Douglas Partners

Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Remediation Action Plan

Proposed Residential Development
11 – 19 Centenary Road
Merrylands, NSW

Prepared for
St Vincent de Paul Society NSW

Project 71184.06
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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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Executive Summary

This Remediation Action Plan (RAP) has been prepared by Douglas Partners Pty Ltd (DP) and proposes a strategy for remediation of residual hydrocarbon contamination affecting soil and groundwater at 11-19 Centenary Road, Merrylands, hereon in referred to as the "site". The work was commissioned by St Vincent De Paul Society NSW (SVDPS).

It is understood that the RAP is required to support a rezoning proposal and ultimately a development application (DA) for the site. Therefore, the goal/objective of the remediation programme will be to render the site suitable for the proposed multi-storey residential apartment development.

Two underground storage tanks (USTs) were present at the site and some residual soil and groundwater contamination remains following their decommissioning (removal). The dissolved-phase hydrocarbon plume has been monitored over the period of time. The site owner has previously notified the site to the NSW EPA under Section 60 of the *Contaminated Land Management Act 1997* (CLM Act 1997) of the identified contamination at the site.

The proposed development is currently a concept design comprising:

- A four storey apartment building; and
- One level basement car park.

The site is currently zoned as R3 Medium Density Residential and it is understood that an application will be made to Council to change the zoning to R4 High Density Residential to permit high-density housing and other permissible uses within the R4 zone. It is further understood that the rezoning application notes that the development would likely comprise residential apartments with **two** basement levels.

The deeper the basement excavation, the further it will penetrate into the saturated zone where the bulk of the mass of residual contamination is likely to be present within fracture zones. Two scenarios (one level basement and two level basement) have therefore been considered for the preferred remediation option.

Several remediation options were evaluated. The preferred remediation options are summarised in the following table.

Table E1: Preferred Remediation Options

Scenario	Preferred
One Level Basement – Soil	Excavation and off-site disposal and management of residual contamination *in situ* by a vapour barrier
One Level Basement – Groundwater	Monitored natural attenuation
Two Level Basement – Soil	Excavation and off-site disposal and if required management of residual contamination *in situ* by a vapour barrier
Two Level Basement – Groundwater	Monitored natural attenuation

The full details of this RAP should be further refined in the context of the final design of the proposed development. Consideration should be given to cost and timing constraints such that the preferred options may vary to that outlined in Table E1 above. The refinements and design details should include the following:

- Confirmation of the preferred remediation option(s);
- Proposed sequence of remediation to be coordinated with the Remediation Contractor;
- Development of site specific remediation acceptance criteria (RAC) (as appropriate, depending on the option selected) which may involve a site specific human health risk assessment;
- Procedures for the validation of remediation (dependent upon the options adopted) including:
    - Sampling strategy including validation testing frequencies and analytes;
    - Monitoring during remediation and long-term monitoring;
    - Data quality objectives;
    - Quality assurance / quality control (QA/QC) procedures;
    - Use of on-site observations, visual/olfactory evidence; and
    - Chemical analysis / monitoring data.

It is considered that remediation of the site in accordance with the procedures and validation methods outlined in this RAP can render the site suitable for the proposed development and appropriately manage potential temporary impacts on the environment subject to:

- Finalisation of building design (including the number of basement levels);
- Finalisation of the preferred remediation option(s) in the context of a final design; and
- Refinement of this RAP and adopted remediation options based on the final design and input from the developer.

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1. Introduction

This Remediation Action Plan (RAP) has been prepared by Douglas Partners Pty Ltd (DP) and proposes a strategy for remediation of residual hydrocarbon contamination affecting soil and groundwater at 11-19 Centenary Road, Merrylands, hereon in referred to as the "site". The work was commissioned by St Vincent de Paul Society NSW (SVDPS). The scope of work was completed with reference to DP's proposal dated 17 February 2015.

A locality and site plan are shown on Drawing 1, Appendix A.

It is understood that the RAP is required to support a rezoning proposal and ultimately a development application (DA) for the site. Therefore, the goal/objective of the remediation programme will be to render the site suitable for the proposed multi-storey residential apartment development.

Based on the available information, it is considered that the proposed works are categorised as Category 2 Remediation with reference to DUAP EPA (1998) *State Environmental Planning Policy No. 55* (SEPP 55). The Council should therefore be notified of the proposed Category 2 works at least 30 days before commencement of the works.

The scope of the RAP has been established on the basis of the findings of the previous investigations in the context of the proposed development. The scope of the RAP is to:

- Provide a summary of the site history, regional topography, geology and hydrogeology;
- Provide a summary of soil and groundwater data to date;
- Develop a conceptual site model (CSM);
- Establish an appropriate remediation strategy so as to render the site suitable for the proposed use;
- Establish appropriate requirements for the validation and verification of the successful implementation of the remediation strategy, and the remediation acceptance criteria to be adopted for the validation of the site;
- Outline the requirements for the remediation works to be completed in an environmentally acceptable manner; and
- Outline the requirements for appropriate work, health and safety (WHS) procedures to be adopted for the remediation work so as not to pose a threat to the health of site workers or users.

The following site investigations / reports have previously been carried out at the site:

- DP (2009a), *Report on Phase 1 Contamination Assessment with Limited Sampling, Proposed Building Additions, 11-19 Centenary Road, Merrylands*, DP Ref: 71184.00;

- DP (2009b), *Report on Phase 2 Contamination Assessment, 11-19 Centenary Road, Merrylands,* DP Ref: 71184.01;
- DP (2010), *Report on Groundwater Monitoring Event, Assessment of Contamination and Natural Attenuation Parameters*, 11-19 Centenary Road, Merrylands, DP Ref: 71184.01-2;
- DP (2011), *Report on Remediation Action Plan*, *11-19 Centenary Road, Merrylands*, DP Ref: 71184.01-3;
- DP (2013a), *Report on Tank Pit Validation Assessment, 11 – 19 Centenary Road, Merrylands,* DP Ref: 71184.02;
- DP (2013b), *Interim Environmental Management Plan, 11 – 19 Centenary Road, Merrylands*, DP Ref: 71184.02;
- DP (2013c), *Report on Six Monthly Groundwater Monitoring Event – June 2013 (E1), 11 – 19 Centenary Road, Merrylands*, DP Ref: 71184.02;
- DP (2014a), *Report on Six Monthly Groundwater Monitoring Event – December 2013 (E2), 11 – 19 Centenary Road, Merrylands*, DP Ref: 71184.02;
- DP (2014b), *Report on Six Monthly Groundwater Monitoring Event – June 2014 (E3), 11 – 19 Centenary Road, Merrylands*, DP Ref: 71184.03;
- DP (2015a), *Report on Six Monthly Groundwater Monitoring Event – December 2014 (E4), 11 – 19 Centenary Road, Merrylands*, DP Ref: 71184.04; and
- DP (2015b), *Report on Six Monthly Groundwater Monitoring Event – December 2014 (E5), 11 – 19 Centenary Road, Merrylands*, DP Ref: 71184.05.

2. Site Identification and Description

The site is identified as part of Lots 19 – 24 in Deposited Plan 2020 and Lot 1 in Deposited Plan 597975 in the Parish of St John, County of Cumberland and the local government area of Holroyd City Council. The street address is 11 - 19 Centenary Road, Merrylands. The site covers an area of approximately 0.28 ha (refer to Drawing 1, Appendix A) and is currently zoned as R3 Medium Density Residential.

The site is bordered by Alderney Road and Centenary Road to the north and west respectively. Residential properties border the site to the east and south. Adjacent to the southern boundary is unused land that forms part of the adjacent residential property. This residential property is used by the SVDPS as an office.

The majority of the north-eastern section of the site is occupied by a single-storey, slightly dilapidated warehouse building of timber, steel and corrugated iron construction with concrete flooring. During previous remediation works (see Section 5), two USTs were removed from the external south-western corner of this building. Subsequent to validation, the remediation pit was reinstated with virgin excavated natural material (VENM) and the ground surface was sealed with asphalt. The far north-eastern corner of the site comprises a vegetated area with some mature trees.

The western portion of the site is occupied by a two-storey building that is used for retail purposes. The ground level of the building is of brick construction and the second storey is of lightweight construction with external concrete column supports. The ground level flooring comprises concrete and wooden floors which have been carpeted.

The area between the two buildings is paved with asphalt and used as a car park with vehicle access via Alderney and Centenary Roads. The site boundaries are typically covered with grass and scattered mature trees. The ground surface within the site falls gently to the west.

3. Geology and Hydrogeology and Climate

Reference to the 1: 100 000 Series Geological Sheet for Sydney indicates that the site is underlain by Bringelly Shale which typically comprises shale, carbonaceous claystone and fine to medium grained lithic sandstone. Bringelly Shale typically weathers to form residual clayey soils of moderate to high reactivity.

The geological mapping was confirmed by the previous investigations with fine to medium grained sandstone and laminite encountered in all bores.

A groundwater bore search of the (former) Department of Water and Energy website database (this function has now been incorporated into NSW Office of Water) was conducted as part of DP (2009a). There was no record of any groundwater wells within a 500 m radius of the site. Additionally, no groundwater was observed during augering at any of the sample locations. Coring techniques precluded observations of the depth to the groundwater table in all groundwater bores.

During the DP (2015b) GME, groundwater levels, were recorded to be between 36.75 m relative to Australian Height Datum (AHD)) and 33.45 m AHD, mainly within the bedrock horizon. The average depth to groundwater across the site was 2.45 m bgl. Based on groundwater level data obtained during the December 2014 and the current GMEs, the general groundwater gradient at the site is expected to be in a west/south-westerly direction.

Stormwater runoff would be expected to infiltrate into the soils (in unpaved areas) or be collected at drains located around the site. The nearest major water body is Prospect Creek located approximately 3 km south-west of the site. A minor (ephemeral) tributary to Finlayson's Creek is also present approximately 300 m to the west of the site. Therefore, on a regional scale, groundwater is expected to flow in a south-westerly direction.

The ground surface falls to the west at an average slope of approximately 3 degrees, with ground surface Reduced Levels (RL) ranging from about RL 39.50 m AHD at the north-east corner to RL36.60 m AHD at the north-west corner. The off-site sample locations (BH303 and BH304) had RLs of 36.75 m AHD and 36.80 m AHD respectively.

Monthly rainfall statistics for the nearest weather station (i.e. the Greystanes – Bathurst Street weather station located 4.8km from the site) were sourced from the Bureau of Meteorology (BOM) website and the "monthly total" rainfall figures for 2013, 2014 and up to June 2015 are presented in Figure 1 below. The data indicated that between December 2014 and June 2015, monthly rainfall ranged between

38.8 mm (February 2015) and 403.4 mm[1] (April 2015). In this regard, the average monthly rainfall between January and June 2015 was 130.5mm. It is anticipated that the rain events preceding the July 2015 sampling period could potentially have an impact on groundwater levels and contaminant concentrations in the groundwater.

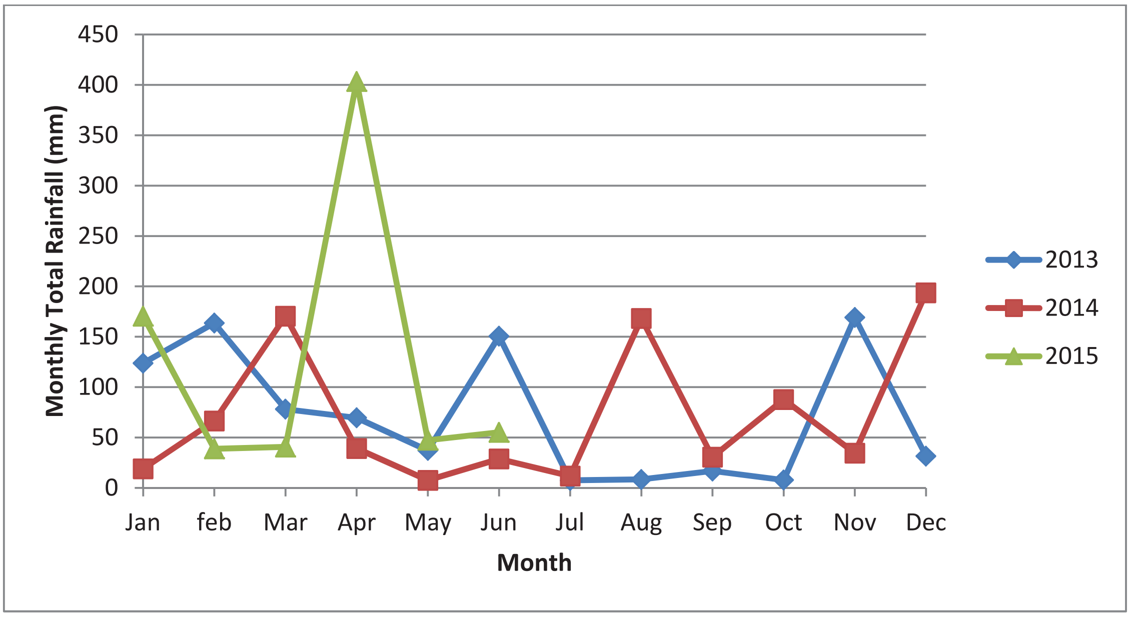

Figure 1: Monthly Total Rainfall for 2013, 2014 and up to June 2015.

4. Proposed Development

The proposed development is currently a concept design comprising:

- A four storey apartment building; and
- One level basement car park.

The site is currently zoned as R3 Medium Density Residential and it is understood that an application will be made to Council to change the zoning to R4 High Density Residential to permit high-density housing and other permissible uses within the R4 zone. It is further understood that the rezoning application notes that the development would likely comprise residential apartments with **two** basement levels.

[1]Source:

http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_stn_num=067017

5. Summary of Previous Investigations, Remediation and Validation

The results of DP (2009a, 2009b and 2010) indicated the presence of TRH C_6-C_9 and BTEX impacted soil and groundwater associated with USTs at the site. Consequently, the site owner took a proactive approach wherein it voluntarily notified the NSW EPA under Section 60 of the *Contaminated Land Management Act 1997* (CLM Act 1997) of the identified contamination at the site.

In addition to the above, it is noted that DP (2010) comprised a GME to evaluate whether groundwater conditions at the site were conducive to monitored natural attenuation (MNA). The assessment involved a review of the previous results, sampling of the three groundwater monitoring wells from DP (2009b) (i.e. Bores 201 – 203) plus the construction and sampling of four additional groundwater wells (301 – 304), two of which were located off site (303 and 304). It is noted that the locations of the off-site wells were restricted by the presence of both buried services and overhead electrical cables along both sides of Centenary Road. Consequently, BH303 and BH304 were placed in close proximity to each other at a location immediately up-gradient of the identified sensitive receptors (i.e. the residential properties across Centenary Road). The results of DP (2010) showed the following:

- Light non-aqueous phase liquid (LNAPL) was not detected by the interface probe, although a thin oily sheen was observed in two of the bores i.e., Bores 203 and 302, which are located adjacent to the UST and cross-gradient to UST, respectively (see Drawing 1, Appendix A);
- Strong hydrocarbon odours were noted to be present in the groundwater from the wells adjacent to the UST, i.e. Bores 203 and 302, whilst slight hydrocarbon odours were noted at Bores 201 and 202;.
- The analytical results for the primary contaminants of concern (i.e., TRH, BTEX and PAH) indicated that the groundwater up-gradient of the UST (301) did not show any discernible signs of hydrocarbon associated contamination;
- Substantially elevated TRH C_6-C_9 (11000 – 35000 µg/L), benzene (830 - 10000 µg/L), toluene (5100 – 19000 µg/L), ethylbenzene (1000 – 1300 µg/L) and total xylenes (3580 – 5000 µg/L) concentrations, in exceedance of the adopted groundwater investigation levels (GIL), were however, recorded in the groundwater samples retrieved from Bores 203 and 302. The concentrations of medium to heavy chain hydrocarbons (TRH C_{10} – C_{36}) and PAH (naphthalene) also exceeded the adopted GILs in these two bores. A review of the chromatograms for Bores 203 and 302 indicated that the chemical “signature” of the TRH was similar to petrol. Furthermore, elevated concentrations of a number of petroleum related, non-halogenated volatile organic compounds (VOC), in particular, cyclohexane, n-propylbenzene, 1,2,4 trimethylbenzene and 1,3,5 trimethylbenzene were also detected in Bores 203 and 302. In summary, the analytical results from DP (2010) indicated that the groundwater in the vicinity of the USTs is significantly impacted by petroleum hydrocarbons;
- Samples collected at the down-gradient site boundary (Bores 201 and 202) recorded elevated TRH C_6–C_9 and BTEX concentrations. The recorded concentrations were significantly lower than recorded at Bores 203 and 302 (adjacent to the source of the contamination). The only primary contaminant of concern that exceeded the adopted GIL was TRH C_6–C_9 in Bore 201 (530 µg/L). Bore 202 recorded minor concentrations of TRH C_6–C_9 and BTEX were detected which were also below the adopted GIL;
- Samples collected from the off-site, down-gradient bores (Bores 303 and 304) recorded lower TRH contaminant concentrations than those detected at the site boundaries. Whilst detectable concentrations of TRH C_6 – C_9 (Bores 303 and 304), BTEX (Bores 303 and 304) and VOC (Bore

303) were recorded in the off-site, down-gradient bores, the concentrations were well within the adopted GIL;

- The field parameters indicated that the recorded values of both dissolved oxygen and redox potential were indicative of the occurrence of natural attenuation through oxidation of petroleum hydrocarbons;
- The presence of increased concentrations of dissolved CO_2 along the flow path of the plume, and the presence of elevated methane concentrations within the plume further suggested that natural attenuation is occurring (at least partially) with the petroleum hydrocarbons breaking down under aerobic conditions to form methane;
- Relatively low nutrient concentrations i.e., ammonia and phosphorous were detected in the analysed samples. In this regard DP 2010 noted that the efficiency of the process may be further enhanced by appropriately introducing nutrients to the groundwater;
- With respect to electron receptors, sulphate concentrations in the three most contaminated bores (Bores 203, 302 and 201) showed significantly lower sulphate concentrations than the baseline bore (BH301) and the fringe bore (BH303). Similarly, the recorded concentrations of ferrous iron (the product of reduced ferric iron) were greatest in the bores with the highest concentrations of petroleum hydrocarbon contaminants (Bores 203 and 302). Therefore, there was evidence of both sulphate and ferric iron reduction which would support the oxidation and biodegradation of petroleum related hydrocarbons. In addition to the above, there appeared to be some signs of an increased alkalinity trend along the flow path of the contamination plume, which further supported the inference that natural attenuation was occurring at the site.

Based on the results of DP (2009 and 2010), a Remediation Action Plan (RAP) (DP, 2011) was prepared with a view to remediate soil and groundwater contamination. The proposed remediation strategy comprised a phased approach. DP (2009a, 2009b, 2010, 2011) were the subject of an audit by a NSW Environment Protection Authority (EPA) accredited auditor, Mr Philip Mulvey of Environmental Earth Sciences Pty Ltd (EES). Based on the auditor’s comments on the reports, the DP (2011) RAP was finalised and submitted to the NSW EPA.

DP (2011) documented a two stage remediation process. Phase 1 of the remediation works which were completed in 2012 included removal of the USTs, excavation and disposal of contaminated soil, backfilling the excavated area with validated VENM and implementing six monthly groundwater monitoring events. Phase 2 of the remediation works (to be completed in the future) involves further sampling to characterise the site and appropriate remediation of any additional and residual areas of contamination.

An air monitoring event (AME) was also undertaken in the process of finalising the RAP. The purpose of the AME was to confirm whether the detected petroleum hydrocarbon contamination in the subsurface had intruded into the building and resulted in unacceptable health impacts on the air quality of the site, such that corresponding remediation action/management could be incorporated. Based on the findings of the AME, it was considered that the site was not impacted by vapour intrusion from the volatile contaminants in soil/groundwater at the time of sampling and at the sampling locations. Further details on the AME are provided in DP (2011).

Between July and September 2012, the first phase of remediation comprising the removal of two USTs and disposal of some of the surrounding contaminated soil was completed. However, the GMEs had not yet commenced. DP (2013a) reported on the remediation that had been undertaken including the removal of two USTs and excavation and disposal of surrounding hydrocarbon contaminated soil. The extent of the excavations to remove contaminated soil was limited so as to maintain the structural integrity of the existing operational building structures and underground services. The validation results suggested that TRH C_6-C_9 and BTEX soil contamination remains at depths of more than 2 m below the current ground level which was identified within the weathered sandstone, particularly at the base of the remediation excavations.

In view of the residual soil and groundwater contamination, an interim environmental management plan (IEMP) was prepared for the site (DP, 2013b). The IEMP detailed interim management strategies for the maintenance of the existing ground surfaces and also recommended commencement of the current six monthly GME of the groundwater monitoring wells. In this regard, given that BH303 and BH304 were placed in close proximity to each other, BH304 was excluded from the GMEs as BH303 was considered to provide data that would be representative of the off-site sampling locations.

In June 2013, the first GME (E1) was carried out and the results were reported in DP (2013c). The results of DP (2013c) indicated that whilst the concentration of the contaminants of concern had marginally increased since the January 2010 monitoring event, the increased concentrations were likely to be associated with the recent remediation works that had temporarily altered the groundwater conditions and geochemical processes at the site. Therefore, DP (2013c) concluded that "*….the elevated contaminant concentrations detected during the current monitoring round may not necessarily be indicative of deteriorating groundwater conditions and are more likely to be associated with stabilisation of groundwater conditions at the site. As such, robust trend analysis cannot be conducted at this stage until the data set is expanded through/by additional rounds of monitoring. Therefore further rounds of groundwater monitoring will be required to evaluate a trend in the contaminant plume*."

In December 2013, the second GME (E2) was carried out and the results were reported in DP (2014a). The results indicated that contaminant concentrations during the second GME "*were generally lower than those detected during the June 2013 monitoring round (E1), and in some cases were lower than those recorded during DP (2010). However, anomalous variations in contaminant concentrations can occur due to natural fluctuations in groundwater quality which are affected by many factors including climatic influence. As such, in order to evaluate whether there is a sustained trend of contaminant depletion in the plume, further rounds of groundwater monitoring as per the RAP and IEMP will be required to carry out a more detailed trend analysis of the contaminant plume.*"

In June 2014, the third GME (GME E3) was carried out and the results were reported in DP (2014b). The results indicated that during the third GME "*with the exception of BH203 (located adjacent to the former USTs), contaminant concentrations in the remainder of the bores (where hydrocarbons were previously detected) were generally lower than those detected during the December 2013 (E2) and June 2013 (E1) monitoring rounds, and in some cases were lower than those recorded during DP (2010). Whilst the concentrations of the petroleum hydrocarbon contaminants in BH203 (located adjacent to the former USTs) increased when compared to E2, these increased concentrations may not necessarily be indicative of deteriorating groundwater conditions. Furthermore, as the concentrations of benzene, toluene and ethylbenzene in the down-gradient site boundary bores are now below the laboratory's detection limits, these results suggest that the plume may be shrinking. However, anomalous variations in contaminant concentrations can occur due to natural fluctuations in groundwater quality which are affected by many factors including climatic influence. As such, in order to evaluate whether there is a sustained trend of contaminant depletion in the plume, further rounds of* *groundwater monitoring as per the RAP and IEMP will be required to carry out a more detailed trend analysis of the plume.*"

In December 2014, the fourth GME was carried out and the results were reported in DP (2015a). The results indicated that during the fourth GME "*with the exception of BH302 (located cross-gradient to the former USTs), contaminant concentrations in the remainder of the bores (where hydrocarbons were previously detected) were generally lower than those detected during the December 2013 (E2) and June 2013 (E1) monitoring rounds, and in the majority of the bores were lower than those recorded during DP (2010). Whilst the concentrations of the petroleum hydrocarbon contaminants in BH302 (located cross-gradient to the former USTs) have increased when compared to E3, these increased concentrations may not necessarily be indicative of deteriorating groundwater conditions. Furthermore, as the concentration of TRH, benzene, toluene, xylene and, to a lesser extent, ethylbenzene in the down-gradient site boundary bores are typically showing a downward trend, these results suggest that the plume may be shrinking and a reduction in contaminant mass is occurring. The inference of a reduction in contaminant mass is further supported by the pronounced reduction in contaminant concentration during the current GME at BH203 (located adjacent to the former UST area) which was previously the worst affected bore. However, anomalous variations in contaminant concentrations can occur due to natural fluctuations in groundwater quality which are affected by many factors including climatic influence. As such, in order to evaluate whether there is a sustained trend of contaminant depletion in the plume, further rounds of groundwater monitoring as per the RAP and IEMP will be required to carry out a more detailed trend analysis of the plume.*"

In July 2015, the fifth GME was carried out and the results were reported in DP (2015b). The results indicated that during the fifth GME "*with the exception of BH203 (located adjacent to the former source), hydrocarbon contaminant concentrations in the remainder of the wells within and close to the fringe of the plume (i.e. BH302, BH201 and BH202) appear to have reduced when compared to the results of the June 2013 (E1) monitoring rounds, and in some instances (such as for TRH, benzene, toluene and xylenes), have been recorded at concentrations below those detected during DP (2010).*

However, at BH203 (adjacent to the former source), the concentrations of the hydrocarbon contaminants appear to have increased when compared to E4 concentrations. Furthermore, at the site boundaries (BH201 and BH202) a marginal increase in TRH C_6-C_9 concentrations was observed when compared to E4, the recorded contaminant concentrations at these wells were nevertheless below January 2010 (pre-remediation) concentrations. The increased contaminant concentrations at BH203 and to a lesser extent at the site boundary wells during this GME are not necessarily indicative of deteriorating groundwater conditions as the observed spike may be associated with recent rain events that could have resulted in flushing out of contaminants. As previously mentioned, the results to date also indicate that contaminant concentrations in the core of the plume, specifically in BH203 (the previously worst affected bore located adjacent to the former source) and BH302 (cross-gradient to the former source), are pulsing, as spikes in contaminant concentrations in BH203 have been observed during the June GMEs and reduced concentrations/troughs have been recorded in BH203 during the December GMEs. Consequently, the spike observed in BH203 during the current monitoring round is likely to be associated with this seasonal fluctuation wherein contaminants from the vadose zone are likely to have been released as a result of preceding rainfall events.

In the case of TRH, benzene, toluene and xylenes, a comparison of the contaminant concentration troughs for the bores in core of the plume (i.e., BH203 and BH302) indicates that, generally, there is a decreasing trend of hydrocarbon contaminant concentrations as, since the January 2010 GME, each trough is significantly lower than the previously recorded trough. This decreasing trend suggests that *there is a reduction in contaminant mass within the plume. Furthermore, the reduced contaminant concentrations at the remainder of the bores (i.e. BH302, BH201, BH202 and BH303, which in some instances are below the laboratory's limit of reporting) when compared to January 2010 GME is also most likely indicative of a stable and/or shrinking hydrocarbon plume. This inference is further supported by the fact that since completion of the remediation works, TRH C_6-C_9 and BTEX concentrations in the offsite down-gradient sentinel well (BH303) have consistently been below the laboratory's limit of reporting. Notwithstanding, it is noted that the current monitoring round is only the fifth round of a three year monitoring programme. As such, anomalous variations in contaminant concentrations can occur due to natural fluctuations in groundwater quality which are affected by many factors including climatic influence. Therefore, in order to evaluate whether there is a sustained trend of contaminant depletion, it is considered prudent to expand the existing data set through/by additional rounds of monitoring as per the current bi-annual monitoring programme.*

The analytical results for the natural attenuation parameters generally indicate that even though relatively low nutrient concentrations (ammonia and phosphorous) were detected, there is evidence of both oxygen depletion in the plume and breakdown products of petroleum related hydrocarbons. There is also evidence of the presence of the electron receivers which would be required for oxidation of the petroleum related hydrocarbons to proceed. These results generally support the conclusion that the groundwater conditions at the site are conducive to natural attenuation. Furthermore, the favourable natural attenuation parameters coupled with the recorded lower contaminant concentrations in all bores other than BH203 (located adjacent to the source) also suggest that natural attenuation is occurring in the contaminated groundwater. However, the results also indicate that the natural attenuation process may be further enhanced by increasing nutrient concentrations in the groundwater."

The updated schedule for the GMEs is provided in Table 1 below.

Table 1: Schedule for Six Monthly Groundwater Monitoring Events

Event	Status
Event 1 (E1) Six Monthly groundwater monitoring round and provision of letter report detailing the findings of the assessment. Groundwater wells 301, 201, 202, 203, 302 and 303.	Completed
Event 2 (E2) **December 2013** Six Monthly groundwater monitoring round and provision of report detailing the findings of the assessment. Groundwater wells 301, 201, 202, 203, 302 and 303.	Completed.
Event 3 (E3) **June 2014** Six Monthly groundwater monitoring round and provision of report detailing the findings of the assessment. Groundwater wells 301, 201, 202, 203, 302 and 303.	Completed

Event	Status
Event 4 (E4) **December 2014** Six Monthly groundwater monitoring round and provision of report detailing the findings of the assessment. Groundwater wells 301, 201, 202, 203, 302 and 303.	Completed
Event 5 (E5) **June 2015** Six Monthly groundwater monitoring round and provision of report detailing the findings of the assessment. Groundwater wells 301, 201, 202, 203, 302 and 303.	Completed
Event 6 (E6) **December 2015** Six Monthly groundwater monitoring round and provision of report detailing the findings of the assessment. Groundwater wells 301, 201, 202, 203, 302 and 303.	To be completed
Summary Report – January 2016 Preparation of a summary report detailing the results and implications of the data sourced from the three years of monitoring.	To be completed

A summary of the groundwater monitoring data to date is included in Appendix B. The data are tabulated against groundwater screening criteria that were the adopted for the previous investigations and on-going monitoring.

5.1 Existing Monitoring Well Network

The following table provides a summary of the existing groundwater monitoring well network.

Table 2: Summary of Well Construction Details

Monitoring Well ID	BH201	BH202	BH203	
Slotted Well Screen	10.15 – 1.50 m	10.35 – 1.50 m	10.10 – 1.50 m	
PVC Blank	1.50 – 0.00 m	1.50 – 0.00 m	1.50 – 0.00 m	
Gravel Pack	10.15 – 1.00 m	10.35 – 1.00 m	10.10 – 1.00 m	
Bentonite	1.00 – 0.00 m	1.00 – 0.00 m	1.00 – 0.00 m	
Monitoring Well ID	**BH301**	**BH302**	**BH303**	**BH304**
Slotted Well Screen	8.43 – 2.50 m	9.75 – 2.50 m	10.10 – 2.50 m	10.10 – 2.50 m
PVC Blank	2.50 – 0.00 m	2.50 – 0.00 m	2.50 – 0.00 m	2.50 – 0.00 m
Gravel Pack	8.43 – 2.00 m	9.75 – 2.00 m	10.10 – 2.50 m	10.10 – 2.00 m
Bentonite	2.00 – 1.00 m	2.00 – 0.00 m	2.50 – 2.00 m	2.00 – 1.50 m

6. Conceptual Site Model (Proposed Development)

To assist in the understanding of the site and the potential environmental risk since remediation of the former UST area, a conceptual site model (CSM) has been prepared. A CSM is a representation of site-related information regarding contamination sources, receptors and exposure pathways between those sources and receptors. The CSM provides the framework for identifying the potential sources of contamination and how potential receptors may be exposed to contamination either in the present or in the future *ie* it enables an assessment of the potential source – pathway – receptor linkages.

6.1 Contamination Sources

Based on the available information, after remediation of the former UST area, the following (Table 3) potential residual sources of contamination are present at the site. In this regard, it is noted that the primary source of contamination (i.e., the former USTs and associated infrastructure) have been decommissioned and removed from the site.

Table 3: Potential Contamination Sources after UST Remediation and Contaminants of Concern

Potential Source	Description of Potential Source	Primary Contaminants of Concern
Residual impacted soil/sandstone bedrock (S1)	The validation results for the UST remediation works that were completed in 2012 indicate that TRH C_6-C_9 and BTEX soil contamination remained at depths of more than 2 m below the current ground level which was identified within the weathered sandstone, particularly at the base of the remediation excavations. As such, during the remediation works, excavation of this residual impacted soil/bedrock was limited because of the potential to undermine of the structural integrity of the existing operational buildings and underground services.	TRH and BTEX
Dissolved Phase Plume (S2)	The results of GMEs 1 to 5 have shown that as a result of leaks from the former USTs, a dissolved phase plume is present in the groundwater. Note: measurable LNAPL has not been observed during the E1 to E5 GMEs.	TRH and BTEX

6.2 Potential Receptors

6.2.1 Human Health Receptors

Potential human-health receptors include:

R1 – Future users (high density residential).
R2 –Users in down-hydraulic gradient properties (residential);

6.2.2 Environmental Receptors

With regard to groundwater and surface water receptors, it is noted that the potential receptor-pathway linkages for groundwater at, or down-gradient, of the site may include:

- Groundwater discharge to water bodies sustaining aquatic ecosystems – however, this linkage is considered unlikely as the nearest down-gradient surface water receptor Finlayson's Creek and Prospect River are located approximately 0.3 km and 3 km west and south-west of the site, respectively. Given the relatively low concentrations of TRH and BTEX recorded in the site boundary wells and noting that the contaminant concentrations in the off-site sentinel well (30 m south-west of the site) were below the laboratory's limit of reporting, it is considered unlikely that the plume would reach the Prospect River at concentrations that would pose any risk to aquatic species.
- Extraction for irrigation of gardens - however, this linkage/use is considered unlikely as there are no registered groundwater bores within a 500 m radius of the site. Consequently, this potential use has not been considered further; and

- Potential potable use - however, this linkage/use is considered unlikely given that integrated water supply/scheme is supplied by pipes to the site and the surrounding properties. Consequently, this potential use has not been considered further.

With regard to the terrestrial ecology, it is noted that any residual impacted soil/sandstone is primarily present at depths of 2 m bgl or greater. As such, Schedule B1 of the NEPC (2013) guidance notes that the habitation zone of the terrestrial ecological species is typically within 2 m from the finished ground surface. Additionally, given that the site is proposed to be developed for high density residential and noting that the areas where the residual impacted soil/sandstone is present is likely to comprise hard cover, the potential for terrestrial ecology to come into contact with the impacted material is considered to be low. On this basis, the potential receptor-pathway linkages for terrestrial ecology is considered to be incomplete.

6.3 Potential Pathways

Potential pathways for contamination (both complete and incomplete) are listed below:

P1 – Ingestion and dermal contact;

P2 – Inhalation of vapours;

6.4 Potential Complete Pathways

A 'source–pathway–receptor' approach has been used to assess the potential risks of harm being caused to human, water or environmental receptors from contamination sources on or in the vicinity of the site, via the identified exposure pathways.

Table 4: Potential Complete Pathways

Contamination Source	Potential Exposure Pathway	Receptor
Residual impacted soil/sandstone bedrock (S1)	P1: Ingestion and dermal contact P2: Inhalation of vapours	R1 – Future users.
Dissolved Phase Plume (S2)	P2: Inhalation of vapours	R1 – Future users. R2 – Users in down-hydraulic gradient properties.

7. Interaction of the Proposed Basement with Residual Contamination

Excavation of a basement across the bulk of the site footprint will form a main component of the remediation of residual soil and groundwater contamination. Whether a one or two level basement is adopted will largely drive the overall mass of residual contamination that is able to be removed by excavation. The deeper the basement excavation, the further it will penetrate into the saturated zone where the bulk of the mass of residual contamination is likely to be present within fracture zones.

The thickness of the dissolved-phase plume has not been fully established to date. Nested or clustered wells screened over short (say 2.0 m) intervals at various depths would be required to fully characterise and define the thickness of the dissolved-phase plume.

The following tables provide a summary of the interaction between the proposed basement and the residual contamination (groundwater levels as measured on 10 June 2015).

Table 5: Penetration of One Level Basement into Saturated Zone

Monitoring Well ID	Bore RL (m)	Water Depth (m bgl)	Water RL (m)	One Level Basement Depth (m) [1]	Penetration of Basement into Saturated Zone [2]
201	37.4	3.95	33.45	3.0	**Nil**
202	36.9	3.10	33.8	3.0	**Nil**
203 [3]	38.3	1.66	36.64	3.0	**1.34**
301	39.1	1.94	37.16	3.0	**1.06**
302 [3]	38.35	1.60	36.75	3.0	**1.40**
303	36.75	2.91	33.84	NA	NA

Notes to table:

1. An assumed basement depth below existing ground level.
2. The difference between the assumed basement depth and the water depth (m bgl).
3. Plume core and general zone of highest residual hydrocarbon impact.

Table 6: Penetration of Two Level Basement into Saturated Zone

Monitoring Well ID	Bore RL (m)	Water Depth (m bgl)	Water RL (m)	Two Level Basement Depth (m) [1]	Penetration of Basement into Saturated Zone [2]
201	37.4	3.95	33.45	6.0	**2.05**
202	36.9	3.10	33.8	6.0	**2.90**
203 [3]	38.3	1.66	36.64	6.0	**4.34**
301	39.1	1.94	37.16	6.0	**4.06**
302 [3]	38.35	1.60	36.75	6.0	**4.40**
303	36.75	2.91	33.84	NA	NA

Notes to table:

1. An assumed basement depth below existing ground level.
2. The difference between the assumed basement depth and the water depth (m bgl).
3. Plume core and general zone of highest residual hydrocarbon impact.

8. Remediation Acceptance Criteria

8.1 On Site Remediation Acceptance Criteria

The appropriate remediation acceptance criteria (RAC) for future site users will depend on the final building design and which remediation option is selected. The remediation options include:

- Substantial removal of residual hydrocarbon mass (two level basement); and / or
- Installation and construction quality assurance (CQA) testing / validation of a vapour barrier that will mitigate vapour intrusion into the basement / building.

The adoption of either of the aforementioned remediation criteria should be made in the context of a final building design whereby excavation depths are known and a better estimate of whether substantial removal of the residual contamination will occur as a result of the basement excavation. Site specific soil and groundwater RAC should be developed for the first option and we point out that this may require a site specific human health risk assessment (HHRA). Likewise, specific (detailed) vapour barrier design and CQA for the second option should be developed should it become the adopted option.

8.2 Off-Site Remediation Acceptance Criteria

In order to establish off-site RAC, vapour intrusion risks to occupiers of down-hydraulic gradient properties (houses) that may in the future, overly the plume should the plume expand have been considered.

8.3 Adopted Criteria

The RAC have been developed for key contaminants only which are the primary risk drivers and dominate the more toxic component of the hydrocarbon mixture (i.e. TRH and BTEX).

The RAC for vapour intrusion for structures overlying the plume (off-site) are based on health screening levels (HSL) for protection of human health (e.g. vapour intrusion) adopted from:

- NEPC (2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999 as amended 2013* (Schedule B1).

The RAC are presented in the following table.

Table 7: Remediation Acceptance Criteria

	Vapour Intrusion (On-site) (µg/L)	Vapour Intrusion and Direct Contact (On-site) (mg/kg)	Vapour Intrusion for Structures Overlying the Plume (Off-site) (µg/L)
Contaminant	**Laboratory Detection Limit [1]**	**Laboratory Detection Limit [1]**	**HSL-A/B VI S 2 m to <4 m [2]**
F1 (C_{6-10} less BTEX)	<PQL	<PQL	1000
F2 (C_{10-16} less Naphthalene)	<PQL	<PQL	1000
Benzene	<PQL	<PQL	800
Toluene	<PQL	<PQL	NL
Ethylbenzene	<PQL	<PQL	NL
Xylene Total	<PQL	<PQL	NL
Naphthalene	<PQL	<PQL	NL

Notes to Table 2:

1. Laboratory detection limit has been adopted in the absence of a site specific human health risk assessment to derive site specific trigger levels (SSTL) OR vapour barrier incorporated into the design
2. NEPC (2013) health screening level A/B (residential) vapour intrusion sand soil groundwater is 2 m to <4 m

\- Not Specified
PQL Practical quantitation limit
NL Not Limiting

9. Remediation Options

The primary source of the contamination, i.e. USTs and associated infrastructure, has been removed. The residual contamination at the site is associated with groundwater and soil (with residual soil impacts likely to be limited to the groundwater smear zone). There are several options available for the remediation of soil and groundwater contaminated with petroleum hydrocarbons and associated non-halogenated VOCs.

As discussed in Section 7, the deeper the basement excavation, the further it will penetrate into the saturated zone where the bulk of the mass of residual contamination is likely to be present within fracture zones. Two scenarios (one level basement and two level basement) have therefore been considered for the preferred remediation option (refer to Section 10).

9.1 Remediation Options for Residual Soil Contamination

The most applicable options for residual soil contamination at the site include:

- Excavation and off-site disposal to landfill;
- Excavation and on-site treatment.

It is considered likely that the two options (disposal or treatment) will both also require management *in situ* and mitigation against vapour intrusion with a vapour barrier. The degree of management and mitigation will be dependent on the depth of basement in the final design, which should be taken into account in the final evaluation of remediation options.

Excavation and Off-Site Disposal
The excavation and off-site disposal option involves excavation of the soil / rock to the depth of the proposed basement level. Impacted soil / rock from the excavation would be stockpiled and tested for waste classification purposes. With reference to Section 7, this option would be better suited to a two level basement where the bulk of the contamination is likely to be removed.

Excavation and On-Site Treatment
The excavation and on-site treatment option involves the excavation of the soil / rock to the depth of the proposed basement level. Impacted soil / rock from the excavation would be stockpiled and treated, likely by landfarming with reference to EPA (2014) *Best Practice Note: Landfarming*.

Landfarming is a biological process which uses naturally occurring micro-organisms, such as bacteria and fungi, to eliminate, attenuate or transform polluting or contaminating substances in soils to reduce the risks to human health and the environment. It is an above-ground, engineered process which involves the spreading of excavated contaminated soils in a thin layer (generally < 0.3 metres) on a suitably prepared surface. This is followed by the stimulation of aerobic microbial activity within the soils through aeration and/or the addition of minerals, nutrients and moisture. Other materials such as compost can be added to improve the properties of the substrate. The movement of oxygen through the soil promotes the aerobic degradation of organic chemicals (EPA, 2014).

Management *In Situ* and Vapour Barrier
Management *in situ* may involve the construction of a sub-slab and wall vapour barrier to mitigate potential vapour intrusion risks associated with hydrocarbon contamination underlying the site. This would be required if the residual soil (and/or groundwater) contamination could not be completely removed by excavation of the basement and where the residual contaminant mass posed an unacceptable vapour intrusion risk. The assessment of the need for a vapour barrier could be done at the completion of excavation or with high density sampling prior to excavation.

9.2 Remediation Options for Residual Groundwater Contamination

The most applicable options for residual groundwater contamination at the site include:

- Excavation and off-site disposal to landfill (relevant to contamination within the proposed basement footprint / site boundary);
- Monitored natural attenuation (MNA);
- *In situ* chemical oxidation (ISCO).
- Pump and treat (P&T);
- *In situ* air sparging (ISA); and
- *In situ* multi-phase extraction (MPE).

It is pointed out that more than one of the above options may be appropriate in certain circumstances. Moreover, the preferred option may vary depending on the development scenario (i.e. one level basement or two level basement).

Excavation and Off-Site Disposal
The excavation and off-site disposal option involves excavation of the soil / rock and associated pore water to the depth of the proposed basement level. Impacted soil / rock / pore water from the excavation would be stockpiled and tested for waste classification purposes. With reference to Section 7, this option would be better suited to a two level basement where the bulk of the contamination is likely to be removed by excavation alone. Control of contaminated groundwater ingress from the western face of the excavation would also need to be managed as part of the detailed design for this option. In this regard, this option may be relevant to on-site groundwater only.

Monitored Natural Attenuation
The term 'monitored natural attenuation' (MNA), refers to the monitoring of naturally occurring physical, chemical, biological processes to demonstrate via multiple lines of evidence that one or any combination of those processes reduce the mass, concentration, flux or toxicity of polluting petroleum hydrocarbon substances in groundwater, to an acceptable level within an acceptable timeframe (Beck and Mann, 2010).

Monitored natural attenuation is typically used in combination with source control (i.e. removal of the source of the contamination) as far as practicable (USEPA, 1999). The primary source control (decommissioning of USTs and associated infrastructure) has already occurred. MNA is already being adopted as the remediation strategy for dissolved-phase hydrocarbons in groundwater at the site. Control of contaminated groundwater ingress from the western face of the excavation would also need to be managed as part of the detailed design for this option.

In Situ Chemical Oxidation
The remediation of groundwater contamination using *in situ* chemical oxidation (ISCO) involves injecting oxidants and potential co-amendment compounds directly into the source zone and down-gradient plume. ISCO technology is based on the oxidative power of specific chemicals such as hydrogen peroxide, potassium permanganate and ozone. Through the process of oxidation, groundwater contaminants are ultimately broken down into carbon dioxide and water. TRH, BTEX and PAHs are all amenable to ISCO (ITRC, 2005).

To effectively degrade contaminants, the oxidant must come into contact with the contaminant molecules. Ideally, the delivery technique would ensure that the oxidant is evenly dispersed throughout the area to be treated. Given the geological conditions at the site (i.e. fractured rock); effective disbursement should be achievable via injection wells.

The relatively high concentrations (>10,000 µg/L) of hydrocarbons at the plume core, the delivery of sufficient oxidant may be challenging at this site.

Pump and Treat
Pump and treat (P&T) technology typically involves pumping of contaminated groundwater to surface for treatment prior to discharge or re-injection back into the aquifer. P&T systems are frequently designed to hydraulically control the movement of contaminated ground water in order to prevent continued expansion of the contamination zone. At sites where the contaminant source cannot be removed (e.g. a landfill or bedrock with DNAPLs), hydraulic containment is an effective option to

achieve source control. In the case of this site, source removal (i.e. UST removal) has occurred and the plume appears to be relatively stable based on concentration data at off-site monitoring wells. On this basis, plume containment is not currently considered to be a key objective of groundwater remediation.

In Situ Air Sparging
The basic *in situ* air sparging (IAS) system strips VOCs (e.g. BTEX) by injecting air into the saturated zone to promote contaminant partitioning (stripping) from the liquid to the vapour phase. Off-gas may then be captured through a soil vapour extraction (SVE) system, if necessary, with vapour-phase treatment prior to its recirculation or discharge.

The low permeability (fractured rock) nature of the site hydrogeology does not make it amenable to IAS.

In Situ Multi-Phase Extraction
Multi-phase extraction (MPE) is an *in situ* remediation technology for simultaneous extraction of vapour phase, dissolved phase and separate phase (e.g. LNAPL) contaminants from the vadose zone, capillary fringe, and saturated zone soils and groundwater. It is a modification of SVE and is most commonly applied in moderate permeability soils. Given the range of phase and zone of contaminant that MPE can be effective on, it typically used in source zones (USACE, 1999).

In general, MPE works by applying a high vacuum (relative to SVE systems) to a well or trench that intersects the vadose zone, capillary fringe and saturated zone. Because the resulting subsurface pressure is less than atmospheric, groundwater rises and, if drawn into the well, is extracted and treated aboveground before discharge or reinjection.

The low permeability (fractured rock) nature of the site hydrogeology would be a good fit for MPE. However, MPE has a high capital and operation and maintenance cost. It may be suitable as a contingency or it could be undertaken prior to excavation of the basement to remove a substantial component of the overall contaminant mass.

10. Preferred Remediation Options

The preferred remediation options are summarised in the following table.

Table 8: Preferred Remediation Options

Scenario	Preferred
One Level Basement – Soil	Excavation and off-site disposal and management of residual contamination *in situ* by a vapour barrier
One Level Basement – Groundwater	Monitored natural attenuation
Two Level Basement – Soil	Excavation and off-site disposal and if required management of residual contamination *in situ* by a vapour barrier
Two Level Basement – Groundwater	Monitored natural attenuation

10.1 Basement Excavation

Basement excavation should proceed as part of the general bulk earthworks. When in the vicinity of the former USTs (i.e. the residual contaminated soil) and general hydrocarbon plume footprint, the following steps should be undertaken:

- Excavate contaminated material from the vicinity of the former tank pit, under the supervision (regular inspections as a minimum) of the Environmental Consultant or as required / requested. Stockpile potentially contaminated material in accordance with Section 11.3 and 11.5. VENM that is not impacted by hydrocarbons can be loaded and carted as would occur at a site not affected by contamination;
- Subject to confirmation of final design levels, the basement excavation is likely to extend below the water table and hence dewatering will need to be undertaken as part of the excavation works. All removed water should be either treated on site through holding tanks and filtration processes and tested before it is disposed of to the stormwater/sewer (after obtaining appropriate licences) or removed from site by a licensed contractor; and
- Undertake waste classification assessment of the stockpiled material to allow for appropriate disposal of the material off-site. Collection of samples as per Section 10.2.

At the completion of excavation to design levels:

- Collection of validation samples from excavation to characterise the excavation boundary conditions and validate the removal of the contaminated material and follows:
  - BASE OF EXCAVATION – approximately one sample over nominal 5 m x 5 m grid;
  - SIDE OF EXCAVATIONS - one sample per 10 linear metre and 2 m to 3 m depth intervals;
  - Analysis of validation samples for TRH and BTEX.
- If some of the contaminated materials with concentrations above the RAC (interim RAC being the laboratory limit of reporting in the absence of a site specific human health risk assessment to derive site specific trigger levels (SSTL) or vapour barrier) remain at the base/walls of the excavation, then further “chase out” excavation should be undertaken until the complete removal of contaminated material is achieved; and
- Sealing of the western face of the excavation to prevent contaminated groundwater ingress back into the basement (this is a development design issue).

10.2 Waste Classification

Materials requiring waste classification will be sampled, screened using a phoyto-ionisation detector (PID) and analysed as outlined below.

Fill and VENM soil / rock within the plume footprint - samples will be collected at the following frequency:

- At least one sample per 100 m^3 (with a minimum of three samples per soil type);
- Analysis of metals, TRH, BTEX and PAH (all samples);

- Analysis of phenol, PCB, OCP and asbestos (one in three samples);
- Analysis of specific samples for any identified additional contaminants of concern. Potential for concern will be based on visual and olfactory observations, PID results and proximity to potential sources;
- Analysis of selected samples for TCLP for metals and PAH based on total concentration results as appropriate to complete the waste classification.

VENM soil / rock outside the plume footprint - samples will be collected at the following frequency:

- At least one sample per 1000 m^3; and
- Analysis of metals, TRH, BTEX, PAH phenol, PCB and OCP.

10.3 Vapour Barrier

If remediation (including complete removal by excavation) of soil and groundwater to reduce contaminant concentrations beneath the development, and mitigate the potentially complete vapour intrusion pathway is not proposed then the management of potential vapour intrusion for the development may be achieved by installation of a sub-slab and wall barrier and a passive venting system (where appropriate). Passive venting relies, in part, on vapour not entering the building before it can vent laterally. Passive vents are typically combined with a barrier (e.g. welded HDPE). Air containing vapours will not necessarily vent from a passive system at all times, hence the need for a barrier (without leaks).

The design of a vapour barrier should occur when the detailed design of the proposed development occurs.

10.4 Refinement of the Remediation Action Plan

The full details of this RAP should be further refined in the context of the final design of the proposed development. Consideration should be given to cost and timing constraints such that the preferred options may vary to that outlined in Table 13 above. The refinements and design details should include the following:

- Confirmation of the preferred remediation option(s);
- Proposed sequence of remediation to be coordinated with the Remediation Contractor;
- Development of site specific RAC (as appropriate, depending on the option selected) which may involve a site specific human health risk assessment;
- Procedures for the validation of remediation (dependent upon the options adopted) including:
    - Sampling strategy including validation testing frequencies and analytes;
    - Monitoring during remediation and long-term monitoring;
    - Data quality objectives;
    - Quality assurance / quality control (QA/QC) procedures;

- o Use of on-site observations, visual/olfactory evidence; and
- o Chemical analysis / monitoring data.

11. General Environmental Management Plan

11.1 General

The Contractors will undertake the work with due regard to the minimisation of environmental effects and to meet regulatory and statutory requirements.

The Contractors should have in place an over-arching environmental management plan that incorporates this CEMP so that work on the site complies with, but not limited to, the following:

- *Protection of the Environment Operations Act* 1997;
- *Contaminated Land Management Act* 1997;
- *Work Health and Safety Act* 2011; and
- *Work Health and Safety Regulation* 2011.

The following general measures outlined below should be implemented during the remediation phase. All personnel should be made familiar with the following section prior to the commencement of site works as required.

11.2 Interim Controls

Prior to the commencement of site remediation works, the following interim controls will be in place:

- The construction of permanent fences around the subject area meeting appropriate specifications to prevent unauthorized entry; and
- Any pits or unstable areas on site that may generate potential OH&S or operational risk should be demarcated and taped off, with appropriate rectification action undertaken (e.g. backfilling of pits as soon as practicable to prevent undue injuries to workers etc.).

11.3 Soil Management Plan

(a) Transport

Transport of materials to or from the site will be via an appropriate predefined haul route. All haulage routes for trucks transporting soil, materials, equipment or machinery to and from the site should be selected to meet the following objectives:

- Comply with all road traffic rules;
- Minimise noise, vibration and odour to adjacent premises; and
- Utilise State Roads and minimise use of local roads.

Removal of waste materials from the site will only be carried out by a licensed contractor holding appropriate consent and approvals to dispose the waste materials in accordance with the Protection of the Environment Operations Act 1997 (POEO Act) and with the appropriate approvals obtained from the EPA, if required.

The remediation work will be conducted such that all site vehicles:

- Conduct deliveries of soil, materials, equipment or machinery during the specified hours of remediation, as approved by Council;
- Have securely covered loads to prevent any dust or odour emissions during transportation; and
- Exit the site in a forward direction where possible.

In addition, measures will be implemented to ensure no contaminated material is spilled onto public roadways or tracked off site on vehicle wheels.

All loads will be tarpaulin covered and may be lightly wetted as required to ensure that no materials or dust are dropped or deposited either outside or within the site. Prior to exiting the site each truck should be inspected by the client's representative and either noted as clean (wheels and chassis) or hosed down prior to leaving the site. Any soil spilled onto street will be cleaned by mechanical or hand methods on a daily basis.

(b) Disposal of Materials
All materials excavated and removed from the site should be appropriately waste classified and should only be disposed to a site legally allowed to receive it in accordance with relevant legislation, regulatory guidance, licences or EPA approvals/ advice including the POEO Act.

(c) Noise Control Plan
The remediation works should comply with the requirements specified by the authorities (e.g. Council and/or EPA). Noise and vibration should be restricted to reasonable levels. All equipment and machinery should be operated in an efficient manner to minimise the emission of noise.

11.4 Vibration Control

The use of any plant and/or machinery should not cause unacceptable vibrations to nearby properties and should meet Council requirements.

11.5 Dust Control

Dust emissions should be confined within the site boundary. The following dust control procedures will be employed to comply with this requirement as necessary:

- Erection of dust screens around the perimeter of the site;
- Securely covering all loads entering or exiting the site;
- Use of water sprays across the site to suppress dust;

- Covering of all stockpiles of contaminated soil remaining onsite more than 48 hours; and
- Keeping excavation and stockpile surfaces moist.

11.6 Odour Control

No odours should be detected at any boundary of the site during remediation works by an authorised Council Officer relying solely on sense of smell. The following procedures should be employed to comply with this requirement as required:

- Use of appropriate covering techniques such as plastic sheeting, polythene or geotextile membranes to cover excavation faces or stockpiles;
- Fine spray of water and/or hydrocarbon mitigating agent on the impacted areas/materials;
- The use of water spray, as and when appropriate, to eliminate wind-blown dust;
- Use of sprays or sprinklers on stockpiles or loads to lightly condition the material;
- Restriction of stockpile heights to 2 m above surrounding site level. If required, restrict uncovered stockpiles (e.g. stockpiles subject to landfarming or works) to appropriate sizes to minimise odour generation;
- Ceasing works during periods of inclement weather such as high winds or heavy rain; and
- Regular checking of the fugitive dust and odour issues to ensure compliance. Undertake immediate remediation measures to rectify any cases of excessive dust or odour (e.g. use of misting sprays or odour masking agent);
- Adequate maintenance of equipment and machinery to minimise exhaust emissions.

11.7 Stormwater Management and Control

As necessary, the remediation contractor shall take appropriate measures to ensure that potentially contaminated water does not leave the Site. In particular, stormwater management for the duration of the remediation works shall be utilised and monitored to minimise stormwater flow into the area of the UST thereby reducing any flushing of contaminants from the groundwater smear zone into the groundwater. Such measures shall inter alia include:

- Construction of stormwater diversion channel and linear drainage sumps with catch pits in the remediation area to divert stormwater from the potentially contaminated areas; and
- Provision of sediment traps such as silt fences (or equivalent) at suitable locations on the down-gradient side of the Site as necessary.

11.8 Groundwater Management

Given that dewatering may need to be undertaken as part of the works, water requiring off-site discharge should be disposed of in accordance with relevant guidelines and licenses. It is noted that if a pump and cart option is not adopted, then disposal to the sewer or stormwater will require appropriate management, monitoring and/or treatment prior to such action given the level of contamination detected in the groundwater. Monitoring is to be conducted to ensure water quality meets disposal guideline criteria prior to disposal to stormwater/sewer. If groundwater does not meet the consent conditions for disposal into the stormwater system, then arrangements may need to be made for treatment or discharge into the sewerage system (including consent of the appropriate authorities). It is noted that the approval body for discharge into the stormwater system is Holroyd City Council. Sydney Water is responsible for discharge into sewerage.

Advice should be sought from Council and, if required, the EPA, in regards to licensing requirements. All regulatory requirements relating to dewatering must be met prior to commencement of any dewatering works. It may be necessary to obtain a temporary dewatering license for the duration of the remediation works.

11.9 Occupational Health and Safety

The Contractors shall develop a site emergency response plan (ERP) and occupational health and safety plan (OHSP). This will ensure the safety of the personnel working on site, given any likely emergency situation which may occur. The OHSP and ERP should include emergency phone numbers and details of local emergency facilities.

Appropriate fencing and signage should be installed around and within the site to prevent unauthorised access to the site, restricted access remediation areas and deep excavations.

All personnel on site should be required to wear the following personnel protective equipment (PPE) at all times:

- Steel-capped boots;
- High visibility clothing; and
- Hard hat meeting AS1801-1981 requirements.

The following additional PPE will be worn as required:

- Hearing protection meeting AS1270-1988 requirements when working around machinery or plant equipment if noise levels exceed exposure standards;
- Safety glasses or safety goggles with side shields meeting AS1337-1992 requirements (as necessary, particularly during demolition);
- Disposable coveralls (if necessary) to prevent contact with splashed contaminated soil, materials or water;
- Nitrile work gloves meeting AS2161-1978 requirements or heavy duty gauntlet gloves; and
- Any additional protection identified by the Environmental Consultant.

In the event that personnel are required to work in areas of potential contact with asbestos containing materials, the following additional protection will be required:

- Disposable coveralls to prevent contact with asbestos materials; and
- Particulate respirator (Class P2) or equivalent.

Excavation, handling, stockpiling, transport etc. of materials containing asbestos should be undertaken by a licensed contractor in accordance with relevant regulatory requirements.

All contractors are required to show compliance with the Work Health and Safety Regulation 2011, including the preparation of a Site Safety Management Plan and Safe Work Method Statements.

11.10 Hours of Operation

All remediation work should be conducted within the hours specified by Council.

11.11 Contingency Plans to Respond to Site Incidents

The key to effective management of incidents is the timely action taken before any situation reaches a reportable or critical level. Therefore, surveillance activities are extremely important, and should be conducted for the measures prescribed herein and any other measures as seen appropriate by the PR. During work activities on the site, the following inspection or preventative actions must be performed by the main contractor and carefully documented:

- Regular inspection of works;
- Completion of routine environmental checklists and follow-up of non-compliance situations;
- Maintenance of supervision on-site;
- An induction process for site personnel involved in the remediation works that includes relevant information on environmental requirements, and ensures that all site personnel are familiar with the site emergency procedures.

The Principal's site foreman should be responsible for initiating an immediate emergency response using the resources available on the site. Where external assistance is required, the relevant emergency services should be contacted. A list containing contact details for key personnel who may be involved in an environmental emergency response should be completed and be readily available to personnel at all times.

11.12 Identify Regulatory Compliance

The work should be undertaken with all due regard to the minimisation of environmental effects and to meet all statutory requirements, including, inter alia, provisions specified in:

- *Protection of the Environment Operations Act* 1997;
- *Contaminated Land Management Act* 1997;
- *Dangerous Goods Act* 2008;
- *Work Health and Safety Act* 2011;
- *Work Health and Safety Regulation* 2011;

- *Water Management Act* 2000 and any related requirements specified by EPA (e.g. for dewatering works); and
- DUAP EPA (1998) *State Environmental Planning Policy No. 55* (SEPP 55).

11.13 Community Liaison

The developer or their delegated representative will manage all community consultation. Site signage in relation to project contact persons will be limited to that required by DA consent conditions and/or regulatory requirements, with additional signage indicating that public enquires shall be directed to the developer or their delegated representative.

12. Conclusion

It is considered that remediation of the site in accordance with the procedures and validation methods outlined in this RAP can render the site suitable for the proposed development and appropriately manage potential temporary impacts on the environment subject to:

- Finalisation of building design (including the number of basement levels);
- Finalisation of the preferred remediation option(s) in the context of a final design; and
- Refinement of this RAP and adopted remediation options based on the final design and input from the developer.

13. References

Beck, P; Mann, B (2010) A technical guide for demonstrating natural attenuation of petroleum hydrocarbons in groundwater, CRC CARE Technical Report No.15

DP (2009a), Report on Phase 1 Contamination Assessment with Limited Sampling, Proposed Building Additions, 11-19 Centenary Road, Merrylands, DP Ref: 71184.00

DP (2009b), Report on Phase 2 Contamination Assessment, 11-19 Centenary Road, Merrylands, DP Ref: 71184.01

DP (2010), Report on Groundwater Monitoring Event, Assessment of Contamination and Natural Attenuation Parameters, 11-19 Centenary Road, Merrylands, DP Ref: 71184.01-2

DP (2011), Report on Remediation Action Plan, 11-19 Centenary Road, Merrylands, DP Ref: 71184.01-3

DP (2013a), Report on Tank Pit Validation Assessment, 11 – 19 Centenary Road, Merrylands, DP Ref: 71184.02

DP (2013b), Interim Environmental Management Plan, 11 – 19 Centenary Road, Merrylands, DP Ref: 71184.02

DP (2013c), Report on Six Monthly Groundwater Monitoring Event – June 2013 (E1), 11 – 19 Centenary Road, Merrylands, DP Ref: 71184.02

DP (2014a), Report on Six Monthly Groundwater Monitoring Event – December 2013 (E2), 11 – 19 Centenary Road, Merrylands, DP Ref: 71184.02

DP (2014b), Report on Six Monthly Groundwater Monitoring Event – June 2014 (E3), 11 – 19 Centenary Road, Merrylands, DP Ref: 71184.03

DP (2015a), Report on Six Monthly Groundwater Monitoring Event – December 2014 (E4), 11 – 19 Centenary Road, Merrylands, DP Ref: 71184.04

DP (2015b), Report on Six Monthly Groundwater Monitoring Event – December 2014 (E5), 11 – 19 Centenary Road, Merrylands, DP Ref: 71184.05

EPA (2014) Best Practice Note: Landfarming

EPA (2014) Waste Classification Guidelines Part 2: Immobilisation of Waste

EPA (2014) Waste Classification Guidelines, Part 1: Classifying Waste

ITRC (2005) Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater, 2nd ed. ISCO-2, Washington, D.C., Interstate Technology & Regulatory Council

USACE (1999) Engineering and Design – Multi-Phase Extraction, EM 1110-1-4010

USEPA (1999) Monitored Natural Attenuation of Petroleum Hydrocarbons, USEPA Remedial Technology Fact Sheet EPA/600/F-98/021

14. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for the development described herein at 11 – 19 Centenary Road, Merrylands in accordance with DP's proposal dated 17 February 2015 and acceptance received from St Vincent de Paul Society NSW. The report is provided for the exclusive use of St Vincent de Paul Society NSW for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the environmental components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About this Report

Drawing

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

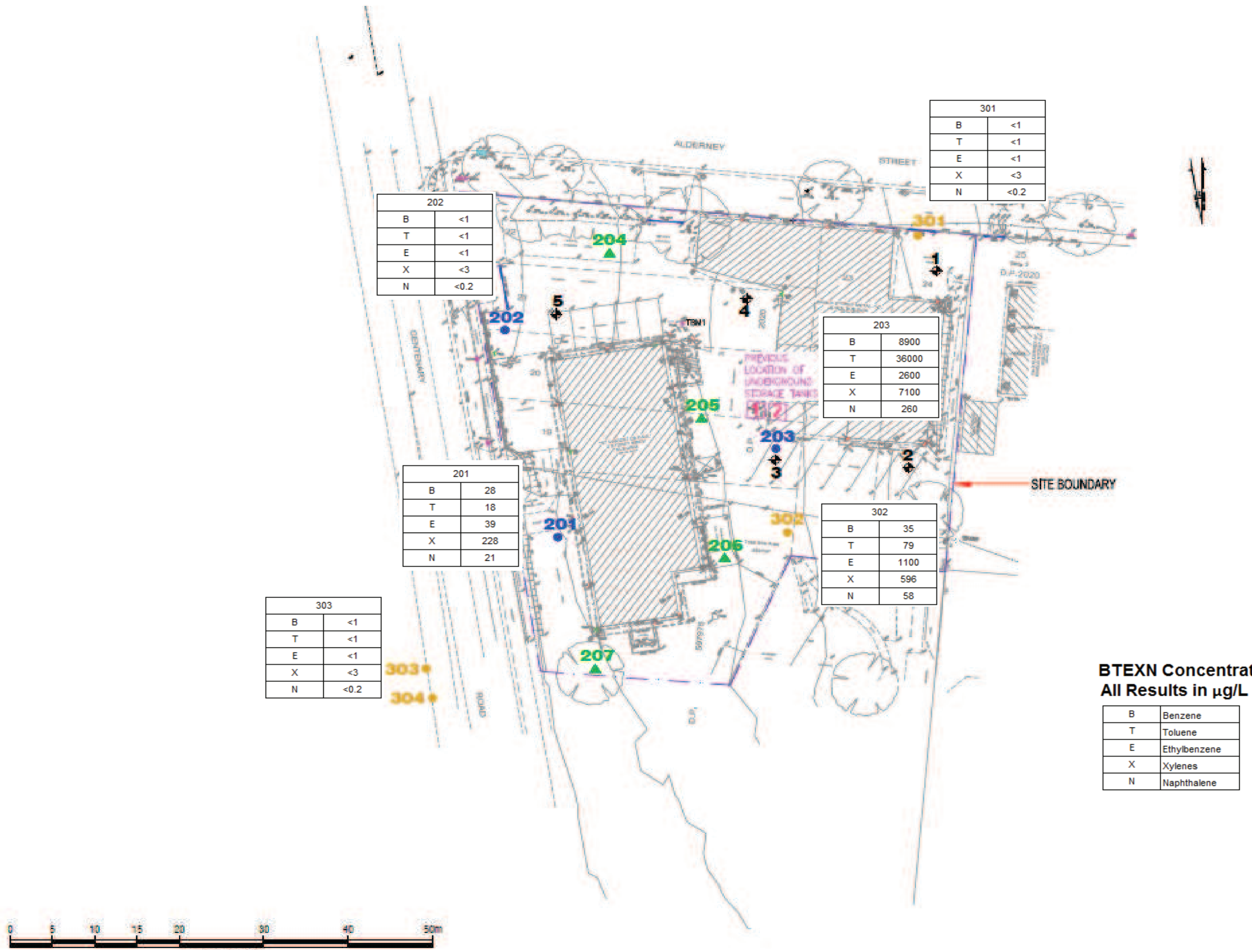
If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

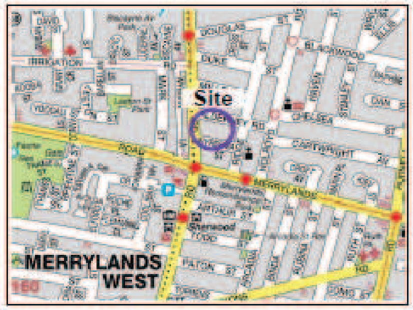
About this Report

Site Anomalies
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection
The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.





Locality Plan

301	
B	<1
T	<1
E	<1
X	<3
N	<0.2

202	
B	<1
T	<1
E	<1
X	<3
N	<0.2

203	
B	8900
T	36000
E	2600
X	7100
N	260

201	
B	28
T	18
E	39
X	228
N	21

302	
B	35
T	79
E	1100
X	596
N	58

303	
B	<1
T	<1
E	<1
X	<3
N	<0.2

BTEXN Concentration in Groundwater in June 2015
All Results in µg/L

B	Benzene
T	Toluene
E	Ethylbenzene
X	Xylenes
N	Naphthalene

LEGEND

- ✚ Test bore location (May 2009)
- ▲ Test bore location (Aug 2009)
- ● Ground water well (Aug 2009)
- ● Ground water well (Dec 2009)

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: St Vincent de Paul Society	TITLE: **Site Plan and Location of Monitoring Wells**	Project	71184.06
	OFFICE: Sydney	**Remediation Action Plan**	Drawing	1
	SCALE: As Shown / DATE: 23 October 2015	**11 - 19 Centenary Road, Merrylands**	Revision:	1

Appendix B

Summary of Groundwater Monitoring Results

Douglas Partners
Geotechnics | Environment | Groundwater

Table 1: Summary of Analytical Results for Primary Contaminants of Concern (All Results Reported in µg/L unless otherwise specified

	PAH							TRH											VOCs												
Sample ID	B(a)P	Naphthalene	acenaphthene	acenaphthylene	fluorene	phenanthrene	Total +ve PAH	C6-C9	C6-C10 Less BTEX (F1)	C10-C36	TRH >C10 - C16	TRH >C10 - C16 (F2)	TRH >C16 - C34	TRH >C34 - C40	Benzene	Toluene	Ethylbenzene	Total Xylene	1,2-dichloroethane	cyclohexane	Trichloroethene	Styrene	Isopropylbenzene	n-propyl benzene	1,3,5-trimethyl benzene	1,2,4-trimethyly benzene	sec-butyl benzene	4-isopropyl toluene	n-butyl benzene	Phenols (mg/L)	Hardness by calculation ($mgCaCO_3/L$)
DP 2009 Assessment																															
BH201	<0.1	3.9	-	-	-	-	3.9	790	-	360	-	-	-	-	240	400	15	124	-	-	-	-	-	-	-	-	-	-	-	<0.05	2,400
BD1/300809 4	-	-	-	-	-	-	-	920	-	282	-	-	-	-	220	530	19	164	-	-	-	-	-	-	-	-	-	-	-	-	2,400
BH202	<0.1	<0.1	-	-	-	-	<0.1	1300	-	<250	-	-	-	-	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	<0.05	1,300
BH203	<0.1	52	-	-	-	-	52	29000	-	2420	-	-	-	-	7100	14000	850	3700	-	-	-	-	-	-	-	-	-	-	-	0.23	280
nsate Sample /2008	<1	<1	-	-	-	-	<1	<10	-	<250	-	-	-	-	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	-	-
Trip Spike/ 310809	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.85	0.95	0.95	0.98	-	-	-	-	-	-	-	-	-	-	-	-	-
Trip Blank/ 310809	-	-	-	-	-	-	-	<10	-	-	-	-	-	-	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	-	-
2010 Assessment																															
BH201	<1	2.1	-	-	-	-	2.1	530	-	310	-	-	-	-	140	170	<10	95	-	<10	-	-	-	<10	<10	<10	-	-	-	-	2014.3
BH202	<1	<1	-	-	-	-	<1	130	-	<250	-	-	-	-	62	71	4	15.9	-	-	-	-	-	-	-	-	-	-	-	-	-
BH203	<1	120	-	-	-	-	120	35000	-	4420	-	-	-	-	10000	19000	1300	5000	-	170	-	-	-	<100	120	440	-	-	-	-	1740.94
BH301	<1	<1	-	-	-	-	<1	<10	-	<250	-	-	-	-	<1	<1	<1	<3	-	<1	-	-	-	<1	<1	<1	-	-	-	-	2896.6
BH302	<1	69	-	-	-	-	69	11000	-	2220	-	-	-	-	830	5100	1000	3580	-	60	-	-	-	86	160	500	-	-	-	-	1980.57
BD1/011209			-	-	-	-		9600	-	2200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH303	<1	<1	-	-	-	-	<1	140	-	<250	-	-	-	-	45	71	4.2	17.6	-	1.2	-	-	-	<1	<1	1.5	-	-	-	-	1255.54
BH304	<1	<1	-	-	-	-	<1	80	-	<250	-	-	-	-	30	50	3.6	13.8	-	-	-	-	-	-	-	-	-	-	-	-	-
TB/011209	-	-	-	-	-	-	-	<10	-	<250	-	-	-	-	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	-	-
TS/011209	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.66	0.96	0.97	101% and 99%	-	-	-	-	-	-	-	-	-	-	-	-	-
June 2013 Monitoirng Round (E1)																															
201	<0.1	6.7	<0.1	<0.1	<0.1	<0.1	6.7	690	670	300	70	60	<100	<100	35	17	15	112	<1	4	<1	<1	<1	2	8	17	<1	<1	<1	<1	1800
BD1/060613	-	-	-	-	-	-	-	600	-	200	110	-	<100	<100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BD2/060613*	-	-	-	-	-	-	-	280	150	<100	<50	<50	<100	<100	37	18	<10	120	-	-	-	-	-	-	-	-	-	-	-	-	-
202	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	1400	1600	164	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1500
203	<0.1	94	<0.1	<0.1	<0.1	<0.1	94	78000	36000	4430	3100	2800	520	<100	14000	26000	2900	8000	17	290	2	31	68	230	270	1300	6	4	10	10	1600
301	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<10	<10	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3300
302	<0.1	220	0.2	<0.1	0.4	0.3	220	20000	12000	4000	1600	1400	<100	<100	290	2200	3800	5370	<1	250	<1	<1	99	330	320	1100	9	4	15	15	4400
303	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	12	12	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1300
Trip Spike	-	-					-	-	-	-	-	-	-	-	0.97	0.99	1.02	102% &103%	-	-	-	-	-	-	-	-	-	-	-	-	-
Trip Blank	-	-					-	<10	<10	-	-	-	-	-	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	-	-
December 2013 (Monitoirng Round E2)																															
201	<0.5	23	<0.1	<0.1	<0.1	<0.1	23	350	270	540	280	260	<100	<100	21	9	35	119	2	10	<1	<1	3	7	13	17	<1	<1	<1	-	1800
202	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	88	88	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	1400
BD1/021213 [6]	-	-	-	-	-	-	-	76	-	255	<50	-	<100	<100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BD1/021213 [7]	-	-	-	-	-	-	-	110	110	<100	<50	<50	<100	<100	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	-	-
203	<0.5	92	<0.1	<0.1	0.2	<0.1	92	37000	20000	3230	1700	1600	<100	<100	4100	11000	1500	5100	4	110	2	14	30	120	170	670	4	3	7	-	680
301	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	<10	<10	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	3400
302	<0.5	160	0.2	<0.1	0.5	0.4	160	9100	5400	3410	1700	1500	<100	<100	72	830	3300	1430	<1	140	<1	2	57	240	190	750	9	5	15	-	4700
303	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	<10	<10	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	1500
Trip Spike	-	-	-	-	-	-	-								93.00%	102.00%	107.00%	109%													
Trip Blank	-	-	-	-	-	-	-	<10	<10						<1	<1	<1	<3													
June 2014 (Monitoirng Round E3)																															
201	<0.1	0.8	<0.1	<0.1	<0.1	<0.1	0.84	32	25	<250	<50	<50	<100	<100	<1	<1	<1	11	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	1600
BD2/020614 [7]	-	-	-	-	-	-	-	<20	<20	<100	<50	<50	<100	<100	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	-	-
202	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	110	110	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	1400
203	<0.1	250	<0.1	<0.1	0.2	0.1	250	65000	20000	7370	4800	4500	<100	<100	13000	29000	2400	6400	<1	160	3	18	51	160	230	980	5	3	8	-	2000
301	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	<10	<10	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	3300
BD1/020614 [6]	-	-	-	-	-	-	-	<10	-	<250	<50	-	<100	<100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
302	<0.1	95	0.3	0.1	0.8	0.8	97	5500	3600	3630	2200	2100	<100	<100	66	320	2500	650	<1	78	<1	1	52	200	170	510	7	4	16	-	4300
303	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	<10	<10	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	1300
TS	-	-	-	-	-	-	-	-	-	<250	-	-	-	-	102.00%	96.00%	102.00%	101.00%	-	-	-	-	-	-	-	-	-	-	-	-	-
TB	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	-	-
December 2014 (Monitoirng Round E4)																															
201	<0.1	3.4	<0.1	<0.1	<0.1	<0.1	3.4	200	160	294	68	64	<100	<100	4	4	14	74	<1	<1	<1	<1	<1	2	5	5	<1	<1	<1	-	1600
202	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	82	82	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	1200
BD1/081214	-	-	-	-	-	-	-	110	110	279	<50	-	<100	<100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BD2/081214	-	-	-	-	-	-	-	110	110	410	110	110	<100	<100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
203	<0.1	71	<0.1	<0.1	0.3	0.2	72	3900	2100	2300	1200	1100	<100	<100	35	200	1800	379	<1	<1	<1	<1	50	130	54	190	6	1	6	-	4200
301	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	<10	<10	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	3200
302	0.3	240	0.1	0.1	0.3	0.4	240	81000	22000	9300	6000	5800	190	<100	14000	40000	2900	8700	<10	<10	<10	25	59	170	280	1100	<10	<10	<10	-	1300
303	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.1	<10	<10	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	1400
TS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	118.00%	107.00%	107.00%	109.00%	-	-	-	-	-	-	-	-	-	-	-	-	-
TB	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	-	-
June 2015 (Monitoirng Round E5)																															
201	<0.1	21	<0.1	<0.1	<0.1	<0.1	21	510	350	360	250	230	<100	<100	28	18	39	228	3	5	<1	<1	3	5	11	23	<1	<1	<1	-	1900
BD1/10072015	-	-	-	-	-	-	-	680	-	360	230	-	<100	<100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BD2/10072015	-	-	-	-	-	-	-	760	560	150	110	90	<100	<100	33	18	46	300	-	-	-	-	-	-	-	-	-	-	-	-	-
202	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	110	120	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	1200
203	<0.1	260	<0.1	<0.1	0.3	0.1	260	74000	26000	5600	3000	2700	<100	<100	8900	36000	2600	7100	<10	230	<10	22	31	150	260	940	<10	<10	11	-	360
301	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	<10	<10	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	3300
302	<0.1	58	0.1	<0.1	0.4	0.3	59	3400	2600	2400	1400	1300	<100	<100	35	79	1100	596	<1	80	<1	<1	51	110	100	310	8	3	13	-	3700
303	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	NIL (+)VE	<10	<10	<250	<50	<50	<100	<100	<1	<1	<1	<3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	1200
TS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93.00%	99.00%	99.00%	102% & 126%	-	-	-	-	-	-	-	-	-	-	-	-	-
TB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<3	-	-	-	-	-	-	-	-	-	-	-	-	-
GSC	Not specified	16 [1] NL [3]	-	-	-	2 [4]	Not specified	150 [2]	NL [3]	600 [2]	NL [3]	NL [3]	NL	NL [3]	950 [1] 30000 [3]	180 [4] NL [3]	80 [4] NL [3]	550 [4] NL [3]	1900 [4]	1300 [5]	330 [4]	1100 [5]	30 [4]	210 [5]	87 [5]	15 [5]	160 [5]	-	780 [5]	320	-

Notes:

1 ANZECC 2000 - b) Trigger Values for a 95% Level of Protection of Species in Fresh Water (Table 3.4.1).

2 ANZECC threshold not available. It is noted there is a 'low reliability' Interim Working Value (Section 8.3.7) final chronic value of 7 µg/L for petroleum hydrocarbon but that commercial laboratories are not generally able to achieve the necessary detection limits to demonstrate compliance. For reference purposes, DP has referred to other available Austra guidelines for TRH viz. Airport (Environment Protection) Regulations (1997), Schedule 2 Water Pollution Accepted Limits: Table 1.03 – Accepted limits of contamination. It should be noted however that these have not been endorsed by NSW EPA and are used as 'screening levels' only

3 Groundwater health screening levels (HSLs) for vapour intrusion into commercial/industrial sites, sourced from the Schedule B1 of National Environment Protection Council, National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1) (NEPM 2013). Used as screening criteria only.

4 Low reliability trigger values for Freshwater species sourced from ANZECC 2000 have been used in the absence of high reliability trigger values

5 USEPA Regional Screening Levels for Chemical Contamination at Superfund Sites (updated May 2013) threshold criteria for tap water used as screening criteria in the absence of NSW EPA and national standards

6 Intra-laboratory sample collected from monitoring well reported directly above

7 Inter-laboratory sample collected from monitoring well reported directly above

TS Trip spike

TB Trip blank

300 Exceedance of GSC

PQL Practical quantitation limits