12 Delineation and Characterisation of Contamination

12.1 Site Areas and Material Types

The identification of those impacted sample locations below are based on the data gathered during this investigation. It should be acknowledged that there exists the probability that the impacted areas (i.e. nominated for remediation) will not be confined to one identified impacted area or a defined hotspot. Moreover, the impacted area would be better defined to be based on the equidistant space between an impacted location and an acceptable adjacent location.

12.1.1 Former Gasworks Area

This area includes the stratified areas of the Gasholders, the Retort and the Gas Purifiers (refer to **Figure 3**).

The impacts in the former gasworks area are extensive and consist of high concentrations of PAHs, B(a)P, TPHs, benzene and xylenes in the fill materials and natural soils. Impacts are particularly prominent in the areas of former infrastructure including the sources listed in **Section 11.1**.

Gasholders

The Gasholder Area shows impacts at the surface and shallow subsurface layers, particularly in areas of pipework, considering the extensive network in this area. Free tar impacted soil was observed and analysed in the Silty Clay at one location (MG02/1.8mbgl), but was not prominent in locations away from pipework. The vertical extent of impacts from surface and near-surface activities is approximately 4.0mbgl (vertical extent identified at sample location MG02 and MG07). The lateral extent of impact from surface and near-surface activities is highly dependent on the network of underground pipes, the full extent of which is currently unknown. Soil impacts from leaking pipes are assumed to be localised around and immediately below the pipework.

The base of the Northern Gasholder (i.e. at 6.0mbgl) is significantly impacted with free tar. Also, tarry material was observed seeping from the brick annulus wall in trench MG05 and the opposite trench wall, suggesting lateral movement of free tar adjacent to the Gasholder. There was no free tar observed underneath the Southern Gasholder.

The vertical extent of impact below the Northern Gasholder is generally limited to between 8 – 10mbgl. This is based on minor benzene impacts identified at sample location BHD (8.4mbgl). The vertical extent of impact below the Southern Gasholder can also be limited to between 8 – 10mbgl (based on reported marginal benzene detection at sample location BHA1 at 10.2mbgl).

The impacts observed underneath the Southern Gasholder appear minor in comparison to those identified underneath the Northern Gasholder, being only marginally elevated benzene concentrations and no free tar observed. Also, the benzene impacts beneath the Southern Gasholder do not appear to leach, whereas the benzene and others contaminants beneath the Northern Gasholder have a propensity to leach.

The mechanisms that have resulted in the differing impacts underneath each gasholder are not fully understood. However throughout the life of the gasworks

operation, the brick annulus and metal lining of the gasholders may have provided an effective seal to prevent leakage of tar residues from the base. The operation and maintenance of the gasworks may have included regular cleaning of the gasholders to prevent accumulation of tarry waste at the base, therefore reducing the likelihood of tar leakage into the underlying soils. Although this may have been the case, residual tarry wastes may have been dumped inside the Northern Gasholder during plant shut down and demolition of this structure and other gasworks structures on the Site, thereby providing a tar source in the Northern Gasholder regardless of historical operation and maintenance procedures.

It is known that the Southern Gasholder was retained for temporary storage of gas that was produced at the AGL Mortlake site. For this to occur, there may have been regular cleaning and maintenance to maintain this structure in good condition, therefore tarry residues may also have been removed for this purpose.

On the basis of the current conditions of the Southern Gasholder, and its heritage status, it is unlikely that the Southern Gasholder area would require remediation. Any remediation in this area is unlikely to have a significant impact on reducing sources or mass contamination.

Infiltrating water and migrating groundwater has the potential to leach benzene and other relatively soluble organic compounds, such as naphthalene, from free tar source zones beneath the Northern Gasholder. The leachate tests results confirm that this is a likely scenario. This has the potential to cause an ongoing groundwater impact without implementing a management strategy such as source removal to the extent practicable.

It should be considered that the lateral extent of impact may be dependent on the base construction and permeability of the Gasholder annuli. The gasholder annuli may be effectively creating a seal. This is likely to be the cause of the positive head of groundwater observed in the Gasholders (i.e. water level stands above the common shallow groundwater on the outside of the annulus) discussed in **Section 8.1**.

Considering the soil profile surrounding the Gasholders, the following observations can be made:

- Impacts appear to extend up to 5m laterally from the annuli given that there were no observed contamination (odours or discolouration) at depth at the nearest deep sample locations MW06D, MW07D and MW18D, but may extend to at least 15m laterally based on identified deep impacts at location BHF at 8.4mbgl.

The latter is possible considering the gas product was stored under pressure inside the Gasholders and tarry residues may have been forced out through soil pores and weathered shale fractures to impact a greater radial area away from the Gasholder. This again is dependent on the permeability of the annulus of the Gasholder.

The Northern Gasholder has been infilled with Gravely Sands and Demolition Wastes, which appears to be a burial area for demolished Site structures. The depth of this Gasholder is approximately 6mbgl, which appears to be the vertical extent of this material based on drilling results and historical information. At this depth free tar is likely to be impacting this material inside the Gasholder annulus.

The lateral and vertical extent of impacts is defined by the stratified area outlined on **Figure 7 – Remediation Areas and Excavation Depth Estimates.**

Remediation/Management

Remediation of the surface layers of Ash and Coke Gravel fill material is required.

Areas impacted with free tar requiring remediation include:

- MG02/1.8m – tar pipe in Silty Clays;
- BHC/6.0m – brick annulus of Northern Gasholder in Red/Grey Clays; and
- BHD/7.0m – fractured weathered shale below Northern Gasholder.

Remediation of the contamination hotspots BH06/0.4m (B(a)P) and MG05/0.5m (TPH (C_{10}-C_{36})) in Reworked Clay material is required.

Remediation of the entire area at sample location MG05 (i.e. PAH, TPH and xylenes hotspots at 1.8mbgl and remaining materials to 5.0mbgl) in Red/Grey Clay materials is required.

Remediation of the contamination hotspot at sample location BHD/8.4 (benzene) in Weathered Shale materials is required.

Remediation of the Gravely Sands and Demolition Waste materials inside the Northern Gasholder is required.

Retort

Apart from the surficial layers of Ash and Coke fill, free tar is the principal source of contamination in this area. Free tar is visible in some surface fill materials, but prominent in subsurface fill layers of Reworked Clays and Silty Clays underlying the Retort Area. Free tar is also prominent in the soil pores of Red/Grey Clays underlying the Retort Area to a depth of approximately 6.0mbgl (TP15A and BHG), however the vertical migration of tar becomes increasingly impeded by the stiff Red/Grey Clays at depths beyond 4.5mbgl where the majority of sample results indicate a lesser degree of impact or indicate no detection of contaminants.

The Tar Wells are key structures and contamination sources within the Retort Area, constructed to at least 3mbgl (possibly 4mbgl). At least one of the Tar Wells contains a considerable amount of tar, while it is assumed the other holds similar amounts. Tar was observed to be seeping from the sidewall of one of the Tar Wells during sampling at MG06. Free tar impacts are prominent in the Red/Grey Clays underlying the immediate area of the Tar Wells to a depth of 6.0m. At 7.2mbgl contaminants are at concentrations below the investigation criteria, while at 8.1m contaminants are non-detectable.

Other structures that appear coupled with the presence of free tar are brick footings and underground pipework. Delineation of this area was limited due to the presence of a potential heritage item in the form of a brickwork layer, likely to be the floor of the former Retort. Given the data obtained for this area, the following statements can be made:

- The vertical extent of free tar impact in the Retort Area is expected to be approximately 4.0mbgl, although there may be localised pockets of impacted material that extends to a depth of 5.0 – 6.0mbgl. Below the Tar Wells this depth is expected to extend to at least 8.0 - 10mbgl.

- The lateral and vertical extent of free tar impacts is broadly defined by the stratified area outlined on **Figure 7.** This area is effectively the footprint area of the former Retort House.
- The lateral extent of impact may be affected or increased based on the extensive underground tar laidened pipework system present in this area, and suspected leakage of those pipes.
- Impacts may extend laterally to the north below the Retaining Wall area, but it is expected that this may only be up to approximately 5.0m (i.e. to the Site Boundary).

Remediation/Management
Remediation of the surface layers of Ash and Coke Gravel fill material is required.

Areas impacted with free tar requiring remediation include:

- BH07/1.5m;
- TPC/1.0m;
- MG06/1.0m;
- MG06/2.0m;
- MG08/1.5m;
- MG08/2.1m;
- MG09A1/0.7m;
- BH12A/4.2m;
- BHG/6.0m;
- TP15/2.8m;
- TP15/4.1m; and
- TP15A/6.0m.

Remediation of the elevated concentrations of B(a)P at sample location BH08 (1.1m and 1.7m) in Silty Clay materials is required.

Remediation of the elevated concentrations of PAH at sample locations BH12/4.5m and MG10A/2.8m in Red/Grey Clay materials is required.

Gas Purifiers
This area shows significant impacts of free tar in the Sand and Gravel fill material to depths of 2.0mbgl and in the deeper layers of weathered shales at 8.5mbgl. There are no prominent structures in this area and no significant contamination sources other than residual free tar in fill materials and soil pores.

Deep impacts were identified at sample location BHF at a sampling depth of 8.5m in Weathered Shale at refusal. However a vertical limit can be estimated to be between 8 – 10mbgl given similar limits applied beneath the gasholders.

The depth impact identified in this area may not be from surface activities. The impacts may be from a prominent vertical fracture that enabled movement of tars down the profile more readily than in other areas or may be from the lateral leakage

of tars from subsurface storage of gas in the gasholders (i.e. pressure inside the gasholder has forced tars laterally outwards).

Other sample locations indicate no detection of contaminants beyond 4.0mbgl (BH18 and MG11). Therefore based on the data for this area:

- The vertical extent of free tar impacts from surface activities (i.e. gas purifying) are unlikely to extend beyond 4.0mbgl, although soil pores and vertical fractures may have provided a preferential path for contaminants to migrate vertically down to impact much deeper soil horizons to a depth of at least 10mbgl.
- The lateral and vertical extent of free tar impacts from surface activities and deeper tar impacts in this area is broadly defined by the stratified area outlined on **Figure 7**.

Remediation/Management
Remediation of the surface layers of Ash and Coke Gravel fill material is required.

Areas impacted with free tar requiring remediation include:

- BH18/1.8m;
- MG11/2.0m;
- BHF/7.0m; and
- BHF/8.5m.

12.1.2 Northeast

The main source of contamination in this area is the surface layer of Ash and Coke Gravels. There is also a localised free tar impact at TP16 and a localised benzene impact at BH14.

The vertical extent of contamination is approximately 0.5m - 1.0mbgl in Reworked Clay material over the entire area. The overlying ash fill does not appear to have leached and impacted the underlying fill clay. This was also confirmed by leachate tests, which showed B(a)P has a relatively low propensity to leach under acid conditions. Therefore it can be said that under neutral conditions (that is infiltrating surface water), contaminants, particularly B(a)P, would not leach.

The vertical extent of the benzene hotspot at BH14 was limited to a depth of the underlying Silty Clay. The free tar impact at TP16 was limited to a depth of the underlying Red/Grey Natural Clay. Both of these hotspot areas are localised and it is expected that the diameter of the hotspot (lateral extent) would be limited to the point equidistant to the nearest location that was not impacted.

The lateral and vertical extent of impact in this area is broadly defined by the stratified area outlined on **Figure 7.**

Remediation/Management
Remediation of the surface layers of Ash and Coke Gravel fill material is required.

Areas impacted with free tar requiring remediation include:

- TP16/1.0m.

Remediation of the contamination hotspot at sample locations BH14/1.0m (benzene) is required.

Remediation of the contamination hotspot and all surface materials at sample locations TP16 (0.3m and 1.0m) for B(a)P is required.

Given the highly heterogenous nature of the subsurface conditions, this approach may only address the known areas of visible free tar impacts and contamination hotspots the Northeast Area. It should be acknowledged that the distribution of contamination in this area, and other areas such as South Central and the South West, would be irregular.

12.1.3 South Central

The main source of contamination in this area is the surface layer of Ash and Coke Gravels. There is also a localised benzene impact at MW04s in Silty Clay material. No other significant impacts were identified in this area.

Similarly to the Northeast Area, the vertical extent of contamination is approximately 0.5m - 1.0mbgl in Reworked Clay material. Based on analysis results no leaching of contaminants has occurred.

The lateral extent of impact in this area would be limited to the point equidistant to the nearest location that was not impacted, which is broadly defined by the stratified area outlined on **Figure 7.**

Remediation/Management

Remediation of the surface layers of Ash and Coke Gravel fill material is required.

Remediation of the contamination hotspot at sample locations MW04s/2.1m (benzene) is required.

12.1.4 Southwest

Significant filling has occurred in this area, particularly toward the southern extremity. Filling materials consisted of low levels of contaminants that predominantly meet the investigation criteria. The main source of contamination in this area is the surface layer of Ash and Coke Gravels. There is also a localised contamination hotspot for total PAH, B(a)P and TPH at sample location MW13s/1.0m and another for B(a)P at sample location RP (Retention Pit).

The vertical extent of impact from Ash and Coke materials at the surface across this area is approximately 0.5mbgl.

The lateral and vertical extent of the hotspot at MW13s is considered localised based on the recent data collected at sample locations TP01 and TP02, where no impacts were identified. Considering this, then the lateral extent of impact in this area would be limited to the point equidistant to the nearest location that was not impacted**.**

The extent of impact at sample location RP is reliant on the depth of the Retention Pit and connecting pipework. This information could not be established, given the limitations set for items of potential heritage significance. Deeper sampling at this location was not undertaken due to a potential damage to the structure. The extent of impact at this location is not critical given it adjoins the heritage listed Southern Gasholder and the limitations set for excavations occurring within its vicinity.

Vertical impacts in the vicinity of the Retention Pit are expected to be limited by the underlying stiff Red/Grey Clays at 4mbgl (based on data from surrounding sample locations) and the lateral extent appears restricted to an approximately 2m radius, given the impact is likely from a leaking tar laidened pipes.

The lateral and vertical extent of impact in this area is broadly defined by the stratified area outlined on **Figure 7.**

Remediation/Management
Remediation of the surface layers of Ash and Coke Gravel fill material is required.

Remediation of the contamination hotspot for B(a)P, total PAHs and TPH (C_{10}-C_{36}) at sample locations MW13s/1.0m and RP/2.0m is required.

12.1.5 Retaining Wall

The material used in the Retaining Wall are sandy gravely fills with a component of building demolition wastes. The material was similar in nature to that identified inside the Northern Gasholder, although did not contain the quantities of demolition wastes. For this reason the materials were assessed as one material.

There were two benzene hotspots (TP44 & TP3 on **Figure 4)** identified in previous investigations associated with ashy fill material at the surface of the retaining wall, adjacent to the former Retort House. The materials were also contaminated with asbestos sheeting fragments.

No significant source of contamination appears to be impacting these materials, other than the free tar at the base of the Northern Gasholder (refer to **Section 12.1.1**).

The lateral extent of the Retaining Wall is approximately 3.0 -5.0m along the entire length of the northern boundary and approximately 170m long. No impacts were identified in natural soils below the Retaining Wall at sample locations TP10 and TP18, therefore the vertical impact is expected only to be the thickness of the Retaining Wall (i.e. the thickness is approximately 1.5m).

The materials inside the Northern Gasholder are laterally confined to the annulus (i.e. 21m diameter). The vertical extent, before being impacted by free tar at the base of the Gasholder is unknown, but is expected to be at approximately 4.0mbgl.

Remediation/Management
The material consisting of the Retaining Wall Area is unsuitable for use at the Site and requires remediation or management. This consists of all fill material along the retaining wall (northern boundary 3.0 – 5.0m wide by 170m long and 1.5m thick). This should also consist of the material inside the Northern Gasholder.

12.1.6 Western Lot

No contamination sources exist in this area, other than the surface Ash and Coke material. No impacts were identified beyond 0.5mbgl, suggesting no leaching of contaminants from the Ash material. The lateral and vertical extent of surface impacts is broadly defined by the stratified area outlined on **Figure 7.**

Remediation/Management
Remediation of the surface layers of Ash and Coke Gravel fill material is required.

12.2 Remediation Volume Estimates

Considering the majority of remediation will be driven by the removal of free tar impacted fill and natural soil, remediation of this material will provide a basis to establishing remedial volume estimates. This approach will remove those source areas and reduce the mass contamination, enabling the long term objectives for the Site to be met, as discussed in **Section 11.6**. This forms the basis for determining the extent of remediation to ensure that any remaining materials do not pose an unacceptable risk to the identified receptors.

Free tar impacted fill/soil material includes those samples, and corresponding areas, listed in **Table 8.13** and **Table 8.14**. The majority of site contamination requiring remediation is located in the former gasworks areas in the vicinity of the Gasholders, the Retort and the Gas Purifier Areas.

Removal of the key source material (and structures, where appropriate) will also provide a basis to establishing volume estimates. Primary contamination source areas include the:

- Tar Wells;
- Underground pipework; and
- Base annulus of the Northern Gasholder.

The depth of soil requiring remediation and/or management during the remedial works is dependant on the end land use and whether fill material that is suitable for industrial land use can be separated during remedial excavations from fill material that is not suitable for industrial land use.

A representation of the required remediation areas is presented on **Figure 7.** While cross sectional areas of the Site are represented on **Figures 5** and **6**.

12.2.1 Uncertainty of Estimates

There is uncertainty in the volume estimates, given the highly heterogeneous nature of filling materials and the irregular distribution of contaminants; these are inherent uncertainties for any contamination site investigation and remediation program. However, confidence can be given to lowering the uncertainty and remediating the Site to a level that meets RailCorps long term objectives by using visible free tar impacts as an indicator for remediation.

Considering the good correlation between PID screening measurements and detection of organic contaminants in analytical samples, the PID will be a valuable screening technique to lower volume uncertainty during remedial excavation and also provide an effective measure in determining chase-out quantities.

12.2.2 Contamination Source Areas

Considering the contamination source areas first, it is expected that the immediate surrounding material (both fill and soil) would be impacted from seepage of tar from the source area, similar to what is shown in Photo 14 (tar seeping from the Tar Well). The following nominal measurements have been used to determine volumes of source areas.

Tar Wells

- Each Tar Well is 4m in diameter with an approximate 2m gap between them.

- Lateral impact from Tar Wells is taken as 2.0m – based on midway point between Tar Well and BH08 (that indicates no observed free tar impacts).
- Vertical impact from Tar Wells taken as 10.0mbgl – based on contaminant concentrations likely to meet investigation criteria.
- The estimated volume is 1,120m^3, and removing the volume of tar liquid within the Tar Wells (approximately **100m^3**) gives an estimated volume of **1,000m^3** of **Free Tar Impacts**.
- The NSW DEC general approval of immobilisation for coal tars is unlikely to apply to this material.

Northern Gasholder

- The inground volume of the Gasholder is estimated at 1,900m^3. The extent of tar material accumulated at the base of the Gasholder is unknown. For estimating purposes, the bottom 2.0m of the Gasholder has been taken as impacted with tar. That is from 4.0mbgl to 6.0mbgl.
- The volume of demolition waste would therefore be **1,900m^3** of material that likely to be classified as **Asbestos Waste/Industrial Waste**.
- An assumption has been made that the demolition waste has a porosity of approximately 50%, giving approximately 950m^3 of liquids inside the gasholder. If the bottom third is assumed to be tar, this gives an estimate of **640m^3** of impacted water and **320m^3** of tar at the base of the gasholder.
- The vertical impact from the base annulus can be approximated at 4m below the base, giving the depth of impact to be from 4mbgl to 10mbgl.
- Although the lateral impact is highly dependent on the permeability of the base of the brick annulus, for estimating purposes, the lateral impact from the base has been taken as 2.0m from the outside edge of the annulus. This is based on no observed impact at depth at sample locations MG07 (4.0m) and BH06 (3.0m), which were positioned approximately 2.0m from the outside edge of the brick annulus;
- Therefore the estimated volume is 2,700m^3, removing the volume of bottom third of the inside volume of the gasholder (i.e. the tar liquid accumulated at the base and the volume of demolition wastes at approximately 600m^3) gives an estimated volume of **2,100m^3** of **Free Tar Impacts**.
- The NSW DEC general approval of immobilisation for coal tars is unlikely to apply to this material.

Southern Gasholder

- Given the conditions of the Southern Gasholder presented in **Section 12.1**, and its heritage significance, it is unlikely that remedial work would be required, therefore no volume estimates have been provided.

Pipework

An estimation of the volume of source material inside and immediately surrounding the gasworks pipework is not possible without a higher level of certainty on the location and extent of the network of old pipes. It is considered that this volume may only be a portion of that from the Tar Wells or the Northern Gasholder. Nevertheless,