station • Domain station	The cut-and-cover station box infrastructure would provide a seal/barrier between potential human receptors (such as maintenance workers) and residual contamination (if any). Maintenance work can then progress safely. Excavation of materials would remove potentially contaminated soils from construction footprint. Depending on the nature of contamination and the waste classification, the potentially contaminated spoil can be disposed of safely to a suitable waste management facility or re-used in accordance with current regulatory standards. Further investigations in advance of construction	Further site investigation required for completion of this project would provide information of the nature and extent of contamination, the ground conditions and the disposition and quality of the groundwater. This could be of benefit if any future public works are to be completed in the area.

Concept Design	Benefits	Opportunities
	would enable decisions to be made to maximise potential re-use options and minimise ultimate disposal. Excavation of the contaminated soils would also: • Provide a higher level of certainty that the contamination would not pose a hazard in the future (as the contamination has been removed) • Provide a higher level of certainty that regulatory buy-in and approval would be met • Be completed in a short time frame • Be completed using practical civil engineering methods • Minimise long-term liabilities (as the sources have been removed) • Avoid long-term monitoring. Residual contamination (if any) at the site would be characterised. This would inform a CMP for the precinct. Future users, maintenance workers, etc. would be able to reference the CMP in order to safely execute any planned maintenance works.	
Construction of the cavern stations: • CBD North station • CBD South station	It is noted that while the cavern construction method would be used for the majority of the station boxes, cut-and-cover methods would be required to provide entry/exit points and therefore similar benefits to those above would be applicable.	Further site investigation required for completion of this project would provide information of the nature and extent of contamination, the ground conditions and the disposition and quality of the groundwater. Making this information publicly available may be of benefit to any future development of the area.

9.5 Impact Assessment

9.5.1 Potential Impacts

The following draft EES evaluation objective and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 9-9 Draft EES Evaluation Objectives and Assessment Criteria

Draft EES evaluation objective	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and	Minimise risks associated with disturbance, transport and disposal of solid wastes from excavation works, including potentially contaminated materials and acid sulfate soils.

Draft EES evaluation objective	Assessment criteria
prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	

Completion of the risk assessment (Section 6 of this report) identified the key issues as noted in Section 9.3. These potential impacts are considered in more detail in the following sections.

9.5.2 Spoil Management

9.5.2.1 General

Around 1,300,000 m^3 of spoil would be generated throughout the construction phases of the works.

Arden

Bulk earthworks at Arden would generate approximately 202,000 m^3 of spoil material. The bulk (about 135,000 m^3) would be natural material and would be classified as clean fill. About 35,000 m^3 of the spoil would be acid sulfate soil (Coode Island Silt). Around 32,000 m^3 of the total material is more than likely to be Prescribed Industrial Waste as this material potentially contains contamination and asbestos.

Parkville

Bulk earthworks at Parkville would generate approximately 299,000 m^3 of spoil material. The bulk (239,000 m^3) would be natural material comprising mostly of weathered Melbourne Formation and would be likely categorised as clean fill. About 35,000 m^3 of the total spoil would be fresh Melbourne Formation with this likely to be found at the base of the excavation. This material would likely be potentially acid sulfate rock. Around 25,100 m^3 would be fill and, as for Arden, more than likely to be Prescribed Industrial Waste as this material potentially contains contamination and asbestos.

CBD North

Bulk earthworks during cavern construction and the access shafts/entrances at CBD North would generate approximately 345,000 m^3 of spoil material. About 187,000 m^3 would be natural material comprising fresh Melbourne Formation or moderately weathered Melbourne Formation; a potential acid sulfate rock. Around 16,000 m^3 of the total material is fill and, as for Arden, more than likely to be Prescribed Industrial Waste. The residual spoil (about 142,000 m^3) would be categorised as clean fill.

CBD South

Bulk earthworks during cavern construction and the access shafts/entrances at CBD South would generate approximately 253,000 m^3 of spoil material. About 168,000 m^3 of this would be natural material comprising weathered Melbourne Formation and would be classified as clean fill. A significant proportion of this material (72,000 m^3) would be from the fresh Melbourne Formation or moderately weathered Melbourne Formation; a potential acid sulfate rock. Around 13,100 m^3 of the total material is fill and, as for Arden, more than likely to be Prescribed Industrial Waste.

Domain

Bulk earthworks at Domain would generate approximately 217,000 m^3 of spoil material. The bulk (196,000 m^3) would be natural material comprising weathered and moderately weathered Melbourne Formation that would be categorised as clean fill. The base of the station box would be well above Fresh Melbourne Formation and thus, this material is unlikely to be potentially acid forming. Around 21,100 m^3 of the total material is fill and, as for Arden, more than likely to be Prescribed Industrial Waste.

This spoil can be broadly categorised as:

- Clean fill – suitable for re-use **(Risk #CL043)**
- Acid sulfate soil – requiring management and off-site disposal **(Risk #CL044)**
- Acid sulfate rock – requiring management and off-site disposal **(Risk #CL046)**
- Prescribed Industrial Waste – requiring management and off-site disposal **(Risk #CL048)**
- Prescribed Industrial Waste incorporating asbestos – requiring management and off-site disposal **(Risk #CL049).**

The key impact for all of these relates to consequential impacts resulting from either underestimating the volumes of spoil and/or incorrectly classifying the spoil. Additional impacts relating to tunnel spoil handling and transport are considered elsewhere (in Technical Appendix D *Transport* and Technical Appendix H *Air Quality*). An assessment of potential impacts is described below.

9.5.2.2 Clean Fill

An estimated 880,000 m^3 of natural soils and rock would be generated during excavation with this material having limited contamination or acid generating potential. Impacts are as per tunnels and portals (Section 7.5.2 and Section 8.5.2).

An initial medium risk has been allocated to **Risk #CL043**. Proposed mitigation measures are described in Section 9.5.2.6. Recommended Environmental Performance Requirements would be required to reduce this impact to low.

9.5.2.3 Acid Sulfate Soil

Approximately 35,000 m^3 Coode Island Silt would require excavation during the excavation of Arden Station. Impacts are as per tunnels and portals (Section 7.5.2 and Section 8.5.2).

An initial high risk has been allocated to **Risk #CL044**. Further proposed mitigation measures to meet the recommended Environmental Performance Requirements would be required to reduce this impact to low.

9.5.2.4 Acid Sulfate Rock

An estimated 294,000 m^3 of fresh or slightly weathered Melbourne Formation would require excavation during the excavation of the stations with some acid sulfate rock generated at all stations except Arden and Domain. Impacts are as per tunnels (Section 7.5.2).

An initial high risk has been allocated to **Risk #CL046**. Further proposed mitigation measures to meet the recommended Environmental Performance Requirements would be required to reduce this impact to low.

9.5.2.5 Prescribed Industrial Waste

About 108,000 m^3 of Prescribed Industrial Waste would be excavated from the stations. Impacts are as per tunnels and portals (Section 7.5.2 and Section 8.5.2). An initial high risk has been allocated to **Risks #CL048** and **#CL049**.

9.5.2.6 Mitigation Measures

With the possible exception of the Arden, there is no obvious re-use option for the clean fill on-site and therefore this spoil would have to be removed off-site. Impacts and associated strategies for dealing with the clean fill and acid sulfate soil and rock spoil has been described in the impact assessment for Tunnels (Section 7.5.2).

Mitigation measures for clean fill and acid sulfate soil and rock are described in Section 7.5.2.

The anticipated volumes of Prescribed Industrial Waste are relatively small compared to the total spoil generated during the project. Current information summarised in the Spoil Management Strategy in Appendix E of this report. There is known capacity in metropolitan Melbourne for receiving Prescribed

Industrial Waste within the greater Melbourne conurbation thereby minimising the impacts arising from the creation of new sites or intensifying the use (see Section 1.4.5). As noted above, fill materials may be contaminated with asbestos. Such soils would be managed in accordance with WorkSafe OHS regulations and EPA's asbestos transport and disposal. The contractor would develop appropriate mitigation measures in accordance with WorkSafe Victoria's requirements.

Mitigation measures would be managed by the contractor by compliance with the SEPPs and a number of EPA guidelines on waste categorisation and the management of waste. Recommended Environmental Performance Requirements have been proposed (Section 7.6.2) requiring the contractor to complete further site investigation, waste categorisation, identification of suitable re-use or disposal facilities and identification of a suitable spoil handling methodology. Further information on uncertainties and further site characterisation can be found in Sections 5.6.4 and 5.6.5 respectively

As noted in Section 1.4.5, temporary stockpile areas would be identified at both the western and eastern portals. Potential environmental impacts and recommended Environmental Performance Requirements are described in Section 8.6. Given the limited room to stockpile material during construction, the temporary stockpile areas are envisaged only to be used for unexpected materials.

Summary

Adopting appropriate mitigation measures such as those set out above to meet the recommended Environmental Performance Requirements outlined in Section 9.5.2 would enable the contractor to reduce residual impacts relating to bulk earthworks **(Risks #CL043, #CL044, #CL046, #CL048** and **#CL049)** to low.

There remain potential impacts with the handling and transportation of the material to the final destination; this may affect the local community and users of nearby facilities and the general amenity of the transportation routes (Refer to Technical Appendix D *Transport* and Technical Appendix H *Air Quality*).

9.5.3 Contaminated Land Management Impacts

9.5.3.1 General

This section considers impacts from:

- Groundwater Inflow and Vapour Impacts
- Ground Gases Encountered During Tunnelling and Accumulation in Tunnel Structures
- Durability

Mitigation measures are described for each of the above and then an overarching mitigation approach is outlined.

9.5.3.2 Groundwater Inflow and Vapour Impacts (Construction and Operation)

Groundwater inflows into CBD North and Domain station structures could occur during both construction and operation (see groundwater impact assessment). The volume of inflow depends on the extent to whether construction methods would be drained or undrained and which the structures are made watertight.

An assessment of risks impacts and strategies for mitigations are similar to those described for the tunnels sections from Parkville to CBD North (Section 7.5.3.2)

A potential impact linkage between source, pathway and receptor has been identified for CBD North and Domain stations). These two stations have been assigned an initial high risk **(Risk #CL050)** and further proposed mitigation measures and recommended to meet the environmental performance requirement (Section 9.6.2). Adoption of these would enable the contractor to reduce residual impacts relating to groundwater inflow **(Risk #CL050)** to low.

9.5.3.3 Ground Gases Encountered During Excavation of the Stations

Disturbance of ground and groundwater during construction may release ground gases such as methane and hydrogen sulfide from naturally occurring Coode Island Silt found at Arden. An assessment of risk impacts and strategies for mitigations are similar to those described for the portals (Section 8.5.3.3) and tunnels sections south of the Yarra River (Section 7.5.3.3).

A potential impact linkage between source, pathway and receptor has been identified. Impacts relate to potential flammability and or asphyxiating properties of methane, and an initial medium risk has been allocated to **Risk #CL052**.

Proposed mitigation measures to meet the recommended Environmental Performance Requirements (Section 9.6.3) have been identified above. Adopting these would enable the contractor to reduce residual impacts relating to ground gases **(Risk #CL052)** to low.

9.5.3.4 Vapours Encountered During Excavation of the Stations

Disturbance of ground and groundwater conditions during construction may cause vapours such as petroleum and solvents to migrate towards features within the project boundary. The sources of volatile organic compounds would be from historic releases of contaminants and could be sourced on and adjacent to the stations. Oils or solvents are the most likely source. There is potential for volatile organic compounds to be encountered in soil and/or groundwater in the vicinity of all the stations. Site investigations confirm the presence of volatile organic compounds in soil and/or groundwater at Arden, Parkville and CBD North stations. If the volatile organic compounds are below ground, construction activity may deflect or modify existing vapour migration routes and thus off-alignment sub-surface impacts may need to be considered (e.g. CBD where large buildings with deep basements are likely).

Vapours could be encountered anywhere during station construction, and may result in a short-term release of vapours and consequential odour generation and associated health and safety issues (e.g. flammability). The method of construction (cut-and-cover and cavern) and provision of air ventilation would largely mitigate any risks to workers and train passengers during operation. In circumstances where vapour concentrations exceed standard work place levels, work could be temporarily suspended.

An assessment of risk impacts and strategies for mitigations are similar to those described for the portals (Section 8.5.3.4). Specific mitigation measures can be incorporated into the construction environmental management and health and safety management plans developed by the contractor. Effects are likely to be transient, but a potential impact linkage between source, pathway and receptor has been identified. Impacts relate to potential toxicity of volatile organic compounds and an initial medium risk has been allocated to **Risk #CL054.** Adopting these would enable the contractor to meet the recommended Environmental Performance Requirements (Section 9.6.3) and reduce residual impacts relating to ground gases to low.

9.5.3.5 Durability

Site investigations have identified raised levels of chlorides and sulfates at Arden station, which is linked to the presence of acid sulfate soils in Coode Island Silt. Disturbance of the Coode Island Silt may introduce oxygen and thus may begin to acidify the sediments in direct contact with concrete lining of the tunnel. Durability issues may arise at Arden station.

An assessment of risks impacts and strategies for mitigations are similar to those described for the western portal (Section 8.5.1) and tunnels sections south of the Yarra River (Section 7.5.3.4).

A potential impact linkage between source, pathway and receptor has been identified for the portals and this has been given an initial medium risk **(Risk #CL056).**

Proposed mitigation measures to meet the recommended Environmental Performance Requirements have been identified Adopting appropriate mitigation measures and meeting the associated recommended

Environmental Performance Requirements (Section 9.6.3) would enable the contractor to reduce residual impacts relating to durability **(Risk #CL056)** to low.

9.5.3.6 Piling and Retaining Walls

Piling and construction of diaphragm walls is likely to occur at some or all stations and would disturb the soils and cause the formation of pathways for contamination to migrate from impacted strata to unimpacted strata or may enable entrained gasses and vapours to be released. Piles are likely to extend through any fill, shallow soils and sediments (particularly Coode Island Silt at Arden station) and into the Melbourne Formation.

An assessment of risks impacts and strategies for mitigations are similar to those described for the portals (Section 8.5.3.6).

A potential impact linkage between source, pathway and receptor has been identified for all the stations and this has been given an initial medium risk **(Risk #CL058)**.

Proposed mitigation measures to meet the recommended Environmental Performance Requirements have been identified, such that residual risks relating to piling **(Risk #CL058)** would be reduced to low.

9.5.3.7 Mitigation

Specific mitigation measures are described in the sections above, covering the particular contaminated land aspects or risk. The general mitigation framework is described in for portals in Section 8.5.3.6.

9.5.4 Construction Safety and Environmental Pollution (Construction)

Construction safety and environmental hazards would be similar to those encountered during the construction of the portals – refer to Section 8.5.4.

Potential health and safety and environmental impacts are possible for all stations and these have been assigned an initial high risk **(Risk #CL059)**.

Further Environmental Performance Requirements have been recommended in Section 9.6.4 and in conclusion, adopting the mitigation measures recommended and appropriate environmental protection requirements would enable the contractor to reduce residual impact relating to contaminated ground and groundwater health safety and environmental pollution issues to low.

9.6 Environmental Performance Requirements

9.6.1 General

Environmental Performance Requirements have been recommended for all the medium and above impacts described in Section 9.5. Three categories of recommended Environmental Performance Requirements have been identified:

- Spoil management
- Contaminated land management
- Health and safety and environmental management.

These three aspects are described below.

9.6.2 Spoil Management

Recommended Environmental performance requirements for spoil management from portals **(Risks #CL043, #CL044, #CL046, #CL048** and **#CL049)** can be found below, with additional recommended Environmental Performance Requirements included in Table 9-10.

General **(all risks)**

- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 2009. Environmental Protection (Industrial Waste Resource) Regulations 2009. SR No. 77/2009
- EPA Victoria 2009. Solid industrial waste hazard categorisation and management. Publication IWRG631
- EPA Victoria 2009. Sampling and analysis of waters, wastewaters, soils and wastes. Publication IWRG701
- EPA Victoria 2009. Soil sampling. Publication IWRG702
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480
- WorkSafe Victoria 2010. Guidance Note Asbestos-contaminated soil
- EPA Victoria 2009. Asbestos transport and disposal. Publication IWRG611.1.

Acid sulfate soil and rock **(Risks #CL044** and **#CL046)**

- EPA Victoria 2009. Acid sulfate soil and rock. Publication 655.1
- State of Victoria 1999. State Environmental Protection Policy, Industrial Waste Management Policy (Waste Acid Sulfate Soils) No S125, Gazette 18/09/1999

Table 9-10 Additional Environmental Performance Requirements – Spoil Management – Tunnels

EPR No.	Environmental Performance Requirements	Risk no.
C1	Prior to construction of main works or shafts, prepare and implement a Spoil Management Plan (SMP) in accordance with MMRA's Spoil Management Strategy and relevant regulations, standards and best practice guidance. The SMP shall be developed in consultation with and to the satisfaction of the EPA. The SMP would include but is not limited to the following: • Applicable regulatory requirements • Identifying nature and extent of spoil (clean fill and contaminated spoil) across all precincts • Roles and responsibilities • Identification of management measures for handling and transport of spoil for the protection of health and the environment • Identification, design and development of specific environmental management plans for temporary stockpile areas • Identifying suitable sites for re-use, management or disposal of any spoil • Monitoring and reporting requirements. • Identifying locations and extent of any Prescribed Industrial Waste and characterising Prescribed Industrial Waste spoil prior to excavation • Identifying suitable sites for disposal of any Prescribed Industrial Waste. • The SMP shall include sub-plans as appropriate, including but not limited to an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan (Refer to C2)	CL043 CL048 CL049

EPR No.	Environmental Performance Requirements	Risk no.
C2	Prepare and implement an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan prior to construction of the project as a Sub-Plan of an overarching SMP in accordance with the Regulations, Standards and best practice guidance and to the satisfaction of EPA. This sub-plan would include the general requirements of the SMP and also: • Identifying locations and extent of any potential ASS/ASR • Characterising ASS/ASR spoil prior to excavation • Identification and implementation of measures to prevent oxidation of ASS/ASR wherever possible • Identifying suitable sites for re-use, management or disposal of any ASS/ASR.	CL044 CL046

9.6.3 Contaminated Land Management

Recommended Environmental Performance Requirements for contaminated land management during tunnel construction **(Risks #CL050, #CL052, #CL054, #CL056** and **#CL058)** can be found below, with additional recommended Environmental Performance Requirements shown in Table 9-11.

General **(All)**

- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 1997. State Environmental Protection Policy (Groundwaters of Victoria), Victoria Government Gazette No S160.
- EPA Victoria 2014. The cleanup and management of polluted groundwater. EPA Publication 840.
- National Environment Protection Council (NEPC), 2013. National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended. Schedule A: Recommended General Process for Assessment of Site Contamination, Canberra, A.C.T.: National Environment Protection Council Service Corporation.

For vapour ingress (**#CL050** and **#CL054)**:

- State of Victoria 2001. State Environment Protection Policy (Air Quality Management) No. S240
- NSW EPA 2012. Guidelines for the Assessment and management of Sites Impacted by Hazardous Gases
- CRC CARE 2013. Petroleum hydrocarbon vapour intrusion assessment: Australian guidance, CRC CARE Technical Report no. 23, CRC for Contamination Assessment and Remediation of the Environment, Adelaide, Australia
- British Standards Institute 2015. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS8485:2015, BSI Standards Ltd, UK.

For ground gases (**#CL052)**:

- British Standards Institute 2013. Guidance on investigations for Ground gas – permanent gases and Volatile Organic Compounds (VOCs). BS8576:2013. BSI Standards Ltd, UK.
- British Standards Institute 2015. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS8485:2015, BSI Standards Ltd, UK.

For durability **(#CL056)**:

- *Australian Standard 2159-2009 Piling – Design and installation*
- Environment Agency (2005). Assessment and Management of Risks to Buildings, Building Materials and Services from Land Contamination. R&D Technical Report P5-035/TR/01
- Environment Agency (2000). Risks of Contaminated Land to Buildings, Building Materials and services. R&D Technical Report P331. Available from The R&D Dissemination Centre, WRc Plc, Swindon, Wiltshire.

For piling **(#CL058)**

- *Australian Standard 2159-2009 Piling – Design and installation*
- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 1997. State Environmental Protection Policy (Groundwaters of Victoria), Victoria Government Gazette No S160.
- EPA Victoria 2014. The cleanup and management of polluted groundwater. EPA Publication 840.1
- Environment Agency (2001) Piling and Penetrative Ground Improvement methods on Land Affected by Contamination: Guidance on Pollution Prevention. Environment Agency National Groundwater and Contaminated Land Centre report NC/99/73.

Table 9-11: Additional Environmental Performance Requirements – Contaminated Land Management - Tunnels

EPR No.	Environmental Performance Requirement	Risk no.
C3	Prior to construction of main works or shafts, undertake a remedial options assessment (ROA) for contaminated land. The assessment must: • Consider the outcomes of further investigations • Interpret of groundwater permeation and VOC result • Present and take account of the outcomes of risk assessments • If required, identify remedial options in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA. If required, as an outcome of the ROA, prepare a remedial action plan and integrate the remediation approach into the design in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA.	CL050 CL054 CL056 CL058

9.6.4 Construction Safety Hazards and Environmental Pollution (Construction)

Recommended Environmental Performance Requirements for contaminated land management during tunnel construction **(Risks #CL059)** can be found below, with additional recommended Environmental Performance Requirements shown in Table 9-12.

- WorkSafe 2005. Contaminated Construction Site – Industry Standard
- WorkSafe (2013). Guide For Tunnelling Work.
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480.
-

Table 9-12: Additional Environmental Performance Requirements – Health, Safety and Environmental Management- Tunnels

EPR No.	Environmental Performance Requirement	Risk no.
C4	Prior to construction of main works or shafts commencing, prepare and implement a health, safety and environmental plan for the management of hazardous substances. The plan must include but not be limited to: • Consideration of the risks associated with exposure to hazardous substances for employees, visitors and general public • The identification of methods to control such exposure in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and the EPA. • Method statements detailing monitoring and reporting	CL059

10 Western Turnback

This section describes the project components, existing conditions, key issues, benefits and opportunities, and findings of the impact assessment for the western turnback component of the Concept Design.

10.1 Project Components

This section describes the components and construction activities that could result in impacts to existing conditions in this precinct.

10.1.1 Infrastructure

Operations of the new Melbourne Metro line would require trains to be turned back on the Sunbury line to run back towards the CBD to service the Dandenong corridor. The Western Turnback would be located at West Footscray and includes the construction of a third platform and track at West Footscray Station and modifications to the existing concourse. The scope for the works includes:

- Realigning regional, suburban and freight lines
- Construction of new track and turnouts
- Construction of a new passenger platform and alterations to the existing concourse.

10.1.2 Construction

The works have a site area of approximately 15,000 m^2 wholly within publicly owned (VicTrack) land.

Construction of the turnback would involve mainly surface and shallow sub-surface excavation within the existing rail easement. Therefore, it is anticipated that limited spoil would be excavated and require off-site disposal prior to the construction of above ground infrastructure.

Shallow groundwater (less than 10 m below surface) may be encountered during construction and infrastructure materials may require protection from corrosive ground conditions. However, it is not anticipated that extensive dewatering would be required (and associated water disposal) during construction or operation.

Dewatering activities are unlikely to be required at the turnback during construction. Further discussion on management and disposal of groundwater can be found in Technical Appendix O *Groundwater*.

10.2 Existing Conditions

10.2.1 Land Use

The current and historic land uses in the vicinity of the turnback is highly variable. Some of the key potentially contaminating land uses are summarised in Table **10-1**.

Table 10-1 Summary of main land uses in the vicinity of the turnback

Location	Notable land use
Western Turnback – West Footscray Station	The Western Turnback is within existing railway land at West Footscray station with Cross Street and residential and recreational land (including Whitten Oval and Lions Park) to the north and to the south across Sunshine Road, a mixture of land uses (such as light to heavy industrial, residential and open park land) to the south.

A review of the history the West Footscray station can be found in (Appendix D of this report). This was completed prior to a change in the precinct boundary in the Project Description. This change is not considered material in the assessment of land use history at the site.

10.2.2 History

Key aspects of the site history are as follows:

- West Footscray station opened in 1888; the station building was rebuilt 200 m west of original location in 2013.
- Rail sidings once connected the Hopkins Odlum/Apex Belting manufacturers site (currently Bunnings Warehouse); a quarry south of the line (likely the current-day Sita Coaches site) and the wool store west of Roberts Road (Goldsbrough Mort and Australian Estate).
- Rail sidings connected to Schult and Barrie Chaff Mill directly south of station in 1917.
- The Olympic Tyre and Rubber site was established in the 1930-40s (and closed in 2001) and located to the immediate north of the station bounded by Cross, Hocking and Barkly Streets and Warleigh Road. Three statutory audits were conducted on the sites prior to redevelopment as a residential estate. Groundwater Quality Restricted Use Zones were determined by EPA and comprised of chlorinated solvent and other hydrocarbon plumes which appear to be migrating in an easterly direction (parallel to the station).
- Whitten Oval was possibly a former rock quarry used by the railways between 1860 and 1866 and subsequently infilled with waste.
- A number of rock quarries were located to the south of the station and the nature and extent of back fill used is unknown and may be a source of contamination. Grain and wool mills, explosives ammunition works (Kynock Explosives factory opened 1911), foundries and agricultural implement manufacturers (Graham Campbell Ferrum and Mitchell and Company respectively) were also present to the south of the station.
- Graingers Road (south of West Footscray station) is listed as an EPA Priority Site as a current chemical storage facility requiring assessment and clean up (now occupied by Colours and Chemicals Pty Ltd).

A review of EPA audit sites within 500 m of the turnback was conducted to gain further information of historic land uses and contamination. In total nine audit sites (five with Groundwater Quality Restricted Use Zones) were identified in the vicinity of the turnback. A number of Groundwater Quality Restricted Use Zones are located off the alignment but are not expected to be mobilised during construction. Some contaminants in groundwater associated with these plumes (chlorinated hydrocarbons in particular) may pose a durability risk to in-ground structures if infrastructure intersects groundwater.

10.2.3 Site Setting

Key aspects of the site setting are as follows:

- Topography of the site is relatively flat ranging from approximately 22 to 25 m AHD and sloping to the east
- The site lies between the Maribyrnong River (1,500 m to the east) and Stony Creek (1,500 m to the west)
- Geology: likely to be fill overlying Newer Volcanic basalt and Tertiary aged Brighton Group sediments. Bedrock is likely to be Silurian age Melbourne Formation, however excavation is not expected to advance beyond the Newer Volcanics
- The water table aquifer is likely to be the Newer Volcanics with groundwater salinity expected to be between 1,01 to 3,500 mg/L TDS (Segment B)
- Depth to groundwater is likely to be between 0 m and 10 m BGL.
- Inferred groundwater flow direction is to be towards the Maribyrnong River.

The following potential contamination risks have been identified:

- Shallow contaminated soils associated with ongoing and history rail use within the precinct boundaries. Contaminants may include metals (particularly arsenic), petroleum hydrocarbons, PCBs, asbestos
- Migration of contaminated groundwater or vapours from former quarries (which may have been fill with contaminating materials) to the west and south of the precinct boundaries. Contaminants may include metals, volatile and semi-volatile petroleum hydrocarbons, nutrients (nitrate, phosphate), pesticides and herbicides
- Migration of contaminated groundwater or vapours from the former Olympic Tyres and Rubber sites to the north of the precinct where known groundwater contamination exists (including metals, chlorinated solvents and volatile and semi-volatile petroleum hydrocarbons).

10.3 Key Issues

The key issues associated with the Concept Design relating to contamination that could arise are identified in Table **10-2**.

Table 10-2 Key issues associated with the western turnback

Concept Design	Issue
West Footscray – a third platform and track at Footscray station, with modifications to existing concourse	• Handling and management associated with bulk earthworks, infilling material and hazardous waste and asbestos containing materials. • Potential impact on the environment from construction-related activities including release of asbestos containing materials, releases of air pollutants (dust, odour and vapours), spills and contamination control and related safety issues to construction workers. • Potential short-term impact on construction materials (including ground stabilising agents such as grout/shotcrete) and long-term impact on infrastructure due to adverse ground conditions (aggressive or corrosive soil, rock or groundwater).

10.4 Benefits and Opportunities

There are no identified benefits and opportunities related to contaminated land and spoil management associated with the western turnback other than potential removal of small volume of legacy contamination in the rail corridor.

10.5 Impact Assessment

10.5.1 Potential Impacts

The following draft EES evaluation objective and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 10-3 Draft EES Evaluation Objectives and Assessment Criteria

Draft EES evaluation objective	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Minimise risks associated with disturbance, transport and disposal of solid wastes from excavation works, including potentially contaminated materials and acid sulfate soils.

Completion of the risk assessment (Section 6 of this report) identified the key issues as noted in Section 11.3. These potential impacts are considered in more detail in the following sections.

10.5.2 Spoil Management

10.5.2.1 General

A small (but as yet unknown) volume of fill would be excavated. This material is more than likely to be Prescribed Industrial Waste as this material potentially contains railway land associated contamination and asbestos. The waste spoil from the western turnback would be categorised and managed and disposed of in the same way as outlined for Prescribed Industrial Waste from the portals (Section 8.6.1).

This spoil can be broadly categorised as:

- Prescribed Industrial Waste – requiring management and off-site disposal **(Risk #CL023)**
- Prescribed Industrial Waste incorporating asbestos – requiring management and off-site disposal **(Risk #CL026)**

10.5.2.2 Mitigation Measures

An initial high risk has been allocated to **Risks #CL023** and **#CL026**. It is assumed that this spoil would have to be removed off-site. Impacts and associated mitigation strategies for dealing with the spoil has been described in the impact assessment for portals (Section 8.5.2). Adopting appropriate mitigation measures such as those to meet the recommended Environmental Performance Requirements outlined in Section 10.6.2 would enable the contractor to reduce residual impacts relating to bulk earthworks (**Risks #CL023** and **#CL026)** to low.

There remain potential impacts with the handling and transportation of the material to the final destination; this may affect the local community and users of nearby facilities and the general amenity of the transportation routes (Refer to Technical Appendix D *Transport* and Technical Appendix H *Air Quality*).

10.5.3 Construction Safety and Environmental Pollution (Construction)

Construction activities and excavation of contaminated ground may lead to impact on worker safety, potential impact on segments of the environment including releases of air pollutants (dust, odour and vapours), spills and contamination control relating to dangerous goods (such as fuels).

Construction safety and environmental hazards would be similar to those encountered during the construction of the portals (Sections 8.5.4) and this has been assigned an initial high risk **(Risk #CL042).** Further Environmental Performance Requirements have been recommended in Section 10.6.3 and in conclusion, adopting the mitigation measures recommended and appropriate environmental protection requirements would enable the contractor to reduce residual impact relating to contaminated ground and groundwater health safety and environmental pollution issues to low.

10.6 Environmental Performance Requirements

10.6.1 General

Environmental Performance Requirements have been recommended for all the medium and above impacts described in Section 10.5. As noted previously, three categories of recommended Environmental Performance Requirements have been identified, although for the western turnback only 2 are relevant:

- Spoil management
- Health and safety and environmental management

These two aspects are described below.

10.6.2 Spoil Management

Recommended Environmental Performance Requirements for spoil management from portals **(Risks #CL023** and **#CL024)** can be found below, with additional recommended Environmental Performance Requirements included in Table10-4.

General **(all risks)**

- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 2009. Environmental Protection (Industrial Waste Resource) Regulations 2009. SR No. 77/2009
- EPA Victoria 2009. Solid industrial waste hazard categorisation and management. Publication IWRG631
- EPA Victoria 2009. Sampling and analysis of waters, wastewaters, soils and wastes. Publication IWRG701
- EPA Victoria 2009. Soil sampling. Publication IWRG702
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480
- WorkSafe Victoria 2010. Guidance Note Asbestos-contaminated soil
- EPA Victoria 2009. Asbestos transport and disposal. Publication IWRG611.1

Table 10-4: Additional Environmental Performance Requirements – Spoil Management - Tunnels

EPR No.	Environmental Performance Requirements	Risk no.
C1	Prior to construction of main works or shafts, prepare and implement a Spoil Management Plan (SMP) in accordance with MMRA's Spoil Management Strategy and relevant regulations, standards and best practice guidance. The SMP shall be developed in consultation with and to the satisfaction of the EPA. The SMP would include but is not limited to the following: • Applicable regulatory requirements • Identifying nature and extent of spoil (clean fill and contaminated spoil) across all precincts • Roles and responsibilities • Identification of management measures for handling and transport of spoil for the protection of health and the environment • Identification, design and development of specific environmental management plans for temporary stockpile areas	CL023 CL024

EPR No.	Environmental Performance Requirements	Risk no.
	• Identifying suitable sites for re-use, management or disposal of any spoil • Monitoring and reporting requirements. • Identifying locations and extent of any Prescribed Industrial Waste and characterising Prescribed Industrial Waste spoil prior to excavation • Identifying suitable sites for disposal of any Prescribed Industrial Waste. • The SMP shall include sub-plans as appropriate, including but not limited to an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan (Refer to C2)	

10.6.3 Construction Safety Hazards and Environmental Pollution (Construction)

Recommended Environmental Performance Requirements for contaminated land management during tunnel construction **(Risks #CL042)** can be found below, with additional Environmental Performance Requirements shown in Table 10-5.

- WorkSafe 2005. Contaminated Construction Site – Industry Standard
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480

Table 10-5: Additional Environmental Performance Requirements – Health, Safety and Environmental Management- Tunnels

EPR No.	Environmental Performance Requirement	Risk no.
C4	Prior to construction of main works or shafts commencing, prepare and implement a health, safety and environmental plan for the management of hazardous substances. The plan must include but not be limited to: • Consideration of the risks associated with exposure to hazardous substances for employees, visitors and general public • The identification of methods to control such exposure in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and the EPA. • Method statements detailing monitoring and reporting	CL042

11 Early Works

This section describes the project components, existing conditions, key issues, benefits and opportunities, and findings of the impact assessment for the Early Works component of the Concept Design.

11.1 Project Components

This section describes the components and construction activities that could result in the impacts to existing conditions in this precinct.

11.1.1 Infrastructure and Construction

The early works required prior to the commencement of the main construction works. Details of the early works as outlined in Chapter 6 of the EES.

Early works would include the following activities associated with utilities:

- Relocation – decommissioning and re-commissioning of utilities
- New permanent utilities – to supply new infrastructure associated with the project
- Temporary connections – new utilities for use during project construction phase.

The scope for the early works includes:

- Decommissioning, removal and replacement of existing underground utilities
- Construction of new underground utilities including cabling for substations
- Demolition of acquired sites (where required) for positioning of construction work sites at:
  - Western portal (Hobson Street) – offices and facilities, laydown areas and materials and equipment storage.
  - Arden station (precinct wide) – major staging area for the Melbourne Metro western section works and would include site offices and staff amenities, fabrication sheds, major storage areas and spoil extraction and handling facilities. A tunnel construction water treatment plant and water tanks, and a tunnel air ventilation and extraction plant, would be located on the site.
  - Parkville station – a temporary work construction site (and acquisition) is to be located at 750 Elizabeth Street (currently housing the City Ford car dealership) and the northern section of University Square.

11.2 Existing Conditions

The land uses and potential contaminating activities for the early works locations are covered in the relevant precinct sections of this report.

The potential volumes and characteristics (spoil quality) of spoil generated from early works activities are not able to be quantified at this stage although the volumes are likely to be small in comparison to the project as a whole.

Shallow fill and natural soils are most likely to be excavated as part of early works would likely be managed in small batches

Shallow or perched groundwater may be encountered during the excavation of some underground services. Therefore, small volumes of groundwater may require management and disposal on an ad hoc basis.

11.3 Key Issues

The key issues associated with the project relating to contamination that could arise are identified in Table 11-1.

Table 11-1 Key issues associated with the Western Turnback

Concept Design	Issue	Risk no.
Construction of Western Turnback	• Bulk earthworks and spoil generated during excavation construction works	CL023 CL026
	• Construction safety and environmental pollution.	CL042

11.4 Benefits and Opportunities

There are no identified benefits or opportunities relating to contaminated land and spoil management associated with early works other than the potential removal of small volumes of legacy contamination and replacement of old underground services such as sewer (and potentially reducing spills from these services).

11.5 Impact Assessment

11.5.1 Potential Impacts

The following draft EES evaluation objective and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 11-2 Draft EES Evaluation Objectives and Assessment Criteria

Draft EES evaluation objective	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Minimise risks associated with disturbance, transport and disposal of solid wastes from excavation works, including potentially contaminated materials and acid sulfate soils.

Completion of the risk assessment (Section 6 of this report) identified the key issues as noted in Section 11.3. These potential impacts are considered in more detail in the following Sections.

11.5.2 Spoil Management

11.5.2.1 General

A small (but as yet unknown) volume of fill would be excavated. This material is more than likely to be Prescribed Industrial Waste as this material potentially contains railway land associated contamination and asbestos. The waste spoil from the early works would be categorised and managed and disposed of in the same way was outlined for Prescribed Industrial Waste from the portals (Section 8.5.2) and the western turnback (Section 10.5.2).

This spoil can be broadly categorised as:

- Prescribed Industrial Waste – requiring management and off-site disposal

- Prescribed Industrial Waste incorporating asbestos – requiring management and off-site disposal.

11.5.2.2 Mitigation Measures

It is assumed that this spoil would need to be removed off-site. Impacts and associated strategies for dealing with the spoil has been described in the impact assessment for portals (Section 8.5.2).

An initial high risk has been allocated to the spoil **(Risks #CL020** and **#CL021)**. Impacts and associated mitigation strategies for dealing with the spoil has been described in the impact assessment for portals (Section 8.5.2). Adopting these mitigation measures to meet the recommended Environmental Performance Requirements (Section 11.6.2) would enable the contractor to reduce residual impacts relating to bulk earthworks (**Risks #CL020** and **#CL021)** to low.

There remain potential impacts with the handling and transportation of the material to the final destination. This may affect the local community and users of nearby facilities and the general amenity of the transportation routes (Refer to Technical Appendix D *Transport* and Technical Appendix H *Air Quality*).

11.5.3 Construction Safety and Environmental Pollution (Construction)

Construction activities and excavation of contaminated ground may lead to impact on worker safety, potential impact on segments of the environment including releases of air pollutants (dust, odour and vapours), spills and contamination control relating to dangerous goods (such as fuels).

Construction safety and environmental hazards would be similar to those encountered during the construction of the portals (Section 8.5.4) and this has been assigned an initial high risk **(Risk #CL036)**. Further Environmental Performance Requirements have been described in Section 11.6.3 and in conclusion, adopting the mitigation measures recommended (Section 8.5.4) and appropriate environmental protection requirements would enable the contractor to reduce residual impact relating to contaminated ground and groundwater health safety and environmental pollution issues to low.

11.6 Environmental Performance Requirements

11.6.1 General

Environmental Performance Requirements have been recommened for all the medium and above impacts described in Section 10.5. As noted previously, three categories of recommended Environmental Performance Requirements have been identified, although for the western turnback only 2 are relevant:

- Spoil management
- Health and safety and environmental management.

These two aspects are described below.

11.6.2 Spoil Management

Recommended Environmental Performance Requirements for spoil management from portals **(Risks #CL023** and **#CL026)** can be found below, with additional recommended Environmental Performance Requirements included in Table 11-3.

<u>General </u>**(all risks)**

- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 2009. Environmental Protection (Industrial Waste Resource) Regulations 2009. SR No. 77/2009
- EPA Victoria 2009. Solid industrial waste hazard categorisation and management. Publication IWRG631

- EPA Victoria 2009. Sampling and analysis of waters, wastewaters, soils and wastes. Publication IWRG701
- EPA Victoria 2009. Soil sampling. Publication IWRG702
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480
- WorkSafe Victoria 2010. Guidance Note Asbestos-contaminated soil
- EPA Victoria 2009. Asbestos transport and disposal. Publication IWRG611.1

Table 11-3: Additional Environmental Performance Requirements – Spoil Management - Tunnels

EPR No.	Environmental Performance Requirement	Risk no.
C1	Prior to construction of main works or shafts, prepare and implement a Spoil Management Plan (SMP) in accordance with MMRA's Spoil Management Strategy and relevant regulations, standards and best practice guidance. The SMP shall be developed in consultation with and to the satisfaction of the EPA. The SMP would include but is not limited to the following: • Applicable regulatory requirements • Identifying nature and extent of spoil (clean fill and contaminated spoil) across all precincts • Roles and responsibilities • Identification of management measures for handling and transport of spoil for the protection of health and the environment • Identification, design and development of specific environmental management plans for temporary stockpile areas • Identifying suitable sites for re-use, management or disposal of any spoil • Monitoring and reporting requirements. • Identifying locations and extent of any Prescribed Industrial Waste and characterising Prescribed Industrial Waste spoil prior to excavation • Identifying suitable sites for disposal of any Prescribed Industrial Waste • The SMP shall include sub-plans as appropriate, including but not limited to an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan (Refer to C2)	#CL023 #CL026

11.6.3 Construction Safety Hazards and Environmental Pollution (Construction)

Recommended Environmental Performance Requirements for contaminated land management during tunnel construction **(Risks #CL038)** can be found below, with additional recommended Environmental Performance Requirements shown in Table 11-4.

- WorkSafe 2005. Contaminated Construction Site – Industry Standard
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480

Table 11-4: Additional Environmental Performance Requirements – Health, Safety and Environmental Management- Tunnels

EPR No.	Environmental Performance Requirement	Risk no.
C4	Prior to construction of main works or shafts commencing, prepare and implement a health, safety and environmental plan for the management of hazardous substances. The plan must include but not be limited to: • Consideration of the risks associated with exposure to hazardous substances for employees, visitors and general public • The identification of methods to control such exposure in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and the EPA. • Method statements detailing monitoring and reporting	CL042

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12 Environmental Performance Requirements

This section provides a comprehensive list of the recommended Environmental Performance Requirements and proposed mitigation measures identified as a result of this impact assessment.

- Table 12-1 summarises the existing recommended Environmental Performance Requirements by potential impact.
- Table 12-2 summarises the mitigation measures
- Table 12-3 summarises the additional recommended Environmental Performance Requirements

Precinct specific summaries are then provided in

- Table 12-4 summarises the requirements for the tunnels
- Table **12-5** summarises the requirements for the portals and turnback
- Table **12-6** summarises the requirements for the stations

Each of the precinct specific tables considers the various performance requirements and mitigation measures. These tables only show medium (●) risks and high (●●) risk aspects.

Existing recommended Environmental Performance Requirements, proposed mitigation measures and recommended Environmental Performance Requirements are indicated in Tables 12-4 to 12-6 based on the “code within Tables 12-1 to 12-3. For example, code “A” in the existing recommended Environmental Performance Requirements column of Table 12-4 refers to:

- State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95
- State of Victoria 2009. Environmental Protection (Industrial Waste Resource) Regulations 2009. SR No. 77/2009
- EPA Victoria 2009. Solid industrial waste hazard categorisation and management. Publication IWRG631
- EPA Victoria 2009. Sampling and analysis of waters, wastewaters, soils and wastes. Publication IWRG701
- EPA Victoria 2009. Soil sampling. Publication IWRG702
- EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480
- WorkSafe Victoria 2010. Guidance Note Asbestos-contaminated soil
- EPA Victoria 2009. Asbestos transport and disposal. Publication IWRG611.1

Table 12-1 Summary of existing Environmental Performance Requirements

Code	Category	Environmental Performance Requirements
A	Spoil management General and Prescribed Industrial Waste	• State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95 • State of Victoria 2009. Environmental Protection (Industrial Waste Resource) Regulations 2009. SR No. 77/2009 • EPA Victoria 2009. Solid industrial waste hazard categorisation and management. Publication IWRG631 • EPA Victoria 2009. Sampling and analysis of waters, wastewaters, soils and wastes. Publication IWRG701 • EPA Victoria 2009. Soil sampling. Publication IWRG702 • EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480 • WorkSafe Victoria 2010. Guidance Note Asbestos-contaminated soil • EPA Victoria 2009. Asbestos transport and disposal. Publication IWRG611.1
B	Spoil management Acid sulfate soil and rock	• EPA Victoria 2009. Acid sulfate soil and rock. Publication 655.1 • State of Victoria 1999. State Environmental Protection Policy, Industrial Waste Management Policy (Waste Acid Sulfate Soils) No S125, Gazette 18/09/1999
C	Contaminated land management General	• State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95 • State of Victoria 1997. State Environmental Protection Policy (Groundwaters of Victoria), Victoria Government Gazette No S160. • EPA Victoria 2014. The cleanup and management of polluted groundwater. EPA Publication 840. • National Environment Protection Council (NEPC), 2013. National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended. Schedule A: Recommended General Process for Assessment of Site Contamination, Canberra, A.C.T.: National Environment Protection Council Service Corporation.
D	Contaminated land management Vapour ingress	• State of Victoria 2001. State Environment Protection Policy (Air Quality Management) No. S240 • NSW EPA 2012. Guidelines for the Assessment and management of Sites Impacted by Hazardous Gases • CRC CARE 2013. Petroleum hydrocarbon vapour intrusion assessment: Australian guidance, CRC CARE Technical Report no. 23, CRC for Contamination Assessment and Remediation of the Environment, Adelaide, Australia • British Standards Institute 2015. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS8485:2015, BSI Standards Ltd, UK
E	Contaminated land management	• British Standards Institute 2013. Guidance on investigations for Ground gas – permanent gases and Volatile Organic Compounds (VOCs).

Code	Category	Environmental Performance Requirements
	For Ground Gases	BS8576:2013. BSI Standards Ltd, UK. • British Standards Institute 2015. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS8485:2015, BSI Standards Ltd, UK
F	Contaminated land management For durability	• *Australian Standard 2159-2009 Piling – Design and installation* • Environment Agency (2005). Assessment and Management of Risks to Buildings, Building Materials and Services from Land Contamination. R&D Technical Report P5-035/TR/01 • Environment Agency (2000). Risks of Contaminated Land to Buildings, Building Materials and services. R&D Technical Report P331. Available from The R&D Dissemination Centre, WRc Plc, Swindon, Wiltshire.
G	Contaminated land management For piling	• *Australian Standard 2159-2009 Piling – Design and installation* • State of Victoria 2002. State Environment Protection Policy (Prevention and Management of Contamination of Land) No. S95 • State of Victoria 1997. State Environmental Protection Policy (Groundwaters of Victoria), Victoria Government Gazette No S160. • EPA Victoria 2014. The cleanup and management of polluted groundwater. EPA Publication 840.1 • Environment Agency (2001) Piling and Penetrative Ground Improvement methods on Land Affected by Contamination: Guidance on Pollution Prevention. Environment Agency National Groundwater and Contaminated Land Centre report NC/99/73
H	Construction Safety Hazards and Environmental Pollution	• WorkSafe 2005. Contaminated Construction Site – Industry Standard • WorkSafe (2013). Guide For Tunnelling Work. • EPA 1996. Environmental Guidelines for Major Construction Sites. Best Practice Environmental Practice. Publication 480

Table 12-2 Summary of proposed mitigation measures

No.	Category	Proposed mitigation measures
M1	Spoil Management	• The collection of additional data (samples) in accordance with EPA IWRG702, IWRG621, IWRG611.1, EPA publication 655.1 and Worksafe Victoria guidelines on asbestos in order to allow for the appropriate in situ categorisation of spoil prior to excavation. The collection and analysis of samples would reduce the level of uncertainty around spoil quality and quantity at the point of generation and allow for forward planning of management and disposal options • Engagement with EPA licensed waste disposal and soil treatment facility operators located within a feasible distance from the CBD to identify potential Prescribed Industrial Waste disposal and/or treatment sites • Provide requirements for work site monitoring, material (spoil) tracking, work site environmental management, identify roles and responsibilities and

No.	Category	Proposed mitigation measures
		provide contingency measures to account for: – larger than anticipated volumes or levels of contamination – transport to the wrong disposal/treatment facility – delay in removal of spoil from site (for example, truck breakdown) – emergency measures in the case of a spill or release (or any other unexpected event.
M2	Contaminated land management	• The collection of additional data (samples) in accordance with NEPM, AS4482.1 and AS4482.2 and EPA Publications 668 and 840.1 (the cleanup and management of polluted groundwater) in order to appropriately characterise the nature and extent of contamination to allow for the appropriate design and mitigation measures to be put in place prior to excavation. • The collection and analysis of samples would reduce the level of uncertainty around contaminant nature and extent and be used to conduct a human health or environmental risk assessment if required • Based on additional sampling and risk assessment results, remediation may be required. This may be in the form of treatment of materials to reduce the level of contamination (such as in situ chemical or physical treatment of contaminants) or engineering or design controls to reduce the exposure pathway (such as vapour barriers)
M3	Health, safety and environmental protection	• Identification of chemicals or other hazardous substances in the work space (directly or indirectly) • Assess risks • Determine how to prevent or control exposure • Ensure controls measures are used • Monitor exposure • Undertake appropriate health surveillance • Prepare plans and procedures to deal with emergencies and accidents • Ensure employees are properly informed, trained and supervised

Table 12-3: Summary of additional Environmental Performance Requirements

EPR No.	Environmental Performance Requirements
C1	Prior to construction of main works or shafts, prepare and implement a Spoil Management Plan (SMP) in accordance with MMRA's Spoil Management Strategy and relevant regulations, standards and best practice guidance. The SMP shall be developed in consultation with and to the satisfaction of the EPA. The SMP would include but is not limited to the following: • Applicable regulatory requirements • Identifying nature and extent of spoil (clean fill and contaminated spoil) across all precincts • Roles and responsibilities

EPR No.	Environmental Performance Requirements
	• Identification of management measures for handling and transport of spoil for the protection of health and the environment • Identification, design and development of specific environmental management plans for temporary stockpile areas • Identifying suitable sites for re-use, management or disposal of any spoil • Monitoring and reporting requirements. • Identifying locations and extent of any Prescribed Industrial Waste and characterising Prescribed Industrial Waste spoil prior to excavation • Identifying suitable sites for disposal of any Prescribed Industrial Waste. The SMP shall include sub-plans as appropriate, including but not limited to an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan (Refer to C2)
C2	Prepare and implement an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan prior to construction of the project as a Sub-Plan of an overarching SMP in accordance with the Regulations, Standards and best practice guidance and to the satisfaction of EPA. This sub-plan would include the general requirements of the SMP and also: • Identifying locations and extent of any potential ASS/ASR • Characterising ASS/ASR spoil prior to excavation • Identification and implementation of measures to prevent oxidation of ASS/ASR wherever possible • Identifying suitable sites for re-use, management or disposal of any ASS/ASR.
C3	Prior to construction of main works or shafts, undertake a remedial options assessment (ROA) for contaminated land. The assessment must: • Consider the outcomes of further investigations • Interpret of groundwater permeation and VOC result • Present and take account of the outcomes of risk assessments • If required, identify remedial options in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA. If required, as an outcome of the ROA, prepare a remedial action plan and integrate the remediation approach into the design in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA.
C4	Prior to construction of main works or shafts commencing, prepare and implement a health, safety and environmental plan for the management of hazardous substances. The plan must include but not be limited to: • Consideration of the risks associated with exposure to hazardous substances for employees, visitors and general public • The identification of methods to control such exposure in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and the EPA • Method statements detailing monitoring and reporting.

Table 12-4 Summary of Environmental Performance Requirements – tunnels

Risk no.	Impact category	Impact - event	Project phase	Tunnels Sector						Existing Environmental Performance Requirements (Table 12-1)	Proposed mitigation measures (Table 12-2)	Additional Environmental Performance Requirements (Table 12-3)
				Western portal to Arden station	Arden station to Parkville station	Parkville station to CBD North station	CBD North station to CBD South station	CBD South station to Domain station	Domain station to Eastern portal			
#CL001	Spoil management	Increased volumes and / or incorrect classification of 'Clean Fill' leading to inappropriate re-use.	Construction	●	●	●	●	●	●	A	M1	C1
#CL002	Spoil management	Increased volumes of natural acid sulfate soils (Coode Island Silts and Brighton Group), requiring management / off-site disposal.	Construction	□	□	□	□	●●	□	A and B	M1	C2
#CL005	Spoil management	Increased volumes and / or incorrect classification of natural potential acid sulfate rock, requiring management / off-site disposal.	Construction	□	□	●●	●●	●●	●●	A and B	M1	C2
#CL006	Spoil management	Increased volumes and / or incorrect classification of natural potential acid sulfate rock, requiring management / off-site disposal.	Construction	●	□	□	□	□	□	A and B	M1	C2

Risk no.	Impact category	Impact - event	Project phase	Tunnels Sector						Existing Environmental Performance Requirements (Table 12-1)	Proposed mitigation measures (Table 12-2)	Additional Environmental Performance Requirements (Table 12-3)
				Western portal to Arden station	Arden station to Parkville station	Parkville station to CBD North station	CBD North station to CBD South station	CBD South station to Domain station	Domain station to Eastern portal			
#CL008	Contaminated land management	If groundwater is contaminated with VOCs, inflows may result in raised levels of vapours in the tunnel atmosphere resulting in increased impact on human health.	Construction and Operation	□		●	□	□	●	C and D	M2	C3
#CL010	Contaminated land management	Disturbance of ground gases and migration and accumulation in tunnels	Construction and Operation	●	□	□	□	●	□	C & E	M2	C3
#CL013	Contaminated land management	Impact on durability of building and construction materials	Operation	●	□	□	□	●	□	C & F	M2	C3
#CL015	Construction safety hazards	Potential impact to worker safety	Construction	●●	●●	●●	●●	●●	●●	H	M3	C4

Table 12-5 Summary of Environmental Performance Requirements – portals and above ground features

Risk no.	Impact - category	Impact - event	Project phase	Portal (or turnback)			Existing Environmental Performance Requirements (Table 12-1)	Proposed mitigation measures (Table 12-2)	Additional Environmental Performance Requirements (Table 12-3)
				Eastern portal	Western portal	Western Turnback			
#CL016	Spoil management	Increased volumes and / or incorrect classification of 'Clean Fill' leading to inappropriate re-use.	Construction	●	●	□	A	□□	C1
#CL018	Spoil management	Increased volumes of natural acid sulfate soils (Coode Island Silts), requiring management / off-site disposal.	Construction	●●	□	□	A and B	M1	C2
#CL021	Spoil management	Inappropriate handling, stockpiling and/or treatment of contaminated spoil may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Cat C or fill.	Construction	●●	□	□	A	M1	C1
#CL022	Spoil management	Inappropriate handling, stockpiling and/or treatment of contaminated spoil may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Cat C or fill.	Construction	□	●●	□	A	M1	C1
#CL023	Spoil management	Inappropriate handling, stockpiling and/or treatment of contaminated spoil may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Cat C or fill.	Construction	□	□	●●	A	M1	C1

Risk no.	Impact - category	Impact - event	Project phase	Portal (or turnback) Eastern portal	Western portal	Western Turnback	Existing Environmental Performance Requirements (Table 12-1)	Proposed mitigation measures (Table 12-2)	Additional Environmental Performance Requirements (Table 12-3)
#CL024	Spoil management	Inappropriate handling, stockpiling and/or treatment of asbestos containing materials may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Cat C or fill.	Construction	●●	□	□	A	M1	C1
#CL025	Spoil management	Inappropriate handling, stockpiling and/or treatment of asbestos containing materials may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Cat C or fill.	Construction	□	●●	□	A	M1	C1
#CL026	Spoil management	Inappropriate handling, stockpiling and/or treatment of asbestos containing materials may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Cat C or fill.	Construction	□	□	●●	A	M1	C1
#CL027	Contaminated land management	If groundwater is contaminated with VOCs, inflows may result in raised levels of vapours in the tunnel atmosphere resulting in increased impact on human health	Construction and Operation	●	□	□	C and D	M2	C3
#CL030	Contaminated land management	Disturbance of ground gases and migration and accumulation in tunnels	Construction and Operation	●	□	□	C and E	M2	C3

Risk no.	Impact - category	Impact - event	Project phase	Portal (or turnback)			Existing Environmental Performance Requirements (Table 12-1)	Proposed mitigation measures (Table 12-2)	Additional Environmental Performance Requirements (Table 12-3)
				Eastern portal	Western portal	Western Turnback			
#CL033	Contaminated land management	Disturbance of vapours and migration and accumulation in tunnels	Construction and Operation	●	□	□	C and D	M2	C3
#CL036	Contaminated land management	Impact on durability of building and construction materials	Operation	●	□	□	C and F	M2	C3
#CL039	Contaminated land management	Piling may disturb ground and cause the formation of pathways for contamination to migrate from impacted strata to un-impacted strata or may enable entrained gasses and vapours to be released.	Construction	●	□	□	C and G	M2	C3
#CL040	Contaminated land management	Piling may disturb ground and cause the formation of pathways for contamination to migrate from impacted strata to un-impacted strata or may enable entrained gasses and vapours to be released.	Construction	□	●	□	C and G	M2	C3
#CL042	Construction safety hazards	Potential impact to worker safety	Construction	●●	●●	●●	H	M3	C4

Table 12-6 Summary of Environmental Performance Requirements – stations

Risk no.	Impact - category	Impact - event	Project phase	Station					Existing Environmental Performance Requirements (Table 12-1)	Proposed mitigation measures (Table 12-2)	Additional Environmental Performance Requirements (Table 12-3)
				Arden	Parkville	CBD North	CBD South	Domain			
#CL043	Spoil management	Increased volumes and / or incorrect classification of 'Clean Fill' leading to inappropriate re-use.	Construction	●	●	●	●	●	A	M1	C1
#CL044	Spoil management	Increased volumes of natural acid sulfate soils (Coode Island Silts and Brighton Group), requiring management / off-site disposal.	Construction	●●	□	□	□	□	A and B	M1	C2
#CL046	Spoil management	Increased volumes and / or incorrect classification of natural potential acid sulfate rock, requiring management / off-site disposal.	Construction	□	●●	●●	●●	□	A and B	M1	C2
#CL048	Spoil management	Inappropriate handling, stockpiling and/or treatment of contaminated spoil may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Cat C or fill.	Construction	●●	●●	●●	●●	●●	A	M1	C1

Risk no.	Impact - category	Impact - event	Project phase	Station					Existing Environmental Performance Requirements (Table 12-1)	Proposed mitigation measures (Table 12-2)	Additional Environmental Performance Requirements (Table 12-3)
				Arden	Parkville	CBD North	CBD South	Domain			
#CL049	Spoil management	Inappropriate handling, stockpiling and/or treatment of asbestos containing materials may lead to adverse impacts on the environment, human health and social impacts. Of particular relevance to Category A and B waste as options for disposing of these wastes are more limited that with Cat C or fill.	Construction	●●	●●	●●	●●	●●	A	M1	C1
#CL050	Contaminated land management	If groundwater is contaminated with VOCs, inflows may result in raised levels of vapours in the tunnel atmosphere resulting in increased impact on human health	Construction and Operation	□	□	●	□	●	C and D	M2	C3
#CL052	Contaminated land management	Disturbance of ground gases and migration and accumulation in tunnels	Construction and Operation	●	□	□	□	□	C and E	M2	C3
#CL054	Contaminated land management	Disturbance of vapours and migration and accumulation in tunnels	Construction and Operation	●	●	●	□	□	C and D	M2	C3
#CL056	Contaminated land management	Impact on durability of building and construction materials	Operation	●	□	□	□	□	C and F	M2	C3

Risk no.	Impact - category	Impact - event	Project phase	Station: Arden	Station: Parkville	Station: CBD North	Station: CBD South	Station: Domain	Existing Environmental Performance Requirements (Table 12-1)	Proposed mitigation measures (Table 12-2)	Additional Environmental Performance Requirements (Table 12-3)
#CL058	Contaminated land management	Piling may disturb ground and cause the formation of pathways for contamination to migrate from impacted strata to un-impacted strata or may enable entrained gasses and vapours to be released.	Construction	●	●	●	●	●	C and G	M2	C3
#CL059	Construction safety hazards	Potential impact to worker safety	Construction	●●	●●	●●	●●	●●	H	M3	C4

13 Conclusion

The assessment addresses the specified EES Scoping Requirements and specifically evaluates potential impacts to contaminated land and spoil management based on the assessment criteria.

The focus for the assessment is to:

- Identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil in accordance with relevant best practice principles
- Minimise risks associated with disturbance, transport and disposal of solid wastes from excavation works, including potentially contaminated materials and acid sulfate soils.

The main potential adverse impacts due to Melbourne Metro encountering contaminated land are expected to occur during the construction phase. These short-term impacts would arise primarily from disturbing contaminated soil, potential and actual acid sulfate soil, hazardous gases and vapours, and contaminated groundwater.

13.1 Bulk Earthworks and Spoil Management

The largest potential environmental impacts relevant to contaminated land are associated with the generation, handling, storage, treatment and disposal (and or re-use) of spoil.

Spoil generated by bulk earthworks during tunnelling and excavations of the station boxes, portals and decline structures requires consideration of the nature and extent of contamination to inform the waste classification which then influences how excess material can be managed, re-used or disposed. The project would encounter and disturb both natural and fill (anthropogenic) materials that, once excavated, would become spoil comprising:

- Natural materials including:
  - Natural clean fill – uncontaminated material (i.e. the bulk of the non-acidic material).
  - Natural acid sulfate soils – predominantly Coode Island Silt found in western portal, Arden and below the River Yarra
  - Natural potentially acid-forming rock – associated with Melbourne Formation at depth
- Fill materials include:
  - Clean fill – uncontaminated material of anthropogenic origin.
  - Prescribed Industrial Waste – fill material containing a wide variety of contaminants typically found in old infill within the Metropolitan Melbourne area. No significantly raised levels of contamination were identified and no discrete areas of higher contamination noted. Levels of contamination would not preclude the beneficial use of the land (as a metropolitan railway).
  - Prescribed Industrial Waste – fill containing asbestos containing materials.

Volumes of spoils are large (Table **13-1**).

Table 13-1 Indicative spoil quantities by location and type

Location	Contaminated Spoil (Category A, B & C PIW)[2,3]				WASS[4]		Clean Fill' Material[5]	Subtotal (Natural)[6]	Total[7]
	Category A	Category B	Category C	Total PIW	PASS / ASS	ASR			
Tunnels									
Tunnel – Western Site (Arden)					1,000	12,000	185,000	198,000	**198,000**
Tunnel – Parkville to CBD North						72,000	7,000	79,000	**79,000**
Tunnel – CBD Mined						62,000	31,000	93,000	**93,000**
Tunnel – CBD South to Domain					11,000		95,000	106,000	**106,000**
Tunnel – Eastern Site (Domain/ Fawkner Park)						63,000	74,000	137,000	**137,000**
Subtotals	0	0	0	0	12,000	209,000	392,000	613,000	613,000
Portals									
Western Portal	900	4,500	12,600	18,000	1,000		38,000	39,000	**57,000**
Eastern Portal	200	1,400	6,300	7,900			39,300	39,300	**47,200**
Subtotals	1,100	5,900	18,900	25,900	1,000	0	77,300	78,300	104,200
Stations									
Arden station	6,400	6,400	19,200	32,000	35,000		135,000	170,000	**202,000**
Parkville station		1,300	23,800	25,100		35,000	239,000	274,000	**299,100**
CBD North station	400	2,800	12,800	16,000		187,000	142,000	329,000	**345,000**
CBD South station	400	2,300	10,400	13,100		72,000	168,000	240,000	**253,100**

Location	Contaminated Spoil (Category A, B & C PIW)[2,3]				WASS[4]		Clean Fill' Material[5]	Subtotal (Natural)[6]	Total[7]
Domain station	7,400	7,400	6,300	21,100			196,000	196,000	**217,100**
Subtotals	14,600	20,200	72,500	107,300	35,000	294,000	880,000	1,209,000	1,316,300
Subtotal	**15,700**	**26,100**	**91,400**	**133,200**	**48,000**	**503,000**	**1,349,300**	**1,900,300**	
Grand Total[8]									**2,033,500**

NOTES:

1. Data Source: AJM JV Spoil Management Strategy (SMS) Report V3.
2. Contaminated spoil as defined as Prescribed Industrial Waste in the EPA Industrial Waste Resource Guidelines 2009.
3. Contaminated spoil may also contain asbestos.
4. Waste Acid Sulfate Soils (WASS) comprise Potential Acid Sulfate Soils (PASS), Acid Sulfate Soils (ASS) and Acid Sulfate Rock (ASR).
5. 'Clean Fill' volumes calculated as balance of Total natural spoils and WASS
6. Total volumes of natural material taken from Golder Associates
7. Quantities differ slightly to those calculated by Advisian.
8. Spoil quantities are instu (dense) volumes.

Following the MMRA Spoil Management Hierarchy, waste would be managed as follows:

- Avoidance. Limited scope other than minimising the volume of materials to be excavated, employment of vertical retaining walls rather than benching, etc.
- Re-use/recycling/recovery. There is no obvious re-use option for this material onsite and the spoil would therefore have to be removed off site for re-use or managed as a waste. Residual clean fill would be directed for re-use, subject to finding a suitable site(s) that satisfies a number of criteria. Further testing by the contractor would be required to determine the final waste classification in accordance with EPA regulations and guidelines. The testing regime can be guided by the existing soils data, but would depend on the final excavation volumes. The re-use of this material would be a positive outcome for the project.
- Treatment at off-site facility/containment. Natural acid sulfate soils would be managed in accordance with EPA guidelines on acid sulfate soil and rock with the off-site management in accordance with the Industrial Waste Management Policy (Waste Acid Sulfate Soils). Prevention of acid sulfate soil oxidation is the preferred management option. This could involve strategic infilling of excavations below the water table, or the addition of lime to neutralise potential acid generation. Any off-site facility accepting the ASS would need to have an EPA approved Environmental Management Plan in place. Further testing and optioneering by the contractor would determine the most effective management option.

  Natural potentially acid sulfate rock (Melbourne Formation) would be managed in accordance with EPA guidelines on acid sulfate soil and rock. Any off-site facility accepting the acid sulfate soil and rock would need to have an EPA approved EMP in place. Further testing and optioneering by the contractor would determine the most effective management option.
- Disposal at landfill or licenced facility.133,200 m^3 of the total material would be fill from historic infilling with this material potentially containing contamination and asbestos. The wastes should be separated as far as reasonably practicable into the following waste streams:
  - Categories A, B and C waste would be disposed of at facilities licenced to accept the waste or to a treatment facility that can reduce the concentrations of contaminant prior to disposal. The anticipated waste volumes are expected to be accommodated within the parameters of existing licences at existing facilities within the greater Melbourne conurbation, thereby minimising the impacts arising

from the creation of new sites or intensifying the use. Whilst off-site disposal is considered the least desirable waste management option for the residual waste, given the limited options for on-site re-use, disposal of this spoil to landfill is acceptable. Most environmental impacts of waste management and landfilling relate to the disposal of municipal putrescible waste, and thus disposing of a relatively small volume of contaminated soil is unlikely to lead to a significant additional impact.

Further testing by the contractor would be required to determine the final waste classification in accordance with EPA regulations and guidelines. The testing regime can be guided by the existing soils data, but would depend on the final excavation volumes.

- Spoil with asbestos-containing materials would be managed in accordance with WorkSafe OH&S regulations and EPA's Asbestos Transport and Disposal. The contractor would develop appropriate mitigation measures in accordance with WorkSafe Victoria's requirements.. Residual clean fill would be managed as per clean fill above.

In summary, the management and safe disposal of potentially large volumes of natural and infill materials (including residual clean fill, contaminated spoil and acid sulfate soils and rock) would be a significant logistical issue for Melbourne Metro. However, the scope of the spoil management activities required is considered manageable and there is available capacity for spoil disposal within reasonable accessibility of the CBD (refer to the Spoil Management Strategy in Technical Appendix Q Contaminated Land and Spoil Management). Traffic impacts and mitigation measures for the haulage of spoil to disposal locations have been assessed as adequate (see Technical Appendix D Transport).

13.2 Contaminated Land Impacts

In addition to spoil and spoil management, the following potential contaminated land impacts were identified:

- Contaminated groundwater and vapour ingress. Understanding the nature and disposition of any groundwater plumes contaminated with volatile chemicals is required in advance of any construction and plumes may originate on the site or can migrate into the project boundary from off-site
- Ground gases and vapours. In a similar way to groundwater, any ground gases such as methane or volatile contaminants (such as solvents), may also move from sources towards the surface or other sub-surface structures of the Melbourne Metro. If vapours accumulate, this could lead to risks associated with the accumulation of ground gases and vapours
- Aggressive ground and groundwater conditions and building material durability. Certain chemicals or ground and groundwater conditions are incompatible with modern building materials (such as acidic conditions potentially present in Coode Island Silt)
- Piling, retaining walls and deep excavation. If piles, diaphragm walls or deep excavations are planned during the construction of embankments or as retention walls for the station boxes, this may introduce pathways for contaminant migration or mobilisation
- Safety. Contaminated sites can be hazardous to worker health. The principal route of exposure is via inhalation, with construction workers also potentially at risk from direct or dermal contact. Other chemicals can have physical effects such as flammability.

Potential impacts would be managed as follows:

- Minimise, as far as reasonably practicable, disturbance of groundwater contaminated with volatile organic compounds. Groundwater would need to be managed in accordance with the SEPP (Groundwaters of Victoria), and a number of EPA publications, and if required, vapour barriers would be incorporated into the design of structures.
- Minimise, as far as reasonably practicable, disturbance of gas/vapour contaminated soils. These materials shall be managed in accordance with the SEPP (Air Quality Management) and a number of Australian and UK guidance documents. A key management measure would include further investigation by the contractor prior to construction and preparation of management actions/designs to mitigate any residual impacts

- The contractor shall manage potential contamination related durability impacts (to structural materials) in accordance with Australian Standards. Further site investigations would be completed by the contractor prior to construction to assess ground conditions in areas likely to have aggressive ground conditions
- Select piling and retaining wall techniques that minimise, as far as reasonably practicable, disturbance of contaminated soils. Any structures, piles and the like would also need to take into account potential aggressive ground conditions in accordance with the *Australian Standard (2009) Piling – Design and installation*. Further site investigations would be completed by the contractor prior to construction to assess ground conditions in the areas where piling may take place (such as western portal). This data would then be used by the contractor to assess piling techniques and materials and to prepare suitable method statements describing the particular mitigation solutions
- The implementation of processes and measures to manage contaminated soil, groundwater and gas, that comply with WorkSafe, EPA, NEPM, the relevant SEPPs and Industrial Waste Resource Guides. Management measures would involve the development of health and safety and contamination management plans by the contractor prior to construction.

13.3 Environmental Performance Requirements

Before construction commences, management measures and options would be investigated further to determine the best approaches to avoid disturbing sources of contamination (including the use of construction techniques and materials), pre-classifying fill material and identifying suitable sites for the receipt, management or re-use of spoil generated during the construction of Melbourne Metro.

General Environmental Performance Requirements relating to regulatory requirements, policy, standards and best practice have been recommended covering:

- General spoil management including Prescribed Industrial Waste
- Acid sulfate soil and rock
- General contaminated land management
- Vapour ingress
- Durability
- Piling
- Health, safety and environmental protection.

Additional recommended Environmental Performance Requirements have been identified and are summarised in Table 13-2.

Table 13-2: Additional Environmental Performance Requirements

EPR no.	Environmental Performance Requirements
C1	Prior to construction of main works or shafts, prepare and implement a Spoil Management Plan (SMP) in accordance with MMRA's Spoil Management Strategy and relevant regulations, standards and best practice guidance. The SMP shall be developed in consultation with and to the satisfaction of the EPA. The SMP would include but is not limited to the following: • Applicable regulatory requirements • Identifying nature and extent of spoil (clean fill and contaminated spoil) across all precincts • Roles and responsibilities • Identification of management measures for handling and transport of spoil for the protection of health and the environment • Identification, design and development of specific environmental management plans for temporary stockpile areas

EPR no.	Environmental Performance Requirements
	• Identifying suitable sites for re-use, management or disposal of any spoil • Monitoring and reporting requirements • Identifying locations and extent of any Prescribed Industrial Waste and characterising Prescribed Industrial Waste spoil prior to excavation • Identifying suitable sites for disposal of any Prescribed Industrial Waste. The SMP shall include sub-plans as appropriate, including but not limited to an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan (Refer to C2)
C2	Prepare and implement an Acid Sulfate Soil and Rock (ASS/ASR) Management Sub-Plan prior to construction of the project as a Sub-Plan of an overarching SMP in accordance with the Regulations, Standards and best practice guidance and to the satisfaction of EPA. This sub-plan would include the general requirements of the SMP and also: • Identifying locations and extent of any potential ASS/ASR • Characterising ASS/ASR spoil prior to excavation • Identification and implementation of measures to prevent oxidation of ASS/ASR wherever possible • Identifying suitable sites for re-use, management or disposal of any ASS/ASR.
C3	Prior to construction of main works or shafts, undertake a remedial options assessment (ROA) for contaminated land. The assessment must: • Consider the outcomes of further investigations • Interpret of groundwater permeation and VOC result • Present and take account of the outcomes of risk assessments • If required, identify remedial options in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA. If required, as an outcome of the ROA, prepare a remedial action plan and integrate the remediation approach into the design in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of EPA.
C4	Prior to construction of main works or shafts commencing, prepare and implement a health, safety and environmental plan for the management of hazardous substances. The plan must include but not be limited to: • Consideration of the risks associated with exposure to hazardous substances for employees, visitors and general public • The identification of methods to control such exposure in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and the EPA • Method statements detailing monitoring and reporting.

13.4 Summary

This assessment found a number of environmental impacts that are typical of a large-scale infrastructure project constructed in an urban setting. The impact assessment found that Melbourne Metro would be consistent with the draft EES evaluation objectives as it would prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and manage excavation of spoil and other waste in accordance with relevant best practice principles.

Where possible, clean fill would be re-used at suitable locations off-site subject to the material complying with a number of re-use requirements. Potentially acidic soils and rock would be removed off site to approved locations and subject to treatment and/or management. At the time of writing this impact assessment, there is sufficient capacity in metropolitan Melbourne and surrounds to take this material.

A relatively small volume of solid Prescribed Industrial Waste (contaminated soils and asbestos-containing material) would be generated. Subject to further assessment and classification, this waste would be disposed of to a licenced facility. At the time of writing this impact assessment, there is sufficient capacity in metropolitan Melbourne and surrounds to take this material.

Potential issues relating to disturbance of contaminated land and groundwater have been identified associated with groundwater infiltration and vapour impacts, ground gas and vapour permeation into tunnel and station structure, impact of piling and retaining wall construction and potential durability impacts on construction materials. Potential impacts were identified and performance requirements and measures set out. In all cases, before construction commences, management measures and options would be investigated further to determine the best approaches to avoid disturbing sources of contamination (including the use of construction techniques and materials), the first step would require the contractor to complete further investigations to determine the nature of the impact and implications to the project. Further remediation and or management designs would then be completed if required.

Adopting the recommended mitigation measures would enable the Contractor to meet the recommended Environmental Performance Requirements and would ensure that disturbance and the impacts from disturbance are minimised in accordance with relevant best practice principles.

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