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ENVIRONMENTAL ASSESSMENT WORKS

South Australian Environment Protection Authority

37- 41 Cliff Street, Glenelg East

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Environmental Assessment Works

South Australian Environment Protection Authority

37 - 41 Cliff Street, Glenelg East

EXECUTIVE SUMMARY

Greencap (incorporating AEC Environmental) was commissioned by the South Australian Environment Protection Authority to conduct environmental assessment works for the site located at 37 – 41 Cliff Street, Glenelg East, South Australia. The aim of the works were to delineate existing groundwater and soil vapour contamination plumes previously identified, and to investigate potential preferential soil vapour pathways within the subsurface. It is noted that this report presents a factual account of the environmental assessment works undertaken (as determined in consultation with the client) and it is understood the results will be used to complete risk assessment works by SA Health.

Groundwater Investigations

Previous environmental assessment works conducted at the site identified heavy metal, fuel related and volatile chlorinated hydrocarbon groundwater impacts. The volatile chlorinated hydrocarbon impacts were reported to be an order of magnitude higher than the adopted guideline levels and were shown to migrate offsite and into the secondary quaternary aquifer.

Additional groundwater investigations were undertaken to further assess the extent of groundwater impacts previously identified within the upper aquifer. Particular emphasis was placed on the extent of the volatile chlorinated hydrocarbon compounds due to their higher toxicity compared to other analytes.

The works included sampling all existing groundwater monitoring wells (total of sixteen) along with the installation and sampling of three additional groundwater wells offsite along both Cliff Street and Purdeys Lane to attempt to determine the lateral extent of the chlorinated impacts.

Groundwater results indicate elevated chlorinated hydrocarbon impacts above the adopted guidelines in fifteen of the nineteen groundwater wells. The extent the trichloroethene and tetrachloroethene impacts in groundwater are not delineated to the north west of the site (along the inferred hydraulic gradient).

Soil Vapour Investigation

A soil vapour investigation was undertaken across the site and surrounding residential areas to assess the extent of any soil vapour impacts.

Confirmation sampling was conducted of four existing soil vapour points from which elevated concentrations were reported for chlorinated hydrocarbon compounds. In addition, a total of nine soil vapour points were installed and sampled to determine the extent of any soil vapour impacts. Reported results indicate elevated volatile chlorinated hydrocarbon concentrations were present above the adopted residential guidelines from all locations, with the exception of one location to the south west of the site along Kipling Avenue. Results indicate the extent of the soil vapour impacts has not been delineated, with the exception being to the south west.

Investigation into Preferential Pathways

An investigation into preferential pathways for both groundwater and soil vapour was conducted through the review of service plans, available field logs and conducting down-hole geophysical testing. In addition a field screening assessment using hand held equipment was conducted in services pits across the investigation area.

No significant preferential pathways were identified within the soil profile based on the information obtained. A number of underground utilities were observed in proximity of the site. The screening assessment did not detect any elevated volatile concentrations in accessible service pit/underground services in the vicinity of the site.

Statement of Limitations

This report has been prepared in accordance with the agreement between South Australian Environment Protection Authority and Greencap.

Within the limitations of the agreed upon scope of services, this work has been undertaken and performed in a professional manner, in accordance with generally accepted practices, using a degree of skill and care ordinarily exercised by members of its profession and consulting practice. No other warranty, expressed or implied, is made.

This report is for the use of South Australian Environment Protection Authority and any reliance on this report by third parties shall be at such party's sole risk and may not contain sufficient information for purposes of other parties or for other uses. This report shall only be presented in full and may not be used to support any other objective than those set out in the report, except where written approval with comments are provided by Greencap.

Environmental Assessment Works

South Australian Environment Protection Authority

37 - 41 Cliff Street, Glenelg East

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Greencap Document Control.

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1.0 INTRODUCTION

Greencap (incorporating AEC Environmental) was commissioned by the South Australian Environment Protection Authority (SA EPA) to conduct additional Environmental Assessment Works at 37 - 41 Cliff Street, Glenelg East, South Australia. The objectives of the assessment works were to attempt to delineate existing groundwater and soil vapour contamination plumes and to investigate potential preferential soil vapour pathways within the subsurface. The scope of works was determined in consultation with the SA EPA and SA Health and it is understood that the results presented in this report will be used to complete risk assessment works. The location of the site is presented in Figure 1.

Source: www.maps.google.com.au (viewed 10 November 2014)

Figure 1: Site Location

The required scope of works was requested by the SA EPA and in general terms has comprised:

- an assessment to further delineate a groundwater contamination plume identified within the Q1 aquifer;
- an assessment to further delineate a soil vapour contamination plume;
- an investigation of potential preferential soil vapour pathways in the subsurface and their implication for contaminant migration in the surrounding residential area and exposure; and
- the preparation of a factual report including:
  - results / data;
  - well installation details / logs; and
  - sampling methodologies and locations.

This assessment has been prepared with reference to industry standards and guidelines including the National Environment Protection (Assessment of Site Contamination) Measure 1999 and the Australian Standard AS4482.1 - 2005 (Guide to the Investigation and Sampling of Potentially Contaminated Soil).

2.0 SITE DETAILS

2.1 Site Identification and Zoning

The site is described by Certificate of Title Volume 5877 Folio 549 and comprises allotments 21, 24 and 25 of Deposited Plan 1008. The site is located in the area named Glenelg East in the Hundred of Noarlunga. The registered owner of the site is Glenelg Dry Cleaners Pty Ltd. A copy of the current Certificate of Title is provided in Appendix A.

2.2 Physical Setting

The site is situated in the suburb of Glenelg East, located approximately 8 kilometres south west of the Adelaide CBD and 2 kilometres east of the coast (Gulf St Vincent). The nearest permanent watercourse is the Sturt River which is located approximately 1 kilometre to the east of the site. The site and surrounding locality are relatively level.

2.3 Local Geology (Based on field Investigations)

The local geology has been described based on the assessment works described in this report which comprised the installation of three groundwater wells and nine soil vapour points. The majority of test locations encountered a layer of surface fill generally less than 0.5 metres thick and comprising mixtures of sands, silts, clays and crushed rock along with occasional fragments of concrete. Deeper fill was identified at one test location to a depth of 1.2 metres. The underlying natural soils comprised predominately brown sandy or silty clays.

2.4 Site Description and Current Land Use

The site is a square shaped parcel of land with a total area of approximately 2,700 square metres (m^2). The site is currently operating as a commercial shop and caravan storage facility. A large building is located central to the site as well as smaller shed and garage like structures along the eastern and western sides of the main building. The rear of the site comprises a well compacted open gravel area with some concrete sealed surfaces identified beneath the main building, along the front of the site (fronting Cliff Street) and along the southern boundary of the site.

The site is bound by residential properties to the north, east, south and west. The approximate site layout is presented as Figure 2.

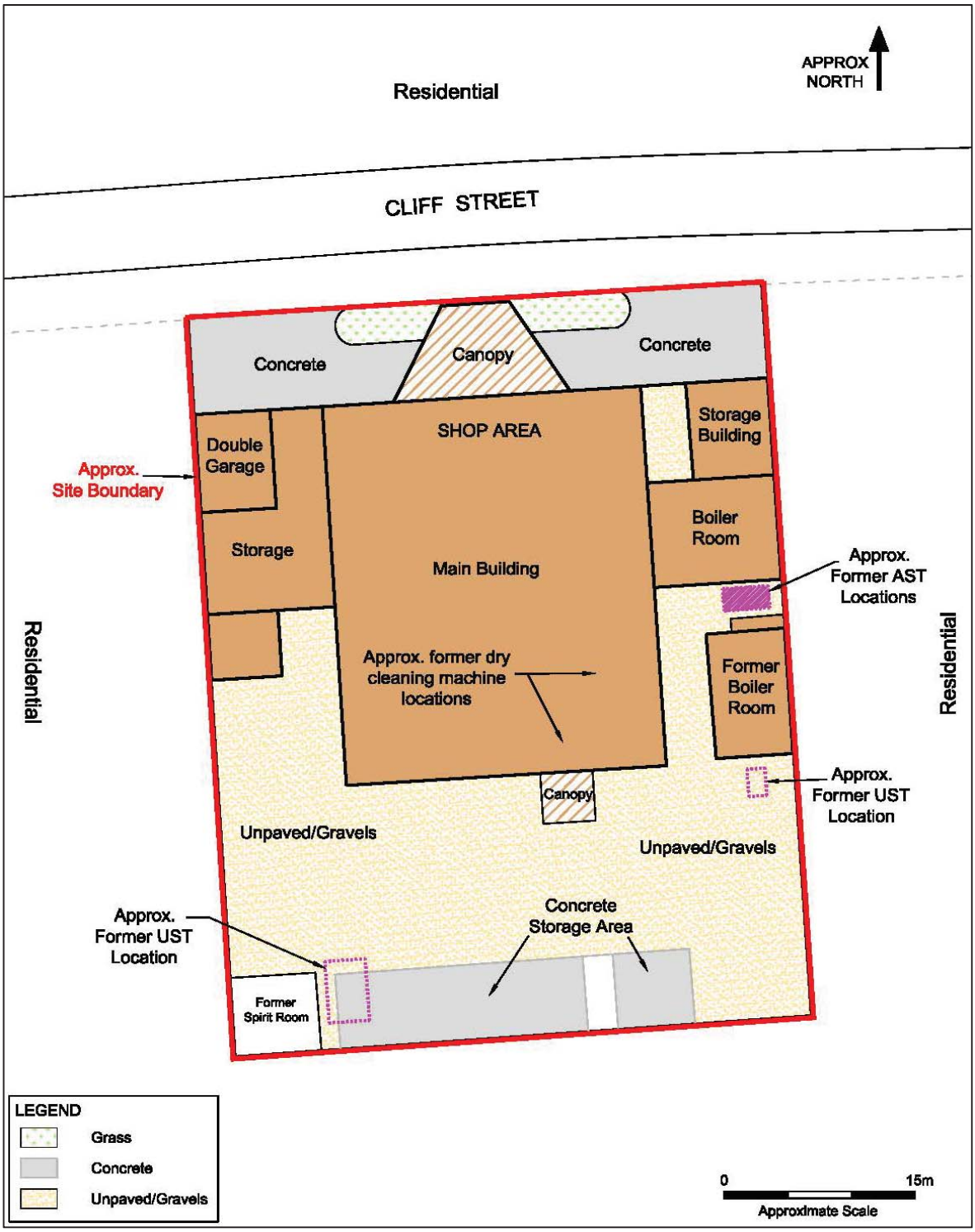

Figure 2: Site Layout

3.0 PREVIOUS ENVIRONMENTAL REPORTS

Three environmental reports prepared previously for the site have been provided to Greencap. Table 1 provides a brief summary of the previous reports. Copies of the previous reports are included in Appendix K.

Table 1 – Previous Environmental Assessments Reports

Date	Consultant and Report Title	Findings
14 November 2002	**Koukourou Engineers** - 'Environmental Site History Report'	The report found the site was likely used as a dairy farm prior to the 1950's, after which dry cleaning has been the primary use. It was concluded that there was a potential for soil impacts present onsite as a result of historical site activities. The investigation also identified two underground storage tanks (USTs); one located in the south western corner of the site (adjacent a former spirit room) and another centrally located on the eastern boundary of the site (south of a former boiler room). Soil impacts were also considered likely to be present adjacent waste disposal pipework, sumps and sewer lines. No investigations into soil or groundwater was undertaken.
November 2004	**Soil and Groundwater Consulting** – 'Phase 2 Environmental Site Assessment, Glenelg Dry Cleaners, 37 – 41 Cliff Street, Glenelg East'	The Phase 2 investigation comprised the drilling and sampling from 8 soil bores across the site as well as the drilling, installation and sampling from 4 groundwater monitoring wells. Analysis of the soil indicated that Tetrachloroethene (PCE) impacts were present underlying the dry cleaning building, the former spirit rom and the southern boundary storage area. Groundwater impacts were also identified including fuel related compounds noted in 3 of the 4 wells and volatile compounds (Trichloroethene (TCE), PCE and dichloroethene) identified in all four wells. PCE concentrations were identified up to 100 times greater than adopted assessment criteria and the impacts were deemed to be possibly migrating offsite.
5 March 2009	**Soil and Groundwater Consulting** - 'Environmental Site Assessment - Phase 2, Glenelg Dry Cleaners, 37 – 41 Cliff Street, Glenelg East'	Additional investigations were undertaken between 2005 and 2008 to further investigate the impacts previously identified in both soil and groundwater. The additional work included the drilling and sampling of 21 soil bores across the site as well as the excavation and sampling from 2 test pits. A total of 12 additional groundwater monitoring wells were also installed and sampled both on and offsite. Elevated chlorinated impacts (TCE and PCE) were identified in both soil and groundwater below the site. It was concluded that "the elevated volatile TCE and PCE concentrations in soils and groundwater below the site may results in vapour accumulation within site structures at the site and present an unacceptable human health risk to site personnel in the current commercial site operations".

It is noted that additional work was undertaken by AECOM and Mott MacDonald since 2009. Some information (but no formal report) was provided to Greencap and it is understood that four soil vapour points have been installed both onsite (one within the main building onsite (SGP1) and one adjacent the building to the west (SGP02)) and offsite (two within the adjacent residential property to the west (SGP03 and SGP04)). The works conducted are also understood to have included a groundwater monitoring event in February 2012.

Only limited information was provided in relation to the installation and sampling of these sampling points work conducted by AECOM and Mott MacDonald and therefore this previous data has not been considered further.

4.0 GROUNDWATER INVESTIGATION

As discussed in Section 3, chlorinated hydrocarbon impacts have been identified in groundwater underlying the site and extending offsite. The extent of these impacts is not known and as such additional groundwater assessment work has been undertaken as discussed in the following sections. Surveying of all existing groundwater wells and aquifer permeability tests were also undertaken in relation to the groundwater assessment as requested by the SA EPA and as detailed in the sections below.

4.1 Sampling of Existing Groundwater Wells

An initial groundwater monitoring event was conducted on 9 and 10 July 2014 of the existing monitoring well network by an experienced environmental scientist. A total of sixteen existing groundwater wells (GW1 to GW15 inclusive, and DC1) were sampled. It is noted that groundwater well DC1 appears to have been drilled and installed into the second quaternary aquifer (Q2) while monitoring wells GW1 to GW15 inclusive were drilled and installed into the first quaternary aquifer (Q1 –water table aquifer). A summary plan showing the groundwater well locations is presented as Figure 3 and a copy is also provided as an attachment to this report.

Figure 3: Groundwater Well Locations

4.1.1 Sampling Methodology

Groundwater samples were collected using industry standard procedures. Initially, standing water levels and the depth to the base of each well were measured from the top of the gatic using a water/oil interphase meter. Measurements were also taken to check for any separate phase (free) product present in the wells.

All purging and sampling was conducted using low flow peristaltic pump methods and using dedicated low density polyethylene (LDPE) tubing. The use of dedicated tubing for each well negated the need for decontamination of equipment between sampling locations. During low flow purging, groundwater level measurements were recorded to confirm that drawdown within the sampled well was being maintained at a minimum. Water quality parameters (pH, temperature, conductivity, oxidation reduction potential and dissolved oxygen) were monitored during purging using a TPS 90FLMV water quality meter. Sampling was conducted when these parameters had stabilised.

All groundwater samples collected from the wells were placed in containers provided by the analytical laboratory. Groundwater samples collected for heavy metals were filtered through a pre-sterilised 150mL vacuum driven disposable filter (0.45 micron) prior to placement in sample containers supplied by the testing laboratory. The samples were stored on ice in a portable cooler immediately following sampling and were delivered under similar conditions to the analytical laboratory with accompanying chain of custody documentation.

The groundwater sampling records and the water quality meter calibration certificate are provided in Appendix B.

4.1.2 Groundwater Analytical Program

Groundwater samples collected from each monitoring wells were analysed for:

- Volatile halogenated compounds;
- Total Recoverable Hydrocarbons (TRH) and BTEX – Benzene, Toluene, Ethylbenzene and Xylenes;
- Anions/Cations including calcium, magnesium, sodium, potassium, sulphate, chloride, alkalinity;
- Nitrate, nitrite and ammonia;
- Manganese;
- Ferrous and ferric iron;
- Methane; and
- Sulphate and sulphite.

Results of the groundwater analyses are discussed in Section 4.3. There is also a summary table of analytical results presented as an attachment to this report. Samples of groundwater were also submitted to a secondary laboratory for QA/QC purposes, and are discussed in detail in Section 6.0.

The laboratories used for the groundwater investigation were Eurofins-mgt (primary laboratory) and ALS Environmental (secondary laboratory). The laboratories are approved by the National Association of Testing Authorities (NATA), and the analyses conducted are within the NATA registration of the laboratories.

4.2 Installation and Sampling of Additional Groundwater Monitoring Wells

Three additional groundwater monitoring wells (MW16 to MW18 inclusive) were installed on 30 September 2014 under the supervision of an experienced environmental consultant. The locations of the additional wells were determined in consultation with the SA EPA and based on the survey and groundwater flow direction as discussed in Section 4.3.1.

The aim of the additional well installation (and subsequent sampling works) was to delineate the extent of the identified chlorinated impacted groundwater, particularly the extent of the TCE and PCE impacts. The three additional groundwater monitoring wells were drilled using solid augers to a depth of six metres and

installed with a three metre screen at the base of each well. A sand pack was placed around the screen of each monitoring well extending 0.5 metre above the top of the screen, and a bentonite plug was placed above the sand pack to the surface (to prevent infiltration of rainfall). All monitoring wells are completed with gatic covers installed flush to the ground surface. The groundwater well locations are shown on Figure 3 and presented as an attachment to this report. Groundwater well installation logs are presented in Appendix I.

Following installation, all three wells were developed on 3 October 2014 to remove excess silt and ensure representative groundwater was flowing into each well.

Groundwater wells MW16 to MW18 inclusive were sampled on 13 October 2014 adopting the same sampling methodology as described in Section 4.1.1. The analytical program for each well was consistent with that described in Section 4.1.2.

The groundwater sampling records and water quality meter calibration certificate are provided in Appendix D. Results of the groundwater analyses are discussed in Section 4.3 and a summary table of analytical results is provided in Appendix B. Samples of groundwater were also submitted to a secondary laboratory for QA/QC purposes, which are discussed in detail in Section 6.0.

4.3 Groundwater Investigation Results

4.3.1 Survey, Gauging and Groundwater Flow Direction

All existing groundwater monitoring wells (GW1 to GW15 inclusive and DC1) were surveyed to the Australian Height Datum (AHD) on 23 July 2014 by Fyfe Pty Ltd. This data was then used in conjunction with gauging data obtained prior to sampling to determine the groundwater flow direction across the investigation area. As presented in Table 2 and Figure 4 the groundwater flow across the investigation area has been inferred to be in a north westerly direction. A copy of the survey results are presented in Appendix E.

Table 2 – Survey and Groundwater Level Results

Location	Easting	Northing	Depth to base of well (m below top of casing)	Reference Elevation (m AHD)	Depth to Water (m below top of well casing)	Groundwater Level (m AHD)
GW1	274296.534	6125605.929	5.040	8.87	3.714	5.156
GW2	274325.723	6125619.773	5.965	8.792	3.582	5.21
GW3	274314.551	6125654.074	4.917	8.435	3.318	5.117
GW4	274293.051	6125631.738	5.859	8.543	3.435	5.108
GW5	274288.318	6125607.089	5.934	8.941	3.807	5.134
GW6	274287.754	6125625.185	5.909	8.766	3.660	5.106
GW7	274299.08	6125599.949	5.915	8.855	3.682	5.173
GW8	274287.122	6125651.827	5.860	8.462	3.392	5.07
GW9	274309.675	6125621.63	7.657	8.818	3.660	5.158
GW10	274321.585	6125634.194	6.908	8.56	3.384	5.176
GW11	274278.884	6125626.643	~6.8 *	8.615	3.523	5.092
GW12	274275.389	6125630.187	6.827	8.525	3.457	5.068

Location	Easting	Northing	Depth to base of well (m below top of casing)	Reference Elevation (m AHD)	Depth to Water (m below top of well casing)	Groundwater Level (m AHD)
GW13	274307.593	6125633.614	6.840	8.768	3.642	5.126
GW14	274278.996	6125610.026	6.415	8.797	3.685	5.112
GW15	274265.558	6125667.996	6.712	8.198	3.183	5.015
DC1	274293.766	6125625.669	11.578	8.685	3.559	5.126

* total depth of well could not be obtained due to blockage near base of well, therefore depth estimated based on drilling log (refer previous reports).

It is noted that the three new groundwater monitoring wells (GW16 to GW18 inclusive) were not surveyed as part of the works undertaken by Greencap and as such are not included in the table above and have not been used for the estimated of the groundwater flow direction.

Figure 4: Inferred Groundwater Flow Direction

No free phase separated hydrocarbons (dense non aqueous phase liquids (DNAPL) or light non aqueous phase liquids (LNAPL)) were detected in any of the wells during gauging

4.3.2 Field Measured Water Quality Parameters

Groundwater quality parameters were monitored during purging and prior to sampling on 9/10 July 2014 and 13 October 2014. The stabilised values of these parameters are summarised in Table 3.

Table 3 - Field measured groundwater quality parameters

Well I.D	pH	Temp (Deg C)	Total Dissolved Solids** (mg/L)	Oxidation- Reduction Potential (ORP) (mV)	Dissolved Oxygen (DO) (mg/L)
GW1	7.10	21.0	2,835	92	2.03
GW2	6.83	19.6	2,637	26	0.98
GW3	6.74	22.5	3,174	103	2.98
GW4	6.73	20.7	2,970	55	2.41
GW5	6.30	21.2	2,867	101	2.12
GW6	6.27	21.6	2,854	108	3.89
GW7	6.82	21.6	2,739	80	3.13
GW8	6.79	22.4	2,995	88	2.52
GW9	6.75	21.2	3,008	115	1.95
GW10	6.62	19.6	3,078	108	0.76
GW11	8.25	22.6	2,982	105	3.05
GW12	6.84	22.7	3,091	102	3.81
GW13	6.68	21.7	2,944	119	1.45
GW14	6.71	22.1	2,944	117	3.09
GW15	6.73	23.4	3,123	142	2.22
GW16	6.98	18.9	3,693	350	1.87
GW17	7.05	19.5	2,579	101	4.10
GW18	7.01	19.5	2,691	252	1.15
DC1	6.29	20.6	2,867	-117	3.60

** Conversion factor of 0.64 used to convert field conductivity (µS/cm) to Total Dissolved Solids (TDS) (mg/L).

As shown in Table 3, the majority of the measured parameters (pH, TDS, ORP and DO) were generally consistent across the well network, however the following variations were measured:

- a pH level of 8.25 measured GW11 compared to the general range of pH levels measured between 6.27 (at GW6) and 7.10 (at GW10);
- an ORP level of 350mV measured at well location GW16 which is at variance to the mean value of 107mV measured across the Q1 well network; and
- an ORP level of -117mV measured within the Q2 well location DC1.

4.3.3 Groundwater Assessment Criteria

The groundwater analytical results have been compared with adopted investigation levels for the protection of irrigation, aquaculture and aquatic marine environmental values, as proposed in the South Australian Environment Protection (Water Quality) Policy 2003 (SA EPP). The criteria has been adopted based on a limited beneficial use assessment undertaken as part of previous site investigation work (refer 2009 S&G report).

Where the abovementioned criteria have not been proposed for particular analytes, the following alternative sources have been used:-

- National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) – Groundwater Investigation Levels for Marine Waters;
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) – Health Screening Levels for Vapour Intrusion (Residential) assuming a Clay soil type; and

- Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ, 2000).

Analytical results have not been compared to potable criteria listed in the abovementioned SA EPP as previous work indicated that the salinity beneath the site is not considered suitable for potable use (refer 2009 S&G report). Furthermore, freshwater ecosystem protection criteria have not been adopted as the nearest freshwater ecosystem identified in proximity of the site (Sturt Drain approximately 1km west) was modified in such a way that it was not considered to be a protected environmental value.

The selected assessment criteria are presented in Table 4.

Table 4 – Adopted Groundwater Assessment Criteria

Analyte	SA EPP Groundwater Criteria, 2003			NEPM		ANZECC 2000
	Irrigation	Aquaculture	Aquatic Marine	Marine Waters - GILs	Vapour Intrusion - Residential	Recreation
Inorganic Pollutants						
Ammonia (as N)	-	-	0.2	-	-	0.01
Chloride	-	-	-	-	-	400
Nitrate (as N)	-	-	-	-	-	10
Nitrite (as N)	-	-	-	-	-	1
Nitrogen (Total Oxidised)	-	-	0.2	-	-	-
Sodium	-	-	-	-	-	300
Metal Pollutants						
Iron	1	-	-	-	-	0.3
Manganese	2	0.1	-	-	-	0.1
Organic Pollutants						
Benzene	-	0.04	0.3	0.5	5	0.01
Naphthalene	-	-	-	0.05	-	-
Chlorinated Compounds						
1,1-dichloroethene	-	-	-	-	-	0.0003
1,2-dichloroethane	-	-	-	-	-	0.01
1,1,2-trichloroethane	-	-	-	1.9	-	-
1,2,4-trichlorobenzene	-	-	-	0.02	-	-
Carbon Tetrachloride	-	-	-	-	-	0.003
Tetrachloroethene (PCE)	-	-	-	-	-	0.01
Trichloroethene (TCE)	-	-	-	-	-	0.03

NOTE:- units of mg/L unless stated otherwise

4.3.4 Laboratory Testing Results

Summary tables of the groundwater results are presented as an attachment to this report. NATA Laboratory certificates for the analyses undertaken are attached in Appendix F.

The majority of the reported groundwater results were below the adopted groundwater assessment criteria which the exception of the following:-

1,1-dichloroethene – concentration of 3µg/L reported from GW13 above the adopted ANZECC 2000 recreation criteria of 0.3 µg/L;

Trichloroethene – five concentrations reported above the adopted ANZECC 2000 recreation criteria of 30 µg/L from monitoring wells GW3 (55 µg/L), GW8 (200 µg/L), GW9 (42 µg/L), GW13 (420 µg/L) and GW15 (83 µg/L);

Tetrachloroethene – elevated Tetrachloroethene concentrations were reported from fifteen of the nineteen groundwater well locations above the adopted ANZECC 2000 recreation criteria of 10 µg/L across the site. Concentrations ranged from 11 µg/L at GW18 (offsite) to 2,800 µg/L at GW6;

Ammonia (as N) – elevated concentrations were reported above the adopted ANZECC 2000 recreation criteria of 10 µg/L from monitoring wells DC1 (760 µg/L), GW6 (20 µg/L), GW17 (50 µg/L) and GW16 (20 µg/L). An elevated concentration of 50 µg/L was also reported from inter-laboratory duplicate sample QC4 (duplicate of GW16). The concentration reported at DC1 (760 µg/L) also exceeds the adopted SA EPP Aquatic Marine criteria of 200 µg/L;

Chloride – concentrations reported in all groundwater wells above the adopted ANZECC 2000 recreation criteria of 400 mg/L ranging from 870 mg/L at GW2 to 1,200 mg/L at GW3;

Nitrogen (Total Oxidised) – two concentrations were reported above the adopted SA EPP Aquatic Marine criteria of 0.2 mg/L from inter-laboratory duplicate samples QW2 (4.63 mg/L) and QC4 (5.44 mg/L) collected from monitoring wells GW12 and GW16 respectively;

Sodium – concentrations reported in all groundwater wells above the adopted ANZECC 2000 recreation criteria of 300 mg/L ranging from 370 mg/L at DC1 to 510 mg/L at GW3;

Iron – two concentrations reported above the adopted ANZECC 2000 recreation criteria of 0.3 mg/L from monitoring wells DC1 (1.2 mg/L) and GW2 (0.7mg/L). The concentration reported from DC1 (1.2mg/L) also exceeds the adopted SA EPP Irrigation criteria of 1 mg/L; and

Manganese – four concentrations reported above the adopted SA EPP Aquaculture and ANZECC 2000 recreation criteria of 0.1 mg/L from monitoring wells DC1 (0.28mg/L), GW2 (1.8mg/L), GW4 (0.15mg/L) and GW10 (0.57mg/L).

Summary plans presenting the approximate extents of the main contaminants of concern (Trichloroethene and Tetrachloroethene) are attached to this report. It is noted that Tetrachloroethene impacts were also detected in groundwater monitoring well DC1 installed within the second quaternary aquifer (Q2).

4.4 Aquifer Permeability Testing

Aquifer permeability tests (slug tests) were conducted on three of the groundwater wells (MW2, MW8 and DC1) on 8 August 2014.

The slug tests were performed using a known volume solid slug to create an instantaneous change in groundwater level within the monitoring well with the subsequent water level recovery monitored using an electronic water level transducer (data logger). Two forms of slug test were performed in each of the monitoring wells: 'falling head' and 'rising head' tests. The slug tests were analysed using the AQTESOLV software program (employing either the Bouwer and Rice method for the slug test analysis (for wells MW2 and MW8) and the hvorslev method for well DC1). The Bouwer and Rice method was used in preference to the commonly used hvorslev method as it was developed specifically for when groundwater exists within the screened interval of a groundwater well. The hvorslev method was used for analysing the DC1 data as the groundwater level was observed to be above the screened interval of the groundwater well. A total of

four slug tests were performed on each of the wells consisting of two 'falling head' tests and two 'rising head' tests. Based on a review of the data, three of the four tests considered to be the most representative were used to estimate the average hydraulic conductivity (K) value for each well (in metres per day). A summary of the estimated K values for each well is presented in Table 5.

Table 5 – Main Hydrogeological Properties

Groundwater Well and Test	K (m/day)
GW2_Fall 2	0.76
GW2_Rise 1	1.26
GW2_Rise 2	1.30
Average GW2	1.11
GW8 - Fall 2	0.80
GW8 - Rise 1	1.06
GW8 - Rise 2	1.08
Average GW8	0.98
DC1_Fall 1	0.72
DC1_Fall 2	0.77
DC1_Rise 2	0.72
Average DC1	0.74
Average Q1 wells	**1.05**
Average Q2 wells	**0.74**

Following the slug testing, the hydraulic conductivity values were estimated to range between:

- 0.76 m/day and 1.30 m/day (average 1.05 m/day) for the Q1 aquifer; and
- 0.72 m/day to 0.77 m/day for the Q2 aquifer.

The slug test analyses are included in Appendix D.

The main hydrogeological properties of both the water table (Q1) and Q2 aquifer systems are provided in Table 6 based on field observation data, surveying of the well network and the use of published hydrogeological data.

Table 6 – Main Hydrogeological Properties

Item	Data	Data Source
Depth to Groundwater (below ground level)	3.47 m to 3.63 m bgl (Q1) 3.58 m bgl (Q2)	Site measurements from wells MW2, MW8 and DC1.
Hydraulic Gradient (L)	Q1 – 0.0032 (dimensionless) Q2 – 0.001 to 0.003 (dimensionless)	-Site measurements and surveying. -Published Gerges data (DWLBC Report, 2006/10, June 2006 – "Overview of the Hydrogeology of the Adelaide metropolitan area"
Hydraulic Conductivity (K)	Q1 – 1.05 m/day Q2 – 0.74 m/day	Based on the results of slug tests conducted for Q1 and Q2 monitoring wells MW2, MW8 and DC1 (an average of three of the four calculated values

Item	Data	Data Source
		from each well was used).
Effective Porosity (P)	0.2 (dimensionless) (20%)	Published value for sand*
Groundwater Flow Velocity (V)	Q1 – 6.13 m/year (20.1 ft/year) Q2 – 1.35 – 4.05 m/year (4.4 – 13.3 ft/year)	Estimate for V per year based on above data: V = ((K x L) / P) * 365
Groundwater Flow Direction (AA4)	North west	Q1 - Site survey and measurements Q2 – Site Survey and published Gerges data

Notes: *P Domenico & F Schwartz, *Physical & Chemical Hydrogeology* (1990)

As shown in Table 6, the groundwater flow velocities in the Q1 and Q2 aquifers were calculated using the average hydraulic conductivities, hydraulic gradients (estimated using groundwater contours shown on Figure 4 and published data) and an effective porosity of 0.2 (published data for sandy aquifers).

Accordingly, the average groundwater flow velocities were estimated at 6.13 m/year for the Q1 aquifer and between 1.35m/year to 4.05 m/year for the Q2 aquifer.

5.0 SOIL VAPOUR INVESTIGATION

Soil vapour investigations were undertaken both on and offsite in order to assess the presence of vapours associated with both chlorinated hydrocarbons and fuel related compounds as discussed in the following sections.

5.1 Sampling of Existing Soil Vapour Points

Four soil vapour points have previously been installed both on and offsite to assess soil vapour. It is noted that one of these soil vapour points was nested (i.e two sampling implants installed at different depths within the one location). As mentioned earlier in this report, there was some uncertainty regarding the suitability of the data obtained from these monitoring points, therefore confirmation sampling and the installation and sampling of additional soil vapour points was undertaken as described in Section 5.2. A summary plan showing the soil vapour point locations is presented as Figure 5 and attached to this report. It is noted that the Figure attached to the report also presents the soil vapour concentrations as measured in the most recent sampling event (refer Section 5.3).

Figure 5: Soil Vapour Point Locations

5.1.1 Sampling Methodology

Soil vapour samples were collected from existing soil vapour points SGP01_0.5, SGP01_2.0, SGP03_1.5 and SGP0.4_1.5 on 23 July 2014 by an experienced Greencap field scientist using thermal desorption tube sampling methodology. The thermal desorption tubes were supplied by the primary analytical laboratory (EnviroLab). A portable air pump was used to regulate the air flow through each of the tubes (at a rate of approximately 100mL/min) to collect the sample. Two samples were collected from each location:

- a sample exposed to the drawn vapours for 1 minute; and
- a sample exposed to the drawn vapours for 5 minutes.

Sampling was unable to be conducted from soil vapour point SGP02_1.5 as no air could be drawn from the well due to a blockage.

Prior to sampling and during the helium leak test described in Section 6.0 (Quality Assurance/Quality Control), all soil vapour points were purged to remove at least one well volume before basic gases (Oxygen, Carbon Dioxide, Methane, Hydrogen Sulphide and Carbon Monoxide) were measured and stabilised using a GA2000 landfill gas meter. A PID concentration was also collected during the purging process. The measured stabilised gases prior to sampling are discussed in Section 5.3.1.

Leak testing was undertaken prior to and during sampling using both helium and isopropanol testing techniques to ensure representative soil vapour was being sampled from each location. These tests are discussed in further detail within Section 6.0 and as well as the collection and analysis of duplicates and blanks.

Soil vapour sampling sheets and equipment calibration certificates (for the helium meter, landfill gas meter and PID) are attached to Appendix G.

5.1.2 Soil Vapour Analytical Program

Thermal desorption tubes collected from each of the four existing locations were submitted to the NATA accredited primary and secondary analytical laboratories (EnviroLab and SGS respectively) and analysed for a suite of volatile compounds (known as a TO-17 suite) which include chlorinated hydrocarbons. Samples were also analysed for petroleum related compounds. It is noted that no analysis was scheduled on the sample collected from location SGP01_0.5 (nested location) as field records indicated a likely breach of ambient air into the well (following helium leak testing undertaken on the vapour point). This may be a result of poor vapour point construction, or damage since installation.

Results of the soil vapour analyses are discussed in Section 5.3. There is also a summary table of analytical results presented as an attachment to this report and NATA laboratory certificates presented in Appendix H. Samples of soil vapour submitted to the secondary laboratory (SGS) for QA/QC purposes are discussed in detail in Section 6.0.

5.2 Installation and Sampling of Additional Soil Vapour Points

An additional nine soil vapour monitoring points (including three nested locations) were drilled and installed between 29 and 30 September 2014 under the supervision of an experienced Greencap field scientist. All additional soil vapour points (SGP05 to SGP13 inclusive) were installed to 1.5 metres ground level, with the exception of the three nested locations (SGP05, SGP11 and SGP13) where an additional probe was installed to 2.5m below ground level. The soil vapour point locations are shown on Figure 5.

All soil vapour points were installed using percussive push tube drilling equipment to reach the target depth(s). The soil vapour points comprised a stainless steel permanent implant (with woven wire screen) connected to Teflon tubing extending to the ground surface. The vapour points were surrounded by a discrete lightly compacted sand pack (grain size of 2-3mm) finishing approximately 150mm above the implant. A bentonite seal/plug was installed above the sand pack finishing approximately 50mm from the ground surface. The vapour points were finished with a gatic cover flush to the ground surface with a

concrete seal. Further construction details are shown on the soil vapour installation logs attached in Appendix I.

Soil vapour points SGP05 to SGP13 (as well as existing soil vapour points SGP01, SGP03 and SGP04) were sampled between 23 and 27 October 2014 by an experienced Greencap field scientist using methodology consistent with that described in Section 5.1.1. In addition, carbon tubes were collected at each of the sampling points to analyse in the event thermal desorption tubes reach saturation and accurate concentrations could not be determined.

The analytical program scheduled for each well was also consistent with that described in Section 5.1.2. Soil vapour sampling sheets and equipment calibration certificates (for the helium meter, landfill gas meter and PID) are attached to Appendix G. The measured stabilised gases prior to sampling are discussed in Section 5.3.1.

Results of the soil vapour analyses are discussed in Section 5.3. There is also a summary table of analytical results presented as an attachment to this report and NATA laboratory certificates presented in Appendix H. Samples of soil vapour submitted to the secondary laboratory (SGS) for QA/QC purposes are discussed in detail in Section 6.0.

5.3 Soil Vapour Investigation Results

5.3.1 Measured Basic Gas Levels

The measured basic gas levels during the July and October sampling events are summarised below in Table 7.

Table 7 – Ambient Air and Stabilised Gases (July and October)

Soil Vapour Point	Measured Parameters					
	Oxygen (O_2) (%)	Carbon Dioxide (CO_2) (%)	Methane (CH_4) (%)	Hydrogen Sulphide (H_2S) (ppm)	Carbon Monoxide (CO) (ppm)	PID reading (ppm)
23 July 2014						
SGP01_0.5	19.6	0.9	0.0	0	0	24
SGP01_2.0	16.2	3.5	0.0	0	5	142
SGP03_1.5	12.8	2.6	0.0	0	0	7.2
SGP04_1.5	13.8	2.7	0.0	0	0	1.8
23-27 October 2014						
SGP01_0.5	20.4	0.8	0.0	0	3	72
SGP01_2.0	17.4	3.2	0.0	0	4	133
SGP03_1.5	19.1	3.6	0.0	0	2	11
SGP04_1.5	18.9	3.5	0.0	0	0	1.8
SGP05_1.5	20.1	2.0	0.0	0	0	14
SGP05_2.5	20.0	2.5	0.0	0	2	30
SGP06_1.5	19.7	1.6	0.1	0	7	3.7
SGP07_1.5	17.6	4.1	0.0	0	3	25
SGP08_1.5	19.3	2.3	0.0	0	1	3.3

Soil Vapour Point	Measured Parameters					
	Oxygen (O_2) (%)	Carbon Dioxide (CO_2) (%)	Methane (CH_4) (%)	Hydrogen Sulphide (H_2S) (ppm)	Carbon Monoxide (CO) (ppm)	PID reading (ppm)
SGP09_1.5	0.4	8.9	0.3	0	10	19
SGP10_1.5	18.2	0.8	0.2	0	15	2.9
SGP11_1.5	16.5	2.1	0.3	1	16	2.0
SGP11_2.5	16.5	1.9	0.2	1	14	1.9
SGP12_1.5	18.2	1.1	0.3	1	15	1.6
SGP13_1.5	16.9	5.6	0.0	0	0	0.2
SGP13_2.5	14.5	6.1	0.0	0	4	0.3
Ambient Air*	21.8	0.0	0.0	0	0	0.0

Notes:

** - Ambient air concentrations at SGP03 prior to purging. For ambient air conditions at all other locations, refer field sampling sheets in Appendix G.*

As shown in Table 7, oxygen levels ranged between 12.8% and 20.4% with the exception of location SGP09 where an oxygen level of 0.4% was measured. This is significantly lower than the other locations and also corresponds to slightly higher carbon dioxide levels at this this location. It is an indication of oxygen reducing conditions, but the exact reason for such a low concentration is not known. A detailed investigation into this low oxygen concentration was not conducted as part of the scope of works completed by Greencap.

CO_2 levels were shown to be relatively consistent across the investigation area ranging from 0.8% to 8.9%, while the majority of measured methane levels were at the ambient level of 0% with the exception of elevated levels measured at locations SGP06, SGP09, SGP10, SGP11 and SGP12 (ranging from 0.1% to 0.3%).

H_2S levels were also consistent, the majority of which were measured at the ambient air level of 0ppm. However three levels were measured at 1ppm from sampling locations SGP11_1.5, SGP11_2.5 and SGP12_1.5. CO levels were shown to be slightly elevated compared to the other measured levels across the vapour point sampling network at locations SGP09, SGP10, SGP11 and SGP12. PID readings were measured to range between 0.2ppm and 142ppm, in which the highest concentration was measured at SGP01_2.0.

5.3.2 Soil Vapour Assessment Criteria

Soil vapour results were compared with Interim Soil Vapour Health Investigation Levels (HILs) for volatile organic chlorinated compounds as outlined in Table 1A(2) '*Interim soil vapour health investigation levels for volatile organic chlorinated compounds*' presented in the NEPM. Commercial/industrial and residential levels have been adopted for the investigation. It is noted that for some volatile compounds there was no criteria adopted and only those listed in the NEPM were used. Alternative sources were not sourced as part of this investigation.

Soil vapour results were also compared to Health Screening Levels (HSLs) presented in the NEPM document for fuel related compounds. The appropriate HSLs used were selected based on the depth of soil vapour point installation (either 1m to <2m or 2m to <4m), the dominant material type in which the vapour points were installed (clay – as discussed in Section 2.3) and the land use (commercial/industrial or residential).

5.3.3 Laboratory Testing Results

A summary of the soil vapour sampling results are attached to this report from the July and October sampling events. NATA laboratory certificates are attached to Appendix H.

A number of soil vapour concentrations exceeding the adopted criteria over both sampling events were reported, as listed below. It is noted that the list below includes actual results which the laboratory was able to obtain, as some estimated results were reported above the linear calibration range of the laboratory in which case accurate results could not be reported (due to the thermal desorption tubes reaching saturation). As such, carbon tube analysis was conducted on selected samples during the October 2014 sampling event to obtain accurate concentrations when a thermal desorption tube became saturated. Carbon tube analysis was conducted on samples collected from locations SGP01_2.0, SGP01_0.5, SGP05_1.5 and SGP06_1.5 (refer summary tables attached to this report for further detail).

cis -1,2-Dichloroethene – a number of concentrations were reported to exceed the Interim Soil Vapour HIL residential criteria of 0.08mg/m^3 from locations SGP01_2.0, SGP01_0.5, SGP09_1.5, SGP10_1.5, SGP11_1.5 and SGP11_2.5. These concentrations ranged between 0.09 mg/m^3 at SGP11_1.5 to 79 mg/m^3 at SGP01_2.0. Elevated concentrations were also reported to exceed the adopted HIL commercial/industrial criteria of 0.3mg/m^3 from locations SGP01_2.0 (79 mg/m^3 to 150 mg/m^3) and SGP09_1.5 (0.54mg/m^3 reported from duplicate sample QSV2);

Tetrachloroethene (PCE) – a number of concentrations were reported to exceed the Interim Soil Vapour HIL residential criteria of 2mg/m^3 from locations SGP01_0.5 (51 mg/m^3), SGP01_2.0 (51-290 mg/m^3), SGP05_1.5 (24 mg/m^3), SGP05_2.5 (2.3 mg/m^3), SGP06 (20 mg/m^3) and SGP07 (3.1 mg/m^3). Elevated concentrations were also reported to exceed the adopted HIL commercial/industrial criteria of 8mg/m^3 from locations SGP01_0.5 (51 mg/m^3), SGP01_2.0 (51-290 mg/m^3), SGP05_1.5 (24 mg/m^3) and SGP06 (20 mg/m^3).

Trichloroethene (TCE) - concentrations were reported to exceed the Interim Soil Vapour HIL residential criteria of 0.02mg/m^3 from all locations (ranging from 0.028 mg/m^3 at SGP09_1.5 to 21 mg/m^3 at SGP01_2.0 within duplicate sample QVP02) with the exception of SGP13 located south of the site where concentrations were reported below the laboratory detection limit of 0.002 mg/m^3. Elevated concentrations were also reported to exceed the adopted HIL commercial/industrial criteria of 0.08mg/m^3 from all locations except SGP13 ranging in concentrations from 0.086 mg/m^3 at SGP04_1.5 to 21 mg/m^3 at SGP01_2.0.

Furthermore, the following observations have been made in relation to the data presented within the attached summary tables:

- The results for SGP01_0.5 have some uncertainty. Previously, this sampling point failed the helium leak test. While this was not the case during the October 2014 sampling event (and as such it was sampled), there is some discrepancy between results for cis-1,2-dichloroethene and TCE. While the thermal desorption tubes reported results beyond the linear calibration range, the carbon tubes reported results below the detection limit (<20,000ug/m^3).
- The result for PCE from SGP06 has been estimated. The TDT (1min) reported a result of 20,000ug/m^3 but the laboratory indicated that the result is outside of the linear calibration range. However, the carbon tube reported a result of 20,000ug/m3. Discussions with the laboratory indicate that the actual result is probably correct at around 20,000ug/m^3, thus the estimated result is considered to be realistic.

No TRH or BTEX compounds were reported exceeding the adopted HSLs from any of the soil vapour points sampled during the July and October 2014 sampling events.

5.4 Investigation into Preferential Pathways

An investigation into preferential pathways for soil vapour was conducted through the analysis of service plans obtained through the publically available "Dial Before You Dig System", as well as:

- undertaking a down-hole geophysical assessment;
- reviewing available groundwater well and soil vapour point installation logs; and
- conducting a PID screening assessment across the investigation area.

5.4.1 Service Plans

A review of the available service plans (SA Power, Telstra, APA (gas) and SA Water) was conducted and the following services were noted in proximity of the site:

- SA Power – Two low voltage underground cables identified north of the site;
- Telstra – One underground cable entering from the north western portion of the site;
- APA – Three underground gas service pipes entering into the north eastern portion of the site (two low pressure lines and one high pressure line); and
- SA Water – A water main is located north of the site connected to a main running the length of Cliff Street. A waste water (sewer) main is also located north of the site running the length along Cliff Street and enters the site within the north western portion. No stormwater lines were noted on the plans, however drainage points were observed on either side of each of the roads within the investigation area.

It is noted that the installation depth and materials surrounding each of the above-mentioned services is unknown. However, the majority are likely to be installed within 1.0m of the ground surface. Copies of the service plans reviewed are attached as Appendix J.

5.4.2 Down-hole Geophysical Logging

To attempt to identify any preferential pathways for soil vapour due to geological formations beneath the site, down-hole geophysical testing was undertaken on three selected groundwater wells (MW2, MW8 and DC1). The testing was undertaken by Borehole Wireline Pty Ltd on 8 October 2014 and supervised by an experienced environmental scientist.

Two geophysical logging probes were used to obtain the data; a *Natural Gamma Probe* (NGRS) and a *Dual Induction/Conductivity Probe*. The Gamma probe measures naturally occurring radioactivity commonly associated with clayey soils and certain rocks (based on presence of Potassium, Thorium and Uranium compounds), while the dual induction/conductivity probe generate an electromagnetic field in the vicinity of the borehole and measures the response of the surrounding lithology from this applied field.

A summary report prepared by Borehole Wireline Pty is attached as Appendix C which includes composite geophysical logging data for each groundwater well and an interpretation into the likely lithological units identified within each groundwater well.

Based on a review of the composite geophysical logs, inter-bedded silt/sand and clay layers were identified throughout the depth of the three surveys. The water levels observed during the gauging of MW2 and MW8 appear to coincide with decreasing gamma and conductivity zones at approximately 3.4-3.6 m bgl. The lithological units identified during the drilling of DC1 appears to generally correlate with the geophysical interpretation, with a clay band identified at 7.3m and increasing clay content identified at approximately 8.5m. A sand layer encountered beneath this clay unit (at approximately 9.1m) is believed to be the Q2 aquifer targeted as part of the previous investigation.

In terms of preferential pathways, no other significant units were identified to that of the two quaternary aquifers (Q1 and Q2) investigated as part of previous investigation work, which could potentially act as preferential pathways for soil vapour (or groundwater movement) beneath the site.

5.4.3 Review of Available Groundwater Well and Soil Vapour Point Logs

Following a review of the available groundwater well and soil vapour point installation logs, the majority of test locations were found to have encountered a layer of surface fill generally less than 0.5 metres thick and comprising mixtures of sands, silts, clays and crushed rock along with occasional fragments of concrete. The underlying natural soils comprised predominately brown sandy or silty clays.

As such, the dominant soil type was determined to be silty clay. No significant preferential pathways were observed within the soil profiles reviewed in close proximity of the site, apart from some minor sand observed within the dominant clay soil type (ie. Sandy Clay layers).

5.4.4 PID screening of service pits

A PID survey of accessible service pits/underground services was conducted across the investigation area on 28 October 2014. The screening exercise was undertaken along Cliff Street, Wilson Terrace to the north, Kipling Avenue to the south, and portions of McGilp Avenue and Diagonal Road to the east and west respectively.

The methodology involved placing a small length of Teflon tubing into each service pit or underground service (such as a gas main or stormwater drain) while connected to a PID to detect any build-up of volatile compounds within the subsurface. The PID is designed as a broadband gas monitor therfore It may ionise everything with an ionisation energy less than or equal to the lamp output (in this case the PID has a 10.6eV gas-discharge lamp). It is noted that the PID was not calibrated specifically to the main chemicals of concern (ie: PCE or TCE). A plan showing the locations of the service pit, stormwater or gas main locations is presented in Appendix J. A copy of the PID calibration certificate is also attached to Appendix J.

All PID concentrations were measured a 0 parts per billion, with the exception of one result (7ppb) from stormwater drain SW7 located approximately 300m east of the site. However, this result is not considered significant given this stormwater drain is located up hydraulic gradient and is therefore not likely to be attributed the impacts identified onsite.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance and Quality Control (QA / QC) measures for the groundwater and soil vapour investigations included:-

- appropriate sample labelling, preservation, storage and transport under chain of custody procedures;
- collection and analyses of field QA / QC samples including duplicate samples and blanks;
- laboratory analyses conducted within appropriate holding times;
- conducting leak testing prior to and during soil vapour sampling;
- use of laboratories that hold NATA accreditation for the analyses undertaken;
- analysis of laboratory QA / QC samples including matrix spikes, matrix spike duplicates, and surrogates; and
- ensuring the sampling equipment (landfill gas meter, helium meter, air sampling pumps and PID) was calibrated before use;

The following sections detail the QA/QC analyses and consider the analytical data quality.

6.1 Internal Laboratory QA

The results of the internal quality assurance programs of the laboratory are presented with the NATA test certificates in Appendices F and H. Appropriate internal QA / QC were reported by both laboratories as follows:

- Accuracy (measured by laboratory spike and surrogate recovery samples) generally within 70% - 130% recovery;
- Precision (measured by duplicate sample analysis) within 30% relative percentage difference; and
- Minimum 95% completeness (measured by total number of analyses within acceptable limits).

6.2 Field Duplicates

6.2.1 Groundwater Analyses

Field duplicate samples were collected and analysed at the primary and secondary laboratories (Eurofins-mgt and ALS respectively) during both the July and October sampling events. Field duplicate samples QW1 and QW2 (duplicates of sample GW12) were collected during the July sampling event, while samples QC3 and QC4 (duplicates of sample GW16) were collected during the October sampling event.

All samples were analysed for the complete suite of analytes as discussed in Section 4.1.2.

The majority of comparable inter and intra laboratory duplicate groundwater analyses had relative percentage difference (RPD) values below the recommended comparison criteria of 50%. However, two ammonia variations of 67% and 86% were calculated between the primary October GW16 result (20 µg/L) and intra-laboratory duplicate (QC3 - 10 µg/L) and inter-laboratory duplicate (QC4 - 50 µg/L) results respectively. The concentrations were reported equal to or greater than the adopted guideline level of 10µg/L, however, these variations are not considered overly significant due to the low concentrations reported. Higher variations can be expected for samples with low analyte concentrations, such as the case with ammonia, as detailed in the NEPM.

A table summarising the field duplicate results for the investigation is presented with the groundwater result summary tables attached to this report.

6.2.2 Soil Vapour Analyses

Field duplicate samples were collected and analysed at the primary and secondary laboratories (EnviroLab and SGS respectively) during both the July and October sampling events. Field duplicate samples QVP01 and QVP02 (duplicates of sample SGP01_2.0) were collected during the July sampling event, while samples QSV1 and QSV2 (duplicates of sample SGP09) were collected during the October sampling event.

All samples were analysed for the TO-17 suite and fuel related compounds as described in Section 5.1.2.

The majority of comparable inter and intra laboratory duplicate soil vapour analyses had relative percentage difference (RPD) values below the recommended comparison criteria of 50%. However, a number of fuel related (TRH and BTEX) and VHC (cis-1,2-Dichloroethene and Tetrachloroethene) variations were calculated ranging between 52% and 152% between the primary and secondary laboratories.

The TRH and BTEX variations ranged from 53% to 152% over both sampling events, however these are not considered overly significant in terms of the investigation as none of reported concentrations from the primary or duplicate samples tested exceed the adopted criteria.

The Tetrachloroethene variations (two variations calculated at 52% from the October sampling event between primary sample SGP04 and duplicate samples QSV03 and QSV4) are also not considered overly significant in terms of the investigation as none of reported concentrations from the primary or duplicate samples tested exceed the adopted criteria.

The minor cis-1,2-Dichloroethene variation (63%) between the primary laboratory (280µg/m^3 – SGP09) and secondary laboratory (540 µg/m^3 – QSV2) is also not considered overly significant as it is not uncommon for larger variations to be observed when analysing organic compounds. The results both exceed the adopted residential criteria and are of the same order of magnitude.

A table summarising the field duplicate results for the investigation is presented as an attachment to this report (with soil vapour result summary tables).

6.3 Soil Vapour Leak Testing

As discussed in Section 5.0, prior to the soil vapour sampling taking place, leak testing was undertaken on each well to ensure that vapour samples were representative of the targeted soil depth being sampled and that ambient air was not being drawn into the vapour well. Two methods of leak testing (helium and isopropanol) were undertaken as discussed in sections 6.3.1 and 6.3.2.

6.3.1 Helium Leak Test

The helium leak test methodology adopted comprised adding helium to a shroud (which overlies the soil vapour point) and the concentration was measured using a GasCheck 5000 handheld helium detector. Soil vapour was then drawn from the vapour point and a real-time helium concentration was measured. A comparison was then made between the shroud concentrations and measured vapour point concentration to ensure the difference in concentration was less than the recommended difference of 10%.

The measured helium concentrations detected within all soil vapour points sampled (with the exception of soil vapour point SGP01_0.5 in July 2014) were less than 10% of the measured shroud concentration indicating the integrity of all soil vapour points are generally sound using the helium leak test method (refer Appendix G for sampling records).

The percentage difference measured between the shroud sample and SGP01_0.5 sample collected (100%) indicates there was a breach of ambient air into the vapour well indicating the construction of the vapour point has likely been compromised. Analysis was therefore not undertaken at this sampling location during the July sampling event.

6.3.2 Isopropanol Leak Test

Isopropyl alcohol leak tests were also undertaken on three selected soil vapour points (SGP03, SGP09 and SGP01) across the investigation area which comprised collecting and analysing a carbon tube sample to determine an isopropanol concentration within a shroud overlying the soil vapour point. Shroud concentrations were reported to range between 1,500,000µg/m^3 and 9,000,000µg/m^3. Isopropanol concentrations were then reported by the analytical laboratories (within the thermal desorption tubes) and a comparison was then made to ensure the difference in concentration was less than the recommended difference of 10%. All results have indicated the generally sound nature of each vapour point as no difference was calculated to be more than 0.6%.

6.4 Blank Samples

6.4.1 Groundwater

Rinsate blank (RB), field blank (FB) and trip blank (TB) samples were collected during the groundwater sampling events and analysed at the primary laboratory. Rinsate samples were collected from clean sampling equipment while the trip blank samples were a laboratory supplied sample (placed in the eksy prior to sampling) and the field blank samples comprised placing a laboratory supplied bottle (filled with laboratory supplied deionised water) open to the air over the duration of the sampling event. A summary of the blank sample testing is summarised in Table 8 below.

Table 8 - Blank sample Analyses

Date	Sample Blanks	Analyses
9 July 2014	RB1, TB1 and FB1	VHC
10 July 2014	TB2 and FB2	VHC
13 October 2014	RB2, TB2 and FB2	VHC

All reported concentrations were below laboratory reporting limits indicating that decontamination procedures were acceptable, cross contamination between samples and sampling equipment did not occur and there was no introduction of volatiles into the samples.

6.4.2 Soil Vapour

Laboratory supplied trip blank and trip spike samples (supplied by the primary laboratory EnviroLab over both sampling events) were analysed by the laboratory to ensure no cross contamination occurred during sample transport from and back to the laboratory. No elevated results were reported above the laboratory detection limits which indicates no cross contamination occurred during sample transport. Results are shown in the laboratory reports attached as Appendix H.

6.5 Data Quality Conclusions

The internal QC procedures reported by the laboratories, field duplicate and blank analyses, and leak testing undertaken, indicate the analytical data is of acceptable quality for the purposes of this investigation.

7.0 CONCLUSIONS

Groundwater Investigation

Previous environmental assessment works conducted at the site identified heavy metal, fuel related and volatile chlorinated hydrocarbon groundwater impacts. The volatile chlorinated hydrocarbon impacts were reported to be an order of magnitude higher than the adopted guideline levels and were shown to migrate offsite and into the secondary quaternary aquifer.

A groundwater investigation was undertaken both onsite and offsite with the aim of determining the extent of groundwater impacts within the Q1 aquifer only, with particular emphasis placed on the chlorinated hydrocarbon impacts which were previously reported. The works included sampling all existing groundwater monitoring wells (total of sixteen) along with the installation and sampling of three additional groundwater wells offsite along both Cliff Street and Purdeys Lane to attempt to determine the lateral extent of these chlorinated impacts within the Q1 aquifer.

One groundwater monitoring event was conducted in July 2014 of the existing 16 groundwater monitoring wells while the second monitoring event was conducted in October 2014 of the three additional groundwater wells installed down the hydraulic gradient of the site. The groundwater flow across the investigation area was inferred to be in a north westerly direction, consistent with that inferred during previous investigations.

A number of contaminant concentrations were reported for heavy metal (iron and manganese), inorganic (ammonia, chloride, total oxidised nitrogen and sodium) and chlorinated hydrocarbon (1,1-dichloroethene, trichloroethene (TCE) and tetrachloroethene (PCE)) above the adopted guidelines. The reported chlorinated hydrocarbon results indicate the extents of the TCE and PCE impacts are not delineated to the north west of the site (along the inferred hydraulic gradient).

Aquifer permeability tests (slug tests) were also conducted and it was estimated that the average groundwater flow velocity within the Q1 aquifer was 6.13 m/year.

Soil Vapour Investigation

Previous investigations indicate that the elevated volatile chlorinated concentrations reported in soils and groundwater below the site may result in vapour accumulation within site structures at the site which may in turn present an unacceptable human health risk to site personnel in the current commercial site operations.

A soil vapour investigation was undertaken across the site and surrounding residential properties to determine the extent of any soil vapour impacts.

Confirmation sampling was attempted at four existing soil vapour points in July 2014 (one of which was nested, i.e comprised two sampling implants at different depths). Elevated concentrations were reported for chlorinated hydrocarbon compounds cis-1,2-dichloroethene, TCE and PCE above the adopted residential and commercial/industrial criteria. It is noted that due to compromised integrity, two of the sampling locations / implants were not able to be sampled.

An additional nine soil vapour points (including three nested locations) were installed in September 2014. A total of thirteen soil vapour points were sampled in October 2014 (four existing points and nine additional points). Elevated soil vapour results were reported for chlorinated hydrocarbon compounds cis-1,2-dichloroethene, TCE and PCE above the adopted commercial/industrial and residential criteria at the majority of locations.

Soil vapour results indicate the extent of the impacts have not been delineated with only one soil vapour point (SGP13 – installed to the south west of the site) reporting results below the adopted criteria.

Investigation into Preferential Pathways

An investigation into preferential pathways for both groundwater and soil vapour was conducted through the analysis of service plans, available field logs, conducting down-hole geophysical testing. In addition a field screening assessment using hand held equipment was conducted in services pits across the investigation area.

To attempt to identify any preferential pathways due to geological formations beneath the site, down-hole geophysical testing was undertaken on three selected groundwater wells (MW2, MW8 and DC1). No other significant units were identified within the two quaternary aquifers (Q1 and Q2) which could act as preferential pathways for soil vapour or groundwater movement beneath the site.

No significant preferential pathways were identified within the soil profile based on the information obtained, however a number of underground utilities were observed in proximity of the site. The field screening assessment did not detect any elevated volatile concentrations in accessible service pit/underground services in the vicinity of the site.

8.0 LIMITATIONS OF THIS REPORT

This environmental site assessment report has been prepared in accordance with industry recognised standards and procedures at the time of the work. The report presents the results of the assessment based on the quoted scope of works (unless otherwise agreed in writing) for the specific purposes of the commission. No warranties expressed or implied are offered to any third parties and no liability will be accepted for use of this report by any third parties.

Information provided by third parties has been assumed to be correct and complete. Greencap does not assume any liability for misrepresentation of information by third parties or for matters not visible, accessible or present on the subject property during any site inspections conducted during the time of the work.

The first stage in the site assessment process generally involves site history research and/or a site inspection. This stage is intended to establish whether there is a likelihood of site contamination. Depending on the location of the site and surrounding land use, there could be contamination present which could not have been identified by preliminary investigation of this nature - for example, if there had been dumping of waste liquids which has left no visual evidence and past owners were not aware of. If recommendations have been made on whether or not to conduct further investigation, these have been based on the likelihood of site contamination, and are generally based on the sensitivity of the proposed future use of the site. A more conservative approach is generally adopted for a sensitive future use such as residential or a child care centre. Subsequent stages of soil or groundwater investigation may follow. The site assessment process is often ongoing, with additional stages of investigation being required to resolve issues raised in previous stages of the investigation. In cases where sampling and analysis of soil and/or groundwater has been conducted, then the following standard limitations apply:-

The results presented in the report apply only to the specific locations and the time the sampling was conducted. The nature and extent of contaminants present on a site can change due to physical disturbance or removal, chemical or biological transformation, or due to the migration of the contaminants to different areas.

The borehole or test pit logs indicate the approximate subsurface conditions only at the specified test locations. Soil and rock formations are variable, and conditions in areas not sampled may differ from those at the actual sampling locations due to natural subsurface variation.

The precision with which subsurface conditions are indicated depends largely on the frequency and method of sampling and investigation, and the degree of subsurface variation. There can be no complete guarantee that contaminants are not present at significant concentrations in some areas, even with the most thorough site assessment.

Any conclusions or recommendations are based solely on the land use assumptions stated in the report. These conclusions or recommendations do not apply to any other land use for the site.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. Opinions and judgements expressed herein are based on Greencap's understanding of current regulatory standards and should not be construed as legal opinions.