the volume would be directly related to the extensiveness of the pipe network, especially those pipes used to transport tar materials. An estimate of 50 tonne of pipework has been provided.

12.2.3 Tarry Impacted Materials

For the purpose of assessing the Site's suitability for the proposed land use, consideration must be given to the presence of tarry impacts in the Site's fill and soils. Typically, given the extent of tar impact in the area of the former gasworks plant, the soils are currently regarded as unacceptable for any land uses (including commercial/industrial).

The statistical analysis of existing data suggests the removal (remediation) of a number of contamination hotspot areas and other areas of elevated contaminants is required to enable soil/fill materials to be considered suitable for the proposed land use. However, in a practical sense, and given the highly heterogenous nature of the subsurface conditions, this approach may only address the known areas of visible free tar impacts in the former gasworks area and outlier areas, such as the Northeast Area.

For the purposes of estimating remedial volumes in the former gasworks area (that is the Gasholder, Retort and Gas Purifier Areas) a nominal depth of at least 4.0m was assumed as the depth of impact from the surface operations over this area, based on the average vertical extent of impact using existing data. Targeting the spatial distribution of free tar addresses the need to remove particular hotspots or areas of elevated concentrations as indicated by the statistical analyses.

- The following volume estimates takes into account removal of the surface ash/coke layers (i.e. 0.5m).
- The spatial area indicated by the orange shading (**Figure 7**) is 2,635m^2. Therefore the estimated volume is **9,225m^3** (based on a depth of 3.5m)**.**
- The deeper impacts in the vicinity of BHF/BHE are estimated to be approximately **2,375m^3** (with the area being 250m^2 to a depth of 9.5m).

Free tar was observed in material at sample location TP16. This location is regarded as being locally impacted by tar material as there was no other free tar observed within its proximity.

- The estimated volume of material impacted in this area is **115m^3**, based on the green shaded extent shown on **Figure 7** to a depth of 1.5m (i.e. with surface ash/coke removed).

Based on the above estimates, the volume of material estimated to be impacted with tarry material is approximately **11, 715m^3**, which is likely to be classified as **Industrial Waste** after treatment and applying the NSW DEC general approval of immobilisation for coal tar impacted soil.

12.2.4 Other Materials

Ash and Coke Gravels

These surface materials exist over the entire Site to a nominal depth of 0.5mbgl. The estimated volume of this material is approximately **2,950m^3**, which is likely to be classified as **Solid Waste** after applying the NSW DEC general approval of immobilisation for ash. This estimate is based on the Site Area (7,732m^2) and the

depth of material (0.5m), removing the areas of the Retaining Wall, the Northern and Southern Gasholders and the Tar Wells.

Gravel, Sand and Demolition Wastes

This material includes the material comprising the Retaining Wall and the backfill material inside the Northern Gasholder.

The volume estimate of the Retaining Wall material is **1,765m³**, which is likely to be classified as **Solid Waste**, however may be classified as Asbestos Waste/Industrial Waste (similar to the material inside the Northern Gasholder) if asbestos containing materials are encountered throughout this material. These estimates are based on the Retaining Wall material area shaded in blue (**Figure 7)** as 1,175m² and an average depth of 1.5m.

The volume of the backfill material inside the Northern Gasholder was estimated above to be approximately 1,900m³.

Reworked Clays

Removal of free tar impacted materials within the former gasworks area would effectively address contamination impacts associated with this material. One area remains impacted by benzene after the free tar removal work and should be addressed during site remediation.

The location requiring management is at sample location BH14. The estimated volume of material requiring remediation is approximately **100m³**, based on a lateral extent as shown on **Figure 7** (shaded green) and a vertical impact of 0.5m (after surface ash/coke removal). This material is likely to be classified as **Solid Waste**.

Gravelly Sand and Clay with Minor Ash

This material exists only in the Southwest Area, where two contamination hotspots exist associated with the fill materials (sampling locations MW13s and RP). Statistical assessment indicates that removal of the two hotspots would result in the rest of this material being suitable for the Site, therefore these two hotspot areas should be addressed during Site remediation.

The estimated volume of impacted material at sample location MW13s is approximately **140m³**, based on a lateral extent as shown on **Figure 7** (shaded green) and a vertical impact of 1.0m (after surface ash/coke removal). This material is likely to be classified as **Solid Waste**.

The estimates for the area impacted at sample location RP has been taken into account for estimating the free tar impacted materials above.

Silty Clays

A contamination hotspot for benzene exists in the South Central Area that should be addressed during site remediation. This area is sample location MW04s.

The estimated volume of material at this location is approximately **100m³**, based on a lateral extent as shown on **Figure 7** (shaded green) and a vertical impact of 1.0m (after surface ash/coke removal). This material is likely to be classified as **Solid Waste**.

12.2.5 Summary of Volume Estimates

A summary of the areas, volume estimates and waste types is provided in **Table 12.1** below.

Table 12.1 – Summary Volume Estimates

Remediation Area	Impacted Area	Estimated Volume (m^3)	Waste Material	Likely Waste Classification
Tar Wells	Base annulus and immediate area	1,000	Free Tar Impacts	Hazardous
	Tar Well contents	100	Tar	Hazardous (Liquid)
Northern Gasholder	Base annulus and immediate area	2,100	Free Tar Impacts	Hazardous
	Gasholder contents	640	Impacted water	Hazardous (Liquid)
		320	Tar	Hazardous (Liquid)
	Buried wastes inside annulus	1,900	Demolition	Asbestos/Industrial
Tar Impacted Soils	Shallow	9,225	Fill and natural clays	Industrial[(a)]
	Deeper	2,375	Natural clays and weathered shales	Industrial[(a)]
	TP16 Hotspot	115	Fill and natural clays	Industrial[(a)]
Site Surfaces		2,950	Ash and Coke Gravels	Solid[(a)]
Retaining Wall		1,765	Gravel Sand and Demolition Wastes	Solid
Hotspots	BH14	100	Fill and natural clays	Solid
	MW13s	140	Fill (southwest site area)	Solid
	MW04s	100	Fill and natural clays	Solid
Pipework	Varying across site	unknown	Tar/ scrap metal	Hazardous/ Solid

(a) assumed after treatment and applying the appropriate NSW DEC general approval of immobilisation.

13 Remedial Option Screening

This section presents details of the remedial options screening undertaken for the contaminated materials (excluding groundwater) requiring remediation at the former gasworks site.

13.1 Remedial Objective and Evaluation Criteria

13.1.1 Remediation Objectives

The remediation objectives outlining the desired outcomes for remediation of the Site are as follows:

- Remediation to a standard suitable for proposed commercial/industrial land use;
- Remediation to a level that mitigates risks to human health and the environment to an acceptable level; and
- Remediation of the contamination sources on the Site to the extent where the SRoH declaration can be removed.

13.1.2 Evaluation Criteria

Evaluation criteria were developed to assess each of the remedial options to nominate preferred remedial strategies on a sound and factual basis. The evaluation criteria related to the:

- Effectiveness of the remediation option to reduce the human health and environmental risk, either by reducing the risk posed by the source, by disrupting the potential exposure pathways to the potential receptors, or by reducing the volume of contaminated material at the Site;
- Timeframe required to achieve the required outcome;
- Likelihood of regulatory and community acceptance;
- Compatibility of the remedial option with other aspects of the proposed site redevelopment and the flexibility of the option to allow for potential changes during the proposed site redevelopment;
- Compatibility of the option with the proposed groundwater management strategy;
- Compatibility of the option with reuse, or potential future reuse of the contaminated materials;
- Indicative cost of implementing the option; and
- Ongoing maintenance requirements associated with the remediation option.

13.2 Long List Remedial Options

As part of the scope of this assessment, CH2M HILL prepared a long-list of potential remedial options for the soil and waste materials at the Site, based on commercially available technologies.

A fatal flaw analysis was then undertaken on the long list remedial options to assess which of the technologies could be applicable to the remediation of the Site. Options identified as having a fatal flaw or were unlikely to meet the remediation objectives were rejected and eliminated from further consideration. The long list of remedial options and the outcomes of the fatal flaw analysis are summarised in **Appendix F.**

13.3 Potentially Suitable Remedial Options

The specific remedial options that were considered as being potentially applicable to the Site were consolidated into a "short-list" of options, as summarised below.

13.3.1 No Action

The application of this option at the Site does not address SRoH issues nor would it be aligned with future land use aspirations. It would also not address the human health and ecological risks associated with existing Site contamination. Consideration may be given to the Southern Gasholder (given its heritage significance), however this area would still require a management plan and access restrictions, as outlined below.

13.3.2 Institutional Controls

Site Management Plan (SMP) - This strategy should be applicable as a component of the remedial strategy where there may be residual contamination risks that need to be managed after remediation. This may include contained/capped areas, management of heritage items where contamination could not be remediated, including impacted groundwater involving ongoing groundwater monitoring. This option is likely to be applicable to the area defined by the Southern Gasholder. This structure has been identified as a state heritage item and registered as part of the Eveleigh Railway Workshops. It is envisaged that this area will be excluded from the Site remediation process given its heritage significance and sensitivity.

Site Access Restrictions - Applicable for ongoing rail use, to protect heritage items, restricting public access & implementation of the SMP.

13.3.3 Insitu Physical/Chemical Treatment

In-Situ Chemical Oxidation - This technology would only be suitable for application after removal or pre-treatment of source materials. This can be used to treat residual BTEX impacted materials in deep soil layers, where depth excavation of materials may be limited by machinery capabilities or considered uneconomical to excavate. This may also be applied as a treatment of BTEX compounds at the base and beneath the Southern Gasholder, given there is unlikely to be excavation of this area. This option could also address groundwater impacts in the deep bedrock groundwater over the long term by treating leaching BTEX compounds. The effectiveness of this option may be impeded by other sources of oxidant-consuming material such as organic matter, in the form of coke and coaly material often associated with MGP sites that may limit reaction process and/or make the process less effective by consuming large quantities of the oxidant.

In-situ Soil Vapour Extraction (SVE) - This technology would only be suitable for application after removal or pre-treatment of source materials. This can be used to treat residual BTEX impacted materials in deep soil layers, where depth excavation of materials may be limited by machinery capabilities or considered uneconomical to

excavate. Pilot tests are recommended and the application has Operation and Maintenance (O&M) requirements and capital.

13.3.4 Insitu Thermal Treatment

This option is suitable for application in combination with SVE to enhance the volatile extraction in a shorter time period. Alone this option would not be appropriate. This option would be applicable after source removal on soils/fractured shale at the limit of excavation depth or in the vicinity beneath the retained Southern Gasholder. The groundwater level in the deeper bedrock layers may limit the effectiveness of this option.

13.3.5 Exsitu Biological Treatment

Biopiles - This option can be used to remediate some organic contaminants and could be an appropriate option, however, historically it has not been particularly effective in reducing the multi-ring (4 and greater) PAH compounds such as benzo(a)pyrene, to acceptable human health levels, but can be effective in reducing the more volatile constituents such as naphthalene and BTEX constituents is a valid objective for onsite re-use at depth. This option would require an alternate treatment site considering restricted available land area on the Site for the treatment process, and the sensitivity and proximity of the adjoining residential neighbourhood and off gases that are produced. This option is not suitable for grossly impacted materials such as free tars. Pre-treatment is usually required to improve handling and transport of the materials. Treatment trials are recommended to assess effectiveness of this option.

Composting – This option results in high fugitive emissions that would require management, and bulking agents used would substantially increase material volume, requiring an alternate treatment site. Semi-volatile and multi-ring PAHs would take a substantial time to degrade.

Landfarming - This option results in high fugitive emissions that would require management, requiring an alternate site for treatment and farming of the contaminated material. Semi-volatile and multi-ring PAHs would take a substantial time to degrade.

13.3.6 Exsitu Physical/Chemical Treatment

Solidification/Stabilisation/Immobilization – This option is appropriate using organic stabilisation processes on material containing tar and moderate concentrations and potentially free tar (gross contaminants). This option can be used in combination with the NSW DEC general approval for immobilisation of coal tar wastes from former gasworks sites (#2005/14), subject to the material being treated initially with calcium or magnesium based cement. This process enables off site disposal of source material and high PAH concentration materials, classified on TCLP alone. Treatment trials are required to determine the effectiveness of this method. Where the PAH contamination can be demonstrated to be present and immobile within ash and coke without treatment, then it may qualify for general immobilisation approval for ash from the NSW DEC (#1999/05). This treatment also has the potential to be applicable to ash/coke impacted material that may be retained on site in combination with a physical separation barrier and a long term management plan.

Chemical Extraction - This option would only be suitable for old service lines and pipes associated with the gasworks operation that contain residual tar. This option would require treatment of the resulting solution containing the contaminants, as well as treatment and disposal of the chemically treated pipework.

13.3.7 Exsitu Thermal Treatment

Incineration and Co-burning - This option would be applicable for high organic content materials such as free tar wastes. Materials can be pre-treated to improve handling and transport. The materials can also be stabilised or subject to other off site treatments to reduce the mass of soil material and oversize materials (segregation). There may be issues gaining regulatory approval and limited available facilities other than through co-burning at a power station or cement kiln.

Thermal Desorption - This option would be applicable for high organic content materials such as free tar wastes, but can have issues with high energy tarry materials. An alternate treatment site would be required, and there are potential issues relating to the availability, transport, set up and commissioning of treatment units.

13.3.8 Containment

Insitu Capping – This option could be applicable considering the Site conditions of relatively shallow impacts of non-leaching material, or materials that meet land use criteria with minimal contamination hotspot removal. The areas of the Site this applies to are the Northeast, South Central, Southwest, Western Lot and sections of the Retaining Wall Areas. A long term management plan would also be required in conjunction with this option.

Containment Area - Similar to the above, this option would be applicable in combination with designated site areas and a long term management plan.

13.3.9 Disposal

This option would only be applicable in combination with other technologies such as stabilisation/immobilisation. Alone this option would preclude highly impacted materials being accepted by licensed landfill facilities, based on the indicative waste classification of some materials being hazardous wastes.

13.3.10 Reuse and Recycle

This option could be used for oversize materials and fill materials meeting land use criteria and/or that are approved for immobilisation under general DEC immobilisation approvals. This option could be used after treatment on an alternate treatment site. This may be applied to the demolition waste materials inside the Northern Gasholder and the Retaining Wall Area, where materials are screened and oversize materials removed off site to a recycling facility, or fill materials may be used to backfill excavated sections of the Site. Consideration must be given to the presence of asbestos containing materials for this option to be applicable.

13.4 Management During Remediation

A number of items will require management during the remedial phase of the Site rehabilitation. The following sections briefly describe the items that should be considered when planning for and implementing remediation.

13.4.1 Groundwater and Surface Water

Considering the expected depth required for source removal, there will be a significant quantity of water, both inground and as surface water contained in structures, requiring management and potential treatment and/or off site disposal. In it's present state groundwater and surface water are impacted by both inorganic and organic contaminants that are likely to preclude the waters from disposal into the stormwater or sewage systems without some form of pre-treatment.

13.4.2 Odours

The adjoining residences and sensitive land use of Burren Street would require protection from potential exposure to vapours emitted during site remediation, especially when excavation and material handling at surface is undertaken. Pre remedial work would be necessary to provide controls of vapour into the atmosphere, and which would need to be documented in an Environmental Management Plan. Management procedures may include capturing and treating vapours and/or odour masking agents.

13.4.3 Archaeological and Heritage Matters

A recent report prepared by Heritage Concepts Pty Ltd[4] documents the items of archaeological and heritage importance at the Site, and also presents recommendations to manage these items during site remediation. In particular, the remedial works should consider:

- The Southern Gasholder being retained insitu and preserved;
- Archival photographic record should be undertaken for all existing items prior to remediation;
- Archaeological monitoring and recording should be undertaken during remediation to monitor unknown items of potential heritage significance;
- Any significant elements of the gasworks should be retained insitu, which should undergo assessment of heritage significance and degree of contamination;
- Retaining items of archaeological significance uncovered during site remediation should be protected and interpreted with appropriate signage post remediation; and
- The protection and interpretation of all remaining gasworks elements (including signage) should be incorporated into the final design of the Site.

The considerations above are subject to the degree of contamination and potential human health risks associated with the item, evaluated against the heritage significance of the item.

[4] Heritage Concepts Pty Ltd *Archaeological Assessment and Remediation Management Strategy – Former Macdonaldtown Gasworks*, November 2006.

14 Conclusions

The conclusions provided below are based on the four 'decisions' identified in Step 2 of the Data Quality Objectives (DQO) assessment provided in **Section 4.1** of this report.

14.1 DQOs

Decision 1: Is there sufficient information on the distribution and characteristics of soil and fill requiring remediation and/or management to allow remedial planning to progress?

The information obtained from the delineation investigation is considered sufficient to understand the degree of site contamination and distribution of contaminants.

The existing soil data is sufficient as a basis for sound remedial objective decisions and to progress remedial planning. The findings of the Delineation Investigation enable a robust and definitive Remedial Action Plan to be developed for site remediation. The RAP should build on the suitable remedial options provided in this report and assess options for technical and economical feasibility.

Decision 2: Do the findings of the investigation provide a higher level of understanding and certainty on contamination source zones and spatial area?

A higher level of understanding of the subsurface conditions has been established based on the information obtained in the Delineation Investigation.

The Delineation Investigation was sufficient to identify and characterise different fill and natural soil material types enabling appropriate statistical analysis to be undertaken to assess material suitability for the proposed land use. Material types and statistical analysis of these materials is presented in **Section 9.0.**

The vertical extent of contamination was delineated in all Stratified Site Areas. It is considered that selection of a suitable remedial option and an assessment of its feasibility in a Remedial Action Plan will provide appropriate management of areas that show minor impacts in the deep weathered zones of the bedrock shales, particular once source zones have been remediated. The outcome of an appropriate remedial option for these areas should consider the long term impact on groundwater.

The lateral extent of contamination was delineated by a high density of sample locations and a high level of understanding of the historical site layout. The improved density of sample locations enabled identification and lateral delineation of source zones including:

- The Tar Wells;
- The Underground pipework;
- The base annulus of the Northern Gasholder; and
- The base annulus of the Southern Gasholder.