URS

Final Report

Hendon Investigation Area - Environmental Investigations (Stage IV) - May 2015

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ABBREVIATIONS

Abbreviation	Description
1,1-DCE	1,1-Dichloroethene
1,2-DCE	1,2-Dichloroethene
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASC	Assessment of Site Contamination
ADWG	Australian Drinking Water Guidelines
AWQG	Australian Water Quality Guidelines
CEC	Cation Exchange Capacity
COC	Chain of Custody
COPC	Chemical of potential concern
CRC	Cooperative Research Centre
CSM	Conceptual Site Model
DEWNR	Department of Environment, Water and Natural Resources
DO	Dissolved Oxygen
EC	Electrical Conductivity
EIL	Ecological Investigation Level
EPA	Environment Protection Authority
ESA	Environmental Site Assessment
ESL	Ecological Screening Level
HIL	Health Investigation Level
HSL	Health Screening Level
IL	Investigation Level
LCS	Laboratory Control Spikes
LOR	Limits of Reporting
m AHD	metres Australian Height Datum
m BGL	metres below ground level
m BGS	metres below ground surface
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	National Environmental Health (Assessment of Site Contamination) Measure
PCE	Tetrachloroethene
PID	Photo Ionisation Detector
QA/QC	Quality Assurance/Quality Control
SA EPA	South Australian Environment Protection Authority
TCE	Trichloroethene
TDS	Total dissolved solids
URS	URS Australia Pty Ltd
VC	Vinyl chloride

EXECUTIVE SUMMARY

URS was engaged by the South Australian Environment Protection Authority (SA EPA) to conduct Stage IV environmental assessment works within a defined Investigation Area located in Hendon, South Australia. The Investigation Area comprises land in the vicinity of a historical industrial area and consists of a number of industrial and residential properties. This report describes the conduct and results of investigations conducted by URS in April/May 2015, which were focussed on the central, southern and western sections of the Investigation Area.

Environmental issues including soil and groundwater contamination associated with former industrial land uses in the Hendon area have been the subject of investigations as far back as 1992. The SA EPA has been undertaking environmental assessment works in the area since 2012. While the contamination is understood to originate from one or more historical industrial sources located within the industrial area, the exact source locations have not been determined.

The most recent previous investigations, conducted by Parsons Brinckerhoff (PB) in 2014, concluded on the basis of measured indoor air concentrations that health risks associated with inhalation of volatile chlorinated hydrocarbons (VCHs) in the residential area were acceptable. PB's reports from 2013a, 2013b and 2014b identified the potential for temporal variability in vapour concentrations due to changes in soil moisture, however, which could alter the outcomes of the health risk assessment.

The objective of this Stage IV environmental assessment was to both update and refine the characterisation of volatile chlorinated hydrocarbon impacts to soil vapour and groundwater across the Investigation Area, in conjunction with acquisition of other exposure pathway data, to support a separate assessment of the potential risks to human health in the southern, central and western sections of the EPA investigation area. Works included groundwater monitoring of selected wells (34 in total), installation of eight new soil vapour wells, and sampling of 19 soil vapour monitoring wells including the newly installed wells. A property survey was also undertaken to gather data on the construction of residential dwellings and the presence of underground structures (cellars/basements).

The EPA has also commissioned a targeted environmental assessment works at the Laugh'n'Learn Childcare Centre, located on the north-western corner of Tapleys Hill Road and West Lakes Boulevard. The most recent vapour sampling event was undertaken by URS in May 2015 and is reported separately (URS, 2015).

Another party is undertaking soil vapour assessment works to the north of the Hendon Industrial area (CH2MHILL, 2015).

The following was concluded from the results of this investigation:

- Volatile chlorinated hydrocarbon impacts continue to be present in shallow groundwater at a depth of typically around 3.5 to 5 m below ground level within the Investigation Area associated with the Hendon industrial area.
- The nature and distribution of VCH impacts is generally consistent with previous observations. The highest reported concentrations of TCE and PCE in groundwater were recorded in wells GW9 and MW02, respectively, both located south of the Philips

Crescent industrial site. Concentrations in a number of wells, including several along West Lakes Boulevard south of the Philips Crescent site, were the highest recorded since 2012.

- The nature and distribution of VCH impacts in groundwater indicates that there are a number of properties within and in the near vicinity of the Hendon industrial area that have historically and may continue to be acting as sources of the reported impacts. Historical activities which may have used solvents in the Hendon industrial area are understood to have included a munitions factory, electroplating and electrical components manufacturing.
- Groundwater flow in the region appears to be influenced by incidental extraction of groundwater by the deep sewer trunk mains, which indicates the potential for transport of VCH-impacted groundwater via the sewerage system.
- The additional soil vapour monitoring wells have contributed to delineation of soil vapour impacts, which appear to align closely to the distribution of VCH impacts in groundwater.
- The property survey has identified the presence of both concrete slab-on-ground and timber floor (crawlspace) residential construction, and notably, that underground structures (cellar/basements) are a feature of the local residential dwellings.

The above summary should be read in conjunction with the Limitations presented in **Section 9.2** of the attached report.

1 INTRODUCTION

URS was engaged by the South Australian Environment Protection Authority (SA EPA) to conduct Stage IV environmental assessment works within a defined Investigation Area located in Hendon, South Australia. The Investigation Area comprises land in the vicinity of a historical industrial area and consists of a number of industrial and residential properties. The location of the Investigation Area is shown in **Figure 1**. This assessment was focussed on the central, southern and western sections of the Investigation Area. The Laugh'n'Learn Hendon childcare centre to the west of the industrial area and the northern section of the investigation area are subject to separate environmental assessment works.

1.1 Background and Objectives

Environmental issues including soil and groundwater contamination associated with former industrial land uses in the Hendon area have been the subject of investigations as far back as 1992. The SA EPA has been undertaking environmental assessment works in the area since 2012. While the contamination is understood to originate from one or more historical industrial sources located within the industrial area, the exact source locations have not been determined.

The most recent previous investigations, conducted by Parsons Brinckerhoff (PB) in 2014b, concluded on the basis of measured indoor air concentrations that health risks associated with inhalation of volatile chlorinated hydrocarbons (VCHs) in the residential area were acceptable. PB's reports from 2013a, 2013b, 2014a and 2014b identified the potential for temporal variability in vapour concentrations due to changes in soil moisture, however, which could alter the outcomes of the health risk assessment.

The objective of this Stage IV environmental assessment was to both update and refine the characterisation of volatile chlorinated hydrocarbon impacts to soil vapour and groundwater across the Investigation Area, in conjunction with acquisition of other exposure pathway data, to support a separate assessment of the potential risks to human health. The investigations focused on residential areas to the south and west of the Hendon Industrial area, and a children's play café located at the corner of Philips Crescent and Circuit Drive, Hendon.

1.2 Scope of Works

The investigation was undertaken in general accordance with the proposed work outlined in URS's proposal '*Environmental assessment works (Stage IV), Hendon industrial area*, *SA* (Ref 03014258-1090) dated 10 April 2015 and the Amended *National Environment Protection (Assessment of Site Contamination) Measure 1999*. The scope of works included the following:

- A Groundwater Monitoring Event (GME) of 34 existing groundwater wells (including designated wells associated with another site in the north western area);
- Installation of six soil vapour wells in the locations designated by the SA EPA (south & west) to further delineate the contaminant plume;
- Installation of two soil vapour wells around the children's play café site located on Philips Crescent;

- A Soil Vapour Monitoring Event (SVME) of 19 (previously installed and new) designated soil vapour wells;
- Design and conduct of a survey for properties within an area designated by the SA EPA to identify construction type, presence of basements/cellars, and groundwater use;
- Tabulation of all data in a format useable for a health risk assessment, including previous monitoring data for trend analysis; and
- Preparation of this factual report.

2 PREVIOUS INVESTIGATIONS

Environmental site assessments at 3-5 Philips Crescent, located within the investigation area and displayed on the attached figures, by Coffey Partners in 1992 (Coffey 1992a and 1992b) identified groundwater impacts consisting of elevated concentrations of metals, boron, fluoride and VOCs including volatile chlorinated hydrocarbons (VCHs) trichloroethylene (TCE), tetrachloroethylene (PCE) and 1,2-dichlroethane (1,2-DCE) . The groundwater flow direction was inferred to be north westerly and it was concluded that VOC impacts may have included on and an off-site source to the north-east. It was noted that TCE was formerly used on the site as a solvent for cleaning circuit board panels. A soil gas survey by Coffey Partners in 1992 (Coffey 1992c) identified widespread elevated concentrations of VOCs within the soil vapour the property located at 3-5 Philips Crescent. It was noted at that time that an unacceptable health risk may have existed for site users and possibly nearby residents.

The SA EPA commenced undertaking additional environmental assessment works in the area in 2012 conducting an Environmental Site Assessment (ESA) (PB, 2013a). The works involved the sampling and extension of the groundwater and soil vapour well network into the area surrounding the 3-5 Philips Crescent site. The investigation identified elevated concentrations of PCE and TCE in groundwater in the vicinity of the Hendon Laugh'n'Learn Child Care Centre (MW07), a well adjacent on Philips Crescent (GW9) and a well adjacent to a residential area (MW14). A vapour risk assessment conducted by PB (2013b) indicated that the vapour risks were below the assessment criteria and considered to be tolerable. However the elevated result for the vapour well in the vicinity of the childcare centre triggered a soil vapour investigation at the site.

Additional investigations were conducted in 2013 and 2014 by PB (2013b, 2014b). The investigations included the extension of the groundwater and soil vapour well network, soil vapour bore monitoring and installation of passive Radiello samplers within service pits surrounding the childcare centre. Elevated concentrations of VOC's were identified in the north eastern corner of the Hendon industrial area, and up hydraulic gradient of the Philips Crescent site indicating that it was likely that there was more than one source of contamination in the Hendon industrial site. Concentrations of TCE were also detected in the passive Radiello samplers within the service pits surrounding the childcare centre. A vapour risk assessment conducted PB (2014b) which concluded, based on available data, that risks to residential receptors including the occupants of the Hendon Child Care Centre were acceptable. A number of contaminant sources were deemed likely within the industrial area. The investigation (PB, 2014b) also identified the possibility of a deep sewer along Tapleys Hill Road acting as a preferential pathway for the migration of chlorinated hydrocarbon impacts.

PB's reports from 2013 and 2014 also identified the potential for temporal variability in vapour concentrations due to changes in soil moisture, which may alter the outcomes of the health risk assessment.

Works have been recently undertaken to the north of the Hendon industrial area by a third party (CH2MHILL, 2015) comprising the installation and sampling of three nested sets of vapour bores (SV18, SV19 and SV20) in the general vicinity of chlorinated solvent impacted vapour bore SV10 (and its paired groundwater monitoring well MW14). It was noted that a potential TCE and PCE source area may be located up hydraulic gradient of MW14 towards MW23; spills or leaks or solvents may have occurred from former activities in this area including a munitions factory during World War II, and an oil store, plating, chemical and printed wiring factory operated by Philips. LAI industries currently manufacture switchboards and control gear assemblies within an industrial property in this area. A human health risk assessment is yet to be undertaken in this area to assess the chlorinated solvent vapour risks to residents and commercial occupants.

3 DETAILED SCOPE AND METHODOLOGY

3.1 Chronology of Works

The scope and timing of field investigations is summarised in **Table 3-1** below:

Table 3-1 Overview of Sampling Works

Investigation Element	Works Conducted	Date of Works
Groundwater Investigations	Gauging of 35 groundwater monitoring wells	27-30 April 2015
	Sampling of 34 groundwater monitoring wells	27-30 April 2015
	Collection and disposal of drum of purge water	15 May 2015
Soil Vapour Investigations	Underground service clearance	6 May 2015
	Installation of eight soil vapour wells	6-7 May 2015
	Sampling of new and existing soil vapour wells	11-13 May 2015
	Survey of well locations	21 May 2015
Property Survey	Property survey/doorknock of properties west and south of the industrial area	12 May 2015

3.2 Groundwater Gauging and Sampling

Groundwater Gauging

A groundwater well gauging round of a total of 35 wells within the Investigation Area was conducted prior to groundwater sampling. Groundwater wells GW01, GW09, MW01-MW27 and BH22 were gauged on 27 April 2015; wells GW02, BH13, BH25, BH22*[1] and MW95 were gauged on 30 April 2015.

At each well, the depth to groundwater and total well depth were measured from the top of casing using an oil/water interface probe. Well gauging results are provided in **Table 1**.

Groundwater Sampling

Groundwater wells were sampled using the low-flow technique in general accordance with Schedule B2 of the ASC NEPM (1999).

Sampling was carried out by pumping each monitoring well at a low flow rate using a pneumatic bladder pump with its intake placed within the screened section of the monitoring well. The low-flow micro-purge pump was set at a consistent depth above the base of the well with the aim of collection of representative samples. Each well was purged prior to sampling, and the standing water level in each well was monitored at regular intervals during the purging process to allow the pumping rate to be adjusted to achieve a stable water level with minimal drawdown, thereby minimising both introduction of air to the groundwater and mobilization of particulate matter from the water table formation.

[1] Well BH22* shown on the attached Figure 3, denotes a well identified in close proximity to well BH22, which was not part of the designated monitoring well network for this investigation, but was included in the gauging event.

While an attempt was made to achieve stable drawdown and groundwater parameters, poor recharge was noted in several wells. Where stabilisation of the groundwater level could not be achieved (MW07 and MW9), a grab sample was obtained prior to the well running dry.

Field parameters of temperature, pH, EC, DO and redox and visual and olfactory evidence of the presence of chlorinated hydrocarbon compounds (where present) were recorded during sampling. These records are summarised in **Table 2** attached. Copies of the groundwater purge and sampling sheets are provided in **Appendix A**.

Groundwater samples were placed in laboratory-supplied bottles and held in chilled conditions pending and during transport to the laboratories under chain-of-custody protocols. Samples were analysed for a VOC screen (inclusive of PCE, TCE, DCE and VC) using an "ultra-trace" method to provide an enhanced limit of reporting. Each sample was also analysed for salinity, major cations and anions and degradation parameters (ethane, ethene, methane and carbon dioxide). QA/QC samples (duplicates/triplicates, field, rinse and trip blanks) were collected in accordance with the ASC NEPM.

Waste groundwater was collected into sealed labelled drums which were disposed of by a licenced waste disposal company (Mulhern Waste Oil). A waste disposal certificate is provided in **Appendix J**.

3.3 Soil Vapour Well Installation

URS installed eight soil vapour wells, denoted SV21 to SV28, between 6 and 7 May 2015. The vapour wells were installed to depths of between 1.9 and 2 meters below ground level (mBGL). The locations of the new vapour wells along with the existing vapour well network are shown on **Figure 2**.

The locations of the soil vapour wells were first cleared by a licenced service locator (Sure Search) and then hand augured to a minimum of 1.2 mBGL for further protection against potential damage to underground services. The bores were then advanced to their final depth using either a hand auger or push tubes advanced using a Geoprobe rig operated by WB Drilling.

"Undisturbed" sample tube (U50) core samples were collected from depths below ground surface of 1.5 to 2.0 m and 2.5 to 3.0 m from soil bores drilled immediately adjacent to soil vapour bore locations SV21, SV22, SV25 and SV27 within the predominant soil type encountered. The samples were sent to the Coffey geotechnical laboratory for analysis for the determination and calculation of bulk density, moisture content, dry density, void ratio, degree of saturation, air and water-filled porosity and specific gravity. The chain of custody and laboratory certificate of analysis is provided in **Appendix B**.

The soil profile encountered during drilling was photographed and logged using visual-tactile methods in accordance with AS1726 (1993). PID headspace readings for soil samples collected at selected intervals during the drilling of each soil vapour well were also recorded.

The wells were constructed by setting a piece of ¼" OD Teflon tubing with a stainless steel screen of approximately 200 mm length at the base of the hole, packing with sand to approximately 100 mm above the screen and isolating from the surface using a bentonite seal and cement/bentonite grout to the surface. Each bore was finished at the surface with a concreted flush Gatic cover protecting the upper end of the tubing, which was terminated with a Swagelok fitting.

Soil vapour well construction and lithological logs (including photographs and PID readings), are provided in **Appendix C**. The locations of the eight new soil vapour wells were measured by licensed surveyor LinkUp on 21 May 2015; the results of this survey are provided in **Appendix D**.

3.4 Soil Vapour Sampling

Vapour wells, SV01-SV03, SV05-SV08, SV11, SV13, SV15M, SV17 and SV21-SV28 were sampled between the 11 and 13 of May 2015. The following works were undertaken:

- Each well was screened in the field using a photo-ionisation detector (PID) and a landfill gas meter for measuring CO_2, CH_4, O_2. Field screening was conducted for sufficient time to allow for purging of the well.
- Leak testing of bores and sample trains using a combination of vacuum and helium was undertaken:
  - Vacuum line test. With all Teflon lines securely fitted using Swagelok nuts and ferrules, and the valves to the well and to the canister closed, a hand pump was used to evacuate the lines, producing a vacuum of at least -15 inHg. Upon cessation of pumping, the vacuum was monitored for one minute. If unacceptable leaks were detected, fittings were checked, tightened, or replaced and the vacuum test repeated.
  - Helium gas leak test. The sampling train was passed through a bucket, which was placed over the well, ensuring an adequate seal with the ground to prevent substantial leakage of the tracer gas. The shroud was filled with the helium tracer gas and the concentration of helium in the sampling train recorded using a helium detector for 5 minutes. The concentration of helium within the shroud was then recorded. If the concentration in the sampling train was greater than 10% of the shroud concentration then fittings were checked, tightened, or replaced, then re-tested.
  - Isopropanol leak test. Consistent with the methodology outlined in CRC CARE TR23, an isopropanol soaked cloth was placed under a hood housing the well head, canister and sampling train. The sample canisters were then laboratory analysed additionally for isopropanol to check for leakage into the sampling train.
- Samples were collected into laboratory-certified, evacuated (summa) canisters, equipped with 1-hour flow regulators. Canister valves were closed while the canisters remained under partial vacuum, to enable checking for leaks following transport to the laboratories. Soil vapour purge records are provided in **Appendix I**.
- Carbon tube samples were collected from the vapour wells as a backup, with the intention of analysis only if required due to a known or perceived problem with the canister results. The tubes were collected using a calibrated sampling pump, with low-flow adaptor. Flow rates were verified with an in-line calibrator. (It is noted that, as discussed later, no analysis of carbon tube samples was deemed necessary).
- Samples were sent under standard URS chain of custody protocols to Eurofins (Air Toxics) in the USA for laboratory analysis of volatile halogenated aliphatic (VHA) compounds of concern including TCE and related breakdown products. Blind field

duplicate samples from SV13 were sent to Eurofins (Air Toxics) in the USA and to the National Measurement Institute (NMI) in Australia. The chain of custody and laboratory certificate of analysis is provided in **Appendix B**.

3.5 Property Survey

A property survey was conducted on 12 May 2015, encompassing over 100 properties west and south of the Hendon industrial area, as shown on **Figure 13**. The two survey areas were targeted based on inferred elevated impacts to groundwater beneath residential dwellings.

The objective of the property survey was to assess the construction of dwellings (timber floor / concrete slab on ground), presence of below ground structures (basements, cellars) and any registered or unregistered groundwater wells. The following works were undertaken:

- Preparation and distribution of a letter and survey form by a URS employee to assess the presence and use of or intended installation of basements and/or groundwater bores.
- Where occupants were home and willing to fill out the survey at the time of the door knock, URS recorded their answers to the survey. Where the occupants were not home or willing to complete the survey at the time of the door knock, an envelope containing the letter and survey was placed within the letter box or provided directly to the occupant.
- A building surveyor from Rider Levett Bucknall SA Pty Ltd accompanied URS personnel during the property survey, to provide an opinion for each property on likely building foundation type, either in lieu of or a supplement to occupant-supplied information.

4 HYDROGEOLOGICAL CONDITIONS

The following data regarding regional geology and hydrogeology was obtained from:

- Department of Mines and Energy (1988) – *1:50000 Geological Map of Gawler 6628-IV*.
- DfW 2012, *Groundwater level and salinity status report 2011 – Central Adelaide PWA*, Government of South Australia, through Department for Water, Adelaide
- Gerges N, 2006, *Overview of the hydrogeology of the Adelaide metropolitan area*, Report DWLBC 2006/10, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Adelaide.
- Selby, J. and Lindsay, J.M., 1982. "*Engineering Geology of the Adelaide City Area*". Department of Mines and Energy, Geological Survey of South Australia, Bulletin 51.
- Sheard & Bowman, 1996 "*Soils, stratigraphy and engineering geology of near surface materials of the Adelaide Plains*" M.J. Sheard and G.M. Bowman, Report 94/9.
- Thomson BP, 1969, *Adelaide* map sheet, 1:250,000 Geological Series, South Australian Department of Mines, Government of South Australia

4.1 Regional Hydrogeology

The site is located on the Adelaide Plains approximately 3 km east of Gulf St Vincent. The major physiographic feature of the region is the northeast to southwest trending Mt Lofty Ranges located approximately five kilometres to the east (Gawler Geological Map 1:50,000). The Adelaide Plains consist of sediments derived from the erosion of the Mt Lofty Ranges.

The geology of the area primarily consists of the Quaternary aged soils and sediments of the Adelaide Plains including the Callabonna Clay, Pooraka Formation and Hindmarsh Clay. The regional geology in the site vicinity consists of the following Quaternary aged lithologies:

- Callabonna Clay which consists of a thin surficial sandy clay;
- Pooraka Formation which consists of silty clay, sand and carbonate with occasional gravel lenses; and
- In the subsurface, Hindmarsh Clay consists of high plasticity grey/green to orange clay with discontinuous gravel and sand lenses. Underlying the Hindmarsh Clay is sand and limestone of Tertiary age.

Up to six thin gravel groundwater formations are present within the quaternary sediments beneath the site. The salinity of the first Quaternary formation is generally high with total dissolved solids greater than 5,000 mg/L. Up to four tertiary aquifers exist within the tertiary sediments beneath the site. Due to its low salinity and high production the greatest proportion of extracted water comes from the first tertiary aquifer. This aquifer is used for seasonal irrigation of golf courses and other recreational grounds.

The regional groundwater flow direction is expected to be to the west – towards West Lakes Boating Lake and the Gulf St Vincent. The West Lakes Boating Lake is located approximately 300 m to the west of the western extent of the EPA Investigation Area. The shallow man-made lake discharges to the Port River which in turn discharges to the Barker Inlet to the north. The site is located approximately 4.5 km north of the River Torrens which flows east to west and discharges into the Gulf St Vincent.

4.2 Registered Bore Search

A search for registered groundwater users located within a 2 km radius of the site was undertaken on 1 June 2015, using the DEWNR WaterConnect on-line groundwater database (DEWNR, 2014a). **Appendix E** provides details of all registered bores reported. A summary of the search results for bores located within a 2 km radius of the site is provided below in **Table** 4-1 and **Table 4-2**.

Table 4-1 Registered Bore Use and Status

Listed Bore Use	Number of bores	% of total
Domestic	150	17
Drainage	27	3
Exploration	3	0
Industrial	4	0
Investigation	179	21
Irrigation	31	4
Monitoring	97	11
Observation	56	6
Town Water Supply	1	0
Unknown	324	37
Total	**872**	

Listed Bore Status	Number of bores
Abandoned	22
Backfilled	53
Operational as required	1
Operational	76
Plugged	2
Rehabilitated	1
Unknown	717
Total	**872**

Table 4-2 Registered Bore Details

Drilled depths: (mbgl)	– Minimum: 1.52 – Maximum: 604.4 – # of datum: 847
Standing Water Levels: (mbgl)	– Minimum: -0 – Maximum: 52 – # of datum: 604
Total Dissolved Solids: (mg/L)	– Minimum: 121 – Maximum: 56,874 – # of datum: 439
pH	– Minimum: 6 – Maximum: 8.4 – # of datum: 227
Yield (L/s)	– Minimum: 0 – Maximum: 40 – # of datum: 363
Groundwater Formation Details:	Hindmarsh Clay, (Quaternary formation) (5) Port Willunga Formation (66) Number of Datum shown in brackets

The varying water level and drill depths noted in **Table 4-2** indicate that the registered bores intersect both Quaternary formation and Tertiary aquifers in this area.

Based on the recorded salinity levels, groundwater within the area may be suitable for potable and other domestic purposes (SA EPA, 2009 and ANZECC, 1992).

A search of the registered well database identified 21 wells within the Investigation Area which were not recorded as investigation, monitoring or observation wells, or which could not otherwise be determined (based on location, depth and drill date) to be associated with previously installed monitoring wells. The location of these wells is shown on **Figure 1** and their details summarised in **Table 4-3** below.

Table 4-3 Registered Bore Details

ID	Aquifer	Max drill depth (m)	Max drill date	Purpose	Latest status
6628-8625		6.4	14/02/1961	Unknown	
6628-8628		49.38	12/04/1946	Unknown	Unknown
6628-8629		91.44	1/04/1940	Unknown	
6628-8634		114.3	1/01/1934	Unknown	
6628-8636	Tow(T1)	176.78	1/01/1934	Unknown	
6628-8637		134.72	2/03/1947	Unknown	
6628-8638		91.44		Unknown	
6628-8639		111.25	1/11/1935	Unknown	
6628-13451		6	12/09/1985	Unknown	
6628-14240		10	9/05/1988	Domestic	Operational
6628-15679		6	2/11/1990	Domestic	Operational
6628-16431		12	16/06/1993	Domestic	
6628-16955		16	2/03/1995	Domestic	
6628-18405		18	2/01/1997	Domestic	
6628-18862		12	16/03/1998	Domestic	
6628-19312		12	14/01/1999	Domestic	
6628-19364		12	18/02/1999	Domestic	
6628-21134		13	3/06/2002	Domestic	
6628-23345		10	25/07/2007	Unknown	
6628-23633		22.2	26/03/2007	Unknown	
6628-25074			29/01/2010	Unknown	

5 SCREENING CRITERIA

5.1 Groundwater

The groundwater screening criteria adopted for this investigation were devised in consideration of both:

- Regulatory water quality criteria, being the most stringent of the SA EPA (2003) Environmental Protection (Water Quality) Policy criteria for each of the protected environmental values; and
- Risk-based criteria selected in consideration of realistic potential beneficial uses of groundwater in the vicinity of the site, sourced from other Australian and international publications.

The selection of assessment criteria is detailed in **Appendix F**, and the adopted assessment criteria are presented on **Tables 4** to **7** attached.

5.2 Soil vapour

No guidelines have been applied to soil vapour results for this investigation. The data will be considered as part of the human health risk assessment being undertaken by URS, and will refer to the NEPM Interim soil vapour Health Investigation Levels for volatile organic chlorinated compounds (VOCCs). Soil vapour data will be utilised in modelling works to predict indoor air concentrations of TCE (and other VOCCs as appropriate) for comparison against the SA EPA/ SA Health Action Levels for sensitive land uses and US EPA threshold values.

6 QUALITY ASSURANCE AND DATA VALIDATION

This section presents the findings of quality assurance/quality control (QA/QC) assessments undertaken with respect to both the groundwater and soil vapour monitoring works undertaken. The soil vapour monitoring field procedures incorporate checks on vapour well and sampling chain integrity, the results of which are discussed in **Section 6.1**. Analytical results for QA/QC samples for soil vapour and groundwater samples, including field and laboratory duplicates, are discussed in **Section 6.2**.

6.1 Vapour Well Integrity

Helium leak test

Field records for helium vapour leak testing conducted in May 2015 are summarised in **Table 6-1** below. In accordance with the ITRC[2] guidance, a maximum relative helium concentration of 10% within the sampling train compared to the hood is considered acceptable for sampling (i.e. small leaks are not considered to invalidate the results). The results from the isopropanol leak testing indicate that the integrity of the wells was acceptable.

Table 6-1 Helium Leak Test Data – May 2015

Location ID	[He] measured in well (ppm)	Maximum [He] measured in hood (ppm)	Well/Hood Relative %
SV01	0	81,000	<0.001%
SV02	0	80,400	<0.001%
SV03	0	83,100	<0.001%
SV05	0	82,300	<0.001%
SV06	0	77,400	<0.001%
SV07	0	84,700	<0.001%
SV08	0	82,200	<0.001%
SV11	0	89,600	<0.001%
SV13	0	77,800	<0.001%
SV15M	0	80,400	<0.001%
SV17	0	83,100	<0.001%
SV21	0	79,400	<0.001%
SV22	0	85,400	<0.001%
SV23	0	88,700	<0.001%
SV24	0	82,500	<0.001%
SV25	0	81,800	<0.001%
SV26	0	78,900	<0.001%
SV27	0	95,300	<0.001%
SV28	0	81,500	<0.001%

[2] ITRC (2007), *Vapor Intrusion Pathway: A Practical Guideline*, Interstate Technology and Regulatory Council Vapor Intrusion Team, Jan 2007.

Isopropanol Leak Test

In addition to the helium leak test, each canister sample was laboratory analysed for isopropanol and compared with a sample collected from beneath a hood* used to cover the well head, sample train and canister at each location.

This enables the relative concentration in the hood to be compared with the sample and thereby, an assessment of leakage can be made. Consistent with the ITRC (2007) guidance and CRC CARE TR23 (Wright, 2013), a leak of up to 10% (well/ hood relative) is considered acceptable as such a minor leak is considered to not invalidate the data.

As can be seen from **Table 6-2**, the only minor leak of note was identified in the hood from vapour bore SV15M.

Table 6-2 Isopropanol Leak Test Data – May 2015

Location	Isopropanol in Canister ug/m^3	Well/Hood Relative %
Hood	630,000*	
SV01	<37	<0.1
SV02	<22	<0.1
SV03	<13	<0.1
SV05	<12	<0.1
SV06	22	<0.1
SV07	12	<0.1
SV08	<11	<0.1
SV11	<11	<0.1
SV13	<56	<0.1
SV15M	3700**	0.6
SV17	<11	<0.1
SV21	<11	<0.1
SV22	<120	<0.1
SV23	<11	<0.1
SV24	<11	<0.1
SV25	<11	<0.1
SV26	<12	<0.1
SV27	<12	<0.1
SV28	<11	<0.1

*Hood sample not collected during Hendon Stage IV investigation. Hood sample value from the Hendon Child Care Centre Investigation (URS 2015) used instead.

**Concentration exceeded instrument calibration range

6.2 Analytical Data Validation

The investigations included laboratory analysis at two different laboratories, incorporated two types of sample collection and three laboratory batches of samples. Chain of custody details and laboratory certificates are provided in **Appendix G**.

A summary of the laboratory batches is provided in **Table 6-3** below.

Table 6-3 Sampling and Laboratory Analysis Summary

Lab Certificate Batch ID	Lab	Sample Date	Sample Type	Sample Technique
MAT KESW15S	Coffey	6 May 2015	Soil	U50 Tubes
EM1504553	ALS Melbourne (primary laboratory)	27-30 May 2015	Groundwater	Low Flow
456252	MGT Eurofins (Secondary Laboratory)	30 May 2015	Groundwater	Low Flow
1505294	Eurofins Air Toxics (primary laboratory)	11- 13 May 2015	Soil vapour	Summa Canisters
URS08/150515	NMI (Secondary Laboratory)	19 May 2015	Soil vapour	Summa Canister

The data validation guidelines adopted by URS provide a consistent approach for the evaluation of analytical data. These guidelines are based upon data validation guidance published in the Amended 1999 ASC NEPM by the National Environment Protection Council (NEPC, 2013). The process involves the checking of analytical procedure compliance and an assessment of the accuracy and precision of analytical data from a range of quality assurance/ quality/m^3) control (QA/QC) measures, generated from both the sampling and analytical programs.

Specific elements that have been checked and assessed by this project are:

- Preservation and storage of samples upon collection and during transport to the laboratory
- Holding times
- Use of appropriate analytical procedures and required limits of reporting
- Frequency of conducting quality control measurements
- Laboratory blanks, field duplicates, laboratory duplicates
- Matrix spike (MS) and surrogates (or System Monitoring Compounds)
- The occurrence of apparently unusual or anomalous results, e.g. laboratory results that appear to be inconsistent with field observations or measurements

Validation summary reports and tables of field duplicates, laboratory duplicates and matrix spike/matrix spike duplicates are provided in **Appendix G**.

From this information an assessment of the quality of the analytical data is such that it can be used as a basis for interpretation with reference to the comments included in **Appendix G**.

Carbon tube samples were collected from the vapour bores as a backup (to be only analysed if required due to a known or perceived problem with the canister results). As the accuracy and precision of the canister results were assessed as acceptable and were consistent with historical results, and the integrity of the canisters has been assessed as sound, the carbon tube samples were not analysed.

7 RESULTS

7.1 Door Knock Survey Results

A property survey was conducted on 12 May 2015, encompassing 115 properties with building structures west and south of the Hendon industrial area, as shown on **Figure 13**. The two survey areas were targeted based on inferred elevated impacts to groundwater beneath residential dwellings. A few properties within the survey area will observed to be vacant.

The findings are summarised below:

- Of the 115 properties door knocked and surveyed, 29 occupants provided responses.
- Of the 29 responses provided, 4 residences were identified to have basements; 3 were identified to have vehicle service pits; and 2 domestic groundwater wells were identified.
- The property construction survey by Levett Bucknall SA Pty Ltd identified 39 properties constructed using an on-ground slab, two properties with both raised floors and on-ground slabs, and the remainder of properties with raised floors.

7.2 Groundwater Field Results

7.2.1 Groundwater Field Parameters and Observations

No odour or sheen was noted during groundwater purging or sampling. Groundwater was generally noted to have a clear/brown colour and low to medium turbidity.

Field parameters measured during groundwater sampling are presented in **Table 2** and summarised below.

Table 7-1 Groundwater Field Parameters

Parameter	Results and Comments
pH	pH varied from 5.34 (GW01) to 7.73 (MW09), with values typically indicative of a mildly acidic groundwater environment
Oxidation/Reduction Potential (ORP)	Field Redox potential varied from -223.3 mV (BH95) to 228.4 mV (GW01), indicative of conditions ranging from both highly reducing to highly oxidising conditions. Highly reducing conditions (ttypically -100 to -300 mV) may allow anaerobic degradation of chlorinated solvents by reductive dechlorination, in the presence of capable microbial community exists (IRTC, 2005).
Dissolved Oxygen (DO)	Dissolved oxygen (DO)[3] varied from 0.01 mg/L (BH95, MW12) to 3.85 mg/L (MW07).

[3] DO measurements were carried out following the removal of a water sample from the well rather than in-situ. As a result, the measured DO may differ from the actual conditions in the aquifer due to disturbance during water retrieval.

Parameter	Results and Comments
Electrical Conductivity (EC) and Calculated Total Dissolved Solids (TDS)	Electrical conductivity (EC) ranged from 0.827 mS/cm (BH25) to 29.99 mS/cm (MW20). Total dissolved solid (TDS)[4] concentrations estimated from electrical conductivity ranged between approximately 554 mg/L (BH25) and 19,423 mg/L (MW20). The spatial variability in groundwater salinity is discussed further in **Section 8**.
Temperature	Temperature ranged from 19.8 (GW01) degrees Celsius (°C) to 23.7 °C (MW26)

7.2.2 Site Hydrogeological Results

Description of the site-specific hydrogeology is based on observations made during the site groundwater monitoring and sampling. The site-specific hydrogeology is summarised below.

Table 7-2 Hydrogeological Summary

Aspect	Results
Depth to Groundwater	Standing water levels (SWL) varied from approximately 3.3 metres below ground level (mBGL) (BH22*) to 4.662 (MW22) mBGL. A summary of SWLs in presented in **Table 1.**
Groundwater Inferred Flow Direction	Groundwater elevations calculated for wells across the site are tabulated in **Table 1** and varied between -0.387 m Australia Height Datum (mAHD) (MW25) and 0.953 mAHD (MW15). Given the variation in salinity, URS gave consideration to applying a correction for variation in density to calculated elevations. However, the calculation (based on Pavelic and Dillon (1993)) indicated corrections typically only of up to around 6 mm, which are not significant to the overall flow direction across a site of this magnitude. For consistency with previous reports, uncorrected elevations have been used in inferring the groundwater contours that are presented graphically on **Figure 3**. From the contours, and consistent with previous investigations (historical gauging results are presented in **Table 3**), the inferred direction of groundwater appears to be towards Tapleys Hill Rd. Groundwater east and west of Tapleys Hill Rd appears to flow towards a low point centred along Tapleys Hill Rd. The apparent impact of sewer infrastructure on groundwater flow direction is discussed in **Section 8.1** of this report.
Groundwater Hydraulic Gradient	The hydraulic gradient calculated from the inferred groundwater contours east of Tapleys Hill Rd is approximately 0.0013 and west of Tapleys Hill Rd is approximately 0.005.
Hydraulic Conductivity	The lithology of the saturated zone is described as silty and sandy clays. Based on literature values, the hydraulic conductivity of groundwater within silty sandy clays might be expected to be of the order of 8.6×10^{-4} to 8.6×10^{-2} m/day (Fetter, 2001). Data obtained from hydrogeologic testing[5] conducted in 2012 estimated the hydraulic conductivity of the groundwater formation beneath the site to range between 2.9 and 3.4 m/day; higher than estimates based on literature values alone.
Seepage Velocity	Assuming an effective porosity of 0.35 and by using the hydraulic conductivity range from hydrogeological testing in 2012 (2.9 to 3.4 m/day), the groundwater seepage velocity beneath the site is estimated in the range of approximately 5 to 20 m/year.

[4] TDS = EC (mS/cm) reading x 670
[5] PB (2013a)

Aspect	Results
NAPL Presence	No NAPL was detected during the gauging of the wells.

7.3 Groundwater Analytical Results

Groundwater analytical laboratory reports and chain of custody (COC) documentation are presented in **Appendix B**. Tabulated summary results and graphical presentations for the targeted contaminants of potential concern are presented as follows:

Figure 5: Groundwater TCE Results
Figure 6: Groundwater PCE Results
Figure 7: Groundwater cis-1,2 DCE Results
Figure 8: Groundwater Total VCHs Results
Figure 9: Groundwater Results – Other Chlorinated Solvents

Table 4: Groundwater Results – VCHs
Table 5: Groundwater Results – Natural Attenuation, Major Ions and Alkalinity
Table 6: Historical Groundwater Results – VCHs
Table 7: Historical Groundwater Results – Natural Attenuation, Major Ions and Alkalinity

7.3.1 Groundwater Analytical Results – VCHs

Table 7-3 provides a summary of groundwater analytical results for halogenated aliphatics, aromatics, fumigants and trihalomethanes where reported concentrations exceeded the LOR.

Table 7-3 Summary of Groundwater Analytical Results – VCHs

VCH	Units	Min result	Max result	Lowest criteria value	Wells exceeding guidelines
Trichloroethene	µg/L	<0.05	1350	20	BH22, GW2, GW9, MW2, MW4, MW5, MW7, MW8, MW13, MW14, MW23.
Tetrachloroethene	µg/L	<0.05	179	40	MW2, GW9, MW4, MW5, MW12 -MW14, MW23.
1,1-Dichloroethene	µg/L	<0.1	165	30	GW9, MW14
1,2-Dichloroethene (sum cis & trans but predominantly present as cis)	µg/L	<0.1	984.6	60	GW2, GW9, MW2,MW4, MW5, MW12, MW13
Vinyl chloride	µg/L	0.4	56.7	0.3	GW1, GW2, GW9, MW2, MW5
Other VOCs				-	-
1,1-Dichloroethane	µg/L	<0.1	16.1	-	-
1,2-Dichloroethane	µg/L	<0.1	1.5	3	-
Chloroform	µg/L	0.11	3.43	3	MW14
Chlorobenzene	µg/L	<0.1	0.36	300	-
Total Trihalomethanes	µg/L	0.11	3.43	250	-

All other analysed halogenated aliphatics, aromatics, fumigants and trihalomethanes were reported below the LOR.

7.3.2 Groundwater Analytical Results – Other Analytes

Table 7-4 provides a summary of groundwater analytical results for natural attenuation parameters, alkalinity and major ions which exceeded adopted guidelines. Results for major ions and alkalinity are discussed in **Section 7.2** while results for natural attenuation parameters are discussed in **Section 7.3.3.**

Table 7-4 Summary of Groundwater Exceedances- Natural attenuation, Major ions, Alkalinity

Natural attenuation, Major ions.	Units	Min value	Max value	lowest guideline value	wells exceeding guidelines
Chloride	mg/L	34	9020	250	BH13, BH22, BH95, GW01,GW02, GW9, MW01 – MW08, MW10 - MW18, MW20-MW27
Sodium	mg/L	37	5930	180	BH13, BH22, BH95, GW1,GW2, GW9, MW1 - MW8, MW10 - MW27
Sulphate	mg/L	19	2120	500	BH22, BH95, GW1, GW2, GW9, MW01, MW02, MW04-MW8, MW10 - MW13, MW16, MW20 - MW22, MW25.

7.4 Soil Vapour Analytical Results

Laboratory certificates for the analysis of VCHs from summa canister samples are attached as **Appendix B.** Tabulated summary results and graphical presentations of selected VCHs are presented as follows:

Figure 10: Soil Vapour TCE Results
Figure 11: Soil Vapour PCE Results
Figure 12: Soil Vapour cis-1,2-DCE Results
Table 8: Soil Vapour Results – VCHs
Table 9: Historical Soil Vapour Results – VCHs

Table 8 also presents a comparison of the results of field screening of soil vapour wells using the PID and the total reported VCH concentrations, which shows a reasonable correlation.

7.5 Soil Physical Properties

Soil physical property testing results from U50 tubes collected from four soil vapour wells, SV21, SV22, SV25 and SV27 are presented in **Table 10**. It is noted that one sample, collected from SV25 1.5-2.0 mbgl, was not suitable for testing due to the presence of gravel pieces and the friable nature of the sample.

8 DISCUSSION

Previous investigations conducted across the Investigation Area on behalf of the SA EPA, most recently by PB (2014) have resulted in the establishment of a conceptual site model which, in brief, describes the nature and extent of VCH contamination in the subsurface, possible transport mechanisms, and exposure pathways and potential receptors.

Table 8-1 below presents a discussion of instances where the findings of the current URS investigations confirm or refine this established site conceptual model.

Table 8-1 Assessment Findings in the context of the Conceptual Site Model

Aspect	Current Conceptual Site Model	Impact of May 2015 Investigation Findings
Site Setting	Shallow groundwater is present at depths of approximately 3.5 m to 5.0 m below ground level. PB (2014) noted that "groundwater within the uppermost groundwater formation is inferred to generally flow towards the west, however monitoring data in the vicinity of Tapleys Hill Road suggests that the deep sewer in this area may be acting as a groundwater drain, resulting in an easterly groundwater gradient in the area west of Tapleys Hill Road".	URS's investigations conducted in April to May 2015 identified groundwater at a similar depth to previous investigations, and notably, observed the same feature of an apparent gradient reversal to the west of Tapleys Hill Road due to low points at MW07 and MW25 (**Figure 3**). PB's suggestion of influence from the sewerage system appears valid, with 525 mm diameter VC (vitreous clay) sewer trunk mains running along Tapleys Hill Road and De Havilland Avenue (**Figure 4**). These mains would be gravity fed and pumped due to the low elevation of the area, providing a mechanism for localised drawdown of the water table in the event of leakage into the sewers. A plot of groundwater salinity across the area (Figure 4) does not provide conclusive support for this mechanism. Areas of relatively low salinity are apparent (consistent with previous investigation results), and may be associated with leaking water mains or higher surface water recharge. A Piper (or trilinear) plots displaying the distribution of cations and anions for groundwater bores sampled in April 2015 are attached in **Appendix H**. The Piper plot shows that cation chemistry is dominated by sodium, with the exception of MW09 (and to a lesser extent, BH25), dominated by magnesium, whilst anion chemistry is dominated by chloride, with the exception of MW09, MW19, BH13 and BH25, dominated by bicarbonate, and GW01, dominated by sulphate. It is noted that the proportion of ions within monitoring wells MW9, MW19, BH13 and BH25 indicate a fresher source of water (i.e. freshwater recharge is typically bicarbonate dominant and of lower salinity), which is consistent with low TDS values recorded at these locations (**Figure 4**).
Nature and Source of Dissolved Phase Contaminants	Volatile chlorinated hydrocarbons including PCE, TCE, 1,1-DCE, chloroform, 1,2-DCA and VC are present in groundwater at concentrations exceeding adopted criteria. Detectable concentrations of other VOCs including TCE breakdown products are also present. Source of identified VCH impacts within the industrial precinct bounded by West Lakes	Results of the current investigation are consistent with sources of volatile chlorinated hydrocarbons within the industrial area, as previously described. It is noted that concentrations of PCE and TCE (highlighted as the likely chemicals released to the environment) in a number of groundwater wells (such as MW02, MW04 and MW06 south and south-west of the 3-5 Philips Crescent site) reported in this monitoring round were the highest recorded values for monitoring rounds since 2012, potentially indicative of ongoing migration of VCH impacts in groundwater. Based on the reported concentrations of specific VCHs in groundwater across the

Aspect	Current Conceptual Site Model	Impact of May 2015 Investigation Findings
	Boulevard, Tapleys Hill Road, Farman Avenue and Gordon Street.	investigation area, sources of the impacts are considered to potentially be derived from: - The industrial site at 3-5 Philips Crescent: – One or more properties south-east of 3-5 Phillips Crescent and north of West Lakes Boulevard (PCE/TCE/1,2-DCE). Potential examples include the existing children's play café/ church at corner of Philips Crescent and Circuit Drive (formerly an industrial property) and the Epic Storage site (formerly South Australian Brush Company site) further to the south-east bounded by West Lakes Boulevard, Willowie Street and Botting Street.. – An industrial property within the north-eastern portion of the industrial area, between MW14 and MW23 (PCE/TCE); and – The industrial property west of well MW18 and bounded by Tapleys Hill Road. – One or more industrial properties to the east of MW08 and Tapleys Hill Road
Presence of DNAPL	Measured VCH concentrations are not considered indicative of the presence of DNAPL, although the presence of DNAPL is not precluded.	PCE and TCE concentrations in groundwater for the 2015 monitoring event were, as for the PB (2014) results, well below 1% of theoretical solubilities. There is again considered to be no indication of the monitoring wells intersecting DNAPL.
Possible Transport Mechanisms	Identified possible transport mechanisms for shallow groundwater impact include: – Lateral migration within the groundwater – Vertical migration of heavier-than-water VOCs within groundwater – Diffusion of vapours into indoor and/or outdoor air and possibly service trenches and underground structures – Lateral migration of groundwater and vapour through the deep sewer and/or surrounding backfill material	Lateral migration of groundwater remains a key transport mechanism for the contaminants of potential concern, and as noted above, groundwater monitoring results are consistent with ongoing lateral migration from the sources. The scope of this investigation did not permit assessment of potential vertical migration within groundwater. Given the investigation findings are supportive of entry of groundwater into the local sewer system, migration of impacts via the deep sewer main is apparently a feasible transport mechanism.
Exposure Pathways Receptors	Potential exposure pathways identified included contact with or ingestion of extracted groundwater, or inhalation of vapours either arising from the subsurface or transported by sewer pipes.	The investigation results are supportive of these potential exposure pathways. It is noted that the property survey has identified that below-ground structures (basements/cellars) are a feature of building construction in the locality, and this must be taken into consideration.

Aspect	Current Conceptual Site Model	Impact of May 2015 Investigation Findings
Soil Vapour Concentrations	A vapour risk assessment conducted by PB on the basis of measured soil vapour concentrations had concluded that health risks associated with indoor vapour intrusion of VCHs within the residential areas, assuming slab-on-ground construction, was acceptable. PB noted that the VCHs could pose risk in the future, as the assessment was sensitive to changes in concentration or soil conditions (especially moisture).	Soil vapour bores SV21 and SV24-SV28 have contributed to the delineation of the soil vapour impacts to the south and west of the industrial area, while results for SV22 and SV23 further characterise elevated vapour concentrations near the source area. The spatial distribution of vapour concentrations across the site, shown graphically in **Figures 10 to 12**, appears to align closely with that of elevated TCE, PCE and cis-1,2-DCE concentrations in groundwater (**Figures 5 to 7**). Moisture contents reported by the geotechnical laboratory from U50 samples collected at 1.5 to 2.0 m depth adjacent three of the newly installed vapour bores SV21, SV22 and SV27 were variable, ranging from 6% in a sample of sand from SV21, with 12 and 25% in samples of sandy clay from SV27 and SV22 respectively. Moisture contents were typically reported at around 10-15% for samples collected at similar depths from or adjacent to soil vapour bores installed across the investigation area in the previous investigations undertaken by PB. The risks associated with the most recent monitoring data will be considered separately in a human health risk assessment report.

9 CONCLUSIONS AND LIMITATIONS

9.1 Conclusions

Consistent with the stated objectives, URS conducted environmental assessment works in the Hendon Investigation area in April/May 2015, which were focussed on updating and refining the characterisation of volatile chlorinated hydrocarbon impacts to soil vapour and groundwater within the central, southern and western sections of the Investigation Area. The following was concluded from the results of this investigation:

- Volatile chlorinated hydrocarbon impacts continue to be present in shallow groundwater at a depth of typically around 3.5 to 5 m below ground level within the Investigation Area associated with the Hendon industrial area.
- The nature and distribution of VCH groundwater impacts is generally consistent with previous observations. The highest reported concentrations of TCE and PCE in groundwater were recorded in wells GW9 and MW02, respectively, both located south of the Philips Crescent industrial site. Concentrations in a number of wells, including several along West Lakes Boulevard south of the Philips Crescent site, were the highest recorded since 2012.
- The nature and distribution of VCH impacts in groundwater indicates that there are a number of properties within and in the near vicinity of the Hendon industrial area that have historically and may continue to be acting as sources of the reported impacts. Historical activities which may have used solvents in the Hendon industrial area are understood to have included a munitions factory, electroplating and electrical components manufacturing.
- Groundwater flow in the region appears to be influenced by incidental extraction of groundwater by the deep sewer trunk mains, which indicates the potential for transport of VCH-impacted groundwater via the sewerage system.
- The additional soil vapour monitoring wells have contributed to delineation of soil vapour impacts, which appear to align closely to the distribution of VCH impacts in groundwater.
- The property survey has identified the presence of both concrete slab-on-ground and timber floor (crawlspace) residential construction, and notably, that underground structures (cellar/basements) are a feature of the local residential dwellings.
- The results of this investigation will be used to support a separate quantitative assessment of the potential risks to human health in the southern, central and western sections of the EPA investigation area.

9.2 Limitations

This conclusion and all information in this Report are provided strictly in accordance with and subject to the following limitations and recommendations:

a) This Report has been prepared for the benefit of the SA EPA.

b) Except as required by law, no third party may use or rely on, this Report unless otherwise agreed by URS in writing. Where such agreement is provided, URS will provide a letter of reliance to the agreed third party in the form required by URS.

c) This Report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by URS for use of any part of this Report in any other context.

d) This conclusion is based solely on the information and findings contained in this Report.

e) This conclusion is based solely on the scope of work agreed between URS and the EPA and described in section *1.3* ("Scope of Works") of this Report.

f) This Report is dated 30 June 2015 and is based on the conditions encountered during the site investigations conducted, and information reviewed, from 10 April to 30 June 2015. URS accepts no responsibility for any events arising from any changes in site conditions or in the information reviewed that have occurred after the completion of the site investigations.

g) The investigations carried out for the purposes of the Report have been undertaken, and the Report has been prepared, in accordance with normal prudent practice and by reference to applicable environmental regulatory authority and industry standards, guidelines and assessment criteria in existence at the date of this Report.

h) Where this Report indicates that information has been provided to URS by third parties, URS has made no independent verification of this information except as expressly stated in the Report. URS assumes no liability for any inaccuracies in or omissions to that information.

i) URS has tested only for those chemicals specifically referred to in this Report. URS makes no statement or representation as to the existence (or otherwise) of any other chemicals.

j) Except as otherwise specifically stated in this Report, URS makes no warranty or representation as to the presence or otherwise of asbestos and/or asbestos containing materials ("ACM") on the site. If fill has been imported on to the site at any time, or if any buildings constructed prior to 1970 have been demolished on the site or materials from such buildings disposed of on the site, the site may contain asbestos or ACM. Without limiting the generality of sub-clauses (h) and (m), even if asbestos was tested for and those test results did not reveal the presence of asbestos at specific points of sampling, asbestos may still be present at the site if fill has been imported at any time, or if any buildings constructed prior to 1970 have been demolished on the site or materials from such buildings disposed of on the site.

k) Investigations undertaken in respect of this Report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and contamination may have been identified in this Report.

l) Subsurface conditions can vary across a particular site and cannot be exhaustively defined by the investigations described in this Report. It is unlikely therefore that the results and estimations expressed in this Report will represent conditions at any location removed from the specific points of sampling.

m) A site which appears to be unaffected by contamination at the time the Report was prepared may later, due to natural phenomena or human intervention, become contaminated.

n) Except as specifically stated above, URS makes no warranty, statement or representation of any kind concerning the suitability of the site for any purpose or the permissibility of any use, development or re-development of the site.

o) Use, development or re-development of the site for any purpose may require planning and other approvals and, in some cases, environmental regulatory authority approval. URS offers no opinion as to whether the current use has any or all approvals required, is operating in accordance with any approvals, the likelihood of obtaining any approvals for development or redevelopment of the site, or the conditions and obligations which such approvals may impose, which may include the requirement for additional environmental works.

p) URS makes no determination or recommendation regarding a decision to provide or not to provide financing with respect to the site.

q) The ongoing use of the site and/or the use of the site for any different purpose may require the owner/user to manage and/or remediate site conditions, such as contamination and other conditions, including but not limited to conditions referred to in this Report.

r) To the extent permitted by law, URS expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by any third party relating to or resulting from the use of, or reliance on, any information contained in this Report. URS does not admit that any action, liability or claim may exist or be available to any third party.

s) Except as specifically stated in this section, URS does not authorise the use of this Report by any third party.

t) It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

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