soil are below risk-based theoretically-derived criteria and are managed appropriately.

Risk-based criteria for soil concentrations have been developed using the Johnson and Ettinger (1991) one-dimensional analytical model to determine theoretical values that would apply to soil at depths below 1.5m based on a potential to generate vapours at levels that would pose a risk to future site users. The depths that the model was applied correspond to 2.5m, 4.0m and 8.0m below the ground surface.

The generation of vapours from residual sources below 8m depth may present a potential risk; however, the risk is considered low and no specific risk-based criteria were developed given the factors outlined below:

- residual source material at or below 8m depth would be managed by implementing a long term Environmental Management Plan (EMP);
- vertical migration of vapours is expected to be restricted in the pore spaces of compacted backfill material, which would limit migration to the ground surface;
- there will exist considerable spatial distance between residual source and human receptors (i.e. at least 8m);
- there will be a limitation on constructing basement structures on the Site (as indicated by RailCorp and to be documented in the EMP), therefore there will be a low potential for vapours to accumulate in underground structures; and
- perched groundwater would intercept vertically migrating vapours, effectively trapping vapours below the perched groundwater.

The adopted risk-based criteria for contaminants of concern are summarised in Table 4.1.

Appendix B provides a summary of the technical approach to developing these criteria, including the rationale for selecting specific contaminants (e.g. whether they are sufficiently toxic and/or sufficiently volatile).

4.1.3 Protecting Groundwater from Ongoing Impacts

As part of the soil remediation strategy, prevention or minimising further migration of contaminants from source materials to groundwater will be a beneficial outcome of soil remediation. The source material in the Tar Wells, the Northern Gasholder, old gasworks pipes and residual contaminants in soil (pores) is likely to be acting as a source for continued contamination of groundwater.

To remedy this scenario, the NSW DEC Groundwater Guidelines (March 2007) provides guidance on a remedial strategy to affect contamination source removal as a strategy to manage contaminated groundwater. This strategy is documented in the guidelines under section 3.5 – *Source Control*. These guidelines provide specific actions that should be undertaken to affect source control. Specifically, the following actions can be applied to the Site:

- Non-Aqueous Phase Liquid (NAPL) must be cleaned up to the extent practicable; and

- Contaminated soils should be remediated to remove the potential risks to groundwater quality, considering the leaching potential of contaminants from soil to groundwater, and that HILs do not take groundwater protection into account.

Of particular importance at the Site is control of tar material (i.e. the NAPLs). Therefore, it can be said that the remedial strategy is one that will affect tar removal to the extent practicable. And following the guidance provided in the Groundwater Guidelines, the remedial strategy should meet the following remedial goals:

- facilitate the protection of human and ecological health against tar impacts;
- reduce the migration of contaminants from subsurface tar to groundwater; and
- reduce tar mass to the extent practicable.

Managing groundwater contamination is discussed further in **Section 5.6**.

Considering the above, the approach to protect groundwater from ongoing impacts will be based on the remedial strategy to affect tar removal to the extent practicable. No specific risk-based criteria will be adopted to validate soil materials at depth on the basis of protecting groundwater. Potential impacts to groundwater will be addressed by implementing a program of Monitored Natural Attenuation (MNA) as part of the long term EMP, which is discussed in **Section 10**.

4.2 Adopted Soil Criteria

The generic and risk-based depth criteria being adopted for the remediation are provided in Table 4.1. These criteria are for the protection of human health.

The following important explanations should be considered when applying the criteria:

- Metals – metals are not considered a contaminant of concern (**Section 3.5**), other than in localised fill material. Therefore metals criteria shall only apply to surface (0.0m – 1.5m) layer.
- BTEX – more conservative ecological health based criteria from NSW EPA, 1994 are used for toluene, ethylbenzene and xylenes in the surface (0.0m – 1.5m) layer, given values are more comparable to human health based benzene criteria and provide a conservative screening value to assess for malodourous materials (i.e. aesthetic criteria **Section 4.6**).
- Benzene and Xylenes – risk-based criteria developed using the Johnson and Ettinger (1991) one-dimensional analytical model indicate values that are below the laboratory analytical limit of reporting (LORs) and the generic criteria. Given this situation, less conservative criteria provided in NSW EPA, 1994 shall apply to all shallow and deep soil layers.

Table 4.1 – Soil Validation Criteria (all values in mg/kg)				
Analyte	**Depth**			
	0.0m – 1.5m	**1.5m – 2.5m**	**2.5m – 4.0m**	**4.0 - 8.0m**
Metals				
As (total)	500	-	-	-
Cd	100	-	-	-
Cr	500[1]	-	-	-
Cu	5,000	-	-	-
Hg (inorganic)	75	-	-	-
Ni	3,000	-	-	-
Pb	1,500	-	-	-
Zn	35,000	-	-	-
BTEX[2]				
Benzene[3]	1	1	1	1
Toluene	1.4	2.6	4.0	7.9
Ethylbenzene	3.1	11.1	17.6	34.8
Total Xylenes[3]	14	14	14	14
Polycyclic Aromatic Hydrocarbons (PAHs)				
PAH – total	100	-	-	-
Benz(a)pyrene	5	NOC	NOC	NOC
Naphthalene	-	3.8	6.0	11.8
Acenaphthene	-	NOC	NOC	NOC
Fluorene	-	NOC	NOC	NOC
Pyrene	-	NOC	NOC	NOC
Benzo(b)fluoranthene	-	NOC	NOC	NOC
Chrysene	-	NOC	NOC	NOC
Phenolic Compounds				
Phenol	42,500	-	-	-
Cyanide (complex)	2,500	-	-	-
Asbestos[4]	No detection of fibres in surface soils (0.5m depth) No visible fragments in the surface soils (0.5m depth)	-	-	-

[1] This value is for Cr(VI) and used as a conservative concentration as a preliminary screening value for Chromium.

[2] Criteria for toluene, ethylbenzene and xylenes at 0.0m – 1.5m are ecological health based, and considered appropriate to screen for aesthetic criteria (i.e. malodourous material) in surface soils.

[3] Risk based values are lower than laboratory analytical limits of reporting (LORs) and HILs, therefore less conservative HILs applied to all depths.

[4] Australian Contaminated Land Consultants Association, Asbestos in Soils – Code of Practice, 2002. Based on a depth to 0.5m below the ground surface.

NOC – Not of Concern. Based on the outcomes of the Johnson and Ettinger (1991) risk-based model, the contaminant has a low vapour potential at the nominated soil temperature of 15°C.

(-) refers to no criteria value.

4.3 Groundwater

The NSW DEC Groundwater Guidelines (March 2007) provide a hierarchy of clean-up objectives for contaminated groundwater. Using these objectives, the soil remediation strategy to affect source control (tar removal) can extend to the long-term objective of groundwater clean-up. However, it should be noted that this RAP addresses the remediation of soil materials, while groundwater is not considered to require remediation as discussed in **Section 3.10**.

The hierarchy is listed as:

1. Clean up so that the natural background water quality is restored;
2. Clean up to protect the relevant environmental values of groundwater, and human and ecological health; and
3. Clean up to the extent practicable.

The Guidelines conclude that regardless of the clean-up approach, the remedial approach should ultimately strive to restore water quality to its natural background condition. Therefore, the soil remediation strategy should consider the potential for ongoing impacts to groundwater. In that regard and considering that groundwater restoration should be a remedial goal, a program of MNA will complement tar removal to the extent practicable to monitor and understand the ongoing impacts to groundwater.

An evaluation on the progress of MNA will be based on the set of metrics as detailed in **Section 10.3.2**. In that regard, specific groundwater criteria will not be used to assess risks presented by contaminated groundwater. More so, the success of the remediation and mitigation of known risks will be assessed based on the restoration of the groundwater conditions within the MNA program. However, generic Groundwater Investigation Levels (GILs) and background groundwater quality should be used on a comparison basis. Baseline conditions of the Site are to be adopted from the groundwater monitoring event immediately after source removal. These baseline conditions can be compared with ongoing MNA data that is to be collected to evaluate the Site relative to the ultimate goal of achieving pre-development (i.e. natural conditions).

In this regard, generic GILs should be adopted from the following sources:

- ANZECC Australian and New Zealand guidelines for Fresh and Marine Water Quality 2000 – trigger values;
- NSW EPA Contaminated Sites: Guidelines for Assessing Service Station Sites, 1994;
- NEPC National Environment Protection Measure, Schedule B (1), 1999 (NEPM); and
- Netherlands (Dutch) Intervention Values – Water, 2000 (where appropriate).

Background groundwater quality should be established by sampling groundwater monitoring wells in non-impacted locations upgradient of the remediation area.

4.4 Surface Water

Surface water has the potential to migrate off site during and subsequent to the site remediation, although the potential can be minimised by implementing surface water controls during remediation works and landscaping following remediation. Generic criteria for protecting fresh water ecosystems should be adopted from ANZECC 2000. The trigger values provided in these guidelines should be used to protect human health and environmental receptors.

4.5 Aesthetic Considerations

4.5.1 Soil Odour

In consideration of the NSW DEC (2006) decision-making process for assessing urban redevelopment sites, soils exhibiting odours should be assessed for their suitability at the Site given the proposed land use as commercial/industrial. In this regard, odorous soils would be considered unsuitable at the final ground surface.

5 Site Remediation

This section provides information on the NSW DECC-endorsed remediation policy, a review of remedial options screening and the selected preferred remedial option.

5.1 Objectives

The remediation objectives follow RailCorp's long term objectives for site use (refer to **Section 1.1**).

5.2 Remediation Policy

The preferred remediation hierarchy for this RAP is in accordance with the *Australia and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*, ANZECC[6] 1992. This policy is also followed by the NSW DECC. These guidelines state that the preferred order of options for remediation and management are:

- On-site treatment of the soil so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level; and
- Off-site treatment of excavated soil which, depending on the residual levels of contamination in the treated material, is then returned to the site, removed to an approved waste disposal facility or used as landfill.

Should it not be possible for either of these options to be implemented, then other options that should be considered include:

- Removal of a contaminated soil to an appropriate site or facility, followed where necessary by replacement with clean fill;
- Isolation of the soil on the site by covering with a properly designed barrier;
- Choosing a less sensitive land use to minimise the need for remedial works which may include partial remediation; and
- Leaving contaminated material in-situ providing there is no immediate danger to the environment or community and the site has appropriate controls in place.

If remediation is likely to cause a greater adverse effect on any aspect of the Site or surrounds than what would occur if the Site was left undisturbed, then remediation should not proceed.

5.3 Review of Potentially Suitable Remedial Options

A remedial options screening was undertaken as part of the scope of work for the CH2M HILL (March 2007) investigation. Specific remedial options were screened from a "long-list" of options as being potentially suitable, and were consolidated into a "short-list" of options, as summarised below. The "short-list" of options included:

- No Action;

[6] *Australian and New Zealand Environment and Conservation Council (ANZECC)*

- Institutional Controls including an Environmental Management Plan (EMP) and site access restrictions;
- Insitu Physical/Chemical Treatment including chemical oxidation and soil vapour extraction;
- Insitu Thermal Treatment;
- Exsitu Biological Treatment including biopiles, composting and land-farming;
- Exsitu Physical/Chemical Treatment including solidification/ stabilisation/ immobilisation and chemical extraction;
- Exsitu Thermal Treatment including incineration/co-burning and thermal desorption;
- Containment including capping and containment;
- Off site Disposal; and
- Reuse and Recycle.

As part of this RAP, these options have been further evaluated to determine the preferred remedial options based on:

- Effectiveness;
- Technology risk;
- Timeframe;
- Permissibility;
- Compatibility;
- Health and Safety Risk;
- Costs; and
- Ongoing Management.

Appendix C presents the outcomes of the remedial options evaluation in terms of *preferred* and *not preferred* options, including the advantages and disadvantages of each "short-list" remedial option.

5.4 Preferred Remedial Options

The evaluation of the "short-list" remedial options provided in **Appendix C** shows that the overall preferred remedial strategy will be one that primarily affects contamination source removal and implements long term management of environmental receptors under a site-specific EMP. The preferred remedial options and/or combination of options are:

1. Installation of Site Security Fencing;
2. Collection of liquid wastes/sludges and disposal at a liquid waste facility;

3. Excavation, organic stabilisation treatment (at an alternate treatment site) and disposal of soil waste at a landfill facility under the NSW DECC General Approval for Immobilisation for coal tar materials – Approval #2005/14 (refer to **Section 3.1.5**);
4. Excavation, thermal desorption treatment (at an alternate treatment site) and disposal of soil waste at a landfill facility;
5. Excavation and disposal of soil waste at a landfill facility under the NSW DECC General Approval for Immobilisation for ash materials – Approval #1999/05 (refer to **Section 3.1.5**);
6. Excavation and disposal of asbestos impacted demolition waste at a landfill facility;
7. Excavation and disposal of untreated fill/soil waste at a landfill facility;
8. Beneficial Reuse and Recycle (including segregation of demolition waste) of suitable materials where appropriate;
9. Insitu (passive) chemical oxidation of residual source materials at depth subsequent to excavation and disposal of above materials; and
10. Long term Environmental Management Plan (EMP) including a Groundwater Management Plan (GMP) with a Monitored Natural Attenuation (MNA) approach.

It is the opinion of CH2M HILL that the proposed combination of preferred remedial options is practical and will facilitate RailCorp in meeting the long term objectives for the Site. The approach also follows the remediation hierarchy outlined in the *Australia and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*, ANZECC 1992.

The features that demonstrate these qualities include:

- Use of proven techniques which are known to be capable of providing a safe solution due to past experience with the techniques, the level of confidence provided by the techniques and the technology being well understood;
- The use of a remediation strategy which can be applied in a relatively short time frame;
- An approach that appreciates the relative sensitivity of the adjoining residential properties, providing protection from long term noise, odours, dust and visual impacts;
- The use of a remedial option that removes or reduces the contamination liability enabling beneficial re-use of the Site for rail-related activities; and
- The use of a remedial option that protects groundwater from ongoing impacts.

CH2M HILL's preferred options are summarised in Table 5.1, and the information presented in **Section 5.5** is also based on these options. This table also provides the likely constraints that may impact implementation of the selected remedial option for each nominated site area. Reference is made to **Figure 4** to identify the Site areas.

Table 5.1 – Preferred Remedial Options

Site Area	Material Type	Extent of Impact	Expected Quantity (m^3)	Remedial Option		Waste Classification		Potential Remedial Constraints
				Pre-treatment/ Treatment	Remedial Action	Preliminary	After Treatment/ Immobilisation Approval	
Site Wide	NA	NA	NA	NA	Environmental Management Plan (EMP)	NA	NA	• None
Site Wide	NA	NA	NA	NA	Site Security Fencing	NA	NA	• None
Tar Wells	Tar sludge	Contained within Tar Wells	100	Potential pre-treatment to improve handling	Liquid Waste Disposal	Hazardous	NA	• Onsite odours • Handling and Transport
	Soil/fill impacted by free tar	Base annulus and proximal soils (within pink shaded area on Figure 4 to a depth of 8m-10m)	1,000	Potential pre-treatment to improve handling (i.e. lowering moisture content, breakdown clay clods to expose higher surface area)	Stabilisation or Thermal Desorption treatment and landfill disposal – Stabilisation to apply NSW DEC immobilisation approval (Approval #2005/14)	Hazardous	Industrial or Solid	• Regulatory approval • Available site area • Available alternate treatment site • Regulatory approval for alternate treatment site • Underground services • Onsite odours • Aesthetic issues for neighbouring residents (noise, odours, dust, visual impact) • Groundwater management during excavation • Transport approvals • Ground stability of western and northern boundary during excavation (protect adjoining properties/structures)

Table 5.1 – Preferred Remedial Options

Site Area	Material Type	Extent of Impact	Expected Quantity (m^3)	Remedial Option		Waste Classification		Potential Remedial Constraints
				Pre-treatment/ Treatment	Remedial Action	Preliminary	After Treatment/ Immobilisation Approval	
Northern Gasholder	Tar sludge	Contained within Base of Gasholder	320	Potential pre-treatment to improve handling	Liquid Waste Disposal	Hazardous	NA	• Potential heritage value of below ground annulus • Regulatory approval • Available site area • Available alternate treatment site • Regulatory approval for alternate treatment • Aesthetic issues for neighbouring residents (noise, odours, dust, visual impact) • Underground services nearby • Management of water and tar inside the Gasholder • Health and Safety issues with asbestos waste • Groundwater management during excavation • Ground stability of western and northern boundary during excavation (protect adjoining properties/structures) • Protection of the heritage value and stability of the Southern Gasholder during excavation • Handling and Transport
	Impacted Water	Contained within Gasholder	640	NA	Liquid Waste Disposal	Hazardous	NA	
	Soil/fill impacted by free tar	Base annulus and proximal soils (within pink shaded area on Figure 4 to a depth of 8m-10m)	2,100	Potential pre-treatment to improve handling (i.e. lowering moisture content, breakdown clay clods to expose higher surface area)	Stabilisation or Thermal Desorption treatment and landfill disposal – Stabilisation to apply NSW DEC immobilisation approval (Approval #2005/14)	Hazardous	Industrial or Solid	
	Demolition Waste	Buried inside Gasholder annulus (blue shaded area on Figure 4)	1,900	Potential pre-treatment to remove free tar or segregate oversize materials	Landfill disposal or Recycling	Asbestos/ Industrial	NA	

Table 5.1 – Preferred Remedial Options

Site Area	Material Type	Extent of Impact	Expected Quantity (m^3)	Remedial Option		Waste Classification		Potential Remedial Constraints
				Pre-treatment/ Treatment	Remedial Action	Preliminary	After Treatment/ Immobilisation Approval	
Retort and Surrounding Former Gasworks Source Areas	Shallow Tar Impacted Soil and Fill	Lateral extent shown as orange shaded area on Figure 4 to a depth of at least 4m	9,225	Pre-treatment – Physical amendment to break down material with high clay content (i.e. lowering moisture content, breakdown clay clods to expose higher surface area) Likely alternative site for pre-treatment and remedial treatment	Stabilisation or Thermal Desorption treatment and landfill disposal – Stabilisation to apply NSW DEC immobilisation approval (Approval #2005/14)	Hazardous or Industrial	Industrial or Solid	• Potential heritage value of Retort floor (brick layers) below ground • Available site area • Available alternate treatment site • Regulatory approval for alternate treatment site • Aesthetic issues for neighbouring residents (noise, odours, dust, visual impact) • Underground services • Groundwater management during excavation • Ground stability of western and northern boundary during excavation (protect adjoining properties/structures) • Protection of the heritage value and stability of the Southern Gasholder during excavation • Handling and Transport
	Deep Tar Impacted Natural Soil	Lateral extent shown as pink shaded area on Figure 4 in the vicinity of boreholes BHE and BHF location to a depth of 8m-10m	2,375			Hazardous or Industrial	Industrial or Solid	
	Tar Impacted Contamination hotspot at TP16 location	Lateral extent shown as green shaded area on Figure 4 to a depth of 1m-2m	115			Hazardous or Industrial	Industrial or Solid	
Existing Site Surfaces	Ash/Coke Fill	Lateral extent shown as yellow shaded area on Figure 4 to a depth of at least 0.5m	2,950	NA	Landfill disposal – application of NSW DEC immobilisation approval (Approval #1999/05)	Hazardous	Solid	• Items of potential heritage value • Aesthetic issues for neighbouring residents (noise, odours, dust, visual impact) • Underground services • Ground stability during excavation along western boundary embankment • Protection of the heritage value of the Southern Gasholder during excavation • Retained (protected) vegetation
Retaining Wall	General Fill and demolition waste	Entire Northern boundary (shaded blue on Figure 4)	1,765	Pre-treatment – segregation of oversize materials	Landfill disposal or Beneficial Reuse or Recycling	Solid	NA	• Items of potential heritage value • Physical segregation of oversize materials • Aesthetic issues for neighbouring residents (noise, odours, dust, visual impact) • Ground stability during excavation (protect adjoining properties/structures) • Retained (protected) vegetation • Health and Safety issues with asbestos • Unexpected materials (e.g. Asbestos material))

Table 5.1 – Preferred Remedial Options

Site Area	Material Type	Extent of Impact	Expected Quantity (m^3)	Remedial Option		Waste Classification		Potential Remedial Constraints
				Pre-treatment/ Treatment	Remedial Action	Preliminary	After Treatment/ Immobilisation Approval	
Contamination Hotspots	Impacted Fill at locations BH14, MW13s and MW04s	Lateral extent shown as green shaded area on Figure 4 to a depth of 1m-2m	340	NA	Landfill disposal or Beneficial Reuse	Solid	NA	• Items of potential heritage value • Aesthetic issues for neighbouring residents (noise, odours, dust, visual impact) • Underground services • Ground stability during excavation (protect adjoining properties/structures)
Site Wide	Old Gasworks Pipes	Varied	Unknown	NA	Tar removal by chemical extraction or other physical process	Hazardous (tar) or Industrial (scrap metal, demolition waste)	NA	• Items of potential heritage value • Regulatory approval • Aesthetic issues for neighbouring residents (noise, odours, dust, visual impact) • Underground services • Ground stability during excavation (protect adjoining properties/structures) • Unknown quantity of tar wastes inside pipes • Unknown extent
Site Wide	Fill and natural soil materials	NA	Unknown	NA	Beneficial Reuse	NA	NA	• Required to meet beneficial reuse criteria (**Section 9.4)**
Deep Excavations proximal to Source Areas	Residual tar sources – subsequent to source removal	Unknown	Unknown	NA	Insitu (passive) chemical treatment - to enhance biodegradation and promote long term MNA	NA	NA	• Stiff/hard clay and weathered shale • Targeting residual sources in soil fractures

5.5 Remedial Options Activities

Based on the selected remedial options, information on the works required prior to, during and at the completion of remedial works is provided below.

5.5.1 Security Fencing

The Site is currently bounded by a chain wire fence that provides adequate security and restricts access to the Site by the general public. The adequacy of the existing fencing may need to be reconsidered prior to any remedial works being undertaken, particularly in regard to site access (**Section 8.3.1**).

5.5.2 Liquid Waste Disposal

Much of the liquid wastes are contained within the Tar Wells or the Gasholders. The liquids within the Tar Wells are considered to be coal tar sludge, while the liquids within the Gasholders are considered to be impacted waters. However, liquids at the base of the Northern Gasholder are also likely to contain coal tar sludge.

Free flowing liquids and sediments may be removed by a specialised vacuum truck that will store and transport the liquids to the waste disposal facility.

Pre-treatment may be required to remove coal tar sludge, for example, by heating the material to lower the viscosity and facilitate vacuum removal. Alternatively, handling and transport may be improved by additives such as fly ash.

5.5.3 Off Site Landfill Disposal

Non-liquid wastes that are classified as either inert, solid or industrial (in accordance with the NSW EPA Waste Guidelines, 1999) can be disposed at a licensed landfill. This also applies to wastes that are impacted with asbestos. The landfill should be licensed to accept the prescribed wastes being generated from a site. Any hazardous wastes would require treatment to a lower waste classification to enable disposal to landfill, or storage until such treatment can be undertaken.

Demolition Wastes (Northern Gasholder and Retaining Wall Material)

A large amount of the demolition wastes buried within the Northern Gasholder and Retaining Wall fill material may be screened to remove oversize materials (i.e. bricks, concrete blocks and metal piping) to reduce the quantity to be disposed at the landfill. However, consideration should be given to the asbestos impacts (i.e. fibro sheeting) and the likely tar impacts at the base of the gasholder.

Ash and Coke Surface Fill

Section 3.1.5 provides detail for the use of general approvals for immobilisation, which can be applied to the ash/coke fill material at the Site. This material can be classified based on leachable concentrations of Benzo(a)pyrene alone. However, if these materials contain other contaminants, they need to be classified accordingly.

5.5.4 Treatment Options and Landfill Disposal

An alternative site is likely to be required to conduct treatment processes prior to disposal, given the on site constraints such as limited space and the sensitivities of adjoining residential properties (further discussed in **Section 8.3.7**).

Soil conditions will present constraints given that excavated natural soils will be stiff clay material (refer to **Section 2.4**). Pre-treatment is likely to be required to ensure the impacted soils are appropriately amended to enable sufficient mixing or blending to improve consistency of the material to be treated.

Pre-treatment activities may also require the use of an alternative site.

Stabilisation

Soils impacted by tar can undergo soil stabilisation to enable the general approval for immobilisation of coal tar (**Section 3.1.5**) to apply to this material for off site disposal. Specifically, the general approval nominates treatment by immobilisation by the addition of a reagent that consists of calcium or magnesium oxide based cement to immobilise contaminants. Other specific conditions include:

- Ratio mixing must not exceed 2 parts reagent to 1 part untreated waste;
- Mixing must be sufficient to ensure that contaminants are completely encapsulated; and
- The unconfined compressive strength of the treated waste must be 1MPa or greater prior to disposal.

The treated material can be classified based on leachable concentrations alone. However, if these materials contain contaminants other than those specified in the general approval, then they will need to be classified accordingly.

Importantly, only untreated materials with concentrations less that the specified levels provided in the general approval (#2005/14) are covered by the approval. Refer to **Section 3.1.5** and **Appendix E** for further detail.

Thermal Desorption

Soils impacted by tars can undergo thermal desorption, as either direct or indirect heat treatment. Contaminants are removed from the solid media by volatilisation, but without combustion of the media.

After treatment, the soil material can be classified for disposal at a licensed landfill facility. Classification for off site disposal should be undertaken in accordance with the NSW DEC Waste Guidelines (2004). One outcome of this process will be to treat the materials so that a classification of solid waste, or at least industrial waste, is achieved for off site disposal.

5.5.5 Beneficial Reuse and Recycling

Materials that may be potentially suitable for beneficial reuse will need to meet the criteria provided in **Section 9.4.**

It will be necessary for any demolition waste materials that may be potentially suitable for recycling to be initially segregated from fill/soil wastes and inspected for gross contamination impacts. Only materials free from impacts should be recycled. Impacted materials are likely to be disposed off Site under a waste classification. Potential materials for recycling are likely to include bricks and concrete, and should exclude fibro cement sheeting wastes that may contain asbestos.

5.5.6 Insitu Chemical Treatment

Passive chemical treatments will be used to enhance biodegradation of residual contaminants through the use of oxygen-releasing compounds. The application of these reagents can be varied, but should provide a long term source of oxygen into the groundwater system and also target residual source material at the base of excavations. The approach of application should consider:

- Concentrated liquid injection – to target source material remaining in deeper soil fractures; and
- Broad scale mixture with backfill material at depth – to provide coverage and mass to enable long term release of the chemical agent.

5.6 Managing Groundwater Contamination

5.6.1 Source Control

The nature of the tar is such that complete removal of all tar material would be impracticable. This can be said given the tar materials Dense NAPL (DNAPL) characteristic, having a propensity to migrate vertically downward from the structures that contain these tars. However, the geological conditions (i.e. stiff clays and weathered shales) are likely to adsorb tars and retarded migration to some degree.

The extent of the migration is highly variable and is dependent on available pathways, nature of releases (types, rates, temperature and pressure), and other factors such as dissolution rates. Therefore the scenario involving DNAPLs is usually one where soils are impacted to varying degrees throughout the soil profile and at varying depth intervals.

Therefore it can be said that given the nature of the tar, complete removal of tar would be impracticable when considering the limitations and constraints of site remediation presented in Table 5.1. The factors that govern these limitations can be summarised as:

- Removal of tar source will be limited by the capability of excavation machinery and the ability to chase-out deep impacted zones, especially where site area limits the capacity for combinations of activities such as deep excavation requiring benching, remediation equipment, pre-treatment facilities, vehicle access, etc.
- Specialised machinery may be required to remove tar material from weathered shale rock layers (i.e. within fractures of weathered shale). In this regard, excavation limits may be governed by the ability to remove impacted rock, therefore a decision can be made on whether the extent practicable has been reached.
- The timeframe to undertake remediation may be significantly impacted if specialised removal requirements were pursued, which would also have financial, community and regulatory implications.

- The high costs and uncertain benefit of undertaking such work presents the basis to the extent practicable approach, where costs are balanced against the environmental benefit of continuing source removal.
- Limitations on the vertical and lateral extent of source removal below the Northern Gasholder will be governed by the retention of the adjacent Southern Gasholder and the need to control the risk of undermining the ground stability. This also applies to the adjacent neighbouring residential properties, the northern adjoining Stabling Yards and the operation rail tracks to the south of the gasworks. This constraint also applies to the extent of source removal below the Tar Wells given similar requirements.

5.6.2 Supportive Measures of Source Control

Tar removal to the extent practicable can be undertaken to address tar source material. The following supportive measures and factors will also form part of the strategy and further protect ongoing impacts to groundwater and potential receptors of groundwater.

- Passive application of an oxidising agent will be undertaken at the base of excavations to promote biodegradation of residual organic contamination.
- A continued program of MNA (refer to **Section 10**) will be conducted.
- A Groundwater Management Plan (GMP), will be included as part of the long term EMP (refer to **Section 10**).
- The groundwater contamination plume has migrated from the Site boundary; however, the plume has not migrated from the adjoining railway land and is therefore not posing a current risk to human health beyond RailCorp-owned land.
- The EMP for the Site is to document the restriction of groundwater use or extraction on the Site and potentially on the adjoining railway land. Areas that are hydraulically down gradient of RailCorp-owned land have been declared by the DNR as an embargo area for domestic use of groundwater.

5.6.3 Determining the Extent of Source Control

This section provides the information and personnel that will be used to determine the extent of tar removal considering the Site limitations and constraints of excavation. The extent of tar removal will be governed by the following points.

- The ground stability and the need to protect the Southern Gasholder – the extent of excavation is to be determined by a geotechnical/structural engineer.
- The weathered shale layer will to be used as a vertical limit to excavation, but at least 8 mbgl in source zones, to be determined by an environmental engineer.

- Spatial distribution and the need to remove tar will be based on whether the net gain to the environment to remove small quantities of tar material would be beneficial, considering time and financial resources of the project. The decision makers at this point should be RailCorp, the environmental consultant and the appointed Site Auditor.
- Visual observations will be used to assess tar residues and validation data (walls and floor of excavations) will be collected by an environmental consultant.

5.6.4 Rationale for Source Control

The measures to be implemented to achieve source control to the extent practicable can be justified by considering the protection of the values of human health and the groundwater environments. The protection of these values can be linked to those identified in the risk assessment (SKM, April 2006) (**Section 3.7**) and the requirement of the NSW DEC Groundwater Guidelines to address source material to protect ongoing impacts to groundwater environments (**Section 4.1.3**).

The following measures will be implemented to protect relevant on-Site and off-Site values. Human health will be protected onsite by remediating the surface soils (i.e. to depths of 1.5m) to remove dermal contact, ingestion and vapour inhalation exposure pathways; and by remediating soils at depth (i.e. below 1.5m) to the remove the vapour inhalation exposure pathway. Human health and the shallow groundwater environment will be protected and improved onsite by affecting tar removal to the extent practicable and remediating impacted fill and soils. The shallow groundwater environment will be protected and improved off site by affecting tar removal to the extent practicable and remediating impacted fill and soils.

Considering the limitations of tar removal to the extent practicable strategy, the on-Site and off-Site shallow and deep groundwater environments may continue to be impacted to some degree given that complete tar removal is likely to be unachievable. However, this is an unknown scenario. Nevertheless shallow and deep groundwater quality is likely to be improved in the long-term. Monitoring of the groundwater environments will enable a better understanding of potential ongoing impacts. A program of MNA will be implemented to understand the unknown long-term impacts to groundwater. Further discussion on the long-term management of the Site and the MNA program is provided in **Section 10.3.3**.

6 Environmental Planning and Approvals

This section of the RAP provides information on the required planning approvals for the site remediation to commence.

6.1 State Environmental Planning Policy 55 – Remediation of Lands

State Environmental Planning Policy (SEPP) 55 provides the planning framework for the remediation of contaminated land within NSW. Clause 9 of SEPP 55 defines Category 1 remediation works as works that require consent. Clause 9 (e) includes remediation which is to be carried out on an area or zone which is affected by a heritage conservation classification under an environmental planning instrument. Therefore, given the existence of the Southern Gasholder, the remediation of the Site falls within Category 1 of SEPP 55.

6.2 State Environmental Planning Policy (Major Projects)

SEPP (Major Projects), 2005 lists development works to which Part 3A of the Environmental Planning and Assessment (EP&A) Act 1979 applies. Clause 28 of Schedule 1 of SEPP (Major Projects) includes Category 1 remediation works within the meaning of SEPP 55 carried out on a 'remediation site'. The Site is under a Voluntary Remediation Proposal (VRP) and is not currently declared a 'remediation site' under the CLM Act, thus this provision does not apply.

The Site is identified as a *Redfern-Waterloo Authority Site* under Schedule 3 of SEPP (Major Projects). Part 5, Clause 5 of Schedule 3 of SEPP (Major Projects) states that development within a Redfern-Waterloo Authority Site with a capital investment value of more than $5 million is to be a Part 3A project. Therefore, considering the capital investment required to remediate the Site, the remediation will fall under Part 3A of the EP&A Act.

6.3 Environmental Planning and Assessment Act

The remediation of the former gasworks site will require assessment under Part 3A of the EP&A Act.

The Site contains a Gasholder that is listed on the State Heritage Register as part of the Eveleigh Railway Workshops in accordance with the Heritage Act, 1977. The Site is also listed as a Heritage Item under Schedule 4 of the Sydney Regional Environmental Plan 26 – City West (SREP 26). **Figure A** below provides the decision process in determining the requirement for assessment under Part 3A of the EP&A Act for the site remediation.

Section 75U of Part 3A of the EP&A Act lists other Acts and their provisions that no longer apply under Part 3A EP&A Act. Included in this list is:

- Section 12 of the Native Vegetation Act, 2003.
- Section 87 and section 90 of the National Parks and Wildlife Act, 1974.
- Approvals under Part 4 or an excavation permit under section 139 of the *Heritage Act 1977*.