The plots indicate that the northern extent of the contamination plume had not been delineated by the previous investigations, particularly for C_{10}-C_{36} and naphthalene, as monitoring had generally not been conducted across the Former Cleaning Shed Site, with the exception of monitoring wells along the northern boundary of the Site.

5.7.3 Data Uncertainties

Data uncertainties that were identified by SKM with the previous investigations include:

- The site inspection undertaken by SKM in April 2004 identified five wells located in the Macdonaldtown Triangle area that were not mentioned in the previous CH2MHill reports. Two of the wells were marked MW22S and MW22D, while the other three were unmarked.
- The GPS data for a number of the boreholes, particularly MW03 and MW04, appears to be inconsistent with their actual position on the Site. When loading into a geo-referenced computer package, the sample locations lie outside the boundaries of the Macdonaldtown Triangle area.

5.8 Identification of Data Gaps

The assessment of the available data that is presented in this section has identified the main contamination issues affecting the Macdonaldtown Triangle area. A summary of the main contamination issues is provided in **Table 4**.

- Table 4 Summary of Contamination Issues

Area	Soil	Groundwater
Former Cleaning Sheds (1.53Ha)	▪ 25 sample locations across Site; - ***complies with NSW EPA sampling design guidelines.*** ▪ Fill material consisting of sand, gravel, ballast, ash and coke breeze is widespread across the area and varies in depth between 0.20 to 2.50 m. ▪ The CH2MHill June 2000 lab results are generally below the Site criteria. Isolated contaminant concentrations exceeding the adopted soil criteria were identified (PAHs, benzene, benzo(a)pyrene, and toluene). ▪ Speciated TPH data not available.	▪ Groundwater investigations of both the surficial and Ashfield Shale aquifer have only been undertaken in the area of the Former Gasworks. ▪ Groundwater wells were installed through November 2001 to determine background water quality at the Site.
Former Gasworks (0.791 Ha)	▪ 20 sample locations across Site; complies with NSW EPA sampling design guidelines. ▪ Fill material is widespread across the area and varies between 0.10 to 3.20 m in depth.	***Surficial Aquifer*** ▪ Concentrations of total PAHs, TPH C_{10}-C_{36}, heavy metals, phenols and BTEX exceed by up to three orders of magnitude the adopted ANZECC (1992) guidelines. Groundwater quality in the surficial aquifer adversely

Area	Soil	Groundwater
	▪ Contamination is widespread throughout the fill material but not underlying soils and include TPH, PAH, and BTEX. ▪ Speciated TPH data is not available for the Site.	impacted by the above compounds. ▪ General groundwater is estimated to be south south-east. Localised subterranean structures may influence groundwater flow ▪ Potential for surficial groundwater to seep out along the fill material and impact adjacent properties ***Ashfield Shale Aquifer*** ▪ Concentrations of total PAHs, benzene, heavy metals and phenols identified in groundwater samples collected from the Ashfield Shale aquifer exceed the adopted ANZECC (1992) guidelines. A range of the above compounds has impacted the groundwater quality in the Ashfield Shale aquifer. ▪ The Ashfield Shale groundwater flow direction is estimated to be in a south south east direction. Localised subterranean structures may influence groundwater flow
Off Site locations	▪ Soil sampling undertaken in the residential properties in Burren Street ▪ Remediation of these areas is being undertaken under a separate contract	▪ Groundwater wells were installed in Burren Street to the west of the gasworks Site and residential properties in Burren Street

This study considers that the Site has been sufficiently characterised in regards to soil contamination. Fill material is expected to be heterogeneous and additional soil sampling will not provide significant value to the existing data set.

However, the concentrations of volatile compounds within the soil gas phase have not been adequately assessed. The previous investigations identified elevated concentrations of volatile compounds in the soils and groundwater that could form an exposure pathway for contaminants, which need to be considered in a risk assessment. This study considers that an evaluation of soil gas is required in order to evaluate the potential risks associated with volatile gas emissions from soils at the Site. Such an evaluation will:

- Minimise uncertainly in relation to the presence of soil gas and soil gas composition; and
- Provide additional data to evaluate and manage the risk of soil gas impacting Site receptors such as construction/maintenance workers and RailCorp employees.

The previous investigations collected data on total petroleum hydrocarbon (TPH) fractions in soils and groundwater. The fractions analysed were unspeciated, meaning that the TPH compounds in a given hydrocarbon range were not differentiated in terms of aliphatic and aromatic compounds. The toxicological risks posed by TPH compounds vary according to both the hydrocarbon fractions

and the speciated fractions. Different reference doses have been developed for aliphatic and aromatic (and alkene) compounds to reflect their significant differences in chemical, physical and environmental fate properties. Consequently, a more accurate assessment of health risks from TPH contamination in soils could be obtained by conducting speciated TPH analysis on areas of the site suspected of having elevated TPH concentrations.

In summary, the main information gaps in the contamination data provided by the previous investigations for the Former Gasworks area are considered to be:

- Concentrations of volatile gases in the soil-vapour phase within shallow soils at the Site;
- The testing of speciated TPH for areas of the site suspected of containing elevated TPH concentrations;
- Groundwater data that defines background conditions along the up-gradient side of the Site;
- Additional groundwater data that defines water quality in the north-eastern area of the site and in the southern portion of the Site where parts of the former gasworks operation existed;
- Additional groundwater data that provides information on flow directions and hydraulic heads at the Site; and
- In-situ permeability data for the shallow and deep aquifers.

Based on the potential contaminants of concern at the Macdonaldtown Triangle area, the soil and groundwater samples should be analysed for:

- pH
- Heavy metals (arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc and manganese)
- Total petroleum hydrocarbons (TPH)
- Speciated TPH
- Benzene, Toluene, Ethyl Benzene and Xylene (BTEX)
- Polycyclic aromatic hydrocarbons (PAHs)
- Semi/Volatile Organic Compounds (SVOC/VOC)
- Phenols

Gasworks waste and contaminants that need not have been targeted by this investigation include cyanide (total and free), sulfate, OCPs, OPPs and asbestos. This is because the results of the previous investigations performed at the Site by others have not identified these contaminants to be of concern.

SKM

6 Site Investigation and Methodology

This section of the report describes the additional fieldwork and laboratory testing conducted for this risk assessment based on an assessment of the data gaps in the previous investigations, as discussed in the previous section. The section initially describes the design of the investigation (Section 6.1) and fieldwork procedures (Section 6.2) and field tests (Section 6.3). Information on the laboratory testing program conducted on the collected samples is then presented (Sections 6.4 and 6.5).

6.1 Investigation Design

The site investigations that were conducted by SKM as part of this study followed a Sampling and Analysis Plan (SAP) developed by SKM in August 2004 (SKM, August 2004), which was independently reviewed prior to the commencement of the fieldwork program by Dr Bill Ryall, a NSW DEC Site Auditor employed by HLA-Envirosciences and appointed by RailCorp.

A summary of the scope of the fieldwork conducted by this study across the Macdonaldtown Triangle area is provided in **Table 5**, with the location of these boreholes shown in **Figure 5.**

Table 5 Summary of Fieldwork

Field works	Number	Location
Groundwater wells installation	6 clustered wells (shallow and deep)	• One well located at the up-gradient northern end of the Cleaning Shed Site to monitor background conditions • Three wells located along the up-gradient northern side of the former gasworks Site to monitor water quality entering the Site
		Three wells located down-gradient of the southern boundary to monitor water quality near the StateRail property boundary
Soil Gas Sampling Wells	5 locations	Boreholes located in areas of elevated volatile compounds
Soil sampling for lab testing(Speciated TPH)	8 locations	Boreholes located in areas of suspected elevated TPH compounds. Samples were biased to those that are likely to exhibit greatest TPH contamination.
Falling head/slug tests	3 wells	Falling head tests were undertaken to confirm previous data only
Groundwater well sampling for lab testing	20	Refer Figure 5 and discussion below

A total of 31 existing wells were identified in the vicinity of the former cleaning sheds and gasworks sites, with information on their current status provided in **Table 1**. Of the existing wells, a total of 20 wells were selected for further sampling and testing. These wells and the reason for their selection are:

- Wells MW14S, MW14D, MW16S, MW16D – These five wells constitute all the functioning wells in the footpaths along Burren Street adjacent to the residential properties. These wells provide data on the quality of groundwater that has migrated to the west of the Site under the nearby residential properties;
- Wells MW17S and MW17D are located in the north-western most area of the Site;
- Wells MW06S, MW06D and MW20S are located in the northern part of the former gasworks Site near the suspected tar tank area;
- Wells MW07D and MW18D are located near the remaining gasholder structure;
- Wells MW12S, MW12D, MW13S and MW13D are located in the southern portion of the former gasworks area; and
- Wells MW03S, MW03D, MW04S, MW04D are located along the south-eastern portion of the former gasworks area.

Wells that were not selected for additional testing and the reasons for their non-selection are:

- MW08D, MW09S, MW10S, MW11S, MW19S were not selected due to access difficulties since they are located in the backyards of residential properties and are located close to other wells that are to be tested. Some of these wells are also not functioning;
- MW15S and MW15D were not selected as these wells had been sealed prior to sampling;
- MW07S near the gasholder was not selected since the well was found to be dry during previous monitoring events; and,
- MW22S, MW22D, MWX, MWY and MWZ are located in the Cleaning Shed area north of the gasworks Site and have not been sampled as part of the additional monitoring as construction type of these wells is not known. Groundwater in these areas is considered to be adequately characterised by the inclusion of monitoring wells adjacent to these locations (MW06S, MW06D, MW17S, MW17D, MW36S, MW36D MW37S and MW37D).

It should be noted that two of the proposed monitoring wells were not sampled, as the condition of these wells prevented the collection of a water sample. MW03S had been damaged and could not be accessed and MW12D could not be located. The completeness of the groundwater assessment is not considered to be impacted by an inability to sample from these monitoring locations, as the shallow aquifer in the vicinity of MW03S is characterised by sampling and analysis of MW04S, MW12S and MW13S. MW12D is located in close proximity to MW13D and is used to characterise the deep aquifer beneath the south western corner of the Former Gasworks Site. The locations of monitoring wells sampled as part of this investigation are shown on **Figure 5**.

The investigation involved the installation of 5 soil-vapour monitoring wells to a maximum depth of 2m in and around the former gas process areas. The five wells were positioned in known areas

of contamination. Three soil-gas wells (MW30, MW31 & MW33) were placed close to previous groundwater monitoring wells (MW03, MW04, MW07) where shallow soil and groundwater contamination had been recorded. The other two other soil-gas wells (MW32 & MW34 were located in close proximity or down-gradient to the former retort house and gasholder structures, which represent potential sources of ground contamination.

This investigation also included the collection of soil samples from each of the soil-gas probe locations to assess the likely aromatic and aliphatic TPH concentrations at the site.

6.2 Fieldwork Procedures

6.2.1 Site Supervision

Fieldwork was supervised by a suitably qualified and experienced environmental engineer/scientist from SKM. The tasks undertaken by SKM field personnel during and after the field investigation are set out in ***SKM Work Instruction WI-CS-2 Field Supervision***. Information t gathered during the investigation are described in ***SKM Work Instruction WI-CS-3 Site Observations***

A field activity daily log was maintained by SKM field personnel throughout the Site work. A copy of the SKM's standard field procedures, Field Activity Daily Log Form ET9 and Chain of Custody documentation is provided in the SAP, with summary information provided in the following sections.

6.2.2 Drilling and Well Installation

Drilling was carried out using a solid stem drilling method by a truck mounted all terrain drill rig. Auger bits were used for drilling through soils, while tricone bits were used for drilling through rock and similar strata. Terratest Engineering Exploration undertook the drilling works.

A log was produced for each borehole location in accordance with Australian Standard AS1726-1993 *Geotechnical Site investigations*. Copies of the borehole logs produced by the SKM investigation together with copies of borehole logs produced by previous investigations at the Site are provided in **Appendix A**.

Each well was fitted with a lockable cap and finished with monument boxes or gatic covers to allow for follow up monitoring and to secure each of the wells.

A total of 15 additional groundwater wells were installed in the vicinity of the former cleaning sheds and gasworks sites. 6 locations had a shallow and deep well constructed to intersect the two-aquifer system. Each well was installed with at least 3m of screened interval within the nominated groundwater aquifer. Selected wells were placed in up gradient locations to provide information on

background groundwater quality. The well locations have been selected based on the expected groundwater flow direction the potential risks associated with areas of concern and are shown in **Figure 5.**

Further details on drilling and well installation are provided in ***SKM Work Instruction WI-CS-4 Investigation Methods*** and ***WI-CS-6 Groundwater Well Design***.

6.2.3 Groundwater Sample Collection

Wells were flushed clean, developed and emptied after construction. A round of groundwater samples were collected 1 week after the development of the well. The wells were checked for phase separated hydrocarbons prior to purging and sampling. Wells were purged by removing not less than three well volumes immediately prior to sampling. Purging continued until the water quality field parameters stabilised to within ±10%. During all groundwater sampling events standing groundwater levels were recorded in AHD to determine the groundwater flow pattern. Groundwater water levels were determined with a Oil/ Water interface probe.

Water quality field parameters were measured using a Horiba U-10 Water Quality Meter. This unit has an inbuilt autocalibration system that is used to check the calibration of the unit prior to use. Sinclair Knight Merz recorded the following groundwater and aquifer parameters – conductivity, temperature, salinity, pH and dissolved oxygen.

The water samples were collected using t Sinclair Knight Merz' Standard Sampling Procedures. Dedicated low-volume Waterra Footvalves were used for sampling each of the nominated monitoring wells. Samples were collected in order of most volatile to least volatile parameters. A summary of the sample container types, preservation and the order of filling is provided in **Table 6**.

SKM

- Table 6 Container Types, Preservation and Order of Filling

Analyte	Container Type	Preservation	Order of Filling (1)
BTEX, VOCs & TPH (C6-C9)	Glass jar with teflon lined lid (40ml)	Hydrochloric acid	1
SVOCs & TPH (C10-C36)	Amber glass bottle with teflon lined cap (1L)	Refrigerate	2
Speciated TPH	Amber glass bottle with teflon lined cap (1L)	Refrigerate	3
PAHs	Amber glass bottle with teflon lined cap (1L)	Refrigerate	4
Heavy metals	Clear plastic bottle (250mL)	Nitric acid	5
Phenols	Glass bottle (1L), or amber glass bottle with teflon lined cap (1L)	Sulphuric acid or refrigerate	6
Hardness	Clear plastic bottle (250mL)	Refrigerate	7

Notes:
(1) Reference US EPA (1986)

Samples were placed into appropriately preserved sampling bottles supplied by the laboratory and placed on ice. Samples for dissolved metal analyses were filtered on Site using 0.45 micron filter papers and placed in acid preserved bottles. Standard Chain of Custody (CoC) forms were used to track the release of water samples. All sampling equipment was decontaminated between sampling events.

Further details on groundwater sampling procedures are provided in ***SKM Work Instruction WI-CS-8 Groundwater Sampling***.

6.2.4 Separate Phase LNAPLs and DNAPLs

As indicated in the previous section, wells were checked for phase separated hydrocarbons prior to purging and sampling using a Solinst 122 Interface Meter. This equipment gives quick and easy determination of both floating non-conductive liquids (LNAPLS) and sinking non-conductive liquids (DNAPLs).

Further details on measuring the thickness of separate phase LNAPLS and DNAPLs are provided in ***SKM Work Instruction WI-CS-8 Groundwater Sampling***.

6.2.5 Permeability

Well permeability tests were undertaken at MW06S, MW07D and MW38D as part of this investigation. The tests were carried out at these groundwater locations to determine the expected permeability of the aquifer beneath the Site. It was considered imperative that the hydrogeological characteristics were evaluated at the Site as groundwater is the predominate mechanism for contaminant transport.