6 FIELD SAMPLING, ANALYSIS AND SAMPLING METHODOLOGY

During the assessment, remediation and validation of contaminated sites the integrity of data collected is considered paramount. With the assessment of the Sapphire Beach site a number of measures were taken to ensure the quality of the data.

These included:

Sample Containers

Soil and groundwater samples collected during the investigation were placed immediately into laboratory prepared glass jars with Teflon lid inserts. Standard identification labels were adhered to each individual container.

Sample Collection

All samples were collected by David Lane of David Lane Associates who is specifically trained in hazardous waste field investigation techniques and health and safety procedures. All techniques used are specified in David Lane Associates Field Manual for Contaminated Sites, which are based on methods specified by the United States Environment Protection Agency (US EPA) and The National Environmental Protection (Assessment of Site Contamination) Measure (NEPM), 1999.

Decontamination

All equipment used in the sampling program were decontaminated prior to use and between samples to prevent cross contamination. Decontamination of equipment involved the following procedures:

- Cleaning equipment in potable water to remove gross contamination
- Cleaning in a solution of Decon 90, and;
- Rinsing in clean demineralised water then wiping with clean lint free cloths.

Sample Tracking and Identification

All samples were identified with a unique sample number and all sampling details were included on the sample label and were reproduced on the field log sheets and chain of custody records. Refer to the Chain of Custody Forms in Appendix 1.

Sample Transport

All samples were packed in ice from the time of collection and were transported under chain of custody from the site to SGS Australia Pty Ltd, a NATA registered laboratory located in Matraville. During the project, the laboratory reported that all the samples arrived intact and were analysed well within their relative holding times for the respective analytes.

Laboratory Duplicates

Laboratory duplicates were sampled and analysed to check for consistency of laboratory performance and the homogeneity of samples.

7 ANALYTICAL METHODS AND DETECTION LIMITS

Typical methods used for analysis and their respective level of reporting are outlined below as follows:

Table 7a
Methods of Analysis - Soils

Analyte	Method	Level of Reporting Soil mg/kg	
Polycyclic Aromatic Hydrocarbons	US EPA SW 846 Method 8270C SGS Method ID SEO-030 - In house method.	**0.1 (Ind. Analyte)**	
Metals	SGS Method ID SEM-005 - In house method. ICP-MS SGS Method ID SEM-010 - In house method.	**Hg** **Ni** **Cd-Cr-Cu-Zn** **Pb** **As**	0.05 0.2 0.5 2 3
Pesticides	US EPA SW 846 Method 8141A SGS Method ID SEO-005 - In house method.	**OCP** **OPP**	0.1 0.1
PCB	SGS Method ID SEO-005 - In house method.	**PCB**	0.1
BTEX	SGS Method ID SEO-017 - In house method.	**Benzene** **Toluene** **Ethylbenzene** **Total Xylene**	0.5 0.5 0.5 1.5
TPH	SGS Method ID SEO-017 - In house method. SGS Method ID SEO-020 - In house method.	**C_6-C_9** **C_{10}-C_{14}** **C_{15}-C_{28}** **C_{29}-C_{36}**	20 20 50 50

Table 7b
Methods of Analysis - Groundwater

Analyte	Method	Level of Reporting Water mg/L
Polycyclic Aromatic Hydrocarbons	SGS Method ID SEO-030 - In house method.	**0.0005 (Ind. Analyte)**
Metals	SGS Method ID EXT-034 – Samples Out-Sourced to MGT Victoria. Analysis by APHA approved methods	**As-Cu-Cr-Ni-Zn** 0.001 **B** 0.005 **Be** 0.02 **Co** 0.01 **Mn** 0.001 **Cd** 0.0002 **Pb** 0.05 **Hg** 0.0001
Pesticides	SGS Method ID SEO-005 - In house method.	**OCP** 0.0002 **OPP** 0.0002
PCB	SGS Method ID SEO-005 - In house method.	**PCB** 0.0001
BTEX	SGS Method ID SEO-017 - In house method.	**Benzene** 0.001 **Toluene** 0.001 **Ethylbenzene** 0.001 **Total Xylene** 0.003
TPH	SGS Method ID SEO-020 - In house method.	**C_6-C_9** 0.04 **C_{10}-C_{14}** 0.1 **C_{15}-C_{28}** 0.2 **C_{29}-C_{36}** 0.2

The integrity of analytical data provides the second step in the QA/QC process for total data compliance. The data validation techniques adopted by David Lane Associates are based upon techniques published by the US EPA and in line with methods and guidelines adopted by the NSW EPA and outlined in the NEPM, 1999.

Descriptions are provided of the specific mechanisms used in the assessment of accuracy, precision and useability of analytical data within the project. Laboratory QA/QC reports are included in the Laboratory Analytical Results.

Blanks

Blanks were used for the identification of false positive data. Laboratory blank samples were analysed.

No cross contamination of samples is said to have occurred as a result of laboratory techniques provided all blanks show concentrations below the levels of detection. No results on blank samples were above the level of reporting for any determination during the project.

Spikes and Control Samples

Control sample spikes were utilised for the organic analysis. This involves analysis of spiked control samples and their duplicates, spiked with a known concentration of organic analytes.

Accuracy was assessed by calculation of the percent recovery (%R). The duplicate sample spikes were used to assess the precision of the methods used. The percent recovery (%R) for all spike analysis were within the acceptance criteria 70-140%.

Duplicates

Duplicate samples were prepared in the field by dual sampling and sending samples to the same laboratory. Approximately 10% of samples collected had duplicate analysis conducted as independent samples.

Field duplicates provide an indication of the whole investigation process ie. the sampling process, sample preparation and analysis. The relative percent differences (RPD) for the project were set at 30% between samples, which for the most part were not exceeded.

Table 7c – Calculated Percent RPD's for Metals

Duplicate	%RPD							
	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
BH2-0.3	5	<0.1	2.5	1.1	1	<0.05	0.6	4.6
BH2-0.3A	5	<0.1	2.4	1.0	1	<0.05	0.6	4.0
RPD %	0%	0%	4.1%	9.5%	0%	0%	0%	14.0%
Acceptable Criteria	30	30	30	30	30	30	30	30

Table 7d – Calculated Percent RPD's for Petroleum Related Analytes

Duplicate	%RPD					
	Benzene	Toluene	Ethylbenzene	Xylene	C_6-C_9	C_{10}-C_{36}
BH2-0.3	<0.5	<0.5	<0.5	<0.5	<20	<50
BH2-0.3A	<0.5	<0.5	<0.5	<0.5	<20	<50
RPD %	0%	0%	0%	0%	0%	0%
Acceptable Criteria	30	30	30	30	30	30

Table 7e – Calculated Percent RPD's for Remaining Analytes

Duplicate	%RPD				
	BaP	PAH	PCB	OCP	OPP
BH2-0.3	<0.05	ND	ND	ND	ND
BH2-0.3A	<0.05	ND	ND	ND	ND
RPD %	0%	0%	0%	0%	0%
Acceptable Criteria	30	30	30	30	30

Surrogates

To assess the performance of individual organic analysis the laboratory used surrogates. Percent recoveries were calculated for each surrogate providing an indication of analytical accuracy.

Surrogate recoveries for soil samples were all within recommended control limits, indicating that there was an acceptable degree of accuracy in analysing for organic compounds.

Comments

The results of the field and laboratory quality assurance and quality control procedures generally reflect the relative nature of the materials being analysed. While a degree of homogeneity is expected, the very nature of the material and the contaminant concentrations would create expectancy for some heterogeneity. The low concentrations present in the soil on site, relative to threshold concentrations, inherently cause some heterogeneity. Heterogeneity was not experienced above the accepted RPD% criteria of 30%.

It is considered that the analytical data generated is of an acceptable degree of accuracy and precision for the purpose of assessing the soil quality on the site.

8 ASSESSMENT CRITERIA

8.1 Rationale for the Selection of Assessment Criteria

The criteria selected have been chosen in accordance with current Australian and NSW EPA guidelines. Australian Guidelines have been used in preference to international guidelines where available. These criteria are the most current and widely accepted guidelines in use at present in Australia, and have generally been developed using a risk-based approach. Therefore, the selected guidelines provide a satisfactory framework for the site assessment.

8.2 Soil Criteria

- Health Based Investigation Levels (HBILs) for differing land uses (Imray, P. and Langley, A.) from the National Environmental Health Forum (NEHF) Monographs, Soil Science No. 1. Levels applicable to Residential with Gardens and Accessible Soils (category A),
- Schedule B-1 *Guideline on the Investigation Levels for Soil and Groundwater* from the National Environment Protection (Assessment of Site Contamination) Measure 1999 Table 5-A Column A, and;
- NSW EPA *Guidelines for Assessing Service Station Sites*, 1994.
- NSW EPA *Guidelines for the NSW Site Auditor Scheme*, 1998.

All assessment criteria are presented in Tables 8a and 8b below:

Table 8a

NSW EPA Soil Investigation Levels For Urban Redevelopment in NSW

Column A Table 5-A NEPM 1999 and,

NSW EPA Guidelines for Assessing Service Station sites 1994.

Analytes	NEHF A Threshold Concentrations (mg/kg dry wt)	Sources
BTEX		NSW Service Station Guidelines
Benzene	1	
Toluene	1.4[a]/130[b]	
Ethylbenzene	3.1[c]/50[d]	
Xylene (total)	14[c]/25[d]	
TPH: C6-C9	65	NSW Service Station Guidelines
TPH: C10-C40	1000	
>C16-C35 Aromatics	90	NEPM 1999
>C16-C35 Aliphatics	5600	
>C35 Aliphatics	56000	
Arsenic	100	NEPM 1999 Column A
Cadmium	20	✔
Chromium	100	✔
Copper	1000	✔
Lead	300	✔
Mercury	15	✔
Nickel	600	✔
Zinc	7000	✔
Total PAH's	20	✔
BaP	1	✔
PCB	10	✔
Pesticides:		✔
(Aldrin/Dieldrin)	10	
Chlordane	50	
DDT+DDE+DDD	200	

Table 8b
NSW EPA Groundwater Investigation Levels
Marine Waters Table 5B NEPM 1999 and,
NSW EPA Guidelines for Assessing Service Station sites 1994.

Analytes	Marine Waters Threshold Concentrations (µg/kg dry wt)	Sources
BTEX Benzene Toluene Ethylbenzene Xylene (total)	300.0	NEPM 1999 Marine Waters
TPH: C6 - C40	7.0	ANZECC Water Quality Guidelines*
Arsenic	50	NEPM 1999 Marine Waters
Beryllium	-	
Boron	1000.0	ANZECC
Cadmium	2.0	NEPM 1999 Marine Waters
Chromium	50.0	✔
Cobalt	1.0	ANZECC
Copper	5.0	NEPM 1999 Marine Waters
Lead	5.0	✔
Manganese	100	ANZECC
Mercury	0.1	NEPM 1999 Marine Waters
Nickel	15.0	✔
Zinc	50.0	✔
Total PAH's	3.0	✔
BaP	1.0	✔
PCB	0.004	✔
Pesticides: (Aldrin/Dieldrin) Chlordane DDT+DDE+DDD	 10.0ng/L 4.0ng/L 1.0ng/L	✔

* No groundwater criteria is present for speciated or total petroleum hydrocarbons in either the NSW EPA Service Station Guidelines or the NEPM Schedule B(1) Guidelines on the Investigation Levels for Soil and Groundwater. The ANZECC Water Quality Guidelines' TPH threshold criteria of 7µg/L is a guideline for protection of aquatic ecosystems, and is derived from a study on the effects of petroleum hydrocarbons on tropical marine organisms.

[a] The toluene threshold concentration is the Netherlands Maximum Permissible Concentration (MPC) to protect terrestrial organisms in soil. This value was obtained by applying the US EPA assessment factor to terrestrial chronic No Observed Effect Concentration (NOEC) data. The MPC is an "indicative" value (Van de Plassche *et al* 1993: Van de Plassche and Bockting 1993).

[b] Human health and ecological based protection level for toluene. The threshold concentration presented here is the Netherlands intervention value for the protection of terrestrial organisms. Other considerations such as odours and the protection of groundwater may require a lower remediation criterion.

[c] The ethylbenzene threshold concentration is the Netherlands MPC for the protection terrestrial organisms in soil. No terrestrial ecotoxicological data could be found for use in the Netherlands criteria derivation. Therefore, equilibrium partitioning has been applied to the MPC for water to obtain estimates of the MPC for soil. The MPC for water has been derived from the aquatic ecotoxicological data (Van de Plassche *et al* 1993: Van de Plassche and Bockting 1993).

[d] Human health based protection level for ethyl benzene or total xylenes as shown. The threshold concentration presented here is the Netherlands intervention value. Other considerations such as odours and the protection of groundwater may require a lower remediation criterion.

[e] The xylene threshold concentration is the Netherlands MPC for the protection terrestrial organisms in soil. No terrestrial ecotoxicological data could be found for use in the Netherlands criteria derivation. Therefore, equilibrium partitioning has been applied to the MPC for water to obtain estimates of the MPC for soil. The MPC for water has been derived from the aquatic ecotoxicological data. The concentration shown applies to the total xylenes and is based on the arithmetic average of the individual xylene MPCs (Van de Plassche *et al* 1993: Van de Plassche and Bockting 1993).

Table 8c
NSW EPA Provisional Phytotoxicity – Metals (mg/kg)

Heavy Metals	NSW EPA Provisional Phytotoxicity (mg/kg)	Heavy Metals	NSW EPA Provisional Phytotoxicity (mg/kg)
Arsenic	20	Lead	600
Cadmium	3	Mercury	1
Chromium	400	Nickel	60
Copper	100	Zinc	200

8.3 Limitations of Assessment Criteria

All criteria have limitations. Not all analytes are covered by each set of guidelines, requiring some criteria to be sourced from elsewhere. This is particularly relevant to the Dutch guidelines, which provide a guideline for assessment for some analytes not covered by the Australian guidelines.

9 RESULTS

9.1 Field Results

9.1.1 Subsurface Conditions

Two distinct geological profiles were observed across the site. These geological profiles are summarised below:

- The western (upper) areas of the site possessed silty clay immediately atop weathered argillite.
- The eastern (lower) areas of the site possessed sandy clay atop medium coarse grained sand and gravel.

9.1.2 Hydrogeology

Groundwater was encountered during site investigation in Borehole three (BH3). The groundwater was encountered at a depth of 4.2 metres from the surface level. The groundwater is predicted to flow in an easterly direction towards the ocean.

9.2 Analytical Results

9.2.1 Soils

A total of nine (9) soil samples and one (1) groundwater sample were submitted to SGS Australia Pty Ltd for a range of laboratory analysis as shown in the sample inventory included as **Appendix 3**.

Analytical results of the soil and groundwater samples are summarised in **Tables 9a – 9f** for TPH/BTEX compounds, PAHs, Pesticide compounds (OCCs and OCPs), PCB and Heavy Metals respectively. Results above background conditions for the site and/or above relevant criteria are highlighted.

Table 9a – TPH in Soil (mg/kg)

Sample ID & Depth (m)	Total Petroleum Hydrocarbons				
	C_6-C_9	C_{10}-C_{14}	C_{15}-C_{28}	C_{29}-C_{36}	Total
BH2-0.3	<20	<20	<50	<50	ND
BH2-0.3A	<20	<20	<50	<50	ND
BH3-3.0	<20	<20	<50	<50	ND
BH4-0.5	<20	<20	<50	<50	ND
Criteria	**65**	**-**	**-**	**-**	**1000**

ND – Not Detected

Table 9b – BTEX in Soil (mg/kg)

Sample ID & Depth (m)	BTEX			
	Benzene	Toluene	Ethylbenzene	Total Xylene
BH2-0.3	<0.5	<0.5	<0.5	<1.5
BH2-0.3A	<0.5	<0.5	<0.5	<1.5
BH3-3.0	<0.5	<0.5	<0.5	<1.5
BH4-0.5	<0.5	<0.5	<0.5	<1.5
Criteria	1	1.4[a]/130[b]	3.1[c]/50[d]	14[e]/25[d]

[a b c d e] – As outlined in Table 9a.

Table 9c – PAH in Soil (mg/kg)

Sample ID and Depth (m)	Contaminant	
	BaP	Total PAH
BH1-0.1	<0.05	ND
BH1-0.5	<0.05	ND
BH2-0.3	<0.05	ND
BH2-0.3A	<0.05	ND
BH2-1.0	<0.05	ND
BH3-0.3	<0.05	ND
BH3-1.0	<0.05	ND
BH4-0.5	<0.05	ND
HS-1	<0.05	ND
Acceptance Criteria	1	20

ND – Not Detected

Table 9d – Organics in Soil (mg/kg)

Sample ID and Depth(m)	Contaminant		
	OCP	OPP	PCB
BH1-0.1	1.7	<0.1	<0.1
BH2-0.3	<0.1	<0.1	<0.1
BH2-0.3A	<0.1	<0.1	<0.1
BH3-1.0	<0.1	<0.1	<0.1
HS-1	<0.1	<0.1	<0.1
Acceptance Criteria	**10**	**-**	**10**

ND – Not Detected

Table 9e - Metals in Soil (mg/kg)

Sample ID and Depth (m)	Acid Extractable Metals							
	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
BH1-0.1	20	0.3	15	54	57	<0.05	3.7	170
BH1-0.5	9	0.3	17	34	24	<0.05	3.3	44
BH2-0.3	5	<0.1	2.5	1.1	1	<0.05	0.6	4.6
BH2-0.3A	5	<0.1	2.4	1.0	1	<0.05	0.6	4.0
BH2-1.0	7	<0.1	2.3	0.8	<1	<0.05	0.7	2.8
BH3-0.3	9	0.2	11	29	14	<0.05	6.8	56
BH3-1.0	7	0.2	6.0	15	9.2	<0.05	6.6	39
BH4-0.5	9	0.3	14	69	19	<0.05	11	120
HS-1	24	0.3	20	42	41	<0.05	3.7	79
Acceptance Criteria	**100[1]**	**20[1]**	**100[1]**	**1000[1]**	**300[1]**	**15[1]**	**600[1]**	**7000[1]**
	20[2]	**3[2]**	**400[2]**	**100[2]**	**600[2]**	**1[2]**	**60[2]**	**200[2]**

[1] NEHF A Criteria [2] NSW EPA Phytotoxicity Criteria

9.2.2 Water

Table 9f – Analytes in Groundwater (µg/L)

Analysis	Date	BH3-W	Acceptance Criteria
BTEX	2.03.06	ND	300
C_6-C_9	2.03.06	ND	
C_{10}-C_{36}	2.03.06	ND	7.0
PAH	2.03.06	ND	3.0
BaP	2.03.06	<0.5	1.0
PCB	2.03.06	ND	0.004
OCP	2.03.06	ND	10
OPP	2.03.06	ND	-
As	2.03.06	2	50
Be	2.03.06	<1.0	-
B	2.03.06	<10	1000.0
Cd	2.03.06	<0.1	2.0
Co	2.03.06	<1.0	50.0
Cr	2.03.06	<1.0	1.0
Cu	2.03.06	3	5.0
Pb	2.03.06	1	5.0
Mn	2.03.06	50	100
Hg	2.03.06	<1.0	0.1
Ni	2.03.06	2.0	15.0
Zn	2.03.06	53	50.0

9.2.3 Soil Analytical Results

Total Petroleum Hydrocarbon:

Concentrations of Total Petroleum Hydrocarbon (TPH) compounds above the Service Station Guidelines (most sensitive) of 1000 mg/kg were not detected in any of the samples taken on site.

Monocyclic aromatic hydrocarbons (C_6 – C_9 and BTEX fractions), associated with petrol contamination, were not detected in any of the samples collected on site.

Polycyclic Aromatic Hydrocarbons (PAH):

A total of seven (7) soil samples and a duplicate were submitted for analysis of PAH compounds. PAH's are generally associated with ash material used as fill. PAH contamination above detection limits was not noted in any sample taken on site.

Heavy Metals:

A total of seven (7) soil samples and a duplicate were submitted for analysis of all eight (8) heavy metals as recommended by the NSW DEC (formerly EPA). No exceedances for any of these eight (8) heavy metals analysed for were recorded for the site acceptance criteria. Provisional phytotoxicity based investigation threshold levels were not exceeded in any sample location.

Pesticides:

Four (4) samples and a duplicate were submitted for pesticide and herbicide analysis (OCP and OPP). Minor concentrations of Organochlorine pesticides were encountered in sample locations BH1, however no concentrations of Organochlorine or Organophosphorus pesticides were recorded above the site assessment criteria.

Polychlorinated Biphenyls (PCB's):

Four (4) samples and a duplicate were analysed for Polychlorinated Biphenyls (PCBs) PCB contamination above detection limits was not noted in any sample taken on site.

9.2.4 Groundwater Results

Total Petroleum Hydrocarbon:

Concentrations of Total Petroleum Hydrocarbon (TPH) compounds above the Service Station Guidelines (most sensitive) of 1000 mg/kg were not detected in the groundwater sample collected on site.

Monocyclic aromatic hydrocarbons (C_6 – C_9 and BTEX fractions), associated with petrol contamination, were not detected in the groundwater sample collected on site.

Polycyclic Aromatic Hydrocarbons (PAH):

PAH's are generally associated with ash material used as fill, resulting from incomplete combustion of organic compounds. PAHs above detection limits were not noted in the groundwater sample taken on site.

Heavy Metals:

The groundwater sample was analysed for heavy metals as recommended by the NSW DEC (incorporating EPA). There were no exceedances above the NEPM 1999 Table 5B Groundwater Investigation Levels.

Pesticides:

No Organochlorine (OC) or Organophosphorous (OP) Pesticides were detected in the groundwater of the site, meeting the site assessment criteria.

Polychlorinated Biphenyls (PCB's):

No Polychlorinated Biphenyls (PCBs) were detected in the groundwater of the site, meeting the site assessment criteria.

10 EVALUATION OF QUALITY ASSURANCE AND QUALITY CONTROL

From a review and evaluation of the QA/QC data provided by David Lane Associates and the intended objectives of the sampling and analysis it is considered the data presented is of sufficient precision, accuracy, representativeness, comparability and completeness for its intended purpose.

Laboratory QA/QC on all samples analysed included calculation of %RPD, matrix spike recovery and blank determinations. Comment on the acceptability of data was given with each analytical report generated.

As the objectives of the David Lane Associates were to provide an indication of contamination across the Sapphire site, assessments for all potential contaminants of concern and qualification of any data is not considered to materially affect usefulness of the data.

10.1 Data Quality Objectives

The Data Quality Objectives (DQO's) for the sampling and analysis investigations were:

- Assess if the site has potentially been contaminated by past activities undertaken on-site and that the assessment strategy is thorough enough to enable comparison with accepted site criteria;
- Identify if the concentration of potential contaminants poses an adverse threat to the environment or health under the proposed commercial land use;
- Collect data on the concentrations of potential contaminants in the soil at the site to be used to complete the assessment. The assessment data was assessed by comparison to the guidelines currently recommended by the NSW EPA. Data exceeding the appropriate guidelines will be reviewed to identify its overall impacts;
- Select a sampling design that optimises the ability to gather relevant data. Implementation of a combination of judgmental and systematic sampling protocol provided the required confidence and is believed justified.