**Table 8.19 – Surface Water – Exceeding Concentrations**

| | | W01 | W02 | W03 | W04 | W05 | W06 |
|---|---|---|---|---|---|---|---|
| | **Location/structure** | Nth Gasholder | Tar Well #1 | Tar Well #2 | Retention Pit | Sth Gasholder | Sth Gasholder |
| **Analyte** | **ANZECC 2000 95%** | | | | | | |
| Naphthalene | 16 | **38.5** | **230** | **20,900** | <1 | <1 | <1 |
| Cadmium | 0.2 | - | - | - | **1** | <0.1 | **1** |
| Copper | 1.4 | - | - | - | **43** | <1 | **7** |
| Lead | 3.4 | - | - | - | **87** | 3 | **107** |
| Nickel | 11 | - | - | - | **16** | <1 | 4 |
| Zinc | 8 | - | - | - | **302** | **16** | **277** |
| Benzene | 950 | 12 | <5 | **1,360** | <1 | <1 | <1 |
| o-xylene | 350 | 2 | 29 | **723** | <2 | <2 | <2 |

*Notes:*
**Bold –** Exceeds investigation criteria.
All values in .µg/L.

Generally, surface water samples collected from the Northern Gasholder and the Tar Wells showed higher impacts of organic compounds to those collected from the Retention Pit or the Southern Gasholder from which reported concentrations below the LOR.

Sample W03 (from Tar Well #2) indicates a higher impact of organic compounds compared to other samples. This is likely due to the free phase product originating from the disturbed tarry materials, while other samples did not contain this product. Sample W03 significantly exceeds the investigation criteria for naphthalene (20,900µg/L), benzene (1,360µg/L) and o-xylene (723µg/L).

The samples collected from the Retention Pit and the Southern Gasholder indicate moderate impacts by inorganics. In particular, lead and zinc report concentrations one to two orders of magnitude above the trigger value criteria. The sample collected from the brick annulus of the Southern Gasholder indicates that the quality is of a higher standard compared with other samples, based on the analytes tested. This may be the result of recharging of fresh water (from rain) at the surface compared to water at the base of the gasholder that would not be readily recharged with fresh rain water.

# 9 Assessment for Unsuitable Materials and Areas

All existing soil data was used to statistically assess the different types of materials identified at the Site. This was conducted to identify which materials and areas were unsuitable and required remediation/management and inturn identified which materials were suitable for the proposed land use.

The material types identified at the Site follow those listed in **Section 8.2** including:

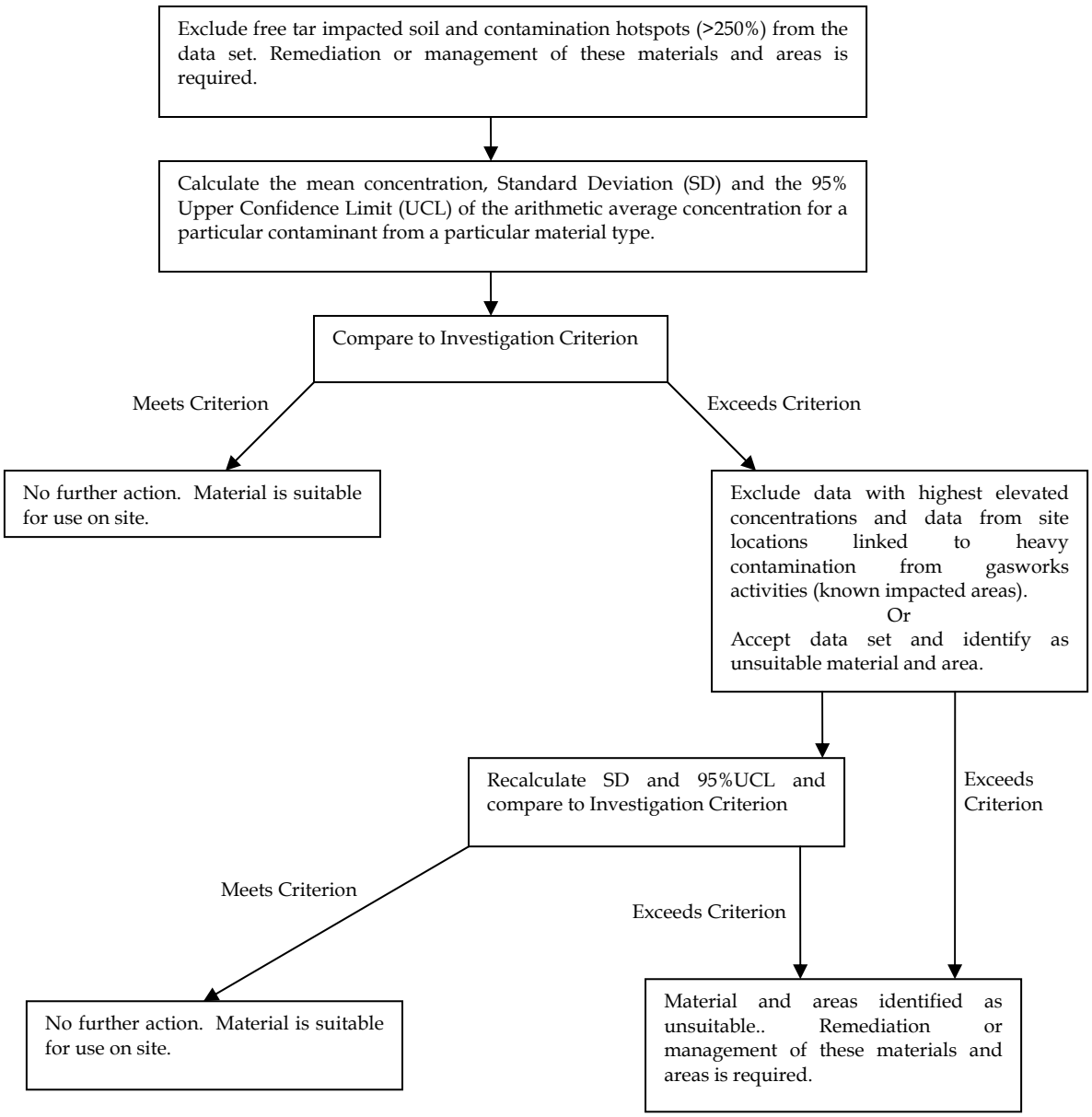
1. Ash and Coke Gravels (Fill);
2. Reworked Clays (Fill);
3. Sands and Gravels (Fill);
4. Gravel, Sand and Demolition Wastes (Fill);
5. Gravely Sand and Clay with Minor Ash (Fill);
6. Silty Clays; (Fill)
7. Red/Grey Clays (Natural); and
8. Weathered Shales (Natural).

Each material type underwent statistical analysis for each contaminant that reported exceedances of the Site criteria or was determined to be a contamination hotspot. Statistical analysis was undertaken in a stepped approach following the flow chart developed for this investigation and presented as **Diagram A** below.

The co-efficient of variation calculation was used to determine the distributions of data sets, which is outlined in NSW EPA (1995) Sampling Design Guidelines. Calculating the 95%UCL for data sets of either normal or log normal distribution was based on Procedure D or Procedure G of the same guidance document.

Results of the statistical analysis were compared against the investigation criteria as outlined in **Section 6.2.3.**

**Diagram A – Identification of Unsuitable Materials and Areas - Decision Flow Chart**




## 9.1 Statistical Results

This section presents the results of the statistical analysis of all material types. From a human health risk perspective, the contaminants of concern that present the greatest risks to human health are considered to be B(a)P and benzene, as these compounds are known carcinogens. Therefore statistical analysis of data and assessment against land use criteria was generally driven by these two contaminants.

Specific contaminants that were not statistically assessed showed either no exceedances of the Site criteria or met the Site criteria subject to removal of free tar and contamination hotspots for other chemicals. This was generally the case for TPH ($C_6$-$C_9$) and xylenes.

It is noted that asbestos impacts should be factored into the assessment of the fill/soil materials. However asbestos impacts have not been used in this process of statistical analysis. Materials impacted with asbestos would require remediation/management in any case, and any remaining materials with likely asbestos impacts would be subject to a long term site management plan.

Statistical analysis results for all materials are presented in **Table 16** to **Table 23**.

### 9.1.1 Ash and Coke Gravels

The statistical results for B(a)P indicate that this material would be unsuitable for use at the Site. Statistical results for the Standard Deviation and the 95%UCL indicate that even after removal of all contamination hotspots the material remains unsuitable.

The statistical results for benzene indicate that this material would be suitable for use at the Site subject to removal of the contamination hotspot at MG02/0.2m. However, given that the B(a)P results discussed above suggest it would be unsuitable for the entire Site, this approach cannot be applied.

### 9.1.2 Reworked Clays

The statistical results for B(a)P indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts and the contamination hotspot at BH06/0.4m.

The statistical results for benzene indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts and the contamination hotspot at BH14/1.0m.

The statistical results for total PAH indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts.

The statistical results for TPH ($C_{10}$-$C_{36}$) indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts and the contamination hotspot at MG05/0.5m.

### 9.1.3 Silty Clays

The statistical results for B(a)P indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts and all elevated concentrations at BH08 (1.1m and 1.7m).

The statistical results for benzene indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts and the contamination hotspot at MW04s/2.1m.

The statistical results for total PAH indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts.

### 9.1.4 Gravel, Sand and Demolition Wastes

The statistical results for B(a)P indicate that this material would be unsuitable for use at the Site, even after removal of ashy material contamination hotspots.

The statistical results for TPH ($C_{10}$-$C_{36}$) indicate that this material would be unsuitable for use at the Site, even after removal of ashy material contamination hotspots.

The statistical results for benzene indicate that this material would be suitable for use at the Site subject to removal of ashy material contamination hotspot at TP44/0.3m and TP3/0.3m. However, given that B(a)P and TPH ($C_{10}$-$C_{36}$) would be unsuitable for the entire Site, as discussed above, this approach cannot be applied.

### 9.1.5 Sands and Gravels

The statistical results for B(a)P indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts and the contamination hotspot and all surface material at TP16 (0.3m and 1.0m).

The statistical results for benzene indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts.

The statistical results for TPH ($C_{10}$-$C_{36}$) indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts.

### 9.1.6 Gravel, Sand and Clay with Minor Ash

The statistical results for B(a)P, total PAHs and TPH ($C_{10}$-$C_{36}$) indicate that this material would be suitable for use at the Site subject to removal of the contamination hotspots at RP/2.0m and MW13s/1.0m.

### 9.1.7 Red/Grey Clays

The statistical results for B(a)P and benzene indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts.

The statistical results for total PAH indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts, the contamination hotspot at MG05/1.8m and all impacted material at MG05, and the elevated concentrations at locations BH12/4.5m and MG10A/2.8m.

The statistical results for TPH ($C_6$-$C_9$) and TPH ($C_{10}$-$C_{36}$) indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts and all impacted material at MG05.

### 9.1.8 Weathered Shales

The statistical results for B(a)P indicate that this material would be suitable for use at the Site without further action.

The statistical results for total PAH indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts.

The statistical results for benzene indicate that this material would be suitable for use at the Site subject to removal of all free tar soil impacts, the contamination hotspot at BHD/8.4m and the dark stained materials at BHA1 (7.0m and 10.2m) and BHB (6.0m). To remove the dark stained impacts at BHA1 and BHB would require excavation beneath the Southern Gasholder. This may not be feasible given the heritage status of the gasholder. Retaining this material indicates that the 95%UCL meets the site criterion for benzene, although the standard deviation is greater than half of the criterion (refer to **Table 23**). It may be more appropriate to remediate accessible areas and retain marginally impacted materials beneath the Southern Gasholder and manage the materials in respect of ongoing groundwater impacts and other receptors. Further discussion on this approach is provided in **Section 12.1.1**.

# 10 Data Quality Assessment

Data Quality Indicators (DQIs) were developed as part of the DQO process to provide goals for the quality of data required to achieve the objectives of the site investigation program. Details on the DQIs and data validation assessment are provided in **Appendix B**.

An assessment of the quality of the environmental data against these DQIs indicated that although there were a small number of non-conformances, the vast majority of the DQIs were achieved. Based on the conclusions of the quality review, CH2M HILL considers that the data supplied for the Site meets the objectives of the Precision, Accuracy, Representativeness, Completeness and Comparability (PARCC) criteria. Therefore, CH2M HILL considers that the data set is of acceptable quality to meet the objectives of this site investigation program.

# 11 Conceptual Site Model

The conceptual site model (CSM) has been developed based on consideration of the Site's history, the existing Site data and the proposed land use for the Site.

## 11.1 Sources

Fill material and natural soil have been impacted by the historical operation of the Site as a Manufactured Gas Plant (MGP). The structures associated with this are shown on **Figure 2.** The contamination sources at the Site include:

- Tar in the Tar Wells;
- Tar residues in the network of underground pipework;
- Tar residues in the base annulus of the Northern Gasholder;
- Tar in soil pores and soil fractures in former MGP areas;
- Potential tar residues in the base annulus of the Southern Gasholder (although not a major source, this area should be identified as a secondary source given the historical use and the marginally elevated concentrations (benzene 2.0mg/kg, naphthalene 5.9mg/kg) in the analytical data collected from underneath the gasholder);
- Demolition wastes containing asbestos sheeting; and
- Ash and Coke Fill materials across the majority of the Site in the surface and shallow subsurface layers

## 11.2 Impacted Media

The environmental media of concern include:

- Shallow fill material, generally to a depth of between 0.5m to 1.0m over the entire Site area (refer to **Figure 5** and **Figure 6** for indication of soil profile);
- Deeper fill deposits in Southwest area, generally to a depth of between 3.0m to 4.0m (**Figure 5**);
- Natural soil material, including Silty Clays overlying Red/Grey Mottled Clays overlying extremely to moderately weathered shale bedrock. The impacts are particularly in the vicinity of the former gasworks area (refer to **Figure 2**), generally to depths up to approximately 4.0m, however in areas around subsurface structures, including the gasholders and tar wells, impacts are likely to extend to depths up to approximately 8 – 10m below the ground surface;
- Perched groundwater in fill and natural Silty Clay materials;
- Deep groundwater within natural shale bedrock;
- Soil pore gas in source zone areas and overlying impacted groundwater areas (i.e. down gradient of source zones); and
- Surface water although not persistent at the Site, may be impacted from surface materials after rain periods.

With respect to groundwater impacts, existing groundwater data (from previous investigations) concludes that the contaminated groundwater plumes are limited to land owned by RailCorp. Therefore, although the plume is likely to be migrating beyond the Site boundary, it is considered that groundwater is unlikely to be migrating from RailCorp land. The hydrogeological regime and groundwater plume details are provided in **Section 3.4**.

## 11.3 Contaminants

The contaminants of concern for soil media include:

- Total Petroleum Hydrocarbons (TPHs) ($C_6$-$C_9$) and ($C_{10}$-$C_{36}$);
- Monocyclic Aromatic Hydrocarbons (Benzene, Toluene, Ethylbenzene & Xylenes (BTEX));
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Phenolic compounds;
- Heavy metals (localised); and
- Asbestos.

The contaminants of concern for water media include those contaminants for soil above (excluding asbestos) and also may include:

- Cyanides;
- Nitrates; and
- Ammonia.

The contaminants of concern for soil pore gas would include those volatile compounds of the above including:

- TPH ($C_6$-$C_9$); and
- BTEX.

## 11.4 Transport Mechanisms and Exposure Pathways

The following transport mechanisms have been identified for all contaminants on Site:

- Surface run-off;
- Wind borne dusts (asbestos fibres);
- Volatilisation;
- Water infiltration;
- Leaching; and
- Groundwater migration (hydraulic gradient – refer to Section 3.4 for additional details).

The exposure pathways considered associated with the CSM include:

- Onsite – Dermal contact, Ingestion and Inhalation for soil, water and gas impacted media; and

- Offsite – Dermal contact and Ingestion for water impacted media.

## 11.5 Receptors

The Site will be retained for RailCorp operations under a commercial/industrial land use scenario. Potential receptors of impacted medium include:

- Construction/maintenance/long term RailCorp employees and contractors may be receptors to impacted soil (including dusts), water and gases/vapours;
- Employees of surrounding properties may be receptors to impacted dusts, water and gases/vapours;
- Residents of the adjoining Burren Street community may be receptors to impacted dusts and gases/vapours;
- Users of extracted groundwater down gradient of the Site may be receptors to impacted waters, although these areas are now included in the Groundwater Embargo area (Zone 2) for domestic use, declared by the Department of Natural Resources;
- Hypogean ecosystems may be receptors to impacted waters; and
- Receiving waters ecosystem (Alexandra Canal) may be receptors to impacted waters.

A diagram representing the CSM is presented in **Appendix D**.

## 11.6 Rationale for Site Remediation

Given the details of the CSM above, it is apparent that site remediation will be required to meet RailCorp's long term objectives for the Site (**Section 1.1.3**). Site remediation should address the contamination source areas in an attempt to meet these objectives and reduce or eliminate exposure pathways to site users and environmental receptors, by focusing on source removal or a reduction in mass contamination. The contaminants that drive the significant health risks are benzene and B(a)P, which are known carcinogens, as well as free tar. Remediation of the sources will mitigate the risks these contaminants pose on the receptors.

Remediation of the source areas will control or remove the exposure pathway of those receptors to the site contamination and protect the environmental values of the site groundwater. This approach will mitigate the significant risk to site users and environmental receptors and enable RailCorp to continue use of the Site without a continuing issue of health risks for workers. Remediation will manage the risks to those receptors by minimising or preventing future leaching of contaminants to groundwater, preventing run-off impacts, restricting direct exposure and restricting generation of vapours.