

LanePiper

Geotechnical & Environmental Engineers
Hydrogeologists & Environmental Scientists

ENVIRONMENTAL AUDIT REPORT (s53V)

18-22 Hamlet St, Cheltenham

For

**Nuplex Industries
(Aust) Pty Ltd**

September 2011

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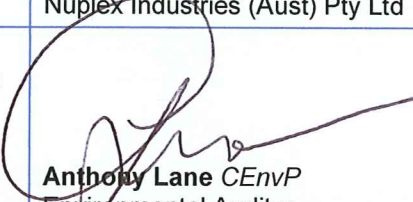
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ENVIRONMENTAL AUDIT REPORT (S53V)

18-22 Hamlet St, Cheltenham

EXECUTIVE SUMMARY

Lane Piper Pty Ltd (Lane Piper) was engaged on 11th May 2007 by the site owner Nuplex Industries (Aust) Pty Ltd to provide the services of Mr Anthony Lane, an EPA-appointed Environmental Auditor. This was in response to a Clean Up Notice issued under section 62A of the *Environment Protection Act 1970* (the Act) to the site owner on the 30th July 2007.

The site is located at 18-22 Hamlet St, Cheltenham (Figure 1, Appendix A). The Auditor was requested to carry out an audit under section 53V of the Act in relation to the risk of any possible harm or detriment to the land and groundwater caused by the activities conducted at the premises.

The summary information on this audit is presented in the following table, in accordance with EPA Pub 1147:

Table 1: Summary of Audit Information

EPA File Reference No.	62617-1
Auditor	Anthony Lane
Auditor Term of appointment	29 July 2009 to 30 May 2014
Name of Person Requesting Audit	John Heke
Relationship to Premises/Location	Site Manager of Nuplex Industries (Aust) Pty Ltd
Date of Request	31 July 2007
Date EPA Notified of Audit	7 August 2007
Completion Date of Audit	8 September 2011
Reason for Audit	CUN EPA Ref: NO9097
Description of Activity	Chemical storage and distribution
EPA Region	South Metro Region
Dominant - Lot on title plan	Lot 1 TP518231
Additional - Lot on plan(s)	
Site / Premises name	
Building / Complex Sub-unit No.	
Street / Lot - Lower No.	18
Street / Lot - Upper No.	22
Street Name	Hamlet
Street Type (road, court, etc)	Street
Street Suffix (North, South etc)	
Suburb	Cheltenham

Postcode	3192
GIS Coordinate of Site Centroid	
Longitude	145.040568
Latitude	37.957236
Members and Categories of Support Team Utilised	• Wendy Morrison – Hydrogeology; Remediation and geotechnology; and Contaminant transport and assessment of exposure pathways and risk. • Peter Gringinger – Hydrogeology; Remediation and geotechnology; and Contaminant transport and assessment of exposure pathways and risk.- • Jon Bartley – Hydrogeology • John Frangos – Human toxicology, Contaminant transport and assessment of exposure pathways and risk.
Outcome of the Audit	Soil contamination was most evident in the South Eastern Corner (SEC), where it was contaminated by Volatile Chlorinated Hydrocarbons (VCHs). It is likely that VCH-contaminated soil extends from the site to the south and possibly also the east. Soil investigations in other areas of the site has not been sufficient in other areas where historical release of these chemicals is suspected. Light Non-Aqueous Liquid (LNAPL) or hydrocarbon sheens were not observed on the water table. Dense Non-Aqueous Liquid (DNAPL) has not been observed visually at the site. Multiple lines of evidence reveal the presence of residual DNAPL in the soil which is also an ongoing source of contamination of groundwater at the site (and potentially off-site). The SEC is the most significant source zone for VHC, with other source areas in the southwest (former UST), the Northern (Former Drum Storage Area) and North Central (former ASTs and TIT1). Groundwater flow direction is not simple or uniform and uncertainty remains. It appears to be generally flowing in a southerly direction, but with westerly or easterly components. A revised monitoring well network is required to better define groundwater flow and delineation of contamination. The major contaminants are VCHs, TPH and BTEX. These contaminants were detected across the site, with the exception of an approximately 30 m wide strip on the northern boundary of the site. Groundwater contamination extends approximately 90m off site to the south to at least Phillip Street. Deeper contamination by VCHs has not been investigated. Some metals are slightly elevated within groundwater at the site, which is believed to be caused by a combination of natural background and further elevated due to site activities. The beneficial uses of land were found to be protected for commercial and industrial uses assuming the current configuration of buildings is largely unaltered (no enclosed structure intended for human occupation

	should be built on the SEC without remedial works) and an appropriate management plan is implemented, primarily to protect persons from potential exposures if the site covering is breached. With the exception of Maintenance of Aquatic Ecosystems, all other protected beneficial uses of groundwater were found to be precluded by contamination arising from the site.
Further Work or Requirements	A number of detailed recommendations are provided in Audit Report (grouped by aspect or issue). A summary of the key aspects with recommendations is as follows: • Conduct additional soil and groundwater investigations to identify the nature and extent of contamination at potential source zones other than the SE Corner (e.g. former drum storage) • Perform further assessments of human health risks associated with the current use of the site, areas immediately to the south and possible future use complying with the current land use zone is required using the current data and the data to be gained in further investigations (on- and off-site risks). This must lead into OHS management measures in a Site Management Plan (SMP) for the purpose of avoiding and managing unacceptable risks due to contamination (update based on additional relevant data). Conduct an evaluation of the monitoring well network and decommission wells not adequately constructed. Additional wells may be required to replace decommissioned wells, investigate potential sources in the northern portion of the site and investigate deeper aquifers. • Develop a numerical groundwater model. This should be used to evaluate the potential for impacted groundwater to be captured by local groundwater extraction wells and to assist with remediation feasibility and planning • A Remediation Feasibility Study (RFS) is required to evaluate short-term options for interim management. This will require revision to evaluate short-term options • The risks posed to off-site workers require immediate re-assessment. This includes the collection of additional data and additional risk modelling. • The SMP for on-site intrusive workers, recommended by GHD, should be implemented as soon as possible after the date of this report. The SMP shall include measures to manage odours, acute and lifetime health risks, and should be revised as the Conceptual Site Model is updated.

Table 2: Physical Site Information

Groundwater Segment	A1
Surrounding Land Use	North: Bay Road borders the northern area of the site. Across Bay Road, a car wash facility is located to the north east and an industrial estate currently under construction to the north of the site. East: Chandos Street borders the site to the immediate east which is followed by the Laminex industrial facility. South: Commercial and industrial warehouses are present to the south of the site consisting of an auto technical and machinery location facility. West: Hamlet Street borders to the west of the site with commercial properties and industrial warehouses beyond Hamlet Street. This includes a toolmaker, Austral Injections, an electrical contractor, an ambulance station and furniture outlet.

The practical purpose of this audit is to provide advice and an opinion regarding the condition of land and groundwater at the site and the potential requirement for ongoing groundwater monitoring or remediation of site.

The Auditor has assessed the groundwater and land quality in this instance by a review of the environmental site assessment report provided by the environmental consultant, GHD (the Assessor).

Audit Findings

Summary of Soil and Groundwater Contamination

Soil contamination was observed to varying degrees within the premises. The historical operations conducted at the site over at least the past four decades has provide for potential soil contamination at several areas of the site due to fixed infrastructure and also manual handling and loading practices. Soil contamination was most evident in the SEC, where it was contaminated by VCHs. The maximum soil contaminant concentrations were detected at the eastern and southern boundaries of the soil investigation; approximately 15 m from the eastern site boundary and adjacent to the southern site boundary. It is likely that VCH-contaminated soil extends from the site to the south and possibly also the east. However, the Auditor also notes that soil delineation in other areas of the site has not progressed with sufficient resolution to rule out with any certainty other surficial release areas (such as the Former Drum Storage Area and the TIT). As soil vapour impacts have been identified with the current low-resolution monitoring and as other source zones are possible, the Auditor has recommended a revised soil vapour monitoring network to address the above-noted issues.

LNAPL or hydrocarbon sheens were not observed on the water table. However, the Auditor notes that the USTs operated for decades and as there are no records of replacement of these USTs, there is the potential that leakage occurred over a significant period of time. Further, the continued presence of PHCs in groundwater is indicative of continuing sources within the subsurface. Therefore, there may be areas where the LNAPL has not been identified as it has migrated deep to the water table and/or that matrix diffusion into the clayey media has

provided a long-term source of PHCs that is partitioning back into groundwater. As degradation of VCHs is occurring to some degree at the site, there is the potential for some of the mass of PHCs to be driving this degradation.

DNAPL has not been observed at the site. As DNAPL is generally not observed, indirect lines of evidence have been used to assess the presence of DNAPL for the purpose of this audit report. The results have indicated the likely presence of DNAPL as an ongoing source of contamination at the site (and potentially off-site). The very high concentrations of VCHs (especially in the SEC) and the known DNAPL behaviour of such material, suggests the prospect for DNAPL to occur beneath the source areas. The presence of DNAPL is in non-compliance with SEPP(GoV), and contributes to detriment of beneficial uses. As site operations have included the loading, storage and handling of DNAPLs (such as PCE, TCE, CF, DCM, and TCAs) since 1949 at this relatively small site, there is a strong possibility for long-term release locations. Although data gaps exist in site historic operations (from 1949), the data compiled interviews with employees and site inspections together provide adequate documentation for such long-term DNAPL releases. The above provide adequate time and opportunity for deeper migration of DNAPL into the Brighton Group Aquifer (and potentially into the Fyansford Formation Aquifer). Subsequently, multiple suspected DNAPL source zones exist across the site (with the exception of the northern ~30m). The most significant source zone is in the SEC (former USTs and ASTs, concrete sump, decanting, drum storage in the Former Drum Shed, and refrigerant storage); with other source areas in the southwest (former UST), the Northern (Former Drum Storage Area) and North Central (former ASTs and TIT1).

Groundwater flow direction is not well defined and appears to be generally southerly, but also have westerly or easterly components (in particular within the Former Drum Storage Area that may take impacted groundwater off-site in this area). Mounding, which is occurring across the site in a few areas, is also complicating the flow pattern. The monitoring well network has been evaluated and a revised monitoring well network is considered by the Auditor to be required to provide adequate data on groundwater flow and delineation of contamination. Due to the historical operations conducted at the site over at least the past four decades, groundwater contamination occurs throughout the site. The major contaminants are VCHs, TPH and BTEX. These contaminants were detected across the site, with the exception of the northern ~30 m of the site. The contaminant plumes overlap with plumes from adjoining source areas (this can be particularly observed for plumes from that appear to originate north of the Poisons Store that overlap with those in the SEC). There is a lack of adequate data (and data quality issues) in relation to the potential for degradation in the Brighton Group Aquifer at the site (i.e. whether one or more aquifer 'types' exist). This and the processes of biodegradation and groundwater flow issues complicate the contaminant hydrogeology at this site. Groundwater contamination extends off site to the south to at least Phillip Street. Deeper contamination by VCHs has not as yet been investigated. The Auditor has recommended a revised groundwater monitoring well network to address the above-noted issues.

Some metals are slightly elevated within groundwater at the site, which is believed to be caused by a combination of natural background and further elevated due to site activities.

Land Contamination and Risks

Following a review of the data provided by the Assessor, and having regard to the SEPP *Prevention and Management of Contaminated Land*, the Auditor has assessed the impacts on the protected beneficial uses of the land.

Maintenance of Land Ecosystems: The contamination of surface soil may be a significant impediment to this beneficial use of the land, especially in the south eastern portion of the site. Soil assessment has been focused on locations where groundwater contamination has been

observed; thus a complete assessment of soil contamination across the remainder of the site is not possible.

Buildings & Structures: The Auditor has not identified soil characteristics that are clearly likely to affect buildings or structures across the site. However, the presence of residual DNAPL suspected to be present in the south east portion of the site may have a detrimental effect (related to vapour and/or groundwater impacts) on utility conduits (especially plastic pipes and insulation), which may adversely affect their integrity. This aspect may require further consideration and management.

Aesthetics: Odorous material was identified at the site during the assessment. Intrusive works will require management to avoid unacceptable aesthetic impact (i.e. odours) if and when remediation occurs or any subsurface maintenance work is conducted.

Production of Food, Flora & Fibre: This is not a protected beneficial use on industrial land and is therefore not considered further.

Human Health: The results of soil assessments indicate that the relevant investigation levels for human health criteria for petroleum hydrocarbons (mainly chlorinated hydrocarbons) in soil have been exceeded. Human health exposures due to inhalation of vapours from contaminated soil and groundwater or NAPL is a potentially significant risk pathway. The Auditor is of the opinion that the VHC impacts currently identified require further assessment to confirm the results of the assessors Health Risk Assessment for on and off-site receptors. Any change to site use involving more frequent or longer duration occupation or redevelopment of the site would represent a potentially unacceptable risk.

In summary, the beneficial uses of land were found to be protected for commercial and industrial uses assuming the current configuration of buildings is largely unaltered (no enclosed structure intended for human occupation should be built on the SEC without remedial works) an appropriate management plan is implemented, primarily to protect persons from potential exposures if the site covering is breached.

Groundwater and Surface Water Contamination and Risks

In accordance with the SEPP *Groundwaters of Victoria* the protected beneficial uses of groundwater in the Area of Interest (i.e. the Segment under audit) which are defined as Segment A1 groundwater have been assessed.

Maintenance of Aquatic Ecosystems: Although aquatic ecosystem protection is considered “relevant” under the policy, the contamination in groundwater seems unlikely to represent pollution with respect to aquatic ecosystems due to the attenuation opportunity in the aquifer provided by the distance to the nearest surface water body (Port Phillip Bay). However, there is considerable uncertainty in this assessment and further investigations and monitoring are required.

Potable Water: The water quality criteria for potable water are greatly exceeded. However, this beneficial use is not a relevant use due to the low likelihood of the use being realised by a bore owner pumping groundwater for consumption.

Stock Water: The water quality criteria for toxicants such as benzene default to human drinking water objectives, which are greatly exceeded. However, this use is not relevant due to the low likelihood of people keeping livestock and watering them from a groundwater bore in this vicinity.

Industrial Water Use: Similarly the groundwater contamination can be shown to preclude a number of potential industrial uses, although these are limited and the likelihood of them being realised in this vicinity is low - but still relevant.

Primary Contact Recreation: This use also defaults to human drinking water quality objectives which are clearly exceeded within the site. However, it is considered by the Auditor not a relevant use due to the low likelihood of the use being realised either by a bore owner pumping groundwater into a swimming pool, or the groundwater discharging to a surface water body used for swimming in the vicinity.

Buildings & Structures: To the extent that contaminated groundwater and NAPL at the site can impact on underground structures then this use is not protected. While this is possible and should be guarded against, it is a low risk due to the 9 m depth to the water table.

In summary, with the exception of Maintenance of Aquatic Ecosystems, all other protected beneficial uses of groundwater were found to be precluded by contamination arising from the site.

Contamination in Surrounding Areas

Chlorinated hydrocarbon contamination has been identified offsite to the south in the adjoining properties (MW26 and MW34) an up to 150 m off-site at Philip Street. BTEX compounds have been identified to the southwest of the site, but are considered to be of lower significance than the VCHs.

Groundwater flow directions are generally southerly, but also have easterly and westerly components. Thus the southern, eastern and western boundaries should be considered to be the hydraulically downgradient boundaries at the site for the purposed of further assessment or management.

Health Risk Assessment

A Health Risk Assessment (HRA) was conducted by GHD (2009) to assess the potential risk to human health associated with the inhalation of vapour emissions from contaminated soil and groundwater at the site. The assessment followed the approach outlined in the NEPM.

The HRA was conducted using the highest soil vapour and groundwater concentrations, which were typically obtained in the SEC. GHD found that there were no unacceptable risks posed to on-site or off-site workers under the current site configuration. However, risks to human health may exist for underground maintenance workers, or if the site is redeveloped. These potential risks should be managed with an SMP. The Auditor considers that additional investigation is required, especially to characterise the risks to off-site workers.

Recommended Measures

The objectives and scope of the Audit in compliance with EPA CUN the Auditor is to recommend measures to reduce and manage risks to beneficial uses at acceptable levels (and also cognisant of the Auditor's discussion of the principles and "drivers" for remediation). The Auditor's recommendations and proposed timelines are as follows (these have been grouped by aspect rather than the numerical order in which they occur in the text of the report):

Table 3: Recommended Measures and Implementation Timetable

Aspect	Recommendation		Recommended Completion Timetable
General Site Investigations			
Site Plan	7	An accurate site plan be constructed and used for future reporting requirements. The site plan should be constructed by a licensed surveyor and include the location of the site boundary, roads, buildings, services and permanent sample locations.	4 Months
Hydraulic Control – Groundwater Flow Directions	28	On and offsite services be investigated to determine if they are leaking and effecting the groundwater flow pattern and contaminant transport	6 months
Groundwater Resources - Unregistered Bore Search	31	Conduct a search for unregistered bores (field event) downgradient of the site – and door knocking (if required).	6 months
Groundwater Resources – Supply Well Information	32	Seek to obtain groundwater extraction and water supply well information for the above-noted wells.	6 months
Mounding and TDS variations	30	Investigate the source(s) of the variation of TDS to show whether the site groundwater is actually other than Segment A1. This includes the areas of mounding noted at the site in the vicinity of monitoring wells MW3, MW12 and MW18.	6 months
Soil Vapour Monitoring			
Soil Vapour Data Gaps	3	Areas with impacted soil vapours (i.e. the SEC and the Former Drum Storage Area, sump in the Poisons Store, and the Area 2 USTs) require further delineation using field screening with temporary locations and analytical laboratory data at permanent monitoring locations. The Auditor notes that the preliminary soil gas survey data are indicative of surficial releases, which should be further investigated.	6 Months
Soil Vapour – Monitoring Network	20	The Auditor recommends the inclusion of a revised soil vapour monitoring network to enable sufficient resolution in line with the on-site and off-site risks posed by the migration of volatile site contaminants. This should be part of an ongoing program in association with groundwater monitoring that takes into account the weathering from source zones over time and preferential pathways with high concentrations (i.e. mass flux).	Commence immediately to develop the monitoring network plan for auditor endorsement and implement within six months.
Soil Vapour Monitoring Event	54	An additional vapour monitoring event (soil vapour and indoor air) should be scheduled as soon as practicable to confirm the current data.	6 Months

Aspect	Recommendation		Recommended Completion Timetable
Health Risk Assessment			
Soil Vapour – Intrusion Risk	21	Further consideration needs to be given to possible vapour intrusion risk to persons occupying buildings off-site (and potentially on-site depending on future investigation results) including incorporation of the recommendation for an enhanced soil vapour monitoring network.	5 Months
Human Health Risk Assessment – Short-Term	4	A detailed assessment of human health risks associated with the current use of the site and areas immediately to the south and possible future use complying with the current land use zone is required using the current data and the data to be gained in further investigations (on- and off-site risks). This must lead into OHS management measures in a Site Management Plan (SMP) for the purpose of avoiding and managing unacceptable risks due to contamination (Commence immediately and update based on additional relevant data).	9 Months
Human Health Risk Assessment – Longer-Term	57	The human health risk assessment should be redesigned and repeated to include all relevant exposure pathways across the site (and those with identified and potential site-related impacts off-site) following adequate delineation and update of the CSM.	Following delineation (upon endorsement by Environmental Auditor).
Risk Modelling	58	Additional risk modelling should rely on the existing soil vapour data and those gleaned from monitoring of the revised network, such that the soil source as well as the groundwater source is included in the modelling.	Commence within 3 months, report with risk assessment (item 4)
Risk Profile – Changing Over Time	59	An assessment of how the risk profile may change with time should be conducted (including partitioning effects such as effective solubilities).	Commence within 3 months, report with risk assessment (item 4)

Aspect		Recommendation	Recommended Completion Timetable
Risk to Off-Site Workers	60	The risks posed to off-site workers require immediate re-assessment. This includes the collection of additional data as recommended above and additional risk modelling.	Commence within 3 months, report with risk assessment (item 4)
Source Zone Investigation			
Source Zones - Investigation	1	Identify potential source zones (Former Drum Storage Area, North Central ASTs, sump in the Poisons Store, and others). Conduct targeted source zone investigations in the northern half of the site to confirm whether there are ongoing sources of contamination in these areas (nature and extents), and if so what management strategies are required.	12 Months
Delineation of VCH Impacts related to Source Zones	38	Investigate other sources of VCH impacts in the subsurface (including areas with upgradient impacts such as the northern half of the site) by soil, soil vapour and groundwater investigations (including installation of wells in the revised monitoring well network).	12 Months
Groundwater Data Gaps	2	Groundwater data gaps in the Northern and Central Areas are to be investigated to delineate sufficiently and to assist in identifying whether there are ongoing sources of contamination in these areas.	12 Months
Revised Monitoring Well Network			
Permanent Monitoring Well Network – Plan and Implementation	11	Develop a plan for and install a revised permanent monitoring network both on- and off-site to evaluate the geology and hydrogeology of the deeper portions of the BGA and into the FFA, as well as the hydraulic connection between these units, assess groundwater flow and dissolved phase contaminant migration within the aquifer(s). Designed meet the intended use and goals to be achieved (delineation and assessing risk).	9 Months
Conceptual Site Model – Delineation of Plumes	33	Use the CSM presented by the Auditor to develop a revised monitoring well network, which has been recommended by the Auditor, to delineate the groundwater plume(s).	9 Months
Delineation of Chlorinated Solvent Impacts	35	Improve the density and quality of the monitoring well network as indicated in Recommendation 11 to gain data that are suitable to be used to evaluate the depth of impact of chlorinated solvents on-site and off-site.	12 Months
Degradation of Chlorinated Solvents - Data	48	Improve the density and quality of the monitoring well network as indicated in Recommendation 11 to gain data that are suitable to be used to evaluate degradation of chlorinated solvents on-site and off-site – including aquifer 'type' and plume stability.	12 Months

Aspect		Recommendation	Recommended Completion Timetable
Risks posed by Groundwater Impacts	56	The revised monitoring network recommended by the Auditor should include locations that are installed to characterise the potential risks at beyond the SEC (Former Drum Storage Area and the Office) and to provide additional information on the risks posed to offsite receptors.	Following endorsement of the plan for the network by Environmental Auditor.
Mass Flux Approach for Monitoring	22	The Auditor recommends a mass flux plane approach for management of contaminant transport (soil vapour and groundwater). This could be accomplished using a mass flux plane approach if sufficient access becomes available down-gradient of the source or a numerical modelling approach matched to field data. The flux plane approach can include monitoring of contaminants across transects perpendicular and parallel to flow. This may require transects off-site, as possible; and will need to take into consideration the implications for monitoring near the source zones. Alternatively the modelling approach would match the groundwater flow behaviour and contaminant behaviour with calibration accomplished by adjusting source parameters to match contaminant concentrations in the monitoring wells	Commence immediately to develop the monitoring network plan for auditor endorsement and implement within 12 months.
Mass Flux Approach - Transects	23	Mass flux approach is to include: Transects (T1 to T4) with both soil vapour and groundwater depth-discrete locations. T1 (full east-west profile) south of the Former Drum Storage Area. T2 (full east-west profile) north of the SEC. T3 from Bay Road to Philip Street. T4 along the lower boundary of SEC (using telescopic methods) to identify secondary sources. Following installation of deeper wells to evaluate the continuity and potential for the silty clay layer at 20 mBGS to limit vertical migration of DNAPL.	12 Months
Mass Flux - Transects	53	Evaluate the use of mass flux from source areas (soil vapour and groundwater) and along the groundwater flow path of plumes using the four transects recommended by the Auditor (soil vapour and groundwater depth-discrete sampling locations).	12 Months
Permanent Monitoring Well Network - Requirements	12	This revised permanent monitoring network is to include the shallow, intermediate and deep portions of the aquifer(s). Based on this recommendation and the Auditor's review of site data, the remaining wells would consist of MW19, MW20, MW22, MW24A, MW24B, MW24C, and MW25 through MW42. As many of these remaining wells have water levels above the well screen, additional wells across the water table would be required (in addition to deeper wells within the aquifer).	12 Months

Aspect	Recommendation		Recommended Completion Timetable
Continuous Low Permeability Unit	13	Obtain sufficient evidence (geological, hydrogeological and geochemical) for the presence of a locally significant low permeability unit that would limit the hydraulic connection between these units (and potentially DNAPL migration).	During installation of monitoring wells, within 12 months
Monitoring Well Network – Shallow Wells	14	As many of the remaining wells have water levels above the well screen, additional wells across the water table would be required (in addition to deeper wells within the aquifer).	Ongoing during planning for well installation
Monitoring Well Network - DNAPL	15	Construction of monitoring wells will need to include consideration of presence of DNAPLs (refer to Figure 4-3) including: well location, well screening (elevation, length and slot size), the filter pack (potentially including fine mesh wire) and seal through fill layers); this is to identify DNAPL migration into the well, decrease well artefacts and provide samples representative of the aquifer. As noted above, the Auditor considers that deeper migration of DNAPL(s) at the site is likely to have occurred. Therefore, new wells would need to incorporate this issue.	Ongoing during planning for well installation
Aquifer Media Sampling	16	Collect aquifer media (soil) samples for organic carbon content, density, grain size, and other relevant physical parameters at boreholes for wells advanced in the BGA and FFA.	During installation of the revised monitoring network, within 12 months
Precautions in Source Zones - DNAPLs	36	Use appropriate pre-cautions during DNAPL investigations, including the installation of sumps at the bases of monitoring wells, where needed.	Ongoing during well installations.
DNAPL Observation - Source Zones	37	Use the above-noted methods for observing the presence of DNAPL including Flute [®] liners during installation of monitoring wells.	Ongoing during borehole advancement (for deeper soil and/or groundwater characterisation).
Assessment of Aquifer Properties			
Down-hole Geophysics	8	Conduct down-hole geophysics on any newly installed wells (refer to Auditor recommendations below) in the BGA and FFA and use this information to inform the revised CSM.	15 Months
Hydraulic Aquifer Response Testing	18	Conduct groundwater pumping tests and slug tests in the BGA and FFA to evaluate the hydraulic conductivity (K), transmissivity (T), and hydraulic connections of these aquifers.	15 Months.

Aspect	Recommendation		Recommended Completion Timetable
Groundwater Monitoring			
In-Situ Monitoring	24	As well and sampling artefacts have affected data quality at this site, in-situ measurement devices to monitor water levels and geochemistry data are required to be part of the program developed within the GQMP. This should include down-hole data loggers with water level, temperature, conductance, DO and redox (in the sandy clay and lower sandy portions of the aquifer(s) impacted by plumes and one upgradient location).	Commencing within six months
Hydraulic Control – Groundwater Flow Directions	26	Groundwater hydraulic control on-site and off-site is to be gained through the revised monitoring network and quarterly SWL monitoring (i.e. gauging) including downhole measurements of field parameters to assist in characterisation of groundwater quality.	Commencing within six months
Quarterly Static Water Level Monitoring	29	Use the quarterly water level monitoring (i.e. gauging) to evaluate the presence and nature of vertical gradients within the upper clay unit and the BGA, as well as between the BGA and FFA.	Commence immediately on the remaining wells and then ongoing for the revised network
Groundwater Monitoring Events (GMEs)	55	The revised monitoring network recommended by the Auditor should be initiated with annual monitoring and reporting to confirm that the risk profile of the site has not changed.	15 Months
In-Situ Monitoring	25	As matrix interference has affected data quality, the SMP should consider alternative sampling methods to reduce the LORs to acceptable levels. Non-detection levels (LORs) should be discussed and presented in tables and figures.	Next GME and ongoing
Elevated Limits of Reporting	5	Ensure that the data quality issues with elevated LORs are addressed and that the LOR values are plotted on summary figures and provided in summary tables, such that there is more transparency in regard to data quality and delineation resolution.	Next GME and ongoing
Addressing Matrix Interference via Partitioning	6	Collect groundwater samples for submission to the analytical laboratory, which enable partitioning to air and soil (depending upon the physical properties of the contaminants), with the intent to address the matrix interference causing elevated LORs. For example, collect half full sample jars for gas extraction at the laboratory and injection into the GC. This is to assist identification of highly volatile compounds that are vulnerable to negative sampling bias such as VC.	Next GME
Scan Sampling	17	Evaluate the use of methods such as ‘scan sampling’ (sampling during groundwater extraction) to enhance detection of chlorinated solvent plumes.	Following installation of the revised monitoring network, within 15 months.

Aspect		Recommendation	Recommended Completion Timetable
Degradation of Chlorinated Solvents – Indicators	51	Analyse groundwater samples for alcohols and fatty acids (indicators of aerobic oxidation - cometabolic) and use this as another line of evidence for the occurrence of degradation.	Following installation of the revised, monitoring network, within 15 months
Well Decommissioning			
Well Decommissioning	9	Decommission the following wells: multilevel wells (MW6 through MW17), long-screened wells MW3, MW4, MW5, MW21 and MW23, wells impacted by leakage (e.g. MW18), low recovery wells (e.g. MW2), any wells where the seal is not sufficiently protective, and finally any wells within source areas where dissolution of the PVC casing is possible (e.g. the SEC).	12 Months
Well Decommissioning	10	The replacement of wells with quality issues located in areas where high concentrations of chlorinated solvents have been detected (historic and recent) is recommended.	12 Months
Groundwater Modelling			
3D Numerical Groundwater Flow Model	27	Based on the CSM, develop a three-dimensional (3D) groundwater flow model (with water mass balance) as the basis of the flow and transport model, using suitable existing data and recommended quarterly monitoring data and the hydraulic response data. Conduct both steady-state and transient calibration for this model.	18 Months
3D Numerical Fate and Transport Model	46	Evaluate the potential for groundwater VCH impacts to reach and be captured by groundwater extraction in the local area using 3D numerical fate and transport modeling (using the recommended 3D groundwater flow model as the foundation for this work).	18 Months
Site Management Plan			
Current SMP - Implementation	61	The SMP for on-site intrusive workers, recommended by GHD, should be implemented within one month of the date of this report. The SMP shall include measures to manage odours, acute and lifetime health risks, and should be revised as the CSM is updated.	2 Months, reassessed and revised (if required) within 12 months

Aspect	Recommendation		Recommended Completion Timetable
Interim Action	41	Interim action (within six months) is recommended to: - keep the section of the site along the southern boundary in the SEC accessible to address interim measures and potentially longer-term remedial measures - cover the grassed area in the SEC to limit recharge through the uncovered and former UST excavation areas - install interim remedial measures to limit the off-site migration of contaminants in the vadose zone and below the water table (i.e. soil vapour and groundwater plumes).	To be completed within six months.
Monitoring Well Network - SMP	19	This revised monitoring network is to form part of an SMP, and is to be maintained until cessation of monitoring is approved by the EPA. The current SMP shall be: revised to include the revised network, follow EPA guidance, and be endorsed by an EPA appointed Environmental Auditor. In addition, the ongoing SMP is to be revised as further information comes to hand from studies and monitoring recommended in this audit report.	18 Months
Ongoing SMP – Long-Term Management Plan	45	Implement a long-term management plan for the site – e.g. an ongoing SMP for the current site built environment, with revisions as needed to take into account modifications and/or redevelopment.	18 Months
Evaluation and Reporting			
Conceptual Site Model - Ongoing	34	Use the CSM to develop future investigation plans, and revise and update this CSM as relevant information is gained during these future investigations.	Ongoing
Data Evaluation of DNAPL Presence	39	Conduct and report on a detailed evaluation of the presence of DNAPLs using the lines of evidence provided above.	18 Months
Shallow VCH Plumes	47	Evaluate/investigate the potential for shallow VCH plumes to intersect PHC contamination off-site in the surrounding commercial/industrial area downgradient of the site.	18 Months
Degradation of Chlorinated Solvents – Degradation Pathways	49	Provide an updated discussion on the potential degradation pathways (biotic and abiotic products) for the VCHs. Include figures showing the pathways and peer reviewed references. This is to be used for site characterisation, groundwater fate and transport modelling, risk assessment, remediation and ongoing management.	6 Months
Intrinsic Capacity of the Aquifer System	50	Further evaluate the importance of the intrinsic capacity of the aquifer system to degrade the volatile contaminants – short-term and longer-term.	15 Months

Aspect	Recommendation		Recommended Completion Timetable
Degradation of Chlorinated Solvents – Microbial Processes	52	Investigate the microbial processes (including microcosm studies) to assist in the understanding of biological degradation – to rule out or confirm the importance of intrinsic aquifer capability to degrade these contaminants (with respect to management of aquifer pollution – beneficial use).	15 Months
Remediation Feasibility Study			
RFS – Short-Term Options	40	A Remediation Feasibility Study (RFS) would be required to evaluate short-term options for interim measures (beyond those recommended by the Auditor).	To be completed within four months.
Revised RFS – Long-Term Options	42	The Auditor considers that a revised RFS would be required to evaluate the long-term clean up options and identify suitable and preferred approach. This approach will need to also contemplate the administrative tools available and effective to manage polluted groundwater to protect future groundwater users from intercepting the plume.	21 Months
Clean Up Plan			
Clean Up Plan	43	The Auditor recommends that the preparation of a Clean Up Plan subsequent to the achievement of adequate characterisation (including geochemical data and groundwater flow) and delineation.	24 Months
CUP in SEC – Consideration of Volatiles	44	The Auditor recommends that the Clean Up Plan for the SEC (e.g. remedial excavation) consider the broad list of volatile detections in soil (TPH C ₆ -C ₉ , chlorobenzene, PCE, TCE, cDCE, 1,1-DCE, 1,1,1-TCA and 1,1-DCA) and those detected in soil vapour including VC.	24 Months

Read in Conjunction with Audit Report

While this Executive Summary has endeavoured to accurately summarise the key points of the Audit Report, the latter shall take precedence and the Executive Summary must be read in conjunction with the full report of the Auditor (Lane Piper document ref. 207214Report01.2.docx).

About this Environmental Audit Report

While this Environmental Audit has been undertaken in accordance with the EPA Auditor Guidelines and current industry practice, there may be some limitations on the meaning and use of this report. The reader is advised to read this report in conjunction with the attached document *About Site Environmental Audits and Reports* (Appendix N).

In September 2007 EPA issues new guidance to Auditors (Publication 1147) which included the need to insert an information document in all audit reports. This document is titled *Information Regarding Environmental Audit Reports* and is included as Appendix M of this report.

Anthony P. Lane
Environmental Auditor
(Appointed pursuant to the *Environment Protection Act 1970*)

ENVIRONMENTAL AUDIT REPORT (S53V)

18-22 Hamlet St, Cheltenham

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About Site Environmental Audits and Reports

LIST OF ABBREVIATIONS AND UNITS

Chemical Names

BTEX	Benzene, Toluene, Ethylbenzene & Xylenes (subset of MAH)
CHC	Chlorinated Hydrocarbons
MAH	Monocyclic Aromatic Hydrocarbons
OCP	OrganoChlorine Pesticides
OPP	OrganoPhosphate Pesticides
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	PolyChlorinated Biphenyls
SVOC	Semi-Volatile Organic Compounds
TDS	Total Dissolved Solids (salinity of water)
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons (= TPH)
VOC	Volatile Organic Compounds

Technical Terms

AHD	Australian Height Datum
AMG	Australian Map Grid
ANZECC	Australian and New Zealand Environment and Conservation Council
AST	Aboveground Storage Tank
BDL	Below Detection Limit
COC	Chain of Custody
CoEA	Certificate of Environmental Audit
CoPC	Chemicals of Potential Concern
DNAPL	Dense Non-Aqueous Phase Liquid
DO	Dissolved Oxygen
EC	Electrical Conductivity
EILs	Environmental Investigation Levels
EPA	Environmental Protection Authority
ESA	Environmental Site Assessment
GCMS	Gas Chromatograph - Mass Spectrometer
GDB	Groundwater Database (Department of Natural Resources and Environment)
GME	Groundwater Monitoring Event
HILs	Health Investigation Levels
LNAPL	Light Non-Aqueous Phase Liquid

LOR	Limit of Reporting
N/A	Not Applicable
NAPL	Non-Aqueous Phase Liquid
NEPM	National Environmental Protection Measure
PID	Photo-ionisation detector (measures in ppm)
PQL	Practical Quantitation Limit
PSH	Phase Separated Hydrocarbon
QA	Quality Assurance
QC	Quality Control
RL	Reduced Level
RPD	Relative Percentage Difference
SoEA	Statement of Environmental Audit
TIT	Triple Interceptor Trap
UCL	Upper confidence Limit ("95% UCL of the mean" is a value for the mean concentration from sampling which has only a 5% chance of being greater than the true mean value.)
UST	Underground Storage Tank

Units

Ha	Hectares
mBGS	Metres Below Ground Surface
mg/kg	Milligram per Kilogram (approximately equivalent to ppm)
mg/L	Milligram per Litre
mTOC	Metres below Top of Casing
ppb	Part per Billion
ppm	Parts per Million
µg/kg	Microgram per Kilogram (approximately equivalent to ppb)
µg/L	Microgram per Litre
µS/cm	Micro Siemens per Centimetre (Electrical Conductivity - Water)

ENVIRONMENTAL AUDIT REPORT (S53V)

18-22 Hamlet St, Cheltenham

1 INTRODUCTION

1.1 Summary Information

Lane Piper Pty Ltd (Lane Piper) was engaged on 31 July 2007 by the current site owner Nuplex Industries (Aust) Pty Ltd (Nuplex) to provide the services of Mr Anthony Lane, an EPA-appointed Environmental Auditor. This was in response to a Clean Up Notice (CUN) issued under section 62A of the *Environment Protection Act 1970* (the Act) to the site owner on 31 July 2007.

The site is located at 18-22 Hamlet St, Cheltenham (Figure 1, Appendix A). The Auditor was requested to carry out an audit under section 53V of the Act) in relation to the risk of any possible harm or detriment to the land and groundwater caused by the activities conducted at the premises.

Nuplex Industries (Aust) Pty Ltd have engaged GHD ("the Assessor") as their environmental consultant for the purpose of investigating the site and its environs for the purpose of providing sufficient information to enable this audit to be completed.

Summary information on this audit is given in Table 1-1, in accordance with EPA Pub 1147.

Table 1-1: Summary of Audit Information

EPA File Reference No.	62617-1
Auditor	Anthony Lane
Auditor Term of appointment	29 July 2009 to 30 May 2014
Name of Person Requesting Audit	John Heke
Relationship to Premises/Location	Site Manager of Nuplex Industries (Aust) Pty Ltd
Date of Request	31 July 2007
Date EPA Notified of Audit	7 August 2007
Completion Date of Audit	8 September 2011
Reason for Audit	CUN EPA Ref: NO9097
Description of Activity	Chemical storage and distribution
EPA Region	South Metro Region
Dominant - Lot on title plan	Lot 1 TP518231
Additional - Lot on plan(s)	
Site / Premises name	
Building / Complex Sub-unit No.	
Street / Lot - Lower No.	18
Street / Lot - Upper No.	22

Street Name Street Type (road, court, etc) Street Suffix (North, South etc) Suburb Postcode	Hamlet Street Cheltenham 3192
GIS Coordinate of Site Centroid Longitude Latitude	145.040568 37.957236
Members and Categories of Support Team Utilised	- Wendy Morrison – Hydrogeology; Remediation and geotechnology; and Contaminant transport and assessment of exposure pathways and risk. - Peter Gringinger – Hydrogeology; Remediation and geotechnology; and Contaminant transport and assessment of exposure pathways and risk.- - Jon Bartley – Hydrogeology - John Frangos – Human toxicology, Contaminant transport and assessment of exposure pathways and risk.
Outcome of the Audit	Soil contamination was most evident in the South Eastern Corner (SEC), where it was contaminated by Volatile Chlorinated Hydrocarbons (VCHs). It is likely that VCH-contaminated soil extends from the site to the south and possibly also the east. Soil investigations in other areas of the site has not been sufficient in other areas where historical release of these chemicals is suspected. Light Non-Aqueous Liquid (LNAPL) or hydrocarbon sheens were not observed on the water table. Dense Non-Aqueous Liquid (DNAPL) has not been observed visually at the site. Multiple lines of evidence reveal the presence of residual DNAPL in the soil which is also an ongoing source of contamination of groundwater at the site (and potentially off-site). The SEC is the most significant source zone for VHC, with other source areas in the southwest (former UST), the Northern (Former Drum Storage Area) and North Central (former ASTs and TIT1). Groundwater flow direction is not simple or uniform and uncertainty remains. It appears to be generally flowing in a southerly direction, but with westerly or easterly components. A revised monitoring well network is required to better define groundwater flow and delineation of contamination. The major contaminants are VCHs, TPH and BTEX. These contaminants were detected across the site, with the exception of an approximately 30 m wide strip on the northern boundary of the site. Groundwater contamination extends approximately 90m off site to the south to at least Phillip Street. Deeper contamination by VCHs has not been investigated. Some metals are slightly elevated within groundwater at the site, which is believed to be caused by a combination of natural background and further

	elevated due to site activities. The beneficial uses of land were found to be protected for commercial and industrial uses assuming the current configuration of buildings is largely unaltered (no enclosed structure intended for human occupation should be built on the SEC without remedial works) and an appropriate management plan is implemented, primarily to protect persons from potential exposures if the site covering is breached. With the exception of Maintenance of Aquatic Ecosystems, all other protected beneficial uses of groundwater were found to be precluded by contamination arising from the site.
Further Work or Requirements	A number of detailed recommendations are provided in Audit Report (grouped by aspect or issue). A summary of the key aspects with recommendations is as follows: • Conduct additional soil and groundwater investigations to identify the nature and extent of contamination at potential source zones other than the SE Corner (e.g. former drum storage) • Perform further assessments of human health risks associated with the current use of the site, areas immediately to the south and possible future use complying with the current land use zone is required using the current data and the data to be gained in further investigations (on- and off-site risks). This must lead into OHS management measures in a Site Management Plan (SMP) for the purpose of avoiding and managing unacceptable risks due to contamination (update based on additional relevant data). Conduct an evaluation of the monitoring well network and decommission wells not adequately constructed. Additional wells may be required to replace decommissioned wells, investigate potential sources in the northern portion of the site and investigate deeper aquifers. • Develop a numerical groundwater model. This should be used to evaluate the potential for impacted groundwater to be captured by local groundwater extraction wells and to assist with remediation feasibility and planning • A Remediation Feasibility Study (RFS) is required to evaluate short-term options for interim management. This will require revision to evaluate short-term options • The risks posed to off-site workers require immediate re-assessment. This includes the collection of additional data and additional risk modelling. • The SMP for on-site intrusive workers, recommended by GHD, should be implemented as soon as possible after the date of this report. The SMP shall include measures to manage odours, acute and lifetime health risks, and should

be revised as the Conceptual Site Model is updated.

The practical purpose of this audit is to provide advice and an opinion regarding the condition of land and groundwater at the site and the potential requirement for ongoing groundwater monitoring or remediation of the site.

The Auditor has assessed the groundwater and land quality in this instance by a review of the environmental site assessment report provided by the environmental consultant, GHD (the Assessor).

A "Clean Up Notice" has been served by the EPA for a number of reasons as set out in the notice :

- *The premises had been used to manufacture, store and distribute chemical products*
- *The report on the site "Further Contamination Characterisation 18-22 Hamlet Street, Cheltenham, Victoria, March 2007, Prepared by SMEC Australia Pty Ltd states that*
 - *Five Underground Storage Tanks (USTs) had been located and have now been removed from the site. Three USTs had been used to store compounds containing Volatile Organic Carbons (VOC) and two USTs had been used to store Volatile Chlorinated Hydrocarbons (VCH). Additionally the site has contamination of soil and groundwater associated with site activities including wash down areas, acid tank storage area, triple interceptor trap, and various spill areas.*
 - *Soils have been contaminated with various contaminants associated with site activities, including but not limited to TCE.*
 - *Groundwater has been contaminated with benzene up to 2,050 µg/L, TPH up to 84,200 µg/L, TCE up to 366,000 µg/L, DCE up to 130 µg/L, carbon tetrachloride up to 77 µg/L, chloroform up to 21,900 µg/L, 1,1 dichloroethane up to 130 µg/L, and vinyl chloride up to 25,000 µg/L.*
 - *Pollution has occurred on land and groundwater by discharge, emission or deposit of material*
 - *Action is needed to determine, control and minimise the possible environmental impacts from the premises*
 - *Groundwater pollution upon and from the premises must be cleaned up to ensure that the quality of groundwater is restored at the premises.*

A number of environmental reports have been reviewed as part of this audit; these reports are listed in Section 3 of this audit report.

1.2 Site Definition

The site is located at 18-22 Hamlet Street, Cheltenham. It is a rectangular-like shaped block, bounded to the north by Bay Street, Chandos Street to the east and Hamlet Street to the west.

Table 1-2: Site Definition and Description Details

Item	Comments/Description
Site Address	The Assessor's report identifies the site as 18-22 Hamlet St, Cheltenham. This was confirmed by the Auditor.
Site Title	PC353481, Lot 1 TP518231
Site Locality Plan, Site Plan	Provided in Assessor's report and reproduced in this report as Figure 1

Item	Comments/Description
(including Sampling Locations)	and Figure 2, respectively.
Land Area	Stated in Assessor's report as approximately 11,300 m ² .
Built Environment	Office and several warehouse buildings. Majority of site ground surface is sealed.
Surrounding Land Use	North: Bay Road borders the northern area of the site. Across Bay Road, a car wash facility is located to the north east and an industrial estate currently under construction to the north of the site. East: Chandos Street borders the site to the immediate east which is followed by the Laminex industrial facility. South: Commercial and industrial warehouses are present to the south of the site consisting of an auto technical and machinery location facility. West: Hamlet Street borders to the west of the site with commercial properties and industrial warehouses beyond Hamlet Street. This includes a toolmaker, Austral Injections, an electrical contractor, an ambulance station and furniture outlet.
Topography	The site slopes gently to the south.
Vegetation	Minor grassed areas

1.3 Sequence of Assessment & Audit

Table 1-3 summarises the tasks and sequences of events to arrive at an assessment and audit of this site.

Table 1-3: Site Assessment & Audit Tasks Sequence

Date	Activity
2 July 2007	Auditor sent proposal to Nuplex Industries (Aust) Pty Ltd
31 July 2007	Auditor formally appointed by Nuplex Industries (Aust) Pty Ltd
6 August 2007	Auditor conducts a site inspection & meeting with Assessor and Nuplex
7 August 2007	Audit notification to EPA
1 February 2008	Auditor received letter from EPA confirming proposed scoped of works
16 May 2008	Site inspection by Auditors Assistant
23 December 2008	Environmental Site Assessment report received
10 March 2009	Vapour Health Risk Assessment Received
10 March 2009	Draft Fate & Transport Modelling Report Received
13 December 2010	Additional Soil and Groundwater Investigation Report Received
21 June 2011	GME (January 2011) Report Received
26 July 2011	Draft Audit report issued
8 September 2011	Final Audit Report Issued

The consultants engaged by the client to undertake the site assessment, remediation and or other inspection and testing roles area summarised in Table 1-4.

Table 1-4: Assessment Team

Company	Role	Comments
GHD	Environmental Assessor	
ALS Environmental	Primary Laboratory	Engaged by GHD
Ecowise Environmental	Secondary Laboratory	Engaged by GHD
SGS Laboratories	Secondary Laboratory	Engaged by GHD

2 AUDIT SCOPE, METHODOLOGY & CRITERIA

The Audit scope and methodology for this 53V audit report was developed by the Auditor in conjunction with the EPA and the client, namely Nuplex Industries (Aust) Pty Ltd. The scope, methodology and criteria of this Audit, which was defined in the Auditor's 29 January 2008 letter to the EPA (our ref: 207214Scope01.3), was approved by the EPA on 30 January 2008. The following sections summarise the scope, methodology and criteria of this Audit.

2.1 Audit Purpose & Objectives

The purpose of the audit as understood by the Auditor is to provide the community, EPA, the client and other stakeholders with confidence in the process and outcomes of an assessment of the risk of any possible harm or detriment to land and groundwater caused by the premises' use as a chemical storage and distribution facility. The assessment would be made of the risks to beneficial uses of groundwater, and therefore to human health and the environment posed by the current condition of the site. The audit should also propose measures required to reduce any risks and subsequently maintain risks at an acceptable level for land and groundwater impacts, with a view to restoring relevant beneficial uses of the groundwater at the site, if necessary.

The purpose of this Environmental Audit is to comply with Requirements 5 to 9 as set out in the CUN dated 20 June 2007.

The objectives of the audit are to assess the risks of harm to the environment at and from the subject site so far as there may be impacts on the use of land, groundwater, surface water (arising from groundwater discharge), and air (derived from contamination of land or groundwater).

The specific requirements of the CUN relevant to the Environmental Audit are:

1. *By 4 July 2007, engage a suitably qualified professional to develop a scope of works for an environmental assessment of the site, which must have regard to requirements (2) and (4). The scope of works must have regard to, but is not limited to the following publications:*
 - a) *SEPP (prevention and Management of Contamination of Land);*
 - b) *SEPP (Groundwaters of Victoria);*
 - c) *SEPP (Waters of Victoria)*
 - d) *SEPP (Air)*
 - e) *EPA Victoria Publication 441 A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes¹;*
 - f) *EPA Victoria Publication 669 Groundwater Sampling Guidelines*
 - g) *AS 4482.1-2005: Guide to the investigation and sampling of sites with potentially contaminated soil – Non-volatile and semi-volatile compounds.*
2. *By 1 November 2007 the occupier must delineate the extent of on and offsite groundwater contamination caused by the premises' former use.*
3. *By 1 November 2007 the occupier must submit a report to EPA that delineates the extent of on and offsite groundwater contamination caused by the premises' former use*

¹ This EPA Victoria publication has been replaced by Industrial Waste Resource Guidelines (IWRG) 701 *Sampling and Analysis of Waters, Wastewaters, Soils and Wastes*.

4. *My 1 March 2008 the occupier must have developed a Clean Up Plan and commence remediation works on the premises, and notify EPA by letter of commencement of works. These works will include, but are not limited to the following*
 - a) *Prevent the further offsite migration of contaminated groundwater*
 - b) *Clean Up of the existing polluted groundwater*
5. *By no later than 1 August 2007, the occupier must engage an environmental auditor appointed under the Environment Protection Act 1970 ("The Act") to prepare the environmental audit report referred to in requirement 8.*
6. *The auditor is to review all reports prepared by the assessors*
7. *By no later than 1 September 2007, the occupier must submit to EPA for written approval to the proposed approach to the audit referred to in requirement 8 including*
 - a) *the name of the auditor; and*
 - b) *the proposed scope of the audit in accordance with the most recent edition of EPA publication 952 "Environmental Auditor Guidelines for the Preparation of Environmental Audit Reports on Risk to the Environment"*
8. *By no later than 1 June 2008 the occupier must submit to the Authority, an environmental audit report prepared by an environmental auditor appointed under the Environmental Protection Act 1970 in relation to the risk of any possible harm or detriment to the groundwater and land environments caused by the manufacture, storage and distribution of chemicals at the premises, as determined by:*
 - a) *Review of any systems, plans, procedures, monitoring programs, data, records, reports or other information relevant to the scope of the audit;*
 - b) *Review of all reports required by this Notice, including but not limited to the Clean Up and site assessments;*
 - c) *Inspection of any relevant activities, processes, plant and/or equipment on site; and*
 - d) *Collection and/or modelling of any data as the auditor sees fit.*
9. *The environmental audit report referred to in requirement 8 must:*
 - a) *Indicate if the activities conducted and substances stored at the premises causes a risk of any possible harm or detriment to the groundwater, air or land environment, as determined by an assessment of attainment of the requirements of the Clean Up Plan, as described in Requirement 4;*
 - b) *Where contamination of a segment of the environment has been determined, delineate the extent of contamination/impact;*
 - c) *Where a risk of any possible harm or detriment to a segment of the environment has been determined in <9(a)>, recommend any measures necessary to reduce the risk to an acceptable level; and*
 - d) *Include recommendations for improving environmental performance, management systems, monitoring programs or other recommendations at the auditor sees fit.*

The following section provides a discussion of the scope to be applied to this audit for the purpose of achieving these objectives, and complying with relevant legislations, policies, regulations and EPA requirements.

2.2 Audit Scope

This section provides a discussion of the scope to be applied to this audit for the purpose of achieving these objectives, and complying with relevant legislations, policies, regulations and EPA requirements.

The audit conducted under s53V of the Act will address the objectives set out above, from our understanding of the site and discussions with Nuplex Industries and other stakeholders.

The key elements of the scope of the audit, in accordance with EPA Publication 953.2 are:

- The activity undertaken (and the components of the activity) in respect of which the audit is conducted
- The segments of the environment to be considered
- The elements of the environment to be considered
- The beneficial uses to be considered
- Risk assessment to be conducted
- The period of time over which the audit is to be conducted
- Exclusions from the scope of the Audit.

It is understood that the scope presented in this letter and the criteria for the audit are subject to further negotiations and agreement between EPA, client and the Auditor.

The Activity Audited:

- Manufacture, storage and distribution of chemicals at the premises.

The Segment Audited:

- The land defined as 18-22 Hamlet Street and 322-328 Bay Road in Cheltenham VIC
- The surface water within Port Philip Bay, if groundwater data collected during the environmental assessment indicates that it is receiving impacted groundwater discharge from the premises.
- The groundwater in the vicinity of the premises that might reasonably be concluded to have been impacted by the site activities.
- The air environment: soil gas derived from contaminated soil and groundwater with potential to impact on indoor air.

The Elements Audited:

- Land
- Groundwater and related land uses
- Surface Water
- Air (including aesthetics and odours)².

The Beneficial Uses:

- Beneficial Uses of land are as set out in Table 1 of *SEPP Prevention and Management of Contaminated Land*.
- Beneficial Uses of groundwater are as set out in Table 2 of *SEPP Groundwaters of Victoria* which is subject to an interpretation of the background salinity of groundwater in each relevant aquifer unit.
- The Beneficial Uses of surface water are those set out in Table 1 of *SEPP Waters of Victoria*.
- The Beneficial Uses of air are those set out in Part III of *SEPP Ambient Air Quality*.

² Aesthetic enjoyment is a "Beneficial Use" of any element considered in an assessment of risk.

The Risk Assessment (& review of HRA) to be Conducted:

- Human Health Risks assessment related to relevant beneficial uses of groundwater and land (surface water and air).
- A review of the Vapour HRA (GHD 2009) was conducted by John Frangos of Toxikos
- A workshop was conducted to discuss the risks between John Frangos, GHD and the Auditor.

The Period of Time:

- The audit is intended to be completed on the basis of currently available information or that which is currently being acquired. Consequently, the audit report was completed on 8 September 2011.

Exclusions from the Audit Scope:

It is noted that the current audit is focussed on the a determination of the risk of any possible harm or detriment to land, groundwater and surface water caused by current and past industrial processes and activities, waste or substance at the premises. The audit does not include:

- The assessment of other groundwater contaminants potentially arising from other nearby sources.
- Assessment or endorsement of a Clean Up Plan or clean up implementation
- A total assessment of the site to determine suitability for future use of the site (s53X Audit).

2.3 Audit Team

Anthony Lane has conducted the audit and prepared this report with assistance from a team of environmental specialists. Table 2-1 identifies the persons assisting in this audit.

Table 2-1: Audit Team

Person	Role	Company
Peter Gringinger*	Remedial technologies and geotechnology; and Hydrogeology	Lane Piper
Wendy Morrison*	Remedial technologies and geotechnology; Hydrogeology; and Contaminant transport and assessment of exposure pathways and risk.	Lane Piper
Jon Bartley*	Hydrogeology	Lane Piper
Danny McDonald	Audit Project Manager / Environmental Geoscientist	Lane Piper
John Frangos*	Toxicology & Risk Assessment Specialist: review of HRA	Toxikos
* Indicates a member of the Auditor's expert team approved by EPA		

2.4 Audit Methodology

The methodology of work undertaken for this audit was as follows.

Task 1: Familiarisation & Preliminary Document Review

This task involved the inception of work, familiarisation with the site and preliminary review of the available documents.

1. Familiarisation with all relevant reports and documents provided at commencement of the audit by the client, Assessor and EPA directives, and advice relevant to the audit.
2. Project inception meeting, to confirm the scope and method of work, and site inspection by key members of the audit team at the commencement of the audit.
3. Inspection of each of the monitoring points (bores, sumps, creeks etc).
4. Familiarisation with the reports and documents provided by client and assessor / engineer and EPA directives, and advice relevant to the audit. Obtaining copies of documents and data in the required formats.
5. Liaison with the client and any Assessors on the progress of investigation works and any Work Plans for further investigations.

Task 2: Site Inspections

6. Inspections of the site by the Auditor, an assistant and members of the Auditor's Specialist Support Team (as required) to observe relevant activities, so far as it is relevant to the scope of the audit. Access to all relevant areas will be facilitated by the client.
7. A second site inspection was conducted by the Auditors Assistant during GHD field works

Task 3: Detailed Document & Data Review

8. Review existing environmental site assessment and remediation reports undertaken at the premises. Assess the adequacy of the site assessments for their capacity to provide data sufficient to define the extent of contamination from the premises and provide the basis for an assessment of risks to land, air, groundwater, and surface waters, to achieve the objectives of the Audit.
9. Review of the final Site Assessment Report/s prepared by the Assessors, and examination of the available data to verify its quality and reliability, by discussion with Nuplex and the Assessors and other parties as required.
10. Review of available hydrogeological assessments. Review of the groundwater data, bore logs and related hydrogeological information to decide whether sufficient information exists about the occurrence and movement of groundwater and the condition of the groundwater as a basis for the ESA.
11. Review of the monitoring bore/well network to ascertain whether it is appropriate for the assessment and monitoring of groundwater.
12. Subject to the Auditor's analysis of the data collected during the assessment process, requesting further work to investigate contamination as the basis for an assessment of the risks to groundwater, surface waters, air and land, noting any relevant matters to be taken into account during the conduct of the assessment.
13. Check of compliance with the EPA requirements under the CUN.
14. Review any reports, measurements, monitoring and other relevant data generated by Mobil and their Assessor/s during the assessment works.
15. Review of air quality monitoring plans and data with the assistance of a member of the Auditor's Specialist Support Team, namely Mr John Frangos.

16. Collect and review any other data or information which the environmental Auditor considers relevant, based on an analysis of data provided during the assessment process.
17. Preparation of auditable queries, if required, on each document reviewed.
18. The Vapour HRA prepared by GHD on behalf of Nuplex was be subject to review by the Auditor engaging the appropriate members of his Specialist Support Team to review the draft Vapour HRA report (John Frangos of Toxikos).

Task 4: Assess Risk to Land, Groundwater, Air and Surface Water

19. Undertake an assessment of risk, to determine the acceptability of the risk to protected beneficial uses of land, groundwater, air and surface water within and beyond the boundary of the premises. The extent of this work is includes a qualitative assessment based on water quality criteria and hydrogeological interpretations, as well as independent review or checking of risk assessment calculations, including human health risk and ecological risk. The significance of risks would be assessed in the context of the likelihood of beneficial uses being realised, and the practicability of any remediation.
20. Check that the water quality clean up criteria used, in any initial assessment of risk, are appropriate under the following SEPPs: Air Quality Management, Groundwaters of Victoria, Waters of Victoria, and Prevention and Management of Contamination of Land.
21. Prepare a summary of preliminary findings on the key aspects of the audit including any draft recommendations necessary to rectify critical data deficiencies before risks can be assessed, or measures needed to assure risks remain acceptable, or those needed to reduce unacceptable risks.
22. Check that the interpretation of groundwater and surface water protection (pollution), with respect to these criteria is appropriate.

Task 5: Prepare Draft Audit Report

23. Upon completion of the Audit (subject to any directions by EPA), a Draft Audit Report was prepared which reviews the adequacy of the assessment and presents a discussion on the environmental quality of the segment and elements under consideration. The draft report was submitted to the client for factual review.

Task 6: Prepare & Issue Final Audit Report

24. The Audit Report will be finalised with due regard to the client's comments on the draft.
25. The Audit Report will be completed, making findings and including any recommendations considered necessary for the on-going clean up and management of contaminated groundwater, surface water and/or land.
26. Issue of Audit Report: Upon completion of the audit (subject to any directions by EPA), a detailed Audit Report was prepared which reviews the adequacy of the assessment and provides justification for the audit outcome, including recommendation for measures necessary to ensure that any risks to beneficial uses is reduced, minimised and maintained at an acceptable level.
27. Lane Piper issued this e-Reports on self-loading CD-ROMs published using Abode Acrobat™.

2.5 Audit Criteria

The criteria for the audit are found in the Act and the relevant policies for land and water protection. These policies in turn refer to guidelines such as contaminated land assessment and water quality guidelines.

Again, in accordance with guidance from EPA, any audit undertaken by an EPA-appointed Environmental Auditor in his statutory capacity is a statutory audit. In this case the audit is to be conducted under s.53V of the Act.

The adopted Criteria for use in assessing data and other information provided in the course of the audit include:

Applicable Environmental Regulations

- *Environment Protection Act 1970*
- *Water Act 1989*
- *SEPP Groundwaters of Victoria*, and related water quality guidelines
- *SEPP Waters of Victoria*
- *SEPP Prevention and Management of Contamination of Land*
- *SEPP Air Quality Management*
- *Industrial Waste Management Policy (Prescribed Industrial Waste)*.

Guidelines

- EPA (2000) *Groundwater Sampling Guidelines*. Publication 669, April 2000.
- EPA (2009) *IWRG701 Sampling and Analysis of Waters, Wastewaters, Soils and Wastes*.
- EPA (2002) *The Clean Up and Management of Polluted Groundwater*. Publication 840, April 2002.
- EPA (2006) *Hydrogeological Assessments (Water Quality) Guidelines*. Publication 668, September 2006.
- EPA (2007) *Environmental Auditor Guidelines for the Preparation for Environmental Audit Reports on Risk to the Environment*. Publication 952.2, August 2007.
- EPA (2007) *Environmental Auditor Guidelines for Conducting Environmental Audits*. Publication 953.2, August 2007.
- Australian & New Zealand Environment & Conservation Council (1992) *Guidelines for the Assessment & Management of Contaminated Sites*.

Site-Specific Environmental Licences, Plans and Reports

- CUN issued by EPA to Nuplex on 20 June 2007.
- Reports on the assessment of contamination of land, air and water in the vicinity of the “premises” as described in Table 3-1.

3 REVIEW OF SITE ASSESSMENTS

3.1 Documents Reviewed

Key reports prepared by the Assessor and which have been relied upon by the Auditor are presented in appendices to the audit report as indicated in Table 3-1.

Table 3-1: Documents Reviewed

Author	Date	Document Title	Presented in
ERM	May 2001	Project Bluff ESA	
Kilpatrick & Associates Pty Ltd	April 2003	Underground Storage Tank Soil Validation Assessment at APS Chemical Factory, Hamlet Street, Cheltenham, Victoria	
Kilpatrick & Associates Pty Ltd	December 2005	Groundwater Assessment Works.	
Kilpatrick & Associates Pty Ltd	March 2006	Draft. Groundwater Investigation Works	
SMEC	March 2007	Final Draft. Further Contamination Characterisation 18-22 Hamlet Street, Cheltenham, Victoria	
SMEC	November 2007	Summary Report – Northern Boundary Soil Gas survey – 18 to 22 Hamlet Street, Cheltenham, Victoria	
SMEC	November 2007	Non-Intrusive Works – 18-22 Hamlet Street, Cheltenham, Vic	
GHD Pty Ltd	June 2008	Geophysical Survey	Appendix E
GHD Pty Ltd	December 2008	Soil and Groundwater Investigation	Appendix F
GHD Pty Ltd	March 2009	Vapour Health Risk Assessment	Appendix G
GHD Pty Ltd	March 2009	Draft Fate and Transport Modelling	Appendix H
GHD Pty Ltd	December 2010	Additional Soil and Groundwater Investigation	Appendix I
GHD Pty Ltd	June 2011	January 2011 Groundwater Monitoring Letter Report	Appendix J

3.2 Environmental Investigations & Results

The Assessor's field investigations were conducted as a multiple event program. The field investigations by the Assessor have been ascribed the following Phase numbers and headings by the Auditor:

- Phase 1: Preliminary Environmental Site Assessment (ERM 2001)
- Phase 2: Environmental Site Assessment (Kilpatrick's 2002 – 2005)
- Phase 3: Environmental Site Assessment (SMEC 2006 – 2007)
- Phase 4: Environmental Site Assessment (GHD 2007 – 2009)
- Phase 5: Environmental Site Assessment (GHD 2009 – 2011).

3.2.1 Site Areas & Infrastructure

The site former and/or current operational areas comprise five main areas (refer to Figure 2, Appendix A):

- Northern – Former Drum Storage Area³, Indoor Acid Storage, and Non-Toxic Storage Area
- North Central – entrances and roadways, ASTs⁴, Triple Interceptor Trap¹(TIT1) and Former Bulk Acid Batching/Wash Area
- Central – Office, Former Product Laboratory, TIT2, Non-Hazardous Store (with an adjacent substation), Poisons Store (with a sump and a substation), Flammables Store, and carpark
- Southeast Corner (SEC) – Former USTs (Area 1)⁵, Former ASTs⁶, Former Drum Shed, Former Concrete Sump, Former Decanting Area and Former Refrigerant/Acid Dock⁷.
- South-West Corner (SWC) – Former Button Factory including Former USTs (Area 2)⁸, Storage Area, and a TIT3.

Table 2 of the Assessors ESA report (GHD 2010) provides a detailed contamination summary for most of the above noted site areas. A summary by the Auditor is presented in Table 3-2.

Site infrastructure (beyond the localised TITs and USTs) includes the underground piping beneath buildings and roadways connecting to sewer lines (i.e. sump at the Poisons Store) and TITs, sewer lines and stormwater lines.

3.2.2 Summary of Work Conducted

The following summary of investigations and comments is based on the summary reported in GHD (2010). The Assessor's sampling locations are shown on Figures 3, 4 & 5, Appendix A.

Table 3-2: Summary of Work Conducted

Work Conducted	Findings & Comments
ERM – February 2001 to May 2001	
Site history review was conducted including aerial photograph review, title search and site inspection.	Searle Australia and Clyde industries (both chemical companies) owned portions of the site. Buildings and ASTs were identified across the site.
A field screening soil gas survey for Volatile Organic Compounds (VOCs) and Semi-Volatile Organic Compounds (SVOCs) using a photo-ionisation detector (PID) and flame ionisation detector (FID) was conducted across the site (0.4 and 0.8m depth) using temporary implants. A total of 56 grid and target locations were tested.	The two main areas of elevated soil vapours were the SEC and the Former Drum Storage Area. Other areas were identified with lower vapour concentrations such as: ASTs in the North Central Area; and USTs at SWC and Central Area beneath the Poisons / Flammables Store). The soil gas survey identified several areas with elevated soil gas readings including the drum storage area, poisons store sump, UST (SW area) and the south east corner.
Ten soil bores (BH1 to BH10) were	PID readings from soil samples were less than 50 parts

³ Figure 2 of ERM (2001) referred to this as the Outdoor Acid Storage Area (Class 8).

⁴ ASTs (Above-ground storage tanks) – up to seven of these were present in this area of the site since 1957.

⁵ Area 1 USTs (in the SEC): PHCs and potentially VCHs. Dispensing point along the southern wall of the Flammables Store. 'Area' nomenclature taken from ERM (2001).

⁶ Two ASTs were shown on the SMEC 2006 report Figure 2c (developed from the 1968 aerial photograph).

⁷ Acid Dock (refrigerant gases) was located on the site from 1975 to 1993.

⁸ Area 2 USTs – contained PHCs (acetone for batch mixing, as well as methanol, toluene and ammonia) in the SWC, one former UST beyond the southwest site boundary, and one former diesel UST in the Former Button Factory Area as reported by ERM (2001).

Work Conducted	Findings & Comments
advanced to between 4 and 10.5 m using hollow flight augers. Boreholes targeted locations identified by the soil gas survey.	per million (ppm). Selected samples analysed for: metals, SVOCs, Total Petroleum Hydrocarbons (TPHs), VOCs and PCBs. Results for SVOCs, VOCs, PCBs and TPH were below laboratory detection limits (LORs), while metal concentrations were below NEPM HIL-F. Composite samples analysed: metals and SVOCs. The Auditor notes that augers can allow downward remobilisation of DNAPL and also smear DNAPL into sand above DNAPL layers during removal.
Five soil bores were converted to groundwater wells (MW1 to MW5). Monitoring wells were gauged and sampled twice (Rounds 1 and 2). Two multilevel groundwater wells (MW6 and MW7) were installed at the inferred up-gradient boundary (east). These wells were gauged and sampled once.	Concentrations of TPH C ₆ -C ₃₆ , (up to 9,000 µg/L) and BTEX; various VOCs including trichloroethene (TCE), vinyl chloride (VC), chloroform (CF), trimethylbenzene, and vinyl acetate; naphthalene and Polyaromatic Hydrocarbons (PAHs); and heavy metals were detected in wells MW1 (now MW18), MW2 and MW3 during the two groundwater monitoring events (GMEs). The Auditor notes that CT was identified in the Former Drum Storage Area (including MW3). CF detected near the ASTs may be related to CF flocculation just upgradient of this area. Borelogs were not provided for MW6 and MW7.
ERM installed ten (10) 25 millimetre (mm) diameter multilevel wells (MW8 to MW17). Two additional GMEs (Rounds 3 and 4).	Reports on the installation of these wells, borelogs or sampling and results are not available. Data from these GMEs is presented in Kilpatricks (2006).
Kilpatricks – June 2002 to December 2005	
Kilpatricks observed the removal of two USTs from “Area 1” in 2003 (reported to be in good condition); and collected and tested validation samples. These USTs were reportedly used for diesel. A UST was removed from “Area 2” and two USTs were removed from “Area 3” by a contractor. No comment can be made on UST integrity as Kilpatricks did not observe removal. Validation samples were collected and tested by Kilpatricks. These USTs reportedly contained petroleum hydrocarbon (PHC) products.	The report is incomplete and does not provide details on UST locations, the depth or location of validation samples, UST or soil disposal, or the type and quality of backfill material. Validation samples were analysed for TPH, BTEX, lead, PAHs and phenols. All results (including samples from stockpiled soil) were below LORs.
Kilpatricks supervised the removal of a concrete sump in the southeast corner (SEC) of the site in 2003.	Kilpatricks noted PCE, TCE, and 1,1,1-TCA impacted soil [indicating surface release] was excavated and removed from the site just south of the shed – where concentrations in soil appeared to increase toward a concrete sump (identified during removal of USTs from the site). Kilpatricks noted that not all of the impacted soils were able to be removed due to access restrictions.
Kilpatricks undertake round of groundwater gauging in February 2005 (MW2 to MW13, and MW15 to MW17). Kilpatricks installed two (2) replacement groundwater monitoring wells MW18 (MW1) and MW19 (MW14) in August 2005.	

Work Conducted	Findings & Comments
Kilpatrick's conducted a GME (Round 5) in October and November 2005.	Neither LNAPL ⁹ nor DNAPL were observed during gauging of monitoring wells. However, Kilpatrick's concluded that: 1) DNAPL was probably present based on the dissolved phase concentrations, and 2) deeper groundwater monitoring wells were required. Several well screens appear to be blocked. Standing water levels were above the well screen in several wells. Exceedances included TPHs; VOCs such as TCE, perchloroethene (PCE), 1,1-DCE (dichloroethene), cis-DCE, and VC; and metals ¹⁰ (Cd, Cr, Cu, Ni, Pb, Zn).
SMEC – June 2006 to August 2007	
SMEC completed a Ground Penetrating Radar (GPR) survey of the site to scan for USTs previously not identified.	The GPR Survey data is not available, so it is unclear what areas were surveyed. No USTs were detected in the areas scanned; however, four potential backfilled trenches were identified.
SMEC conduct a review of all previous environmental assessment work carried out at the site to assess adequacy of previous work and identify any potential data gaps. Summary of previous investigations as identified by SMEC (2006) include: - Chemical storage (methanol, acetone, acids, alkalis and PHCs occurred at the site since at least 1970. - Concentrations of VOCs, PCBs, TPHs and SVOCs in soil samples collected were less than LORs. - Concentrations of metals in soil samples were less than the site assessment criteria (NEPM HIL-F). - Elevated concentrations of TCE were identified in soil samples near southeast site boundary. A visual inspection of the area revealed some limited soil remedial works may have been undertaken in this on-site area. - Two areas of PHC and TCE impacted groundwater are likely to exist on site. One area in the SEC and one in the northwest portion of the site.	The Auditor has not been provided with a copy of this report. Key data gaps identified by SMEC (2006) include: - Insufficient evidence for validation after UST removals, importation of backfill material and remediation of sump area and TCE contamination. - Sampling coverage less dense than the AS4482.1 (2005) grid. - Groundwater wells not sufficiently deep to target potential DNAPL.
SMEC conduct a GME (Round 6) in September 2006 which included gauging all wells and sampling of the following wells: MW3, MW5, MW9/2, MW8/1, MW11/1, MW12/2, MW13/2, MW15/2, MW17/1 and MW19.	
SMEC advanced 25 soil boreholes (BH102 to BH126) with a Geoprobe and hand	Soil contaminated by organic analytes (mainly TPH, and VHCs) was identified in the northeast and southeast

⁹ LNAPL – Light Non-Aqueous Phase Liquid; and DNAPL – Dense Non-Aqueous Phase Liquid.

¹⁰ Cd – cadmium; Cr – chromium; Cu – copper; Ni – nickel; Pb – lead; and Zn – zinc.

Work Conducted	Findings & Comments
auger to a maximum depth of 6.0 m in September 2006.	portions of the site.
SMEC installed and monitored four groundwater monitoring wells (MW20 to MW23) in October 2006.	
Hyder Consulting conducted an air quality study to assess the potential exposure to volatiles at the site (engaged by SMEC). Passive badges were used to sample for VOCs in four targeted locations: - Administration area - Poisons Store (internal) - Poisons Store (external) - Southwest corner of site – decommissioned UST.	VOCs were not detected, and SMEC concluded that there was a minimal risk that occupational exposure levels would be unacceptable.
Slug tests were conducted in monitoring wells MW5, MW19, MW20 and MW21. SMEC conduct another GME in January 2007. All wells were gauged and the following wells were sampled: MW4, MW5, MW6/3, MW9/2, MW11/1, MW8/1, MW12/1, MW13/3, MW15/2, MW16/1, MW17/1, MW20, MW21, MW22 and MW23 Water level loggers were installed in monitoring wells MW19, MW5 and MW11/1.	Hydraulic conductivities (K values) were estimated to range from 0.056 to 0.54 m/day. Groundwater samples from wells MW13, MW15 and MW19, located in the SEC of the site reported concentrations of TPH C₆-C₃₆; Mono-Aromatic Hydrocarbons (MAHs) such as toluene, ethylbenzene and xylenes; and VCHs (in particular, TCE). Groundwater samples from wells MW17 and MW23, located in the southwest corner of the site reported concentrations of TPH C₆-C₃₆, benzene and naphthalene. Groundwater samples from wells MW21, MW8 and MW9, located in the northwest portion of the site reported concentrations of TPH C₆-C₃₆ and VCHs (particularly carbon tetrachloride (CT), CF and TCE). Groundwater concentrations of CF were detected across most of the site; with the highest concentrations detected in groundwater sampled from well MW3, located in the central northern portion of the site, where the former ASTs were located. Regular cyclical fluctuations in water level of 2 mm were observed at approximately 6 hour intervals, and thought to be associated with tidal movement. This seems unlikely to the Auditor.
GHD – September 2007 to October 2009	
Soil Investigations: - Eleven soil bores (VP101 to VP111) were advanced by direct push to approximately 3.5 mBGS in the southwest corner of the site in the vicinity of the former USTs. - Eight soil bores (VP112 to VP119) were advanced by direct push to approximately 3.0 mBGS in the central northern portion of the site in the area of the former ASTs.	Average fill thickness was 0.8 m. Soil samples extended to 3.5 mBGS, which may not be below the base of the former UST. Soil results reported organics (including BTEX) below laboratory detection limits. Minor heavy metals exceeding EILs. Fill thickness varied from 0.2 to 0.9 m. A triple interceptor tank identified at VP118. Organic chemicals were less than the LOR. Minor heavy metals exceeding EILs were identified. A single fragment (20 x 20 x 5 mm) of asbestos cement containing grey asbestos (chrysotile) was identified in the fill.

Work Conducted	Findings & Comments
Nine shallow soil bores were drilled advanced by direct push (in clusters of three), 0.5 to 1.5 mBGS (GBH1A/B/C to GBH3A/B/C) in the SEC of the site in the Former 'Drum Shed' area.	Southeast portion of site consists of uncovered disturbed soil. Fill thickness ranges from 300 to 500 mm. Strong volatile odours were observed during soil bore installation, with associated elevated PID readings (up to 2,264 ppm). Soil results reported elevated concentrations of organics (including ethylbenzene, TPH C₉-C₃₆, TCE, PCE and chlorobenzenes).
Installation of Groundwater Wells: - Existing on-site and off-site 25 mm nested groundwater wells (MW6 to MW13 and MW15 to MW17) were redeveloped. - A nested groundwater monitoring well (MW24A, MW24B, MW24C) was installed in the SEC in July 2008. - Two groundwater monitoring wells (MW25 and MW26) were installed offsite to the south to provide further delineation of the TCE plume in August 2008. - Two groundwater monitoring wells (MW27 and MW28) were installed along the northern site boundary to assess possible migration of contamination on to the site in April 2008. - Two groundwater monitoring wells (MW29 and MW30) were installed off site to the southwest to provide delineation of the benzene plume in October 2008.	
Aquifer Properties Investigation: - Down-hole geophysical survey (natural gamma) was conducted at selected monitoring wells at the site. - Slug tests conducted at four (4) on-site (MW23, MW24A, MW24B and MW27) and four (4) off-site (MW25, MW26, MW29 and MW30) wells.	Subsurface profile was defined by characteristic "fining up" sequence across the site, which typically indicates an alluvial/fluvial depositional environment (i.e. forming the Brighton Group) and is heterogeneous and characterised by localised lenses of high or low permeability. Aquifer K values ranged from 0.05 to 0.7 m/day, with aquifer permeability appearing to increase with depth.
Groundwater Gauging: - Monthly gauging from July 2008 to July 2009 - Groundwater level data loggers installed in MW19, MW20 and MW23 from November 2008 to October 2009.	Slight decline in site groundwater levels over the monitoring period. Wells believed to intersect perched water (MW18, MW12/1 and MW4) showed a significant variation in standing water level (SWL).
Groundwater Monitoring: Groundwater sampling and analysis of MW3, MW4, MW5, MW6/3, MW6/4, MW7/3, MW9/2, MW10/1, MW11/2, MW12/1, MW13/2, MW15/3, MW16/1, MW17/1, MW18, MW19, MW20,	Elevated TCE (up to 332,000 µg/L) and associated degradation/daughter products detected in groundwater in southeast portion of site. TCE concentrations (15,900 µg/L) detected in wells located off-site and hydraulically down-gradient of TCE source zone. TCE concentrations (up to 250 µg/L) detected in

Work Conducted	Findings & Comments
MW21, MW22, MW23, MW27, MW28 in July 2008. - Groundwater sampling and analysis MW3, MW4, MW5, MW6/3, MW7/3, MW9/2, MW11/2, MW12/1, MW13/2, MW15/3, MW16/1, MW17/1, MW18, MW19, MW20, MW21, MW22, MW23, MW24A, MW24B, MW24C, MW25, MW27, MW28 in August 2008. - Groundwater sampling and analysis of MW17/2, MW24A, MW24B, MW24C, MW25, MW26, MW29, MW30 in October 2008.	northwest portion of site. Elevated chloroform (9,920 µg/L) detected in central northern and southeast corner of site. Elevated benzene (442 µg/L) detected in southwest portion of site. BTEX or TPH were not detected in off-site wells MW29 and MW30, located off-site and hydraulically downgradient of benzene plume in southwest portion of site.
Soil Vapour - Three sets of nested soil vapour bores installed in south-east portion of site - Vapour bores were monitored in October 2008.	Detected analytes in the soil vapour include PCE, TCE and associated degradation products (such as 1,2-DCE, 1,1-DCE and VC), as well as benzene, ethylbenzene and xylenes.
Three ambient air samples collected in November 2008.	The ambient air sample results showed no exceedences of National Occupational Health and Safety Commission (NOHSC) guidelines Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment.
Vapours in groundwater well headspace were analysed in December 2008.	Detected contaminants in the groundwater well headspace analyses included TCE and associated degradation products, PCE and toluene. Results indicate the major source of vapours is likely to be resulting from residual soil rather than groundwater
Contaminant Fate and Transport Model completed to gain a better understanding of the off-site migration potential for TCE.	Source is non-steady state, resulting in irregular 'peak and trough' behaviour observed in contaminant concentrations. The Auditor notes that the erratic behaviour (finding of screening level fate and transport model by GHD) is often observed near DNAPL source zones (potential indicator). TCE migration is estimated to extend off-site from between 70 and 200 m.
A Vapour HRA was conducted to assess the potential vapour risk associated with the intrusion of VOCs into the buildings/workspaces at the site.	Vapours emitting from the subsurface soil-gas and groundwater do not pose an unacceptable health risk to industrial works at the site and adjacent sites under the current site configuration. The Auditors review of the HRA is provided in Section 8 of this report.
GHD – November 2009 to January 2011	
TCE Source Zone Soil Investigation - Twelve soil bores (BH101 to BH112) were advanced by direct push to a maximum depth of 13.0 m bgl in the south east portion of the site to investigate secondary TCE sources in this area. - A total of 67 samples were analysed for	Organic analytes including PCE, TCE 1,1,2 trichloroethane (TCA), 1,2-dichloroethane (DCA) and TPH were reported above LORs. TCE concentrations were up to 8,180 mg/kg. Samples at the east and south of the investigation area generally had the highest results for organic contaminants GHD estimated that 1,795 m³ of soil was impacted; however, this estimate was considered to be approximate

Work Conducted	Findings & Comments
organic contaminants. Six samples were analysed for physical properties to assist in model refinement.	as the source area was not delineated. A TCE mass of 1,185 kg was calculated, with 87% of this believed to exist in the upper 4 m of the soil profile.
Groundwater Investigation - Installation of eight monitoring wells on site (GW31, GW32, GW33, and GW35 to GW39); and five off-site wells (GW34A, GW34B, GW40, GW41 and GW42). - A total of 32 wells were gauged and sampled in December 2009. - A total of 37 wells were gauged and sampled in March 2010. - A total of 27 wells were gauged and sampled in January 2011.	Concentrations of VCHs are variable between GMEs. Measurable concentrations of TCE have migrated at least 120 m off site to the south to Philip Street.

Audit Findings:

The Auditor considers that there are still significant gaps in the understanding of sources (and associated plumes), preferential pathways and groundwater flow directions. The Assessor's report does not comply with NEPM B2, Section 3.4.5, which states that "A *chronological list of industrial or contaminating activities should be compiled including any periods during which the land use is unknown or uncertain.*"

While the audit report can be completed at any stage of assessment, it was planned to complete the report when the problem had been delineated and plume stability, health risks and practicability of future management of the contamination had been achieved. This does not appear to have been achieved to date.

The Auditor notes that the CUN requires the occupier to delineate the extent of on-site and off-site groundwater contamination, determine if there is a risk of harm to the environment or human health, develop a clean-up plan, and commence remediation. However, given the site history, the multiple phases of investigation and the inconvenient placement of the primary source adjacent to the southern or down-gradient boundary, the problem has not been delineated satisfactorily. Consequently the potential risks of harm especially to the environment and community offsite to the south have not been fully assessed. This delays the development of a remediation strategy and commencement for site remediation.

Recommendations:

1. Identify potential source zones (Former Drum Storage Area, North Central ASTs, sump in the Poisons Store, and others). Conduct targeted source zone investigations in the northern half of the site to confirm whether there are ongoing sources of contamination in these areas (nature and extents), and if so what management strategies are required.
2. Groundwater data gaps in the Northern and Central Areas are to be investigated to delineate sufficiently and to assist in identifying whether there are ongoing sources of contamination in these areas.
3. Areas with impacted soil vapours (i.e. the SEC and the Former Drum Storage Area, sump in the Poisons Store, and the Area 2 USTs) require further delineation using field screening with temporary locations and analytical laboratory data at permanent monitoring locations.

The Auditor notes that the preliminary soil gas survey data are indicative of surficial releases, which should be further investigated.

4. A detailed assessment of human health risks associated with the current use of the site and areas immediately to the south and possible future use complying with the current land use zone is required using the current data and the data to be gained in further investigations (on- and off-site risks). This must lead into OHS management measures in a Site Management Plan (SMP) for the purpose of avoiding and managing unacceptable risks due to contamination (Commence immediately and update based on additional relevant data).

3.3 Data Quality Review

This section reviews the Quality Assurance (QA) and Quality Control (QC) documentation. Quality assurance encompasses the actions, procedures, checks and decisions undertaken to ensure sample integrity and representativeness, and the reliability and accuracy of analysis results. The QA documentation should also include an indication of the Data Quality Objectives (DQOs) sought in relation to each significant action, test or process involved in the assessment.

The QC activities measure the effectiveness of the QA procedures by undertaking testing, and then comparing results to previously established objectives. QC work will include the internal laboratory testing as well as results of QC samples submitted by the Assessor such as trip blanks and duplicates. The quality of the information and/or data is deemed satisfactory when the QC results demonstrate that agreed objectives have been met.

The Auditor undertook a review of the Assessor's QA/QC as part of the data validation exercise. The findings are summarised in Table 3-3.

Table 3-3: Review of QA/QC Aspects

QA/QC Aspects	Evidence & Evaluation
QA Documentation	
Project Quality Plan/ Work Plan and DQOs	The Auditor was engaged by Nuplex Industries (Aust) Pty Ltd in July 2007; thus, work plans for Phases of work carried out prior to this date were not assessed by the Auditor. GHD provided work plans during the course of the assessment and further scopes of work were outlined in correspondence. A QC program was implemented during the investigation and the quality assurance procedures used have been reiterated in the Assessor's reports.
Data Validation Report	The Assessor provided data validation reports within their site assessment reports.
Data Representativeness	
Use of Composites	Composite sampling was not undertaken during site assessment works.
Holding Times	Soil: Chain of Custody and laboratory reports provide evidence of holding times. Holding times were generally in conformance with Table 4 in AS4482.1-2005. Exceptions are: ● Cyanide (8) ● Soil pH (71) ● Soil moisture (14) ● Monocyclic aromatic compounds (2)

QA/QC Aspects	Evidence & Evaluation
	• Oxygenated compounds (2) • Sulfonated compounds (2) • Fumigants (2) • Halogenated aliphatic compounds (2) • Halogenated aromatic compounds (2). Auditor is of the opinion that these exceedance of sample holding time is not critical to the outcome of the Audit Groundwater: Holding times for groundwater samples were generally in conformance with Appendix A in IWRG701. Exceptions are: • Nitrate (4) • Total Cyanide (8) • Dissolved metals (5) • Ferrous iron (1) • pH (85) • Naphthalene (13). Auditor is of the opinion that these exceedances of sample holding times are not critical to the outcome of the Audit.
Background samples	Soil: No offsite soil samples were collected. Groundwater: The interoperated groundwater flow direction suggests that MW7, MW20, MW27 and MW28 may be considered to intercept background groundwater.
Verification of field procedures	Decontamination procedures were undertaken by the Assessor during soil and groundwater sampling.
Data Precision & Accuracy	
QC Testing – Blind replicates (Primary Lab)	Soil (GHD 2008 & 2010) • Acceptance Criteria: Relative Percent Difference (RPD) < 50% • Soil Samples Analysed: 159 • Blind Replicate Samples Analysed: 10 • Blind Replicate Analyte Pairs: 535 • Number of Analyte Pairs Exceeding Criteria: 13 • Percentage of Analyte Pairs Exceeding Criteria: 2.4% RPD exceedances are confined to metal, moisture, TPH, TCE and PCE analytes. The level of exceedance is generally minor and probably related to sample heterogeneity and the low analyte concentrations of analyte pairs. RPD calculations were not calculated by the Assessor for a large number of analyte pairs as either or both of the pairs were less than the LORs. Groundwater (GHD 2008 & 2010) • Acceptance Criteria: RPD < 50% • Groundwater Samples Analysed: 125 • Blind Replicate Samples Analysed: 9 • Blind Replicate Analyte Pairs: 678 • Number of Analyte Pairs Exceeding Criteria: 5 • Percentage of Analyte Pairs Exceeding Criteria: 0.73% RPD exceedances are confined to TPH, methane, potassium and arsenic. The Auditor notes that the level of exceedance is generally minor and probably related to the low analyte concentrations of analyte pairs. RPD calculations were not calculated by the Assessor for a large number of analyte pairs as

QA/QC Aspects	Evidence & Evaluation
	either or both of the pairs were less than the LORs.
QC Testing – Field Splits (Secondary Lab)	Soil - Acceptance Criteria: RPD < 50% - Soil Samples Analysed: 159 - Field Split Samples Analysed: 10 - Field Split Analyte Pairs: 506 - Number of Analyte Pairs Exceeding Criteria: 17 - Percentage of Analyte Pairs Exceeding Criteria: 3.4% The RPD exceedances are confined to metal and VOC analytes. The Auditor notes that the level of exceedance is generally minor and probably related to sample heterogeneity and the low analyte concentrations of analyte pairs. RPD calculations were not calculated by the Assessor for a large number of analyte pairs as either or both of the pairs were less than the LORs. Groundwater - Acceptance Criteria: RPD < 50% - Groundwater Samples Analysed: 122 - Field Split Samples Analysed: 9 - Field Split Analyte Pairs: 556 - Number of Analyte Pairs Exceeding Criteria: 21 - Percentage of Analyte Pairs Exceeding Criteria: 4.2% RPD exceedances are confined to carbonate, alkalinity, fluoride, TPH, carbon tetrachloride, metals, VOC and TPH analytes and the Auditor notes that the level of exceedance is generally minor and probably related to the low analyte concentrations of analyte pairs. RPD calculations were not calculated by the Assessor for a large number of analyte pairs as either or both of the pairs were less than the LORs.
Trip Blanks	GHD (2008) Nine (9) trip blanks were collected; Four (4) for soil and five (5) for groundwater. All trip blank samples reported concentration below the LORs with the exception of TPH C₆-C₉ in sample TB-2, which reported a concentration of 80 µg/L above the LOR of <50 µg/L. GHD (2010) Eighteen (18) trip blanks were collected in total: four (4) for soil and a total of fourteen (14) for groundwater. Six (6) trip blank samples were collected for the first GME and eight (8) for the second GME. All trip blank samples reported concentrations below the LORs.
Laboratory Internal QC	Evidence of the laboratories internal QC testing is present and complete in the Assessor's reports. Laboratories used in this investigation (Labmark, ALS, Ecovise and SGS) performed internal QC with adequate testing and satisfactory results for matrix spikes, method blanks and laboratory duplicates.
Laboratory Method Detection Limit (or LOR)	Laboratory reports indicate the method detection limits were generally lower than the respective assessment criteria, except for: 1,2-DCA with an LOR of either 250 µg/L, which is above the Primary Contact Recreation of 10 µg/L. 1,2,3-trichlorobenzene with an LOR of either 5 µg/L, which is above the Ecosystems Freshwater (95%) criterion of 3 µg/L. - BaP with an LOR of 1 µg/L, which is above the Primary Contact Recreation criterion of 0.01 µg/L - Mercury with an LOR of 0.0005 µg/L, which is above the Ecosystems

QA/QC Aspects	Evidence & Evaluation
	Fresh Water (95%) criterion of 0.00006 µg/L. Differences between the LORs and the criteria are generally marginal, with the exception of 1,2-DCA. The Auditor considers that does not significantly affect the outcome of the groundwater assessment.
NATA endorsement of laboratory reports	Laboratory reports were stamped with the NATA endorsement stamp and signature.
Calibration of Field Equipment	Calibration certificates of field equipment can be found in the Assessors report.
Decontamination and Equipment Blanks	Soil No rinsate samples were collected during soil sampling as samples were collected directly from push tubes using disposable gloves. Groundwater Twelve rinsate blank samples were collected during the 2008 investigations and 13 rinsate blank samples were collected during the 2010 investigations. Rinsate samples were taken off of the low-flow sampling pump. Analytes were generally below the LOR in the 2008 report and always below the LOR in the 2010 report. GHD (2008) made an assessment of data where analytes were reported above their LOR in the rinsate samples. The Assessor concluded that the low levels detected do not affect the overall data quality or the data from wells samples immediately after the rinsate samples were collected. The Auditor concurred.
Data Comparability	
Standard Procedures	Fieldwork procedures are detailed in the Assessor's reports and are comparable for each phase of assessment.
Qualified Personnel	The Assessor's reports have indicated that the staff involved in managing and reviewing the project and those involved in fieldwork are qualified personnel.
Volatile Losses	Evidence of the use of a PID sensor to screen for VOCs are provided in the borelogs and calibration of certificates appended in the Assessor's Report.
Sample Integrity	Field Chain of Custody/Laboratory request forms can be found in the Assessor's reports.
Sample Locations	Sample locations are recorded on figures attached to assessment reports. The stated location of groundwater wells varied between assessment reports from different assessors
Data Completeness	
Completeness of test program	The scope of work undertaken was generally consistent with that required to characterise the site as set out in the Assessor's Work Plan.
Validity of Data Set	The data quality review indicates no significant systematic errors in the data collection process for soil and groundwater and therefore, the data set used as the basis for the soil and groundwater assessment is considered valid and complete.

Recommendations:

- Ensure that the data quality issues with elevated LORs are addressed and that the LOR values are plotted on summary figures and provided in summary tables, such that there is more transparency in regard to data quality and delineation resolution.
- Collect groundwater samples for submission to the analytical laboratory, which enable partitioning to air and soil (depending upon the physical properties of the contaminants),

with the intent to address the matrix interference causing elevated LORs. For example, collect half full sample jars for gas extraction at the laboratory and injection into the GC. This is to assist identification of highly volatile compounds that are vulnerable to negative sampling bias such as VC.

7. An accurate site plan be constructed and used for future reporting requirements. The site plan should be constructed by a licensed surveyor and include the location of the site boundary, roads, buildings, services and permanent sample locations.

3.4 Review of Contamination Investigations

The Auditor considers that the scope of works, methodology of the site investigations and laboratory analytical program undertaken by the Assessor have been generally appropriate to characterise the contamination at the site. The field assessment and data is considered to be of an acceptable quality as the basis for the Audit. However, further data (including higher resolution) and an increase in data quality is required as outlined in later sections of this report.

3.5 Auditor's Verification of Site Condition

The Auditor has undertaken work to verify that the environmental quality of the site is as reported by the Assessor. Tasks conducted by the Auditor verifying the site conditions are summarised in Table 3-4.

Table 3-4: Auditor's Verification Activities

Activity	Comment
Inspect Site Conditions	A number of site inspections were conducted by the Auditor and/or his Assistant throughout the assessment and audit process. The site inspections occurred on 6 August 2007 & 16 May 2008.
Observe Assessor Sampling	The Assessors sampling was observed by the Auditor's assistant on 16 May 2008.
Confirm QA/QC of Assessors field work	The Assessor demonstrated adequate documentation of QA/QC, facilities and procedures for equipment decontamination, proper sampling technique and sample handling.
Collection of Independent Samples	Based on the level of investigation undertaken and the QA/QC measures undertaken by the Assessor, independent verification was not required.
Photographs	Site photos collected for Site Audit file.

4 CONCEPTUAL HYDROGEOLOGICAL MODEL

Any assessment of the risk to the groundwater environment must be based on a sound understanding of the hydrogeology of the study area. This understanding is documented within the Conceptual Hydrogeological Model (CHM). The scope of the CHM has been based on EPA Publication 668 *Hydrogeological Assessments (Groundwater Quality)*. This EPA guidance document sets out the principles and guidance for hydrogeological assessments necessary to define groundwater quality and contamination.

The CHM is part of any Hydrogeological Assessment Report and requires information on:

- Geographic setting
- Geology & aquifers
- Groundwater occurrence & flow systems
- Groundwater background chemistry & protected beneficial uses
- Groundwater resources and utilisation.

The CHM presented below is based on the findings from a number of investigations undertaken at the site, and other sources as referenced.

4.1 Geographic Setting

The site is located in the south-eastern suburbs of Melbourne west of the Nepean Highway, approximately 2.5 km east of Port Philip Bay and 12 km southeast of the CBD.

The site is in an area with a gently undulating surface, an overall slope to the south west and south. The site elevation is approximately 38 mAHD.

There are no waterways or drainage lines in the immediate vicinity of the site and Port Phillip Bay is 2.5 km to the west. The nearest surface water body is a man-made lake within Sir William Fry Reserve, located approximately 600 m north east (hydraulically upgradient) of the site (GHD, 2010).

4.2 Geology & Aquifers

4.2.1 Regional Geology & Aquifers

The site is within the Port Phillip sedimentary basin. The Port Philip Region was defined by Leonard (1992) as Port Philip Bay and the catchment draining water into this bay (including the Yarra River). The topography ranges from low relief at the bay to over 1,200 mAHD to the northeast along the Great Dividing Range.

The Palaeozoic bedrock is overlain by younger terrestrial (clastic) sedimentary deposits and rock of volcanic origin of Cainozoic age. The Cainozoic sequence in the site vicinity includes the Werribee Formation (WF), Older Volcanics (OV), Fyansford Formation (FF) and the Brighton Group (BG). These are overlain by Quaternary Deposits comprising ridges and sand hills and swamp deposits in lower lying (inter-dune) areas. GHD (2010) describes the longitudinal aeolian sand hills and ridges as up to several metres thick and discontinuous.

The Palaeozoic bedrock mudstones, siltstones and sandstones of the Melbourne Formation form a regional water table aquifer in outcrop and a confined aquifer in the study area where it is overlain by the Tertiary Sandstones.

The bedrock sedimentary formations are of marine origin and are generally poor groundwater resources compared with the Werribee Formation Aquifer (WFA) and the Fyansford-Brighton Group Aquifer (locally the BGA) which contain sand and gravel units.

Leonard (1992) describes three main phases of sedimentary deposition during the Tertiary (from oldest to youngest), with intermittent volcanic activity in the Early and Late Tertiary:

- Early Tertiary: terrestrial deposition – WF
- Middle Tertiary: marine transgression – FF
- Late Tertiary: marine regression and near-shore terrestrial environment – BG.

Werribee Formation

The WF (65 Ma to 23 Ma) overlies the Palaeozoic bedrock and is a sheet-like terrestrial deposit of coarse to fine alluvial sediments (sand, gravel and clay), lacustrine muds and peat/lignite seams¹¹ (including wood fragments). The formation comprises coarse to fine, pyritic, angular sand and silty sand (with at least two coal seams) and minor clay, ligneous clay and occasional gravel and conglomerate. The WF has a regional thickness of 10 to 40 m.

Leonard (1979) noted that thin (3 m to 6 m thick) sandy gravel, sand, silt and clay units underlie the Older Volcanics at numerous locations, and represent alluvial valley fills that were protected by the overlying basalts.

The WF forms a regional confined aquifer (i.e. the WFA) in the study area.

Older Volcanics

In the Melbourne region, the OV form an almost level sheet of basalt lava approximately 240 km² and approximately 10 to 40 m thick. This unit outcrops in the Cranbourne area and reaches a depth of up to 90 m towards Port Phillip Bay (commonly less than 30 m thick along this tract). In many areas the OV are highly weathered.

The OV forms confined fractured aquifer (i.e. the OVA) in the study area.

Fyansford Formation

The Late Miocene to Middle Miocene Fyansford Formation disconformably overlies the Werribee Formation and is a widespread marine carbonate strata throughout the Port Phillip Basin. The formation outcrops at Beaumaris, where it is overlain by Brighton Group sediments. The formation includes fossiliferous shelly claystones, siltstones and marls.

The contact between the overlying BG and the FF is generally assumed to be the change to more productive bores (higher permeability units). However, the lithology of these formations is fairly similar. The FF consists of green to grey calcareous silt and clay, with some areas having thin impure brown coal layers. Salinity is shown to be in the range of 1,000 mg/L TDS or less (Figure 16, Leonard 1992).

The FF forms confined porous media aquifer (i.e. the FFA) in the study area.

¹¹ The Werribee Formation includes coal seams, which were mined at Altona in the late 19th century.

Brighton Group

The Brighton Group (Late Tertiary) outcrops widely, and disconformably overlies the Fyansford Formation. It is a sheet-like deposit of sand, gravel, silt and clay with a thickness of 20 m to 80 m, extending from the eastern and south-eastern suburbs of Melbourne inland to the Dandenong-Cranbourne area. This terrestrial formation was deposited by a regressing sea (either preceding or contemporaneous to onshore terrestrial sedimentation).

The Brighton Group comprises two formations: a predominantly marine sandy fossiliferous unit, known as the Black Rock Sandstone of Late Miocene age and the overlying Red Bluff Sand¹², thought to range in age from Late Miocene into the Pliocene. The Red Bluff Sand is composed of partly consolidated yellow-brown sands (glauconitic¹³ or calcareous), silt and gravels (some conglomerates), that are mostly very weathered (including some ferruginisation). The sands are commonly cross-bedded deposits. The base of the Red Bluff Sands typically includes carbonaceous material.

The BGA is generally fine grained with relatively low permeability (silt to fine sand in a clayey matrix); however, higher permeability units constituting aquifers occur (coarse sand and/or fine gravel lenses) near the base of the Red Bluff Sand.¹⁴ This includes clay-rich and clay-free sand interbeds. The Black Rock Sandstone portion of the BGA disconformably overlies the FFA, and contains ferruginous sandstone and marly sand with local ironstone layers.

Leonard (1992) indicates that the Red Bluff Sands are poorly bedded partly consolidated sand, silt and gravel with lenses of carbonaceous material near the basal unit. Permeability is highly variable, with coarser sand and gravelly units providing higher permeability pathways for preferential groundwater flow.

The BG forms a regional porous media aquifer in the study area. This unit also forms the water table aquifer (i.e. the BGA) in the area of the site.

The BGA and FFA have a combined maximum thickness of 90 m near the coast at Beaumaris (~ 6 km south of the site)¹⁵. The BGA and FFA are considered to be regionally hydraulically connected and to behave as a single aquifer system. There is typically downward percolation from the BGA into the FFA. The BGA is particularly vulnerable to contamination as groundwater in this aquifer is unconfined to semi-confined. The base of the FFA has high permeability units.

Quaternary Deposits

Quaternary deposits include alluvial, swamp, deltaic, fan, apron, and dune deposits. In the south-eastern suburbs of Melbourne, Quaternary sediments are sporadic and thin, and include aeolian (dune) sand, marsh and lagoonal deposits (Leonard 1992). Dune sand deposits occur as a thin (less than 6 m) outcrop in the south-eastern suburbs of Melbourne between Mordialloc and Frankston and in the Beaumaris area.

4.2.2 Site Geology & Aquifers

The site geology, as indicated on the 1:63 360 Geological Survey of Victoria Ringwood Map Sheet (No. 849), comprises Late Tertiary-aged Brighton Group (Tpr) and Quaternary-aged

¹² Bulk aquifer transmissivity is considered to be low, and salinity observed between 850 and 7,500 mg/L.

¹³ Glauconite is an iron potassium phyllosilicate (mica group) mineral of characteristic green colour with very low weathering resistance and very friable.

¹⁴ This appears to be consistent with a fairly low energy meandering river-type depositional environment.

¹⁵ The thickness is likely to be in the range of 60 to 70 m in the site area.

sand hills and ridges (Qpd) deposits. The Quaternary deposits form a series of discontinuous and longitudinal aeolian sand dunes of Pleistocene age (up to several meters in thickness).

The site geology and aquifers are discussed below in relation to hydrogeological cross-sections that: show the geologic units which form aquifer-aquitard systems, illustrate the generalised site geology, and indicate standing water levels (SWLs). Sections A-A' and B-B' (Figures 11 and 12) are oriented north-south and sections C-C', D-D' and E-E' west-east (Figures 13 to 15). The cross-sections were constructed using descriptions from geological logs from bores drilled at the site.

The maximum bore depth at the site is 20.5 m. No bores appear to have reached below the Brighton Group.

Site Soil Profile

The Vapour Health Risk Assessment report (GHD, March 2009), which was focussed on the SEC of the site, indicated that the general soil profile was sandy Fill in the top 1 to 2 mBGS, underlain by clay to sandy clay to 4 mBGS, followed by clayey Sand to 9 mBGS, with sand units below the water table. Cross-section D-D' below is in general agreement on a rough scale. However, section 4.2.3 details the significant amount of variability within these generalised units, which is highly important to understand DNAPL migration at the site. This includes coarse sand layers from 6.4 mBGS to depth of investigation (~15 mBGS) in the recent bores advanced in the SEC of the site.

Section A-A', whose trace is along the eastern portion of the site, shows the fill to be absent in the north central area (Non-Toxic Storage Area – refer to Figure 11, Appendix A) and the sandy clay layer as a continuous presence across the site. Two areas of the section (MW39 and MW26) appear to have been topographic lows, where clay and sandy gravel have been deposited above the sandy clay layer (or was not eroded). A silt/clay unit was encountered below the sand unit at location MW26 (beyond the southern site boundary) at 18 mBGS. There is no further information on the thickness or continuity of this silt/clay lense, which could be overbank fines of the river with variable extent and thickness. Beyond MW26, the geology shown is inferred as there is a lack of geologic logging until MW42 at Philip Street.

The Assessor indicated in the Geophysical Survey report (2008) that the continuity of this silty clay layer (~20 mBGS) is unknown and *“if it is laterally discontinuous may provide a potential pathway for DNAPL migration to depths...below the current maximum vertical extent of investigation”*. However, the Auditor notes that a gravel layer and coarse sand have been identified at this depth. Significant lateral continuity of fluvial deposits beyond the former channel is unlikely. In addition, this silty clay layer is likely to have been altered by dessication fracturing, worm borrows, root holes and other secondary permeability features (may not be hydraulically tight). Thus, the silty clay layer is considered as unlikely to stop DNAPL that may have migrated from at or near ground surface through upper clayey units reach this layer (i.e. 20 mBGS).

Section B-B', along the western portion of the site parallel to A-A', shows the fill to be absent in the north central area (former Drum Storage Area – see Figure 12, Appendix A). Here the upper unit is described in logs as clay (not sandy clay) - shown in pale blue. Across the length of the section the sandy clay unit is absent and the clayey sand is beneath the clay layer. The near surface lower permeability units (clay and sandy clay) are thickest beneath the northern portion of the former Drum Storage Area (i.e. at MW5). Gravelly sand was noted at two locations: near surface at MW29 (likely related to that at MW26), and 18 mBGS at MW38 (laterally equivalent to the silt/clay layer identified at MW26). Gravelly sand at MW38 may be part of a river channel deposit (and as such could coarsen to gravel). These coarse grained

layers can act as higher permeability pathways. Beyond monitoring well MW29, the site geology shown is inferred due to a lack of geologic logging (with the exception of MW40) until MW42 at Philip Street.

Section C-C', whose trace is east-west just south of the drum storage area and perpendicular to B-B', shows the fill to extend across this area. The near surface lower permeability units are thickest beneath the area near the former Drum Storage Area (i.e. at MW9). However, the upper clay layer (pale blue) is thinning from north to south and is absent along section D-D' as provided below. The sand unit is also encountered at a shallower depth at the central to eastern portion than was identified in the sections above. This shows thinner low permeability layers along this section line (i.e. at MW7), which would likely enhance the vertical migration of contaminants into the aquifer (i.e. provide less aquifer protection - increased aquifer vulnerability).

Section D-D', positioned east-west just south of the flammables storage and perpendicular to B-B', shows Fill is present and extend across this area. The near surface lower permeability units are thickest (over 10 m) beneath the Non-Hazardous Store (i.e. at MW12); and is much thinner (about 1 m) at the SEC (Former Drum Shed, concrete sump, USTs and refrigerant store). The upper clay layer is absent. The sand unit is also encountered at a shallower depth at the SEC, which would likely enhance the vertical migration of contaminants into the aquifer (i.e. provide less aquifer protection - increased aquifer vulnerability).

The following information summaries the generalised geology beneath the site with references to wells that demonstrate the geological layers noted:

- **Fill** up to 1 m thick, variously described as asphalt and crushed basalt (MW32) to grey fine to medium sand (MW31) overlying clay.
- **Clay** absent to 2.5 m thick - varies from reddish grey moderate to high plasticity with silt and trace sand (MW33) to brown/grey mottled red moderate to high plasticity clay (MW37) and sandy clay that is above a sandy to clayey deposit.
- **Sandy Clay / Clayey Sand** 2 to 8 m thick (but usually less than 4 m). Red-brown and pale grey, ferruginised and hard in sections (MW27), mottled, and red-brown low plasticity, medium grained (MW31). This layer becomes sandier with depth and grades into a sand layer (i.e. shows a fining upward sequence).
- **Sand** at least 10m thick – red to orange and brown fine to coarse grained, and with occasional “trace” to “minor” clay.

It is notable that overall, the sequence becomes sandier and coarser with depth (fining upward sequence), and bore MW38 encountered gravelly sand at 18 mBGS. None of the bores appear to have reached the base of the Brighton Group (thickness at the site is not known).

At this site, the overall geological profile within the BGA is a fining upward sequence (generally coarsening with depth from clay to a gravelly sand), which formed in a fluvial depositional environment. This was also postulated by GHD (Geophysical Survey, June 2008) following downhole geophysics (gamma logging) of on-site monitoring wells (refer to Figure 4-1 and Figure 4-2). This fluvial sequence is likely to include riverbed deposits of sand and gravel, as well as overbank fines of silt and clay. As the river (likely in this case to be a meandering river) migrates laterally over time, these units will be overlain or the river will down cut into softer clay sediments into and underlying sand and gravel unit from a former river deposit. Sand and gravel units are generally restricted to the main river channel and as such often present as ribbon like deposits winding through the geology. Swamp deposits are often present adjacent to meandering river systems and include peat (with varying organic carbon content) and silt and clay.

4.2.3 Site Geophysical Logs

In their Geophysical Survey report (June 2008), GHD stated that localised perched groundwater was encountered during advancement of the boreholes for well MW22 and the nested bore MW9 (with standing water levels between 9 and 10 mBGS). Other mounding and depressions (anomalies) were noted by GHD to be possibly attributed to increased infiltration rates, due to the removal of USTs or nearby groundwater pumping. GHD (2008) further notes that *"The occurrence of localised perched groundwater observed during drilling at the site by SMEC (2007) may be attributable to 'lensing' or lateral facies variations that are characteristic of an alluvial/fluvial depositional environment and consistent with the gamma ray profiles"*.

GHD (June 2008) notes *"With regard to the silty clay layer noted by SMEC at a depth of 20 m bgl, the gamma ray logs suggested this layer was more silty, rather than clayey, particularly when compared to the overlying clayey layers. However, it was noted that gamma ray data at this depth is limited to groundwater bores MW21 and MW23. Based on the gradational nature of the overlying lithologies, it is inferred that this silty layer forms the base of a 'coarsening upward' sequence and may vary across the site."*

Therefore, for the purpose of refining the CSM, this "cohesive silty clay layer" as described by SMEC (2007) may not be laterally extensive across the site, nor act as a barrier to vertical contaminant migration and/or separate underlying aquifers. However, in contrast GHD (2011) stated *"To allow for detection of...DNAPL, the remaining wells were screened deeper, in the sandier portion of the aquifer, from around 14 to 18 m bgl (immediately above an inferred silt/clay layer previously identified in groundwater bore MW26 at approximately 17 m bgl). The silt/clay layer was considered to act as a potential barrier to further DNAPL migration, hence the screening above this layer."*

The Auditor notes that the borehole logs generally do not identify silt layers or silty sand layers, which are very likely to be present at the site (and which have a bearing on hydrogeological properties). Further, the Auditor considers that this silty clay layer is unlikely to be either continuous or a barrier to vertical migration of DNAPL or other contaminants by vertical gradients (if present).

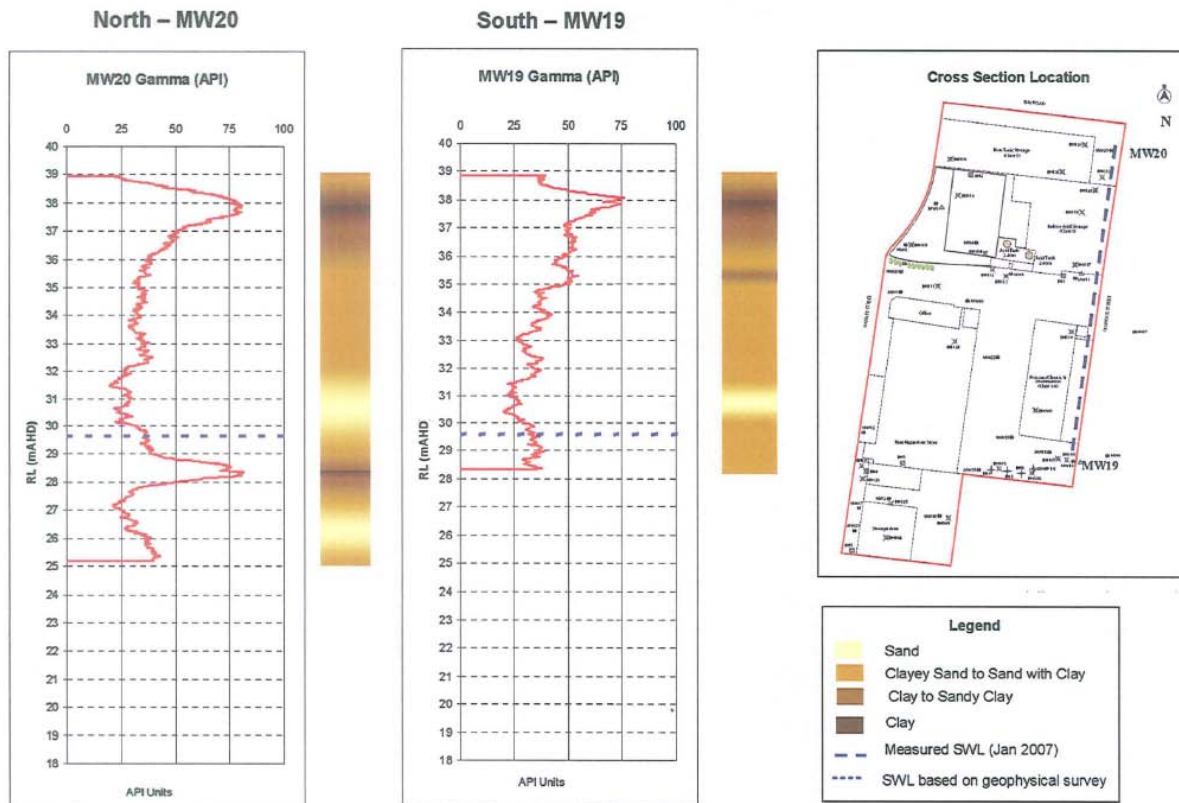


Figure 4-1: Geophysical Logs parallel to Section A-A'

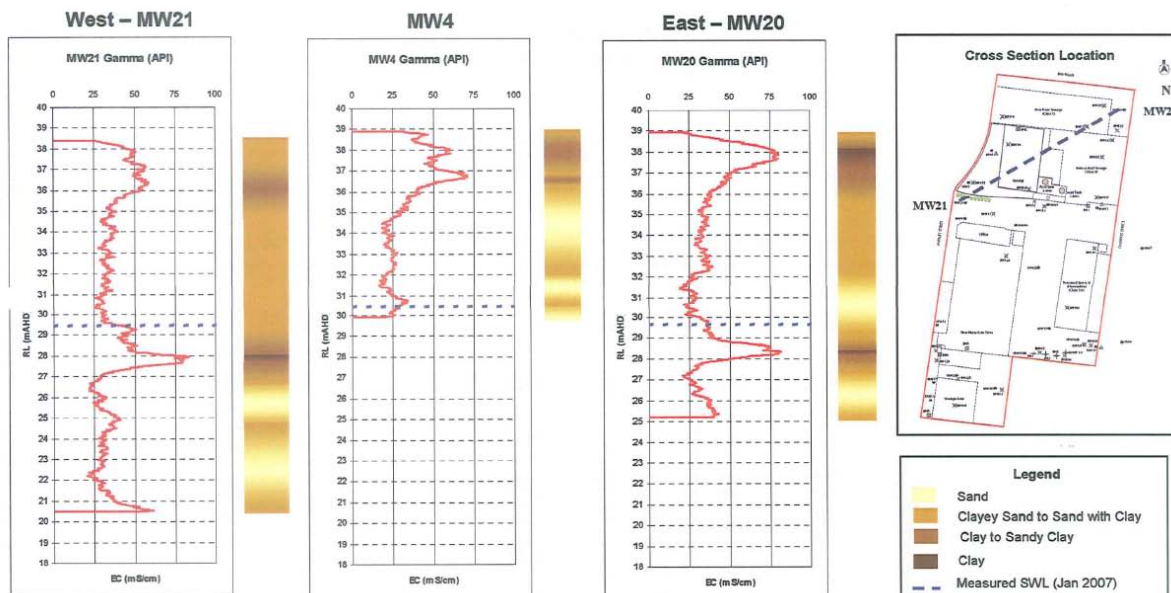


Figure 4-2: Geophysical Logs across the Former Drum Storage Area

4.2.4 Site BGA Hydraulic Properties

Error! Reference source not found. provides a summary of interpreted results from aquifer response testing (rising head and falling head tests) conducted by GHD. The results suggest the hydraulic conductivity (K) is higher in bores screened deeper in the profile.

Table 4-1: Summary of Aquifer Testing (after GHD, 2011)

Bore	Screen Interval	Hydraulic Conductivity (m/day)		
		Min	Max	Mean (n)
MW23	12-20	0.32	0.69	0.57 (4)
MW24A	18-20	0.51	0.62	0.56 (4)
MW24B	13-15	0.29	0.38	0.32 (4)
MW25	13-15	0.18	0.31	0.25 (4)
MW26	16-18	0.07	0.16	0.11 (4)
MW27	8-12	0.06	0.10	0.08 (3)
MW29	8-11	0.03	0.08	0.06 (3)
MW30	8-11	0.08	0.15	0.10 (3)

Recommendation:

- Conduct down-hole geophysics on any newly installed wells (refer to Auditor recommendations below) in the BGA and FFA and use this information to inform the revised CSM.

4.2.5 Site Aquifers

The main geological units that constitute aquifers at the site and immediate vicinity are:

- Fill / Quaternary Sands Aquifer (QSA)** Variably crushed rock, sand thin layer that could contain perched groundwater where above lower hydraulic conductivity clay and sandy clay. Immediately south west of the site, surface geology shows area of finer grained surface sediments.
- Brighton Group Aquifer (BGA)** Fine to medium grained red, orange and grey sand, sandy clay, silt, and minor gravel – at least 10 m thick at the site. Forms a regional water table “inter-granular porosity aquifer” type.
- Not encountered but likely at depth beneath the site are:
- Fyansford Formation (FFA)** Fossiliferous shelly claystones, siltstones and marls
- Older Volcanics Aquifer (OVA)** Dense, residual clays representing highly weathered basalt, with occasional zones of less weathered, fractured basalt. Forms a local confined “fractured rock aquifer” type in the region.
- Werribee Formation (WFA)** Clay, sandy clay, peat, organic clay and sand. Forms a regional confined “inter-granular porosity aquifer” type.

4.3 Evaluation of the Monitoring Well Network

The Auditor has evaluated the status of the current monitoring well network by reviewing:

- Well location
- Well screen depth and interval
- Purge method and rates
- Screened geology
- Stabilised field parameters (see Figure 10, Appendix A).

Details of the monitoring well network are presented in Appendix D.

Audit Findings:

Well Quality Issues

- a) Groundwater has been investigated mainly in the vicinity of the water table (some intermediate depth wells have been installed), which is generally appropriate for LNAPL sites. In addition, groundwater levels appear to be above the well screens in many of the wells (March 2010 data) as shown on the Lane Piper cross-sections (refer to Figures 11 to 15, Appendix A). Whilst this is not an issue for deeper plumes, this is a problem to be corrected for shallow plumes (from LNAPL or shallow impacts from chlorinated solvent source zones). The monitoring network needs to be re-evaluated to determine where additional shallow screened wells are required. Further, there may be wells where the surface to filter pack seal is not sufficiently protective; and other wells within source areas where dissolution of the PVC casing is possible (e.g. at the SEC).
- b) The Auditor notes that the slow recovery of the wells and drawdown leading to the use of bailers and potentially air bubbles in the tubing can enable the volatilisation of VHCs in the groundwater, most notably vinyl chloride. This can generate non-detection values that are not representative of aquifer conditions but are rather sampling artefacts. This has the potential to affect detectable VC concentrations at monitoring wells MW13/2, MW15/3, MW24B and MW24C.
- c) Long-screened monitoring wells enable dilution of the plume(s) that may be entering the well (negative bias - the potential not to find contamination when present); and do not identify the depths where the plumes exist and which units are creating the preferential pathways. Therefore, long-screened wells such as MW3, MW4, MW5 and MW21 should be decommissioned and replaced with appropriate wells along an east-west transect just downgradient of the former Drum Storage Area. The wells in this transect are to be maintained as permanent wells for ongoing monitoring.
- d) Monitoring well and sampling artefacts have affected data quality at this site. Further, the matrix interference that has increased the limit of reporting (LOR) significantly from the Practical Quantitation Limit (PQL) and also investigation levels (ILs) for several compounds including vinyl chloride (VC) is another source of negative bias (potential not to find contamination when present).
- e) Representative DO and redox data within regions known to be either source zones or to contain plumes of PHCs or CHCs needs to be gained. However, many of the wells were purged dry or bailers were used to collect the groundwater samples (and in some cases air bubbles were observed in the sampling tubing during purging). Therefore, the DO and redox data are unlikely to be representative of aquifer conditions.

Well Decommissioning

- a) The following monitoring wells are identified to have quality issues: multilevel wells (MW6 through MW17), each of the long-screened wells MW3, MW4, MW5, MW21 and MW23, wells impacted by leakage (e.g. MW18), low recovery wells where sample quality is poor and volatile losses are known or likely, and wells which have been historically dry and are unlikely to contain water following the drought (e.g. MW2). However, this list may not be exhaustive.
- b) Based on the Auditor's review of site data, the wells that are considered to have low quality issues (i.e. useful wells) are: MW19, MW20, MW22, MW24A, MW24B, MW24C, and MW25 through MW42. As many of these wells have water levels above the well screen, additional wells across the water table would be required (in addition to deeper wells within the aquifer). In terms of geology monitored at the screen the breakdown appears to be the following: Clayey sand (shallow subsurface) noted across well screens of MW24A, MW24C. Sand noted across well screens of MW19, MW20, MW22, MW23, MW24B (also

clayey sand), MW25 (also clay), MW26 (also silt), MW27 through MW34B, MW35 (also clay), and MW36 through MW42.

Permanent Monitoring Well Network

- a) Develop a plan for a revised permanent monitoring network both on- and off-site for the shallower and deeper portions of the aquifer that is to be monitored to assess groundwater flow and dissolved phase contaminant migration within the aquifer(s).
- b) As there are likely multiple DNAPLs released over time that have created various source zones, thus multiple plumes at various depths and locations (complex subsurface distribution) have been generated at the site. As such, transects across sections of the site (across and perpendicular to flow) may be the best option for an efficient and effective long-term monitoring network that provides a reliable and robust data set for the CSM.
- c) Due to the use and impacts by DNAPLs at the site, monitoring groundwater flow (including the horizontal and vertical gradients) and quality in the intermediate and deep portions of the BGA and into the FFA is required to complete the delineation of vertical and deeper lateral impacts. These wells are also to evaluate the thickness, continuity and affect of the silty clay unit (on the hydrogeology of the site and the potential to limit DNAPL migration) at 20 mBGS (if any), as well as the hydraulic connection between the BGA and FFA.
- d) Another issue that has been identified is the need to locate the wells and screens to capture the preferred pathways (likely zones of highest mass flux - elevated concentrations in regions of higher flow rate). The lower permeability media (in the absence of connected secondary porosity) are unlikely to facilitate significant off-site migration.

Soil Vapour Monitoring

- a) The monitoring network for soil gas sampling has not been developed to a high enough resolution considering the on-site and off-site risks posed by the migration of site contamination (many of these compounds are volatile) – refer to mass flux approach recommendation. The Assessor did not take into account the weathering that occurs from source zones over time or the limited potential for preferential pathways with higher concentrations than detected in the relatively coarse resolution network that presently exists at the site.

Mass Flux Approach

- a) A mass flux plane approach may be appropriate for management of contaminant transport (soil vapour and groundwater) both on and from this site. The mass flux approach provides a metric for: the amount of contaminant leaving the source area; the holistic picture of plume attenuation; and loading to a receptor. As there are likely multiple DNAPLs released over time that have created various source zones, thus multiple plumes at various depths and locations (complex subsurface distribution) have been generated at the site. As such, transects across sections of the site (across and perpendicular to flow) may be the best option for an efficient and effective long-term monitoring network that provides a reliable and robust data set for the CSM. Higher resolution multilevel installation would be beneficial to resolve some of the data issues.

Recommendations:

Well Decommissioning

9. Decommission the following wells: multilevel wells (MW6 through MW17), long-screened wells MW3, MW4, MW5, MW21 and MW23, wells impacted by leakage (e.g. MW18), low recovery wells (e.g. MW2), any wells where the seal is not sufficiently protective, and finally any wells within source areas where dissolution of the PVC casing is possible (e.g. the SEC).

10. The replacement of wells with quality issues located in areas where high concentrations of chlorinated solvents have been detected (historic and recent) is recommended.

Permanent Monitoring Well Network

11. Develop a plan for and install a revised permanent monitoring network both on- and off-site to evaluate the geology and hydrogeology of the deeper portions of the BGA and into the FFA, as well as the hydraulic connection between these units, assess groundwater flow and dissolved phase contaminant migration within the aquifer(s). Designed meet the intended use and goals to be achieved (delineation and assessing risk).
12. This revised permanent monitoring network is to include the shallow, intermediate and deep portions of the aquifer(s). Based on this recommendation and the Auditor's review of site data, the remaining wells would consist of MW19, MW20, MW22, MW24A, MW24B, MW24C, and MW25 through MW42. As many of these remaining wells have water levels above the well screen, additional wells across the water table would be required (in addition to deeper wells within the aquifer).
13. Obtain sufficient evidence (geological, hydrogeological and geochemical) for the presence of a locally significant low permeability unit that would limit the hydraulic connection between these units (and potentially DNAPL migration).
14. As many of the remaining wells have water levels above the well screen, additional wells across the water table would be required (in addition to deeper wells within the aquifer).
15. Construction of monitoring wells will need to include consideration of presence of DNAPLs (refer to Figure 4-3) including: well location, well screening (elevation, length and slot size), the filter pack (potentially including fine mesh wire) and seal through fill layers); this is to identify DNAPL migration into the well, decrease well artefacts and provide samples representative of the aquifer. As noted above, the Auditor considers that deeper migration of DNAPL(s) at the site is likely to have occurred. Therefore, new wells would need to incorporate this issue.
16. Collect aquifer media (soil) samples for organic carbon content, density, grain size, and other relevant physical parameters at boreholes for wells advanced in the BGA and FFA.
17. Evaluate the use of methods such as 'scan sampling' (sampling during groundwater extraction) to enhance detection of chlorinated solvent plumes.
18. Conduct groundwater pumping tests and slug tests in the BGA and FFA to evaluate the hydraulic conductivity (K), transmissivity (T), and hydraulic connections of these aquifers.
19. This revised monitoring network is to form part of an SMP, and is to be maintained until cessation of monitoring is approved by the EPA. The current SMP shall be: revised to include the revised network, follow EPA guidance, and be endorsed by an EPA appointed Environmental Auditor. In addition, the ongoing SMP is to be revised as further information comes to hand from studies and monitoring recommended in this audit report.

Soil Vapour Monitoring

20. The Auditor recommends the inclusion of a revised soil vapour monitoring network to enable sufficient resolution in line with the on-site and off-site risks posed by the migration of volatile site contaminants. This should be part of an ongoing program in association with groundwater monitoring that takes into account the weathering from source zones over time and preferential pathways with high concentrations (i.e. mass flux).
21. Further consideration needs to be given to possible vapour intrusion risk to persons occupying buildings off-site (and potentially on-site depending on future investigation results) including incorporation of the recommendation for an enhanced soil vapour monitoring network.

Mass Flux Approach

22. The Auditor recommends a mass flux plane approach for management of contaminant transport (soil vapour and groundwater). This is to include monitoring of contaminants across transects perpendicular and parallel to flow. This may require transects off-site, as possible; and will need to take into consideration the implications for monitoring near the source zones.
23. Mass flux approach is to include: Transects (T1 to T4) with both soil vapour and groundwater depth-discrete locations.
- T1 (full east-west profile) south of the Former Drum Storage Area.
 - T2 (full east-west profile) north of the SEC.
 - T3 from Bay Road to Philip Street.
 - T4 along the lower boundary of SEC (using telescopic methods) to identify secondary sources. Following installation of deeper wells to evaluate the continuity and potential for the silty clay layer at 20 mBGS to limit vertical migration of DNAPL.

In-Situ Monitoring

24. As well and sampling artefacts have affected data quality at this site, in-situ measurement devices to monitor water levels and geochemistry data are required to be part of the program developed within the GQMP. This should include down-hole data loggers with water level, temperature, conductance, DO and redox (in the sandy clay and lower sandy portions of the aquifer(s) impacted by plumes and one upgradient location).
25. As matrix interference has affected data quality, the SMP should consider alternative sampling methods to reduce the LORs to acceptable levels. Non-detection levels (LORs) should be discussed and presented in tables and figures.

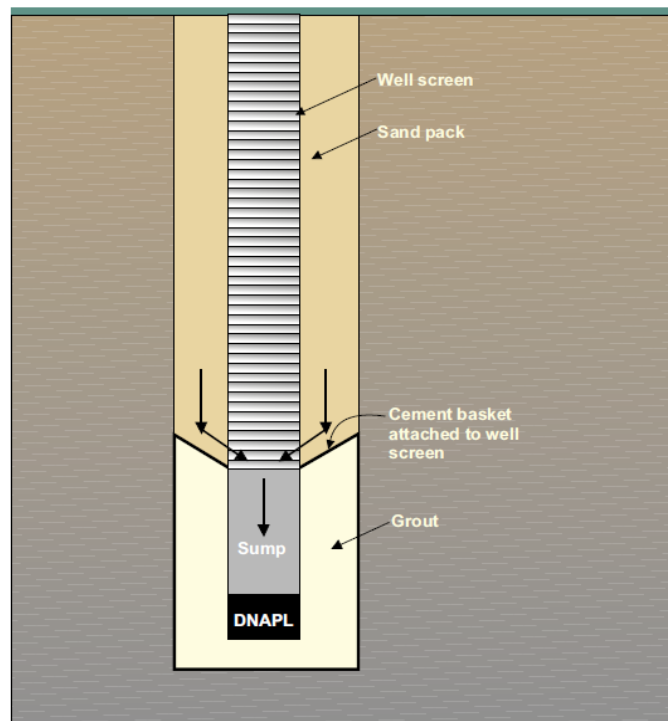


Figure 4-3: Monitoring Well Design for DNAPL Sites (AFCEE, 2000)

4.4 Groundwater Occurrence and Flow

4.4.1 Water Levels & Flow Directions

The Assessor obtained groundwater level measurements and samples for chemical analysis in March 2010 (GHD, 2010).

Groundwater depth from top of casing ranged from 5.07 m (MW18) to 10.70 m (MW24A) below surface, which is groundwater elevation range from 33.75 mAHD to 28.39 mAHD.

Due to the proximity of the site to Port Philip Bay, it is likely that regional groundwater flow is directed to this bay. In relation to the site, shallow groundwater was observed to occur mainly within natural silty sands in the water table aquifer. Due to the overall fining upward sequence, a significant portion of the deeper groundwater is likely to be flowing through coarser grained sediments (faster rate of migration).

Groundwater elevations and estimated flow direction were illustrated in the Assessors ESA report (GHD 2011), and historical figures of the ERM (2001) and SMEC (2006)¹⁶ reports. With a more limited groundwater monitoring well network, the ERM (2001) report documented groundwater flow to the west (refer to Figure 4-4).



Figure 4-4: Groundwater flow as shown in ERM (2001)

As shown on Figure 4-5, the SMEC (2007) report showed groundwater flow (shown to be flowing to the west, south and east) as affected by mounding in at least three areas of the site. Figure 4, Appendix A shows surface features (drainage grates, TITs, sumps, and UST excavation areas) that may be modifying shallow (and potentially deeper) groundwater flow at and from the site. This appears to be the case for the TIT near MW3, and the UST excavation area in the SEC near MW8. The mounding observed at MW9 and MW12 may be due to leaking water mains or other features.

Another important aspect to be considered is the site geology across the well screen, where time delay for hydraulic response to changes in water levels or surface recharge may cause

¹⁶ SMEC 2006 - Contamination Assessment Review - Cheltenham, Draft for Nuplex Industries Pty Ltd.

the water levels to be "out of phase" with wells screened across higher permeability units, including fractures and sand seams in clayey media and/or coarser grained deposits.

The importance of understanding the groundwater flow directions from various areas of the site is related to the migration of plumes from source zones in these various current and former operational areas. The variation in flow directions presents multiple downgradient boundaries for the site, namely the west and southwest from the north-western portion of the site (including the Former Drum Storage Area), the east and southeast from the north-eastern portion of the site, and from the southwest to southeast in the southern portion of the site (including the SEC). The Auditor considers that a more robust understanding of the site groundwater flow (shallow, intermediate and deep) is required.

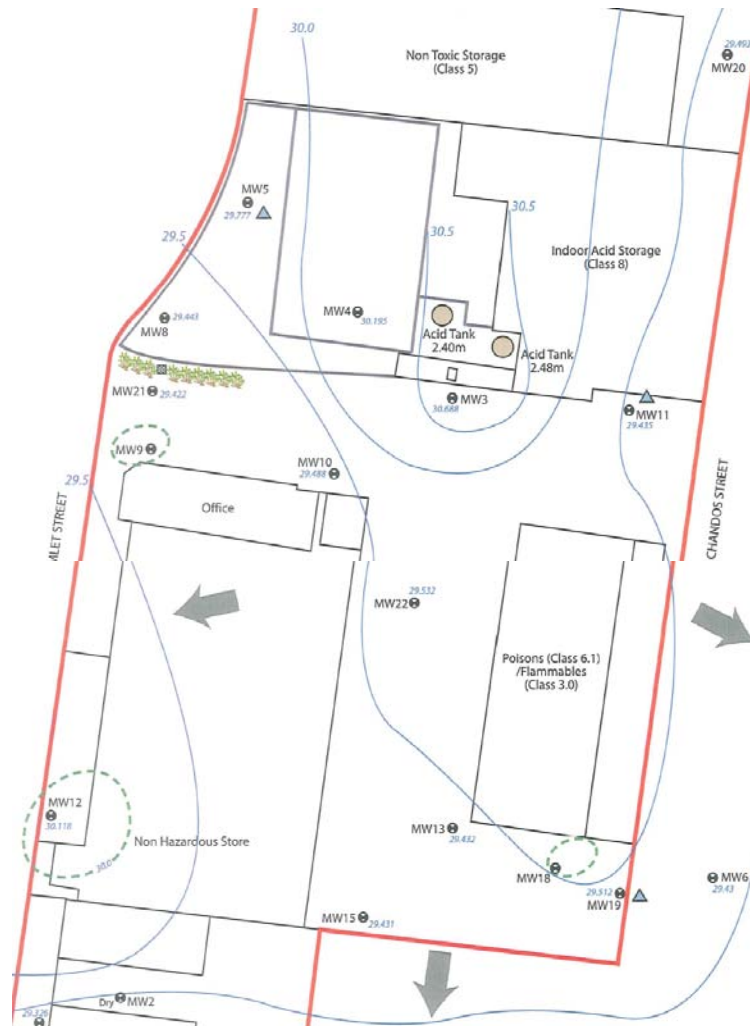


Figure 4-5: Groundwater flow as shown in SMEC (2006)

Groundwater contours were interpreted in the Assessors ESA report (GHD 2011) to show that site groundwater was flowing in a south to south-west direction. As can be observed on this groundwater contour map (Figure 4-7), there are flow components to the southwest, south and southeast similar (but shifted to the east) to that shown in SMEC (2006).

Although flow to the south and west appears to be the most likely from the site location the potential presence of higher permeability river bed sand/gravel means that some deeper groundwater flow may be directed toward and along these higher permeability features, and may be migrating from the site along these pathways (may or may not follow regional flow).



Figure 4-6: Groundwater flow as shown in GHD (2008)



Figure 4-7: Groundwater flow as shown in GHD (2010)

Groundwater elevation data from January 2011 (GHD 2011) shows areas of localised mounding (MW4, MW12, MW40). The inferred groundwater flow pattern and direction has changed significantly over time due to the development of the monitoring network and temporal changes (which may be an artefact of bore construction as discussed earlier). GHD has inferred that there are leaky services (mains water and/or sewage) along Chandos Street and Hamlet Street.

The Auditor has revised the flow contour map (2010 data) by removing wells, which are considered to have installation issues (Figure 8, Appendix A). Groundwater is interpreted to be flowing generally southerly with a westerly component.

Review of the groundwater elevation data above indicates that groundwater discharges from site at the southern and western site boundaries. Offsite groundwater flow over the eastern site boundary is uncertain.

Recommendations:

26. Groundwater hydraulic control on-site and off-site is to be gained through the revised monitoring network and quarterly SWL monitoring (i.e. gauging) including downhole measurements of field parameters to assist in characterisation of groundwater quality.
27. Based on the CSM, develop a three-dimensional (3D) groundwater flow model (with water mass balance) as the basis of the flow and transport model, using suitable existing data and recommended quarterly monitoring data and the hydraulic response data. Conduct both steady-state and transient calibration for this model.
28. On and offsite services be investigated to determine if they are leaking and effecting the groundwater flow pattern and contaminant transport

4.4.2 Vertical Hydraulic Gradients

Thirteen nested bores have been installed at the site as part of the investigations (MW6 to MW17, MW24 and MW34). MW6 to MW17 were installed in 2001 and no logs are available. In addition, there are questions over the integrity of these wells as discussed in the previous sections. There is anecdotal evidence that the screens for these wells were “shoved” into the hole after drilling and that the depth intervals were not isolated by a bentonite seal.

A review of standing water level (SWL) data revealed inconsistencies with the levels in these wells including:

- The SWL was not measured for all well screens intervals on many occasions.
- The depth to groundwater did not always correlate with the screen depth. For several wells (e.g. MW8 and MW9) the middle screened interval reported either the highest or lowest SWL.
- The SWL varied significantly between monitoring events (e.g. MW9/2 May 2008 SWL was 0.457 mTOC, Sep 2008 SWL was 5.810 mTOC)

The Auditor has evaluated the vertical hydraulic gradients across the site. However, this has been a general assessment is due to the concerns with the well integrity and data quality. Monitoring wells located in the south east portion of the site and offsite to the east (MW6, MW7, MW13, MW15, MW16, MW24 and MW34) showed little evidence of a vertical hydraulic gradient. Those located in the central portion of the site (MW8 to MW11) and the south west (MW12, MW17) showed a downward hydraulic head difference of between 0.3 m (MW17) and 6 m (MW9). The largest downward gradients were reported at MW9, and MW10, both located immediately to the north of the offices.

In summary:

- The down gradient boundaries are not shown on this figure; however, there seem to be multiple areas of the site that would be classified as downgradient boundaries based on the equipotential lines shown.
 - a) Groundwater flow across much of the site is shown to be flowing to the southwest (including off-site from the Former Drum Storage Area in the north, and across most of UST Area 1 located in the SEC of the site).
 - b) Flow in the SEC changes from southwest to southeast flow in the area of the USTs.
 - c) There appears to be a southward component along the eastern boundary and then a change in flow to the southeast the south of the site (and in UST Area 2).
- There seems to be a sink near MW23, which has not been discussed but may be related to a leaky sewer (i.e. the sewer taking in water).

Recommendation:

29. Use the quarterly water level monitoring (i.e. gauging) to evaluate the presence and nature of vertical gradients within the upper clay unit and the BGA, as well as between the BGA and FFA.

4.4.3 Evaluation of Groundwater Data

The Auditor has evaluated the groundwater data collected during the Audit by:

- Review of the monitoring well network (Section 4.3)
- Data quality review including Quality Assurance and Quality Control review (Section 3.3)
- Compilation and review of available data.

Groundwater data collected during the Audit is presented in Table 3, Appendix B.

The data, especially for organic compounds, contains several instances of elevated LORs (e.g. up to <50,000 µg/L for VC) and significant variability (e.g. TCR ranges from 874 to 423,000 µg/L at MW15/3) making interpretation difficult. The LORs were usually only elevated for one of the monitoring events at each location. Elevated LORs are an important piece of information which required consideration in the data analysis. The Auditor summarised data collected during the audit to provide a reasonably conservative assessment of the site groundwater that did not discard the elevated LORs nor overstate their significance. This is considered to be a reasonable maximum concentration at each location. The process used for each individual analyte was:

- Key analytes were selected based on reported concentrations and site history
- Where a result was reported for an analyte in one or more GMEs, the highest reported result was selected
- Where all results were reported as less than the LOR, the lowest LOR was selected
- Data for chlorinated hydrocarbons were grouped based on breakdown pathways
- The reasonable maximum concentration at each location is presented in Table 1, Appendix B. These data have been used for figures and interpretation conducted by the Auditor.

4.5 Groundwater Salinity and Protected Beneficial Uses

The electrical conductivity (EC) that was recorded during sampling in March 2010 (GHD, 2010) ranged from 182 µS/cm at monitoring well MW18 to 7,570 µS/cm at monitoring well

MW3 (which is approximately 110 to 4,500 milligrams per litre (mg/L) total dissolved solids (TDS).

The median EC for monitoring wells that could be inferred to be hydraulically up-gradient of the site on the north boundary (MW20, MW27 and MW28), is 1,249 $\mu\text{S}/\text{cm}$. The median March 2010 field EC for the on-site monitoring wells is 2,980 $\mu\text{S}/\text{cm}$ (data from 13 wells).

Table 4-2: Groundwater EC and Salinity (after GHD, 2011)

Bore	Bore Location	Field EC ($\mu\text{S}/\text{cm}$) Mar-10	Lab TDS (mg/L) Mar-10	Lab TDS (mg/L) Jan-11
MW3	North Central (Acid Wash/TIT)	7570	8000	3700
MW4	Northern (Former Drum Storage Area)	471	254	788
MW5	Northern (Former Drum Storage Area)	4510		
MW6/4	Offsite – east along Chandos Street	1175	640	580
MW7/3	Offsite – east along Chandos Street	1978	1190	1350
MW11/2	Northern (Indoor Acid Storage)	3080	1690	1180
MW12/1	Central (easement north of former UST)	337	180	290
MW13/2	Central (southeast side of Flammable Store)	3200	2480	2130
MW15/3	SEC (Former Acid Dock and Drum Shed)	2750		1700
MW16/1	SWC (east side of Former Button Factory)	3510	2080	2010
MW17/1	SWC (west side of Former Button Factory)	1169		850
MW18	SEC (north of USTs)	182		128
MW19	Off-site - east of USTs in SEC	2008	1310	962
MW20	North east corner of site boundary – upgradient well location along Bay Road	1249	760	820
MW21	Northern (Former Drum Storage Area)	2900		1480
MW22	Central (roadway near Poisons Store)	5720		
MW23	SWC (west side of Former Button Factory)	1046		
MW24A	SEC (Former Drum Shed Area)	5900	3700	
MW24B	SEC (Former Drum Shed Area)	4170		
MW25	Off-site – south of SEC (south of MW24)	1577	1220	
MW26	Offsite – south of SEC (toward Chandos St)	4550	2560	
MW27	North boundary – upgradient well location along Bay Road	1219	756	816
MW28	North boundary – upgradient well location along Bay Road	1467	832	798
MW29	Off-site – south of Former Button Factory			488
MW30	Off-site – west of SWC along Hamlet Street	792	430	456
MW31	Central – inside the Poisons Store	2980	1670	
MW32	Central – roadway near Flammables Store	7340	4720	

Bore	Bore Location	Field EC (μ S/cm) Mar-10	Lab TDS (mg/L) Mar-10	Lab TDS (mg/L) Jan-11
MW33R	SWC (east side of Former Button Factory)	2550	1420	1370
MW34A	Off-site – south of SEC (south of USTs)	5840	3210	
MW34B	Off-site – south of SEC (south of USTs)	2580	1480	
MW35	Central – east side of the Flammables Store	3470		
MW36	Northern – south of Non-Toxic Store	3150	1760	1080
MW37	Northern (Former Drum Storage Area)	5570	3040	2140
MW38	Central – roadway north of Office	2079	1180	662
MW39	Central – roadway north of Flammables Store	501	266	230
MW40	Off-site – south of SWC along Hamlet Street	476	252	276
MW41	Offsite – south	725	380	438
MW42	Offsite – south	3410	1910	2020
Notes				
1. Blank cells indicate that data not provided in assessors report				

The Melbourne Groundwater Map (DSE, 2009) shows the watertable aquifer groundwater salinity at the site as close to the boundary of groundwater 501-1000 mg/L TDS (Segment A2) and 1001-3500 mg/L TDS (Segment B).

The median EC data from March 2010 places the site in Segment B. Based on the site-specific data that have been noted to be below 500 mg/L, the Auditor considers that the groundwater segment appropriate for the site is Segment A1.

Recommendation:

30. Investigate the source(s) of the variation of TDS to show whether the site groundwater is actually other than Segment A1. This includes the areas of mounding noted at the site in the vicinity of monitoring wells MW3, MW12 and MW18.

4.6 Groundwater Resources & Utilisation

The site is located in the Moorabbin Groundwater Management Area (GMA). This means this is an area that contains valued groundwater resources that are currently or potentially under stress.

A search of the Groundwater Management System database conducted by the Assessor identified 91 groundwater bores located within a 1 km radius of the site (GHD, 2010). Salinity data was not available for any of the bores. Table 4-3 summarises the details of groundwater bores near the site.

Table 4-3: Nearby Registered Groundwater Bores

Date Completed	Depth (m)	Distance (km) and direction from site	Bore Use	Comments
30/4/1959	39.62	700 m S	Domestic	Bores often installed during drought

Date Completed	Depth (m)	Distance (km) and direction from site	Bore Use	Comments
17/6/1983	23.17	850 m SE	stock	can be used for garden watering.
7/1/1992	40	500 m S	Irrigation	Bores located in golf clubs, a memorial park and surrounding reserves.
1/2/1973	33.5	700 m S		
1/6/1982	26.2	500 m SW		
2/10/1985	41.1	700 m S		
17/2/1984	18.28	200 m SW	Not known	Appears to be in similar locations to the irrigation bores. Most likely used for similar purposes.
17/2/1984	40	200 m SW		
18/9/1985	45.7	700 m S		
19/9/1985	29.3	700 m S		
18/10/1988	35.0	650 m E		
-	-	80 bores	Investigative	The majority are close to Southland shopping centre and other former or current industrial sites.

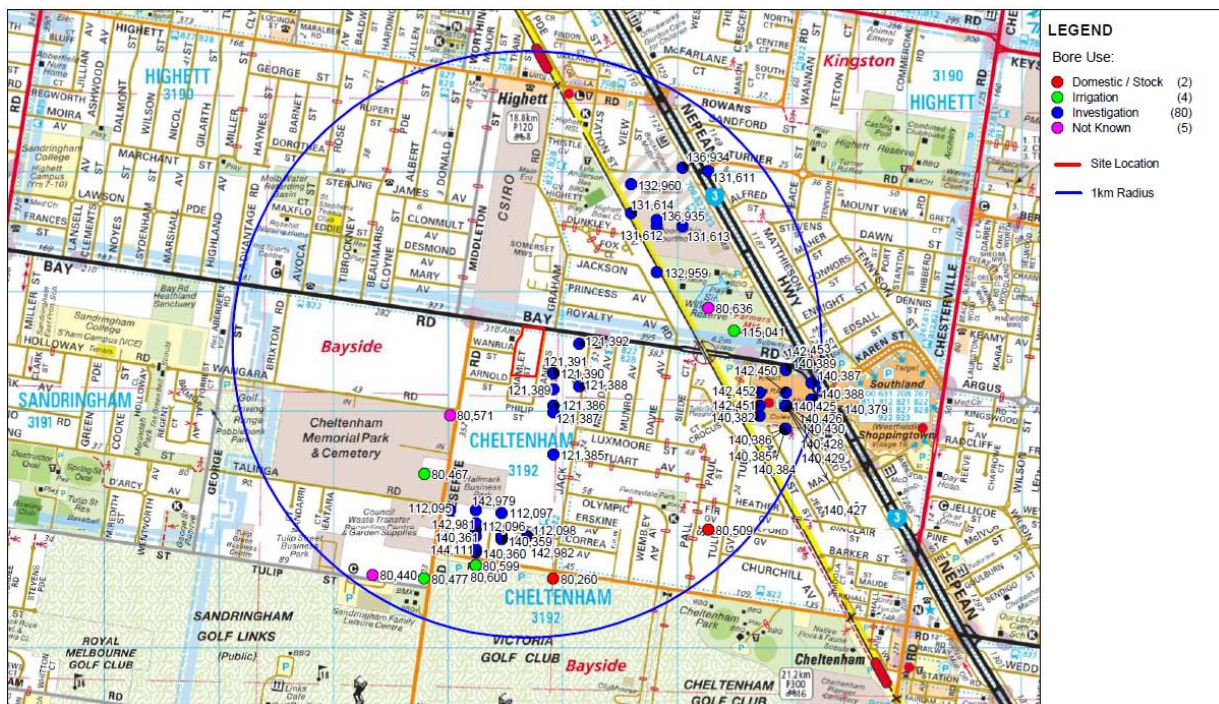


Figure 4-8: Registered Groundwater Bores within 1 km of Site (GHD 2010)

These results show there are eleven registered bores which could potentially be used for groundwater extraction. Groundwater may be utilised by persons with unregistered bores, or registered bores that have not yet appeared on the database.

GHD (2010) describes extraction bores that could be used, down gradient of the site. These include:

- Irrigation well at Cheltenham Memorial Park and Cemetery (500 m south) with screen interval of 12.2 to 30.5 mBGS – elevation in mAHD has not been provided.
- Possible irrigation well at the above cemetery (200 m southwest) with screen interval of 25 to 37 mBGS
- Irrigation well within the Victorian Golf Club (750 m south of the site) with screen interval of 18.6 to 23.1 mBGS.
- Potential for an extractive groundwater supply well at the car wash across Bay Road.
- The Auditor has knowledge of groundwater use at the golf course to the south.

Given restrictions on the use of reticulated water in Melbourne, the relatively low salinity of the groundwater in the site vicinity, and the “as of right” access to groundwater for domestic and stock watering purposes, the Auditor considers it is reasonable to expect groundwater use to increase in the future, including for commercial purposes and domestic uses such as garden watering.

Recommendations:

31. Conduct a search for unregistered bores (field event) downgradient of the site – and door knocking (if required).
32. Seek to obtain groundwater extraction and water supply well information for the above-noted wells.

5 CONCEPTUAL SITE MODEL

5.1 CSM – Introduction and Contents

Conceptual Site Models (CSMs) assist in the assessment of risk and provide a rational basis for design of remedial solutions to groundwater contamination. CSMs are living documents (working hypotheses – U.S. EPA 2004) that are revised throughout the life of environmental work (i.e. an iterative process) conducted at a site. The CSM development process is also used to identify data gaps, uncertainty and to define the risk assessment approach¹⁷. The CSM is a working hypothesis for the understanding of site contamination and are updated as new information is obtained. In relation to groundwater plumes, the CSM has been used to evaluate the capability of the existing groundwater monitoring network.

The CSM generally includes the following aspects:

- Conceptual Hydrogeological Model (CHM)
- Primary and secondary sources (i.e. release areas and source zones)
- Known contaminant distribution
- Migration mechanisms
- Known and/or potential contaminant migration pathways (natural and man-made)
- Fate and transport of site contaminants including partitioning and plume migration contaminant sinks¹⁸ (including biogeochemistry)
- Disposition of receptors and qualitative risk assessment.

Site contamination includes both PHCs and associated LNAPL and VHCs and associated DNAPL. The CSM needs to take into consideration the partially consolidated sands and the ferruginisation of the Red Bluff Sands in the Brighton Group in relation to LNAPL (above the water table) and DNAPL (above and below the water table) migration and potential for accumulation zones to form.

This subsection is focussed on DNAPLs as these products form a more complex contaminant distribution in the subsurface, have the potential to migrate to depth in the aquifer, and are more recalcitrant (remaining at sites for long time periods).

5.2 LNAPL

Petroleum Hydrocarbons (PHCs) have been documented at the site (main locations are the Former Drum Storage Area, the SEC and the former Button Factory).

As noted in the borehole logs of the Assessor's report (GHD 2010), NAPL was detected using the Oil Red O tests on soil samples collected within the vadose zone within the SEC (BH110 at 3.6 mBGS in a medium grained Sand). Whilst, the Oil Red O technique does not allow LNAPL to be differentiated from DNAPL, the Assessors descriptions indicate that the product detected may be LNAPL.

¹⁷ Conceptual models for DNAPL sites are provided in Pankow and Cherry (1996) and are discussed within Appendix C of this audit report.

¹⁸ For example, low permeability portions of aquifers, which may enable matrix diffusion and sorption of contaminants from groundwater (and the related partitioning and subsequent diffusion of LFG).

Oil Red O tests

- BH101 at 11 m (m. gr. Sand, moist with trace clay); PID of 50.1 ppm. DNAPL not detected. Soil sample not submitted for analysis.
- BH108 at 5.7 m (clayey Sand; DNAPL not detected; no PID recorded or observations noted).
- BH110 at 3.6 m (m. gr. Sand, moist with clay); no PID recorded or observations noted; NAPL identified; sample not submitted for analysis.

5.3 DNAPL

Investigation of DNAPL source zones includes evaluation of the release type and mechanisms, source zone architecture, and potential long-term stability and fate. Release types for chlorinated solvents that may create groundwater impacts include releases of dissolved phase, DNAPLs, and also flow through impacts from sources located at other sites. Soil impacts also include surface application and/or release of DNAPLs. Release mechanisms can be significant for DNAPL sites.

For example, there can be a significant difference in distribution of DNAPL and associated phases (soil vapour, sorbed, and dissolved) depending upon the rate and timing of releases. Poulsen and Kueper (1992) documented the migration of PCE DNAPL based on release conditions (similar in nature to that from a leaking drum or a concrete sump – as appears to have occurred at the site). This work documented that catastrophic releases can create different distributions for DNAPL than small releases over time (small releases at the same location were shown to migrate deeper). This is because DNAPLs tend to migrate along the same pathways during repeated releases (more vertical versus lateral transport); thus reducing lateral migration. However, in a catastrophic release of large volumes of DNAPL, the DNAPL will migrate fairly quickly through the vadose zone to and often beyond the top of the saturated zone (i.e. beneath the water table).

Appendix C provides further details on site DNAPL compounds and the CSM for this site.

Recommendations:

33. Use the CSM presented by the Auditor to develop a revised monitoring well network, which has been recommended by the Auditor, to delineate the groundwater plume(s).
34. Use the CSM to develop future investigation plans, and revise and update this CSM as relevant information is gained during these future investigations.

5.4 DNAPL lines of evidence approach

DNAPL presence can be assessed by direct observation and/or indirect lines of evidence. Direct observation of DNAPLs includes observing or collecting DNAPL seeping from embankments, during intrusive investigation and/or sampling, or when using testing methods such as Flute[®], Sudan IV dye (or Oil Red O) and fluorescence. As the observation of DNAPL within a monitoring well is a rare event, the lack of this observation is not to be taken as evidence for the lack of DNAPL presence at a contaminated site where DNAPL was used, stored and spilled. Rather, the lines of evidence for DNAPL in the subsurface are required to be adequately evaluated to provide proof of the absence of DNAPL.

As stated by the U.S. EPA (1992), DNAPL may often be undetected by direct methods, leading to incomplete site assessments and inadequate remedial designs. Therefore, indirect information on the presence of DNAPL is required for sites where DNAPL has not been visually detected (95% of known DNAPL sites - where DNAPLs have been known to be

produced, used, stored, released and/or disposed). The U.S. EPA (1993)¹⁹ re-evaluated groundwater and other data from 712 National Priority List (NPL) sites (virtually all categories of Superfund site types) using the method indicated in U.S. EPA (1992) to identify the proportion where DNAPL may have been present. Of these 712 sites, only 44 had positive observations of DNAPL (6%).

As Clause 18 of SEPP *Groundwaters of Victoria* requires that NAPL should be removed from an aquifer to the satisfaction of EPA (to the extent practicable), a lines of evidence approach detailed below has been conducted for the purpose of this audit report.

The US EPA (1993) noted that the three most frequently detected compounds were PCE, TCE and 1,1,1-TCA, which are compounds used ubiquitously as industrial solvents (with TCE as the most frequently detected). These chlorinated solvents have been used at the site (refer to Appendix C). These solvents have also been identified in samples collected from soil, groundwater and soil vapour (refer to Appendix C).

Indirect lines of evidence to assess DNAPL presence and extent of source zones²⁰:

- DNAPLs known to be manufactured, used, stored, released (land application or leakage from tanks) or disposed on-site.
- DNAPL compounds (i.e. aqueous phase and/or sorbed phase) at depth (deeper than would be expected by dissolved phase transport alone).
- DNAPL compounds cross-gradient to or up-gradient of the identified/known DNAPL source/release area.
- Calculation of the equivalent moles of the DNAPL compounds to assess concentrations prior to degradation to daughter products.
- Method using PID readings stated by the U.S. Air Force Center for Environmental Excellence (AFCEE), 2000 - elevated PID readings (in excess of 1,000 ppm) may indicate DNAPL presence²¹.
- Soil assessment using the methodology of Feenstra, MacKay, and Cherry, 1991.
- Soil assessment using the methodology of UK EA (June 2003) – the sum of individual normalised soil concentrations, where a total greater than 1 indicates DNAPL presence.
- Persistence – dissolved phase versus DNAPL.
- Groundwater assessment using the methodology of UK EA (2003) – sum of individual normalised groundwater concentrations, where a total greater than 0.1 (including processes that decrease observed concentrations) indicates DNAPL presence.
- Soil vapour survey data (potential for vapour plumes in vadose zone emanating from DNAPL) as stated by U.S. AFCEE (2000).
- Dissolved phase concentrations increasing with depth.
- Higher (or elevated) concentrations in groundwater hydraulically up-gradient from a known or suspected release area (anomalous locations for contamination).
- Erratic spatial distribution of dissolved phase compounds as a possible consequence of DNAPL source area (complex 3-D, heterogeneous).
- Inexplicable deterioration of wells or pumps, possibly caused by solvents present as DNAPLs (U.S. AFCEE, 2000).

¹⁹ U.S. EPA-540R-93-073. In 1980, when Comprehensive Environmental Response Compensation Liability Act (CERCLA) was enacted, the DNAPL paradigm did not exist, and as such Superfund site investigations were undertaken without regard to DNAPLs.

²⁰ Taken from Pankow and Cheery, 1996, and Feenstra and Cherry, 1991 unless otherwise noted.

²¹ This is site-specific and compound specific, especially with multi-component DNAPLs.

The Auditor's evaluation of these lines of evidence for the site is given in Appendix C.

Audit Findings:

- The site meets the following lines of evidence (noted above) for the presence of DNAPLs: 1, 2, 3, 5, and 7 through 12. Information for line of evidence 11 is not known as with the exception of MW24A (total depth 20 mBGS) deeper bores have not been installed.
- The following DNAPLs have been used at the site: PCE, TCE, CF, DCM (dichloromethane), 1,1,1-TCA and 1,1,2-TCA. TCE, DCM, CF and TCA were brought to the site in drums. At the Former Drum Storage Area, drums were stored on gravel surface and some of these drums were cracked and/or leaking.
- The following DNAPL compounds have been detected at the site: CT and 1,2-DCA.
- Probable TCE DNAPL presence was indicated at the SEC based on soil data. Due to the depth reached in the subsurface, there is also the potential for PCE DNAPL to be present at BH107_7.8, PCE and TCE DNAPL at BH107_9.1, and PCE DNAPL at BH112_6.8.
- Whilst the Auditor's evaluation has focussed on data collected by the Assessor from the SEC of the site, due to the continued presence of DNAPL compounds in groundwater upgradient of this area (including the former Drum Storage Area) there is at least one DNAPL source zone to the north. However, the current data set is not sufficiently robust to enable further evaluation impacts at the northern half of the site.
- As is typical of DNAPL migration in heterogeneous media, the more accurate CSM would include multiple plumes from the areas of DNAPL accumulation and/or migration.
- Soil vapour concentrations within the SEC were evaluated using Henry's Law, with the result that TCE DNAPL presence was indicated. The data also indicate the potential presence of CF and 1,2-DCA to be present in the subsurface as DNAPLs.
- The continued presence of volatile chlorofluorocarbons (CFCs) in soil gas above the water table may also indicate the presence of a source zone in the SEC for these refrigerants.
- The Auditor considers that there is a possibility that some DNAPL (TCE and potentially others) have migrated off-site to the east as indicated by groundwater concentrations in samples from monitoring well MW19, and to the south as indicated by detections from groundwater samples collected at well MW26. Depth of vertical and lateral migration in the SEC of probable and possible DNAPLs has not been delineated.
- There is a high potential for DNAPL migration to the base of the aquifer at this site due to the release mechanisms and the coarsening downward (from fines to sand to gravels) geology present. The CHM shows that significant accumulation zones with depth are unlikely until the base of the aquifer was reached.
- The results of this DNAPL lines of evidence approach conducted for the purpose of this audit have indicated the likely presence of TCE (and potentially PCE) DNAPL as an ongoing source of contamination at the site (and potentially off-site).

Recommendations:

35. Improve the density and quality of the monitoring well network as indicated in Recommendation 11 to gain data that are suitable to be used to evaluate the depth of impact of chlorinated solvents on-site and off-site.
36. Use appropriate pre-cautions during DNAPL investigations, including the installation of sumps at the bases of monitoring wells, where needed.
37. Use the above-noted methods for observing the presence of DNAPL including Flute® liners during installation of monitoring wells.
38. Investigate other sources of VCH impacts in the subsurface (including areas with upgradient impacts such as the northern half of the site) by soil, soil vapour and

- groundwater investigations (including installation of wells in the revised monitoring well network).
39. Conduct and report on a detailed evaluation of the presence of DNAPLs using the lines of evidence provided above.
 40. A Remediation Feasibility Study (RFS) would be required to evaluate short-term options for interim measures (beyond those recommended by the Auditor).
 41. Interim action (within six months) is recommended to:
 - a) keep the section of the site along the southern boundary in the SEC accessible to address interim measures and potentially longer-term remedial measures
 - b) cover the grassed area in the SEC to limit recharge through the uncovered and former UST excavation areas
 - c) install interim remedial measures to limit the off-site migration of contaminants in the vadose zone and below the water table (i.e. soil vapour and groundwater plumes).
 42. The Auditor considers that a revised RFS would be required to evaluate the long-term clean up options and identify suitable and preferred approach. This approach will need to also contemplate the administrative tools available and effective to manage polluted groundwater to protect future groundwater users from intercepting the plume.
 43. The Auditor recommends that the preparation of a Clean Up Plan subsequent to the achievement of adequate characterisation (including geochemical data and groundwater flow) and delineation.
 44. The Auditor recommends that the Clean Up Plan for the SEC (e.g. remedial excavation) consider the broad list of volatile detections in soil (TPH C₆-C₉, chlorobenzene, PCE, TCE, cDCE, 1,1-DCE, 1,1,1-TCA and 1,1-DCA) and those detected in soil vapour including VC.
 45. Implement a long-term management plan for the site – e.g. an ongoing SMP for the current site built environment, with revisions as needed to take into account modifications and/or redevelopment.

5.5 DNAPL 1% Rule-of-Thumb

The presence of DNAPL in the subsurface is indicated by visual observation and/or in situ concentrations greater than 1% of effective solubility (Pankow and Cherry, 1996). The U.S. AFCEE (2000) uses this method at their sites and Mercer and Cohen (1993) also present this method in their DNAPL text. This rule of thumb must be used as one line of evidence for DNAPL assessment, i.e., used in conjunction with other independent lines of evidence that constitute the CSM. However, lower groundwater concentrations do not rule out the possibility of NAPL within the subsurface. Lower concentrations in groundwater samples where DNAPL is present may be due to:

- dilution from long well screens
- soil sampling interval
- distance of sampling point from source
- multi-component effects on solubility
- dispersion
- biodegradation.

The Auditor evaluated the groundwater data in terms of the 1% rule of thumb to identify the potential for DNAPL presence at the site (details are presented in Appendix C). Groundwater concentrations were also evaluated using the strategies incorporated in UK EA (2003), including effective solubility and the use of sum of the observed concentrations and

solubilities. Most of the findings are located in the SEC potentially due to the significance of this source zone and also potentially due to the low resolution of data elsewhere at the site.

Audit Findings:

- TCE DNAPL presence was indicated from groundwater sampled at wells MW1 (formerly in south eastern portion of the SEC), MW13/2 (near former piping along Flammables Store), MW15/3 (western portion of SEC), MW19 (off-site just east of SEC), MW24B (SEC) and MW24C (SEC).
- DNAPL is likely to be in the vicinity of MW26 (off-site downgradient of SEC) – and there is a limited possibility that concentrations at MW26 represent the core of the plume (with the peak concentrations).
- The actual location of the DNAPLs at the site cannot be identified based on dissolved phase concentrations, as the higher concentration portions of the plume(s) can travel large distances in sandy aquifers.
- As the weathering DNAPLs and partitioning of chlorinated solvents in the subsurface will change over time, thus the impacts in the media and COPCs will vary over time. For example, as TCE has a high solubility in groundwater, concentrations of TCE are likely to dominate total groundwater concentrations (such as in the SEC) until the source is greatly depleted. As other COPCs have greater affinity for soil or soil vapour, these compounds are likely to be more dominant with respect to soil (sorption) and soil vapour.
- As depth of impact is another identifier of the presence of DNAPLs, the deeper well screen at MW26 (16 to 18 mBGS) indicates that DNAPL has reached to at least 18 m BGS (about 8 m below the water table). Further, as the geology shows generally increasing grain size with depth, there is a moderate to strong possibility that DNAPL has gone deeper in this aquifer.

Recommendations:

46. Evaluate the potential for groundwater VCH impacts to reach and be captured by groundwater extraction in the local area using 3D numerical fate and transport modeling (using the recommended 3D groundwater flow model as the foundation for this work).
47. Evaluate/investigate the potential for shallow VCH plumes to intersect PHC contamination off-site in the surrounding commercial/industrial area downgradient of the site.

5.6 DNAPL Degradation

Besides the physical process of partitioning, chlorinated solvents in the subsurface undergo degradation transformations in form by biological (biotic) and abiotic processes. The main contaminants detected within groundwater at the site include chlorinated solvents, namely parent products such as TCE, TCA, CF and degradation compounds. Generally, degradation of organic compounds requires the presence of enzymes generated by bacterial organisms (microbes), and this degradation is in simplified terms a process of oxidation-reduction reactions. The electrons generated are transferred to a terminal electron acceptor (TEA), and the energy released is captured and utilised by the microbe. Details are given in Appendix C.

In the subsurface, redox zones are formed due to the reactions of the various TEAs, with DO consumed first, which changes the impacted region of the aquifer from aerobic to anaerobic conditions (with redox lowering to about 820 mV). Subsequently, the available nitrate, manganese and ferric iron (reduced to ferrous iron) are consumed. This would take the aquifer contaminated by the dissolved phase chlorinated solvents to approximately -50 mV. In general, the outer oxygenated envelope at the front and edges of the plume is the only location within the plume that has interaction with available oxygen. In practice, there are microcosms of varying redox zones within the aquifer impacted by the VCH plume(s).

The Assessor (GHD) stated that the rate of reductive dechlorination is *“likely to be inhibited given that ORP conditions are generally oxidising (with DO concentrations generally in excess of 0.5 mg/L). Overall degradation of PCE and TCE at the site by reductive dechlorination is considered to be limited.”* The Auditor considers that apparently elevated DO and redox values are not in line with the significant concentrations of PHCs and CHCs in the plumes some of which span most of the site (the degradation of which would remove O₂ and lower redox likely to negative values). In addition, this statement by GHD is not in line with sampling observations of strong H₂S odours (e.g. MW15/2).

GHD (2011) state that “based on the concentrations of cis 1,2-DCE across the site, and their spatial correlation with TCE concentrations, it appears that reductive chlorination is occurring to some extent in or in close proximity of the source zone at the site.” Further, the Assessor also indicated that reductive dechlorination is not significant and that DCE stall is occurring. The Auditor notes that DCE stall is generally attributed to a lack of appropriate bacterial strains/communities, which prevents the complete degradation of TCE to ethene with accumulation of DCE as a result. The proliferation of VC has been documented in the SEC of the site, and appears to be related to the presence of PHCs that are a source of carbon for the relevant bacterial populations. In addition, DCE can be degraded under aerobic conditions at the leading edge of the plume. Therefore, the Auditor considers that there is a need for greater resolution of geochemical and contaminant data to make meaningful conclusions for this site.

Chlorinated solvents have been classified by U.S. EPA (1998) to display three types of degradation trends based on the amount of organic carbon available to the in-situ microbes. Type1 (highly anaerobic) is generally observed where organic carbon concentrations (such as PHCs or natural carbon) are sufficient to facilitate degradation of CHCs²²; Type 2 (mildly to moderately anaerobic) where the natural fraction of organic compounds (foc) in the aquifer is present in sufficient amounts (many aquifers are Type 2)²³; and Type 3 where neither of the latter conditions are met and PCE, TCE and DCE do not degrade (U.S. EPA, 1999).²⁴

Type 3 environments comprises well oxygenated aquifers with little or no organic matter and DO concentrations greater than 1 mg/L, which are toxic to anaerobic dechlorinating microbial species; and where anaerobic dechlorination will not occur (AFCEE 2004). In this aquifer type, highly chlorinated VCHs such as PCE, TCE, TCA and CT will not degrade by biological processes; and thus, very long dissolved-phase plumes are more likely to form (AFCEE 2004). However, less-chlorinated VCHs such as VC (and possibly DCE) can be rapidly oxidised under these conditions. A Type 3 environment is found in aquifer sediments with inherently low organic carbon content and where no anthropogenic carbon has been released.

The DO concentrations in Table 25 (GHD 2010) shows a range from 0.00 to 6.74 mg/L, with most of the readings in the 4 to 6 mg/L range. As noted previously, the Auditor considers these field readings to have quality issues related to well construction (including long-screened wells), water levels (near the base of the well screen) and/or sampling (bailers and/or other issues). However, if these data were accurate, then as noted above no anaerobic reductive dechlorination would be occurring at the site as concentrations above 1 mg/L are toxic to those microbes. GHD do not have any data in relation to sulphides in this table; however, strong sulphide odours were noted in sampling records.

²² AFCEE (2004) notes that these are typically sites contaminated by fuel releases, landfill leachate or other anthropogenic carbon because these organics exert a tremendous electron-acceptor demand on the aquifer. Natural possibilities for high natural organic carbon are wetlands. Type 1 characterised by very low DO, nitrate and sulfate.

²³ AFCEE (2004) Type 2 aquifers have slower dechlorination of highly chlorinated CAHs (high oxidation states) and incomplete dechlorination of lesser chlorinated CAHs - which may result in accumulation of DCE and VC.

²⁴ Microbial Processes Affecting Monitored Natural Attenuation of Contaminants in the Subsurface, Sept 1999.

Audit Findings:

- Data gaps in the understanding of the processes occurring at the site are mainly due to the current monitoring well network and sampling issues, but can also be due to intermingling of plumes from various source zones. There are significant data quality issues and geochemical conflicts in the data set. Thus, the Auditor considers that the current geochemical data set is not sufficient to provide resolution necessary for a detailed assessment of degradation. Therefore, conclusions by the Auditor at this point would be largely speculative (including in regard to DCE stall).
- However, there have been significant concentrations of VC detected at the site and degradation of chlorinated compounds is occurring to some degree in some regions of the subsurface. It seems apparent that the elevated detections of DCE and VC are likely to be related to the comingling of sources and/or plumes of PHCs and CHCs (where PHCs would serve as carbon source for reductive dechlorination).
- Further, should the CHC plumes that are and have migrated off-site encounter fuel or other carbon sources in groundwater, then reductive dechlorination could be enhanced, thus creating the potential to generate VC off-site.

Recommendations:

48. Improve the density and quality of the monitoring well network as indicated in Recommendation 11 to gain data that are suitable to be used to evaluate degradation of chlorinated solvents on-site and off-site – including aquifer 'type' and plume stability.
49. Provide an updated discussion on the potential degradation pathways (biotic and abiotic products) for the VCHs. Include figures showing the pathways and peer reviewed references. This is to be used for site characterisation, groundwater fate and transport modelling, risk assessment, remediation and ongoing management.
50. Further evaluate the importance of the intrinsic capacity of the aquifer system to degrade the volatile contaminants – short-term and longer-term.
51. Analyse groundwater samples for alcohols and fatty acids (indicators of aerobic oxidation - cometabolic) and use this as another line of evidence for the occurrence of degradation.
52. Investigate the microbial processes (including microcosm studies) to assist in the understanding of biological degradation – to rule out or confirm the importance of intrinsic aquifer capability to degrade these contaminants (with respect to management of aquifer pollution – beneficial use).

5.7 Plume Stability and Mass Flux

The Auditor has evaluated the data in regard to the stability of the groundwater plume(s) at and emanating from the site. The Auditor considers that there are multiple plumes of various ages and sources at the site. Due to the issues noted in Appendix C on the monitoring network and sampling quality at the site, only a preliminary assessment can be made in terms of plume stability in relation to contamination at and derived from the site.

The Assessor had noted in Section 10.4 (GHD 2011) that the "plume" of contamination did not appear to be in a steady-state condition based on the notable fluctuations in concentrations observed between sampling events, and that local and variable recharge create pulsing of contaminants from the unsaturated zone to the water table.

The Auditor notes that one sign of proximity to a DNAPL source zone is significantly fluctuating concentrations over time. Further from the source zone (i.e. along the flow line) the plume concentrations have more moderated fluctuations due to dispersion. The pulsing to the water

table would not be likely to affect the concentrations in groundwater much below the water table.

A mass flux plane approach may be appropriate for management of contaminant transport on and from this site. This includes on-site monitoring of mass of contaminants travelling across sections perpendicular and parallel to the longitudinal axis of the site (i.e. north to south; where the southern flow direction may be the predominant flow path - this to be confirmed). This may also require similar transects off-site, as possible; and will need to take into consideration the implications for monitoring near the source zones.

Pankow and Cherry (1996) in support of mass flux: *"the ultimate impact of plumes emanating from solvent DNAPL source zones can be evaluated in terms of the impact of relatively small annual mass fluxes to the receptor such as water-supply wells or surface waters. In some cases, the fluxes present significant risk to human health and/or the environment, and extensive remedial action is warranted. In other cases, the fluxes are insignificant, and remedial action would provide little or no actual environmental risk reduction."*

The mass flux approach provides a metric for: the amount of contaminant leaving the source area; the holistic picture of plume attenuation; and loading to a receptor.

Audit Findings:

The Auditor considers that plume stability is unlikely to have been achieved at the site for the majority of plumes identified thus far. This would need to be verified following revision to the existing monitoring network.

Recommendation:

53. Evaluate the use of mass flux from source areas (soil vapour and groundwater) and along the groundwater flow path of plumes using the four transects recommended by the Auditor (soil vapour and groundwater depth-discrete sampling locations).

6 LAND CONTAMINATION AND RISK ASSESSMENT

This section provides the Auditor's response to a principal aspect of the audit scope, which is to assess the current risk of any possible harm or detriment to the land environment and its acceptability to the beneficial uses of land with regard to the objectives set out in SEPP *Prevention and Management of Contamination of Land* (2002).

6.1 Beneficial Uses to be Protected

The beneficial uses considered during this audit were those, which were conducive to the use of the land for public benefit, welfare, safety, health and aesthetic enjoyment, and include all those listed in the SEPP *Prevention and Management of Contamination of Land* (2002) are:

- Maintenance of Ecosystems (Natural, Modified and Highly Modified Ecosystems)
- Human Health
- Buildings and Structures
- Aesthetics
- Production of Food, Flora and Fibre.

The land uses that may be relevant to the protection of all or some of those beneficial uses are:

- Parks and Reserves
- Agricultural
- Sensitive Use (High Density)²⁵
- Sensitive Use (Other)²⁶
- Recreation/Open Space
- Commercial
- Industrial.

Table 6-1 summarises the protected beneficial uses and relevant land uses defined in the SEPP *Prevention and Management of Contamination of Land* (June 2002). The "ticks" in the table mean that the respective beneficial use is protected for each land use under the policy.

²⁵ While high density can be defined as a setting in which there is "minimised access to soil" by occupants, other residential settings may include medium and low density residential settings in which there may be more frequent access to soil in private garden areas.

²⁶ Sensitive Use as defined in the SEPP *Prevention and Management of Contamination of Land* (June 2002) means "a residential use, a child care centre, a pre-school centre or a primary school as defined in Minister's Direction no. 1 as amended from time to time under section 12(2)(a) of the Planning and Environment Act 1987"

Table 6-1: Protected Beneficial Uses of Land

Beneficial Use	Land Use							Explanation
	Parks & Reserves	Agricultural	Sensitive Use (High density residential)	Sensitive Use (Other)	Recreation / Open space	Commercial	Industrial	
Maintenance of Natural Ecosystems	✓							Contamination must not adversely affect the maintenance of relevant ecosystems. Natural ecosystems include parks and forested areas. These are generally undisturbed by human activity and mainly occur in non-urban areas.
Maintenance of Modified Ecosystems	✓	✓		✓	✓			These land uses may contain ecosystems disturbed by human activity but with significant ecosystems remaining. Includes public open space and low density residential allotments.
Maintenance of Highly Modified Ecosystems		✓	✓	✓	✓	✓	✓	These land use areas may contain ecosystems highly modified by human disturbance. These would be expected in any residential, public open space or commercial/industrial area where there are landscaped garden and lawn areas.
Human Health	✓	✓	✓	✓	✓	✓	✓	If persons are exposed directly to soil then their health must be protected. Exposure might occur to residents digging in gardens, workers engaged in excavations for construction or maintenance of underground services. Exposure can also occur from volatile organic vapours migrating through the soil and structures.
Buildings & Structures	✓	✓	✓	✓	✓	✓	✓	Contamination must not cause the land to be corrosive to or adversely affect the integrity of structures or building materials.
Aesthetics	✓		✓	✓	✓	✓		Contamination must not cause the land to be offensive to the senses of human beings.
Production of Food, Flora & Fibre	✓	✓		✓				Contamination of the soil in these land use areas should not affect the quality or yield of produce, or affect the level of an indicator in the food, fibre or flora such that it exceeds the Australian and New Zealand Food Authority Standards Code.

6.2 Contamination Assessment Criteria – Soil

6.2.1 Soil Assessment Guidelines

Table 2 of the SEPP *Prevention and Management of Contamination of Land* (2002) specifies the “Indicators and Objectives” to be applied to the assessment of land contamination. These objectives refer to the (NEPM) *National Environment Protection (Assessment of Site Contamination) Measure* issued in December 1999 by the National Environment Protection Council (NEPC).

The NEPM presents guidelines for soil and groundwater in the assessment of site contamination and specifies Investigation Levels at which further assessment of human or ecological risks or management of contamination is required. The human health levels are referred to as Health Investigation Levels (HILs), and the ecological levels as EILs. The NEPM EILs are equivalent to the ANZECC B criteria, with the following exceptions:

- The NEPM EIL includes criteria for two additional metals (barium and vanadium) and specifies methyl mercury separately from total mercury
- ANZECC B specifies criteria for antimony and tin, not included in NEPM
- The criteria for chromium, copper and lead in the NEPM-EILs are higher than the more conservative ANZECC B levels
- The NEPM also specifies separate criteria for chromium III and chromium VI.

The initial screening levels for determining the issue of a CoEA, and therefore, generally the most conservative of these levels, are the EILs, with the exception of lead where HIL-A is lower than the EIL.

Where these levels do not offer a value for a particular parameter, alternate and equivalent sources of investigation levels are used including:

- ANZECC B (1992)
- Environmental Quality Objectives in the Netherlands (1994) (referred to as Dutch criteria)
- NSW EPA *Guidelines for Assessing Service Station Sites* (1994).
- USEPA *Regional Screening Levels*. United States Environmental Protection Agency (2010)

“Investigation levels” are not intended to be interpreted as “maximum permissible levels”, “clean up levels” or “safe levels”, rather, they are levels at which further investigation or assessment should be undertaken to provide assurance that unacceptable contamination does not occur. Subsequent assessment on a site-specific basis often results in higher levels being acceptable. However, since the “investigation levels” are generally set at conservatively low levels, they are often taken to be the acceptable levels.

The SEPP *Prevention and Management of Contamination of Land* (Table 2) specifies the NEPM EILs and HILs as objectives to be met unless a site-specific assessment of risk yields alternative values.

Where results in excess of NEPM EILs (or equivalent criteria) are noted, these are compared with the NEPM HILs. The site may not qualify for a CoEA if a significant amount of soil at the site exceeds the NEPM EIL criteria, in the absence of a suitable risk assessment. A CoEA is less likely to result where soil exceeds NEPM HIL criteria.

In cases where excess contamination occurs and where further remediation may not occur, a risk assessment to determine site specific criteria or a regime of management of

contamination may be required, and may result in the issue of a CoEA or SoEA depending on site-specific situation.

As it is the Auditor's duty to first consider either a CoEA can be issued, it follows that the assessment must be for all beneficial uses and all land uses.

6.2.2 Site-specific Land Use & Criteria

The site is proposed to be used for ongoing commercial or industrial uses, probably with associated office facilities. The land use(s) associated with this development would be:

- Commercial
- Industrial.

Therefore the beneficial uses and assessment criteria commensurate with these uses are:

- NEPM EIL.
- NEPM HIL-F.

Whilst the above criteria were the primary criteria used, they have been supplemented with criteria from other jurisdictions where the above criteria do not specify allowable concentrations for a particular analyte. In addition, the data was also assessed against NEPM HIL-A to provide a complete assessment of the site.

The following sections provide a summary of those results that exceed NEPM criteria or equivalent.

6.3 Overview of Assessment

Assessment of soil has been undertaken in several stages prior to and during the Audit (refer to Section 3.2.2 for details of assessments). The soil assessment works focused on understanding and delineating areas of known or suspected contamination, rather than a complete assessment of the site (as may be required for a section 53X Audit).

The adequacy of sampling is generally assessed against the guidance provided in the Australian Standard AS4482.1, *"Guide to Sampling and Investigation of Potentially Contaminated Soil, Part 1: Non-Volatile and Semi-Volatile Compounds"* (2005). It should be noted that the standard provides a range of guidance in addition to tabulation (Table E1 of AS4482.1-2005) of a grid spacing required to detect a circular "hotspot" of arbitrary diameters. The standard also stresses the need for using knowledge of site history to plan the sampling strategy. Reliance on Table E1 of AS4482.1 (2005) as the key guidance for specifying a soil sampling strategy is therefore misleading.

The Auditor has reviewed the soil sampling undertaken by the assessor and makes the following comments:

- The amount of soil sampling conducted is significantly less than specified in Table E1 of AS4482.1.
- Soil sampling locations have been targeted to areas of known or suspected contamination.
- Additional targeted soil sampling would be required to assess additional potential source areas (albeit of lower significance than the source areas investigated) and to delineate the previously investigated target areas.
- However, the level of detail of soil assessment conducted is adequate to make an assessment of the risk of any possible harm to the land environment as part of this audit.

The following sections provide a detailed analysis of data collected under the Audit (GHD 2008 and GHD 2010) and provide reference to data collected prior to the Audit (SMEC 2007 and ERM 2001).

6.4 Protection of Ecosystems – Land

The site contains no natural unmodified ecosystems. The intended land use of the site is likely to be low or medium density residential. Therefore, the soil and fill remaining on the site may reasonably be expected to sustain the "modified ecosystems" and "highly modified ecosystems" found in urban gardens in compliance with the SEPP *Prevention and Management of Contamination of Land* (2002). The soil must sustain plants including ornamental flowers, shrubs, lawn and possibly small trees in such gardens, as well the soil in-fauna.

A summary of analyte concentrations reported above the adopted ecological criteria are shown in Table 6-2.

Table 6-2: Soil Results Exceeding Ecological Criteria (mg/kg) – 2008 and 2010 data

Analyte	Criteria	Background Range	No. analysis	Max Conc.	Average Conc.	No. analysis above EIL	No. analysis above EIL & Background
Arsenic	20 ¹	1-50	108	66	7.1	6	3
Barium	300 ¹	100-3000	54	583	22	1	0
Cadmium	3 ¹	1	108	8.9	0.47	2	2
Copper	100 ¹	2-100	108	817	13	2	2
Lead	600 ¹	2-200	108	1540	23	1	1
Mercury	1 ¹	0.03	108	10.2	0.22	4	4
Nickel	60 ¹	5-500	108	94	5.4	2	0
Vanadium	50 ¹	20-500	54	140	42	15	0
Ethylbenzene	3.1 ²	–	121	13.8	0.42	3	–
Toluene	1.4 ²	–	121	29.5	0.84	4	–
Xylene (total)	14 ²	–	121	94.9	1.4	1	–
TPH C ₆ -C ₉	65 ²	–	117	1,860	30	5	–
TPH C ₁₀ -C ₃₆	1000 ²	–	114	2830	110	1	–
Notes 1. NEPM EIL Criteria 2. NSW Service Stations. Minimum value of Terrestrial Organisms and Health & Ecological criteria							

Several organic compounds were detected above LORs, and above human health criteria (refer to Section 6.5.2). However, NEPM EILs do not provide criteria for these analytes. The NSW EPA Service Station Guidelines were adopted for PHCs; however, no criteria were adopted for VCHs. The Auditor considers that the elevated chlorinated hydrocarbons could further impact the beneficial use of Maintenance of Highly Modified Ecosystems in the southeast portion of the site.

Chromium (total) concentrations of up to 669 mg/kg exceed NEPM EIL criteria for chromium VI (1 mg/kg). Chromium was not been speciated, so it cannot be confirmed if chromium exceeds the adopted criteria.

The contamination of surface soil may be a significant impediment to this beneficial use of the land, especially in the SEC of the site. Soil assessment has been focused on locations where groundwater contamination has been observed; thus conclusions on the assessment of soil contamination across the remainder of the site are not possible. However, as recommended by the Auditor, an SMP should be implemented to minimise risks associated with soil and soil vapour intrusion at the site.

6.5 Protection of Human Health

6.5.1 Soil Results – Inorganics

Analyte concentrations reported above the NEPM HIL-A criteria are shown in Table 6-3.

Table 6-3: Inorganic Soil Results Exceeding NEPM 1999 HIL-A Criteria (mg/kg)

Assessor	Sample Location	Sample Depth	Cobalt	Lead
NEPM HIL-A			100	300
NEPM HIL-F			500	1500
GHD (2008 & 2010)	GBH1A	0.5	106	
	GBH1B	1	548	
	GBH3A	0.5	250	
	VP101	0.5		1540
	VP105	0.5		305
SMEC (2007)	BH102	0.6	170	
	BH105	2.8	130	
	BH109	0.6	110	
	BH109	1.1	120	
	BH111	0.2	200	
	BH118	0.3		
	BH124	0.6	110	
Note: Blank cell indicates that concentration is below criteria or analyte not tested				

The inorganics, cobalt and lead exceed the NEPM HIL-A and HIL-F criteria.

The reported concentrations are greater than 2.5 times the HIL-A (cobalt at GBH1B and lead at VP101) criterion, but less than 2.5 times the HIL-F criterion and therefore considered suitable for the statistical analysis.

The mean concentration of cobalt in the GHD samples (n=54) is 26 mg/kg, well below the HIL-A criterion of 100 mg/kg and the HIL-F criterion of 500 mg/kg. The standard deviation of cobalt in the GHD samples is 82 mg/kg. Hence cobalt is considered to be protective of human health for commercial and industrial uses, but sample GBH1B is not protective of low-density residential uses. These cobalt results do not constitute “hot spots” as defined by NEPM and may represent local anomalies and natural variation. There are no evident sources of cobalt at the site; however, the imported fill material used to level the site (is a potential source).

The mean concentration of lead in the GHD samples (n=64) is 23 mg/kg, well below the HIL-A criterion of 300 mg/kg and the HIL-F criterion of 1,500 mg/kg. The standard deviation of lead in the GHD samples is 150 mg/kg. Hence lead is considered to be protective of human health for commercial and industrial uses, but sample VP101 is not protective of low-density residential uses. Lead may have been sourced from the former UST in the area.

6.5.2 Soil Results – Organics

Analyte concentrations reported above the adopted human health criteria are shown in Table 6-4. NEPM HIL-A does not specify criteria for non-speciated TPH, BTEX or chlorinated solvents. Organic chemicals without NEPM criteria were compared to criteria from other jurisdictions (See section 6.2.1).

Table 6-4: Organic Soil Results Exceeding Human Health Criteria (mg/kg) – GHD 2008 and 2010 Data

Analyte	Dutch Intervention	HIL-A	NSW Service Station (Health & Ecological)	USEPA RSLs (Industrial Soil)	USEPA RSLs (Residential Soil)	No. analysis	Max Conc.	Average Conc	No. analysis above lowest criteria
Ethylbenzene	50	-	50	29	5.7	121	13.8	0.42	1
Xylenes (Total)	25	-	25	2,600	600	121	94.9	1.4	1
1,1,1-trichloroethane	15	-	-	39,000	9,000	118	33.4	0.8	2
1,1-dichloroethene	0.3	-	-	1100	250	118	2	0.28	3
Chloroform	10	-	-	1.5	0.3	118	1.5	0.26	1
Trichloroethene	60	-	-	14	2.8	118	1210	18	17
Tetrachloroethene	4	-	-	2.7	0.57	118	157	1.9	8
TPH C ₆ - C ₉	-	-	65	-	-	117	1,860	30	5
TPH C ₁₀ - C ₃₆	-	-	1,000	-	-	114	2,830	110	1

Concentrations of several organic chemicals exceeded the adopted guidelines as shown in Table 6-4

6.5.3 Asbestos

A single fragment of asbestos cement bonded material (containing chrysotile) was identified at VP117 at 0.23 m within the Fill. The Auditor considers it likely that other fragments of asbestos cement may be located at the site, but does not consider it likely that asbestos presents a major contamination risk driving remedial action. Its presence, under current regulatory framework could increase remediation costs significantly if asbestos contaminate soil/fill was removed from site.

6.5.4 Conclusions for Human Health

The significance of contamination of soil by organic compounds found at the site cannot be assessed by comparison with human health investigation levels as there are insufficient criteria available. A site specific assessment of health risk is required for this purpose.

However, the presence of organic compounds, especially chlorinated solvents in the soil and groundwater would produce vapours in the soil above the watertable that can be detrimental to human health. As the soil gas is a component of “land” defined under SEPP *Prevention and Management of Contaminated Land*, this was assessed by a health risk assessment presented in Section 8, and found to be acceptable for ongoing commercial/industrial use without site development. However, construction of a building above the source area may present an unacceptable risk for commercial or industrial site use.

Based on the outcomes from the soil laboratory testing results and health risk assessment, there is an acceptable risk to human health from contaminants in soil at and adjacent to the site provided an SMP is implemented. As recommended by the Auditor, further consideration needs to be given to possible vapour intrusion risk to persons occupying buildings off-site. This is discussed further in Section 8.5.

6.6 Protection of Buildings and Structures

Australian Standard AS3600 – Concrete Structures, prescribes a pH guideline of 4 for soils and NEPM (1999) sets a sulphate level of 2,000 mg/kg for protecting building and structures.

Acid sulphate soils were not suspected at this site due to the geological and physiological characteristics of the site. Therefore, testing was not performed for acid generation and neutralisation.

The pH of the site soils at the site ranged from a minimum of 4.8 to a maximum of 8.5. Soil of this pH is not likely to present a corrosion hazard to buildings and structures. Sulphate concentrations were not analysed.

Elevated concentrations of VCHs identified (see Table 6-4) in the SEC may be detrimental to building elements particularly drains and conduits which may be constructed from PVC or other plastics.

6.7 Protection of Aesthetics

Aesthetics, especially odour is an important criterion for the Auditor to consider. The objective for “Aesthetics” in the SEPP *Prevention and Management of Contamination of Land* (2002) is that “contamination must not cause the land to be offensive to the senses of human beings.” The aesthetic beneficial use is not protected by policy in the industrial land use setting, although it is protected in the commercial setting which forms part of the land use in the industrial land use zone.

Odours were recorded on borelogs in various parts of the site:

- SEC: Strong volatile odours generally below 1 mBGS
- Former Drum Storage Area: Sweet odour reported at 2.4 mBGS
- SWC: Slight hydrocarbon odour at 3 m depth in the former UST pit.

These odours could preclude this beneficial use in the event that a commercial office building or similar was built over these areas of the site.

Aesthetically unacceptable material or odours were not identified at the remainder of the site. The Auditor considers it possible that unacceptable odours may be present at other areas of the site that have not yet being investigated.

6.8 Production of Food, Flora and Fibre

The SEPP *Prevention and Management of Contamination of Land* (2002) indicates that contamination of land must neither adversely affect produce quality or yield, nor affect the level of an indicator in food, flora and fibre. This beneficial use is not protected at commercial or industrial sites under SEPP (PMCL), however was assessed in this audit to provide a complete assessment, especially if land use were to change.

Arsenic, barium, cadmium, copper, lead, mercury, nickel and vanadium exceed the NEPM EIL criteria, with the majority of elevated results from the top 1.0 m of soil. In addition elevated concentrations of TPH, BTEX and VCHs have been detected in various areas of the site. It is considered that the elevated organic and inorganic analytes are not protective of the beneficial use Production of Food, Flora and Fibre.

6.9 Summary of Auditor’s Opinion on Land Contamination

Following a review of the data provided, and having regard to the SEPP *Prevention and Management of Contaminated Land* (2002), the Auditor is of the opinion that some of the beneficial uses of the land are precluded due to contamination status of land. Table 6-5 summarises the outcome of the land contamination assessment and identifies the land uses for which one or more beneficial uses may be precluded, making the land unsuitable for some uses. It also identifies the need for a management plan in some cases.

In summary, the beneficial uses of land were found to be protected for commercial and industrial uses assuming the current configuration of buildings is largely unaltered (no enclosed structure intended for human occupation should be built on the SEC without remedial works) and an appropriate management plan is implemented, primarily to protect persons from potential exposures if the site covering is breached.

Table 6-5: Summary of Land Use Assessment

Land Use	Suitable Without Management Plan	Suitable With Management Plan	Unsuitable
Parks and Reserves	—	—	✖
Agricultural	—	—	✖
Sensitive Use (high density residential)	—	—	✖
Sensitive Use (other) ¹	—	—	✖
Recreation / Open Space	—	—	✖
Commercial	—	✓ ²	—
Industrial	—	✓ ²	—
Notes			
1. Sensitive Use (other) = land used for residential use (other than high density), a child care centre, pre-school, or primary school.			
2. The HRA concludes that the risks for current site use are not un-acceptable, however the risks may be unacceptable for redevelopment scenarios including occupation of the SEC by a commercial or industrial (enclosed) building			

7 GROUNDWATER RISK ASSESSMENT

This section provides the Auditor's response to a principal aspect of the audit scope, which is to assess the current risk of any possible harm or detriment to the groundwater and surface water environments with regard to the objectives set out in SEPP *Groundwaters of Victoria* and SEPP *Waters of Victoria*. Section 3.5 of this report discusses risk to the land environment.

7.1 Beneficial Uses to be Protected – Groundwater

Table 7-1 presents the classification of beneficial uses of groundwater protected in accordance with SEPP *Groundwaters of Victoria*.

Table 7-1: Protected Beneficial Uses of Groundwater Segments

Beneficial Uses	Segments (mg/L TDS)				
	A1 (0-500)	A2 (501- 1,000)	B (1,001- 3,500)	C (3,501- 13,000)	D (greater than 13,000)
1. Maintenance of ecosystems	✓	✓	✓	✓	✓
2. Potable water supply					
Desirable	✓				
Acceptable		✓			
3. Potable mineral water supply	✓	✓	✓		
4. Agriculture, parks & gardens	✓	✓	✓		
5. Stock watering	✓	✓	✓	✓	
5. Industrial water use	✓	✓	✓	✓	✓
6. Primary contact recreation (e.g. Bathing, swimming)	✓	✓	✓	✓	
7. Buildings and structures	✓	✓	✓	✓	✓

Based on the testing program undertaken at the site, the groundwater in the water table aquifer at this site has the following salinity and Segment classification under SEPP *Groundwaters of Victoria*:

- 110 to 9820 mg/L TDS
- Average (mean) 1657 mg/L TDS
- Average (median) 1215 mg/L TDS
- TDS of hydraulically up gradient wells (MW20, MW27, MW28) is 820, 816, 798 mg/L in January 2011
- Is conservatively classified as Segment A1, however the fresher samples may represent local freshwater recharge rather than background.

Therefore, the Beneficial Uses for Segment A1, as shown in Table 7-1, are protected at this site.

7.2 Contamination Assessment Criteria – Groundwater

The water quality guidelines applying to the assessment of groundwater contamination in Victoria are those specified in Table 3 of the *SEPP Groundwaters of Victoria*. These are presented in Table 7-2.

Table 7-2: Water Quality Criteria for Groundwater

Beneficial Use Category	Applicable Water Quality Criteria
Maintenance of Aquatic Ecosystems	Those applicable under the relevant SEPP for receiving waters. In this case the SEPP <i>Waters of Victoria</i> applies and the water quality guidelines are found in Chapter 2 of the ANZECC (2000) <i>Australian Water Quality Guidelines for Fresh and Marine Waters</i>
Potable Water Supply	Chapter 4 of the ANZECC (1992) <i>Australian Water Quality Guidelines for Fresh and Marine Waters</i> NHMRC (2004). <i>National Water Quality Management Strategy. Australian Drinking Water Guidelines</i>
Agriculture, Parks & Gardens	Chapter 5 of the ANZECC (1992) <i>Australian Water Quality Guidelines for Fresh and Marine Waters</i>
Stock Watering	Chapter 5 of the ANZECC (1992) <i>Australian Water Quality Guidelines for Fresh and Marine Waters</i>
Industrial Water use	Chapter 6 of the ANZECC (1992) <i>Australian Water Quality Guidelines for Fresh and Marine Waters</i>
Primary Contact Recreation	Chapter 3 of the ANZECC (1992) <i>Australian Water Quality Guidelines for Fresh and Marine Waters</i>
Potable Mineral Water	Australian Food Standards Code (1987) – <i>Standard 08 Mineral Water</i>
Buildings & Structures	No criteria – “shall not be corrosive to structures”.

It is noted that more recent guidelines are available including:

- NHMRC/NRMCANZ, 2004 *Australian Drinking Water Guidelines*. National Water Quality Management Strategy
- ANZECC/ARMCANZ, 2000 *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy.
- NHMRC, 2008 *Guidelines for Managing Risks in Recreational Water*.

The EPA has not adopted these at this time, except in the case for Maintenance of Aquatic Ecosystems whereby the guidelines refer to ANZECC/ARMCANZ (2000). Additionally, EPA's guidance has included advice to the effect that ANZECC/ARMCANZ (2000) can be used if it represents “better science”.

While ANZECC (1992) water quality criteria have been used in previous assessments, the Auditor has reviewed the results against the ANZECC (2000) to confirm whether the findings should be varied.

7.3 Groundwater Protection Assessment Summary

In assessing the protection/pollution status of groundwater, all beneficial uses protected under this segment must be considered. The following is the Auditor's assessment of the protection

status of the groundwater with regard to each beneficial use relative to the relevant water quality criteria.

7.4 Maintenance of Aquatic Ecosystems

Groundwater results which exceed the ANZECC (2000) *Freshwater Ecosystem Guidelines* are presented in Table 7-3.

Table 7-3: Groundwater Laboratory Results Exceeding Ecosystem Maintenance Criteria

Analyte	Units	Criteria	No. analysis	Max Conc.	Average Concentration	No. analysis above Criteria
Ammonia (N)	µg/L	900	27	2180	159	1
Cyanide	µg/L	7	28	116	2	4
Nitrate (N)	mg/L	7.2	130	116	13	57
Lead	µg/L	3.4	133	1070 ¹	14	30
Cadmium	µg/L	0.2	133	44.5	1.3	40
Copper	µg/L	1.4	133	71	6.1	99
Mercury	µg/L	0.6	133	98	2.3	7
Nickel	µg/L	11	133	134	16	63
Zinc	µg/L	8	130	554	62	128
Naphthalene	µg/L	16	115	38	25	4
Notes						
1. The two highest lead results of 1070 µg/L (MW7/3) and 385 µg/L (MW11/2) occurred in the January 2011 GME and are inconsistent with previous data at those wells. The next higher lead result is 44 µg/L.						

The Auditor notes that several organic compounds, especially VCHs have been detected in groundwater at elevated concentrations; however, no criteria exist for those compounds. These organic compounds have been discussed further in Section 7.5 and in the risk assessment (Section 8). If the groundwater flowing beneath this site could be shown to be discharging into a surface water body at the concentrations found at this site, then this could constitute pollution.

Elevated concentrations of nitrate, cadmium, copper, nickel and zinc were detected in the upgradient bores (MW20, MW27 and MW28), suggesting that these analytes may be regionally elevated. However, the maximum concentrations of these analytes are generally recorded in groundwater sampled from on-site wells. Therefore, the Auditor considers that it is likely that site operations have caused an increase in groundwater concentrations of these above-noted compounds. The distribution of these elevated analyte concentrations are presented on Figures 16 & 17, Appendix A. Elevated nitrate, copper, nickel and zinc were reported in other nearby audits (refer to Appendix C).

On balance it seems that the metal contamination may have derived from a range of sources, may be naturally elevated and further elevated by site operations.

The permeability of the aquifer is considered to be low to very low, based on the slow recovery of the bores during purging and sampling.

The nearest downgradient surface water body is the Port Phillip Bay, located 1 km southwest of the site. Given the observed concentration distribution on the site, the significant distance to the potential discharge point and the nature of the aquifer, there is a substantial time for attenuation of the metal and organic contaminants to occur prior to discharge to the bay, assuming it is not a natural background level.

Therefore, this beneficial use of groundwater is considered not to be precluded by contamination from the site.

7.5 Potable Water Supply

Groundwater results which exceed the ANZECC (1992) *Raw Drinking Water* criteria or the NHMRC (2004). *Australian Drinking Water Guidelines* are presented in Table 7-4.

Table 7-4: Groundwater Laboratory Results Exceeding Raw Drinking Water Criteria

Analyte	Units	Criteria	No. analysis	Max Detect.	Average Concentration	No. analysis above Criteria
Iodide	mg/L	0.1 ²	40	8	1.4	15
Benzene	µg/L	1 ²	123	442	96	15
Ethylbenzene	µg/L	3 ¹	123	138	88	9
Toluene	µg/L	25 ¹	123	12,200	279	10
Xylene Total	µg/L	20 ¹	123	525	263	5
1,1-dichloroethene	µg/L	0.3 ³	113	2,720	152	20
1,2-dichloroethane	µg/L	3 ²	113	2,930	190	22
Carbon tetrachloride	µg/L	3 ^{2/3}	113	86	97	14
Dichloromethane	µg/L	4 ²	52	179,000	3788	14
Trichloroethene	µg/L	30 ³	113	423,000	18,451	51
Tetrachloroethene	µg/L	10 ³	113	5,740	356	31
Vinyl Chloride	µg/L	0.3 ²	113	440	940 ⁵	3
1,2-dichlorobenzene	µg/L	1 ¹	113	73	95	8
1,4-dichlorobenzene	µg/L	3 ¹	113	6	93	1
Chlorobenzene	µg/L	10 ¹	113	1460	118	5
Ammonia (N)	µg/L	10 ³	27	2,180	159	13
Chloride	mg/L	250 ¹	132	5,030	608	76
Cyanide	µg/L	80 ²	28	116	2	1
Nitrate (N)	mg/L	10 ³	130	116	13	43
Nitrite (N)	mg/L	0.9 ²	122	1.31	0.09	3
Sodium	mg/L	180 ¹	132	2400	482	110
Sulphate	mg/L	250 ¹	132	638	203	50
TDS	mg/L	500 ¹	132	9820	1616	113

Analyte	Units	Criteria	No. analysis	Max Detect.	Average Concentration	No. analysis above Criteria
Lead	µg/L	10 ²	133	1070 ⁴	14	11
Arsenic	µg/L	7 ²	133	305	26	29
Cadmium	µg/L	2 ²	133	44.5	1.3	11
Iron	µg/L	300 ^{1/3}	98	30.8	1.2	16
Manganese	µg/L	100 ^{1/3}	112	1190	120	37
Mercury	µg/L	1 ^{2/3}	133	98	2.3	6
Nickel	µg/L	20 ²	133	13.4	16	36
Notes 1. ADW 2004, Aesthetics 2. ADW 2004, Health 3. ANZECC 1992 Raw Drinking Water 4. The two highest lead results of 1070 µg/L (MW7/3) and 385 µg/L (MW11/2) occurred in the January 2011 GME and are inconsistent with previous data at those wells. The next higher lead result is 44 µg/L. 5. Average concentration is greater than the maximum detect as elevated LORs are included in the calculation of average values						

Concentrations of TDS and the major ions (chloride, sodium, sulphate and manganese) are generally considered to be naturally occurring and are not considered to be contamination. However, the highest values are unlikely to be natural and may be due to contamination although the source is not obvious. Elevated metal concentrations are likely to be naturally occurring, however may have been further elevated by site activities as discussed in Section 7.4.

Concentrations of organic compounds exceed the ANZECC 1992 raw drinking water criteria in onsite and offsite wells, and are considered to be caused by site activities. Land use around the site includes mechanics (with USTs) and other manufactures, suggesting that there may be multiple sources of organic contaminants within the area; however there is no evidence of organic contaminants from offsite sources migrating onto the site.

The groundwater bore search (see Appendix C), identified two bores as being registered for domestic/stock within 1 km of the site. The bores are positioned to the south and southeast of the site, which is considered to be hydraulically down-gradient given the uncertainties in groundwater flow direction (see Section 4.4). These bores were installed in 1959 and 1983 and may have been lost or destroyed since installation. The Auditor has been advised by the client (and site owner) that there is no plan to provide a groundwater supply bore at the site. Whilst there are no controls on the actions of occupiers of hydraulically downgradient sites, the poor financial feasibility of such a supply, the expected poor yield of this aquifer to a bore and the reticulated potable water supply also militate against such use.

This beneficial use of groundwater is considered to be precluded by contamination from the site. However, this beneficial use (drinking water) is not relevant at this site and the chance of groundwater being utilized at or near the site in the future for this purpose is low. Groundwater extraction for irrigation or industrial use is more likely.

7.6 Potable Mineral Water

The groundwater does not conform to the definition of mineral water (potable groundwater which in its natural state contains carbon dioxide and other soluble matter in sufficient concentration to cause effervescence or impart a distinctive taste, SEPP (GoV) nor is the site in a recognised mineral water province as envisaged in EPA Pub 592 Policy Impact Assessment of SEPP (GoV).

If this beneficial use was deemed to be relevant, it would be precluded by contamination from the site.

7.7 Agriculture, Parks and Gardens

Groundwater results which exceed the ANZECC (1992) *Agriculture, Parks and Gardens* criteria are presented in Table 7-5.

Table 7-5: Groundwater Laboratory Results Exceeding Agriculture, Parks and Gardens Criteria

Analyte	Units	Criteria	No. analysis	Max Conc.	Average Conc.	No. analysis above Criteria
Chloride	mg/L	30	132	5,030	608	121
Fluoride	mg/L	1	84	2.8	0.26	8
Lead	µg/L	50	133	1070 ¹	14	2
Arsenic	µg/L	100	133	305	26	16
Cadmium	µg/L	10	133	44.5	1.3	4
Cobalt	µg/L	50	41	279	25	7
Iron	µg/L	300	98	30.8	1.2	16
Mercury	µg/L	2	133	98	2.3	5
Notes						
1. The two highest lead results of 1070 µg/L (MW7/3) and 385 µg/L (MW11/2) occurred in the January 2011 GME and are inconsistent with previous data at those wells. The next higher lead result is 44 µg/L.						

As discussed above, chloride is considered to be naturally occurring and is not considered to be contamination. However, the highest chloride concentration of 5,030 mg/L seem unusually high and could be due to a contaminant source. The elevated metal concentrations are also likely to be naturally elevated; however, these concentrations are likely to have been further elevated by site activities.

The elevated fluoride concentrations were concentrated in the SEC of the site. GHD (2009) opined that the elevated fluoride is due to leakage from reticulated water services. However, the Auditor considers that the elevated fluoride may be due to site activities; fluoride is added to drinking water at approximately 1 mg/L, and would be expected to be diluted by groundwater if originating from a water pipe.

ANZECC 1992 *Agriculture, Parks and Gardens* criteria does not specify any criteria for the majority of the organic analytes. The Auditor notes that concentrations of several organics,

especially VCHs are elevated and could further preclude this beneficial use due to tainting effects of water on produce irrigated with this water.

Four groundwater bores registered for irrigation use have been identified within 1 km of the site (ref section and figure). One is located to east and is not considered to be hydraulically down gradient. The remaining three are located to the south or southwest and may be used for irrigation by the Cheltenham memorial park or a golf course. The Auditor has knowledge of the installation of bores on local golf courses.

This beneficial use of groundwater is considered to relevant based on the potential use near to site and to be precluded by contamination from the site.

7.8 Stock Watering

Groundwater results which exceed the ANZECC (1992) *Stock* criteria are presented in Table 7-6.

Table 7-6: Groundwater Laboratory Results Exceeding Stock Criteria

Analyte	Units	Criteria	No. analysis	Max Conc.	Average Concentration	No. analysis above Criteria
Benzene	µg/L	10	123	442	96	8
1,1-dichloroethene	µg/L	0.3	113	2,720	152	20
1,2-dichloroethane	µg/L	10	113	2,930	190	19
Carbon tetrachloride	µg/L	3	113	86	97	14
Trichloroethene	µg/L	30	113	423,000	18,451	51
Tetrachloroethene	µg/L	10	113	5,740	356	31
Fluoride	mg/L	2	124	2.8	0.26	1
Nitrate (N)	mg/L	30	130	116	13	11
TDS	mg/L	3000	132	9820	1616	18
Lead	µg/L	100	133	1070 ¹	14	2
Cadmium	µg/L	10	133	44.5	1.3	4
Mercury	µg/L	2	133	98	2.3	5
Notes						
1. The two highest lead results of 1070 µg/L (MW7/3) and 385 µg/L (MW11/2) occurred in the January 2011 GME and are inconsistent with previous data at those wells. The next higher lead result is 44 µg/L.						

Metal concentrations are considered to be naturally elevated as well as further elevated by site activities as discussed above. Organic compounds are elevated due to site activities.

The zoning of the site and the industrial nature of the surrounding area suggest that this beneficial use is unlikely. Such activity would not be permitted by the local planning scheme. Therefore this beneficial use is not relevant at this site.

This beneficial use of groundwater is considered to be precluded by contamination from the site.

7.9 Industrial Water Use

Industrial water uses defined in the ANZECC 1992 (Chapter 6 Industrial Water Quality) relevant to groundwater extractive use are generic processes (heating and cooling), textile industry, chemical and allied industry, food and beverage industry, iron and steel industry, tanning and leather industry, pulp and paper industry and the petroleum industry).

Table 7-7: TDS of Industrial Water Uses

Industrial Water Use	TDS
Once through cooling and make-up water systems for fresh water	<1000 and <500, respectively
Textile industry	<100 mg/L
Food and beverage industry	<850 mg/L
Iron and steel industry	<1000 mg/L
Pulp and paper industry	<500 m/L
Petroleum industry	<750 mg/L

The groundwater cannot typically be used for the industries listed above as the TDS required is less than the background water quality from this site. Whilst the groundwater was conservatively classified as segment A1 (see section 7.1), the mean & median TDS 1657 1215 mg/L respectively indicating that a “mixed groundwater” as would be obtained through pumping is likely to have a TDS greater than required for many industrial processes

Generic processes (heating and cooling) are the only industrial beneficial listed in the ANZECC 1992 guidelines that are not precluded by salinity levels with no criteria specified. However it was noted in Table 6.2 of the ANZECC 1992 guidelines, *Effects of some water quality parameters on heating equipment*, that dissolved solids “Process interfere and cause foaming in the boilers”.

GHD (2010) report anecdotal evidence that the carwash facility located adjacent to the site (across Bay Road to the north, and hydraulically up-gradient) extracts and used groundwater for car washing.

While the natural salinity of the groundwater may restrict its use for a range of industrial purposes, the concentration of contaminants would further restrict the use of the groundwater. The odours arising from the groundwater would also be a constraint on the use of this water. Therefore, this beneficial use is considered to be precluded by contamination from the site.

7.10 Primary Contact Recreation

This beneficial use relates to the use of groundwater to fill swimming pools, or in cases where a water body occurs on a site where it receives groundwater discharge and may be used for swimming. In this case the land is zoned for industrial use and swimming pools are unlikely to be installed.

Water quality criteria for toxicants for primary contact recreation are the same as for drinking water. However, the ANZECC (1992) refers to a 20 times allowable factor for short duration exposure given the minimal ingestion of water during swimming (and perhaps more given the less than daily frequency of swimming). This factor does not apply to organic contaminants as exposure pathways other than ingestion exist (e.g. inhalation).

In this case concentrations of the inorganics ammonia, chloride, cyanide, nitrate, nitrite, sodium, sulphate, TDS, lead, arsenic, iron manganese, mercury and nickel are greater than the drinking water criteria (see Table 7-4). Of these, ammonia, TDS, lead, and mercury are also above the PCR criteria when the 20 times rule has been applied. The organic compounds identified as exceeding the drinking water criteria (see Table 7-4) also exceed the PCR criteria as the 20 times rule is not applicable to organics.

The site is Zoned Business 3 which would limit the potential for construction of swimming pools. The high cost of a bore and pump for this limited purpose make it a very unlikely prospect. This beneficial use of groundwater is precluded by contamination derived from the site. However, it is concluded that the realisation of this beneficial use of groundwater is unlikely.

7.11 Buildings and Structures

Groundwater should not be corrosive to building elements due to contamination.

In this case the watertable is typically found at 8 to 11 m below the surface and therefore typically more than 7 metres below the likely foundations of a new building element. Groundwater has been measured at 1.1 m below the ground surface at MW9/3. This is believed to be perched groundwater.

Elevated concentrations of dissolved organic compounds along with DNAPL may be detrimental to PVC or plastic building elements such as conduits or drains.

This beneficial use of groundwater is precluded by contamination derived from the site.

7.12 NAPL and SEPP Groundwater

Clause 18 of SEPP *Groundwaters of Victoria* requires that NAPL should be removed from an aquifer to the satisfaction of EPA, and to the extent practicable. At 95% of DNAPL sites, DNAPL is not observed and thus indirect lines of evidence are used to assess the presence of DNAPL at these sites. This lines of evidence approach has been conducted for the purpose of this audit report, and the results have indicated the likely presence of TCE DNAPL as an ongoing source of contamination at the site (and potentially off-site). Consequently, the presence of DNAPL is in non-compliance with the policy, and as discussed in the above sections, also contributes to detriment of beneficial uses.

7.13 Summary of Auditor's Opinion on Groundwater Contamination

Pollution was reviewed with respect to all beneficial uses in Segment A1, given the classification of the groundwater salinity (measures as TDS) in the aquifer. Table 7-8 summarises these findings.

Table 7-8: Summary of Groundwater Pollution Assessment

Beneficial Use Category	Protected Beneficial Uses of this Segment of Groundwater	Precluded	Existing Use	Likely Use	Un-likely Use
Maintenance of Aquatic Ecosystem	✓	No		✓	
Potable Water Supply	✓	Yes			✓
Potable Mineral Water					
Agriculture, Parks & Gardens	✓	Yes	✓		
Stock Watering	✓	Yes			✓
Industrial Water use	✓	Yes		✓	
Primary Contact Recreation	✓	Yes			✓
Buildings & Structures	✓	Yes			✓

The Auditor concludes that a number of beneficial uses of the groundwater at the site are precluded, most of which are considered not relevant in terms of their low likelihood of use in accordance with section 13 of EPA Publication 759.1. Although aquatic ecosystem protection is considered "relevant" the contamination is unlikely to represent pollution with respect to aquatic ecosystems due to the distance to the nearest surface water body and the likelihood of natural attenuation of the contamination in the aquifer occurring. The beneficial use of irrigation is an existing use at sites located approximately 700 m to the south. The access to groundwater down-gradient of this site should be managed to minimise the chance of drawing this contaminated groundwater into a water supply bore.

8 HEALTH RISK ASSESSMENT

8.1 Purpose of Assessment

The SEPP *Prevention and Management of Contamination of Land* (2002) states in Clause 21(a) that where contamination at a site is of a level which precludes a protected beneficial use of the relevant land use, a state of pollution exists and the land must be cleaned up and/or managed so that there is no immediate threat to human health on-site or off-site.

It is noted that SEPP *Groundwaters of Victoria* characterises groundwater pollution in terms of the beneficial uses of water measured against water quality criteria and does not explicitly refer to the possible human health risks arising from inhalation of vapours from contaminated groundwater or NAPL. The Auditor has considered the potential for harm to human health via this exposure pathway and undertook an assessment of risks accordingly.

8.2 Summary of Approach

A Health Risk Assessment (HRA) was conducted by GHD (2009) to assess the potential risk to human health associated with the inhalation of vapour emissions from contaminated soil and groundwater at the site. The assessment followed the approach outlined in the National Environmental Protection Measure (NEPM).

The HRA was conducted using the highest soil vapour and groundwater concentrations, which were typically obtained in the southeast corner of the site. Initially, a screening assessment was conducted by comparing the highest detected vapour concentrations from the soil vapour wells or groundwater well headspace to screening criteria. Eighteen chemicals of potential concern were identified.

The potential lifetime cancer risk and non-cancer “hazard index” was estimated using vapour emission modelling from the contaminated soil and groundwater vapour. The model was run twice, once using groundwater bore headspace data and once using soil vapour data.

The Risk Analyst on the Audit team (John Frangos, see Appendix K) noted that the “*HRA does not address whether the dissolved phase concentrations are stable or likely to increase or decrease in the future. Also the HRA suggests that a DNAPL may be present and this may lead to an increase in soil gas and/or dissolved phase concentrations in groundwater*”. The Auditor agrees that the weathering of DNAPL and subsequent partitioning in the other phases means that the risk profile is likely to change over time, and that this needs to be taken into consideration within the HRA that has been recommended by the Auditor.

GHD (2009) assumed that the only complete exposure pathway was through inhalation of vapours. The following populations were modelled:

- b) Industrial workers in onsite building
- c) Industrial worker in outdoor area
- d) Industrial workers in adjacent offsite buildings
- e) Intrusive maintenance workers
- f) Possible future uses
 - Commercial slab on ground redevelopment
 - Commercial development with basement carpark

- Residential slab on ground development
- Residential development with basement carpark.

While there are no development plans for the site, possible redevelopment scenarios were assessed as Nuplex is considering options for a commercial or industrial redevelopment and the Auditor also required a health risk assessment of a residential scenario.

8.3 Summary of Findings

GHD (2009) findings are summarised in Table 8-1.

Table 8-1: Modelled HI and Cancer Risk

Modelled Population	Data Source	HI	Cancer Risk
Current Land Use Scenarios			
Industrial Worker in onsite building	Soil Vapour	Risks of onsite industrial workers assessed on the basis of measured indoor air concentrations and TWA criteria.	
	Groundwater Headspace		
Industrial Worker in outdoor area	Soil Vapour	1.40E-01	9.90E-07
	Groundwater Headspace	6.60E-03	5.30E-08
Industrial worker in adjacent offsite building	Soil Vapour	Not Assessed	Not Assessed
	Groundwater Headspace	3.70E-03	3.20E-08
Potential Scenarios with Current Site Use			
Intrusive Maintenance worker	Soil Vapour	1.00E+01	7.20E-05
	Groundwater Headspace	2.70E-02	2.20E-07
Potential Redevelopment Scenarios			
Commercial Slab on Ground	Soil Vapour	2.40E+00	1.75E-05
	Groundwater Headspace	6.00E-02	4.70E-07
Commercial with Basement	Soil Vapour	5.30E+00	3.90E-05
	Groundwater Headspace	8.80E-02	6.90E-07
Residential Slab on Ground	Soil Vapour	7.20E+01	6.40E-04
	Groundwater Headspace	1.60E+00	1.60E-07
Residential with Basement	Soil Vapour	1.90E+00	1.70E-05
	Groundwater Headspace	3.20E-02	3.00E-07
Note:			
1. Bolded cells indicate that the risks are not considered to be acceptable.			

8.4 HRA Conclusions

The findings of GHD (2009) HRA are (in summary):

- There is no unacceptable health risk to the currently existing on and off site receptor populations.
- There is a potentially unacceptable health risk to an intrusive maintenance worker. In addition to the lifetime cancer and non-cancer risks to intrusive maintenance workers, there may also be an acute risk to intrusive maintenance workers.
- There is a potentially unacceptable health risk to the modelled commercial and residential redevelopment scenarios.

GHD (2009) state that an SMP is required to manage the potential lifetime and acute risks to intrusive maintenance workers.

8.5 Auditor Review of HRA

The Auditor has reviewed the GHD (2009) risk assessment with the assistance of his EPA approved expert support member, John Frangos. The HRA was initially reviewed in 2009 immediately after its issue and has been reviewed again for the purposes of this Audit and to take into account the additional data and understanding obtained following further site investigations (GHD 2010) and development of the CSM (Section 5 and Appendix C).

Auditor findings:

- a) The HRA is based on one round of soil vapour and groundwater bore headspace data at a limited number of locations across the site.
- b) The risk assessment is focused on assessing the risks posed by contamination existing in the south-eastern portion of the site.
- c) The risk assessment only considers a vapour pathway. Other pathways such as dermal and ingestion should be considered, especially for the intrusive maintenance worker and residential scenarios.
- d) Cancer and non-cancer risks modelled by GHD (see Table 8-1) are reported to be two to five times higher for a soil gas source rather than a groundwater headspace source. This, along with additional soil assessment in the southwest corner of the site, suggests a significant soil source that requires consideration in future risk assessments
- e) The risks posed to onsite indoor workers have not been calculated from soil or groundwater headspace data. Instead, indoor air monitoring was conducted and results compared to TWAs which found that the risks were not-unacceptable. The use of TWAs may not be appropriate, especially for onsite office workers not involved in handling these chemicals for their work.
- f) The risk assessment states that *“onsite soil-gas near MW24 is located outside the building footprint and only poses a potential risk to outdoor workers”* The Auditor considers that this assumption is not justified given MW24 and the adjacent soil vapour wells are located within 10 m of a building.
- g) The risks to onsite office workers has not been determined
- h) The risks to offsite industrial or office workers has not been adequately assessed due to:
 - The assessment was based on groundwater bore headspace measurements at MW26. A more conservative and appropriate approach would have been to base the assessment on the higher results reported at MW24, in close proximity to the site boundary

- Potential generation of vapours from the soil source has not been considered as the assessment of risk to offsite workers was based on groundwater headspace data
 - The workshop adjacent to the site at 15 Chandos Street includes a small office, which has not been included in the risk assessment. The planning scheme also allows for this site to be used for a number of other uses including home occupation, and education facility.
 - GHD found that a potential new commercial building placed near the site boundary (at MW24) would pose an unacceptable risk to occupants. It is unclear why the risks should then be considered to be acceptable for offsite workers, approximately 10 m to the south of this location
 - The Auditor considers that additional data or modelling is required before a determination can be made by the Auditor that concurs with the GHD finding that the risks posed to off-site industrial or office workers is acceptable
- i) The risk assessment provides an assessment of risk at a point in time, but no assessment of how these risks may change over time. Contaminant concentrations may change over time due to natural attenuation. Of particular significance is the breakdown product VC, which is more toxic and more volatile than many of its parent products

Recommendations:

54. An additional vapour monitoring event (soil vapour and indoor air) should be scheduled as soon as practicable to confirm the current data.
55. The revised monitoring network recommended by the Auditor should be initiated with annual monitoring and reporting to confirm that the risk profile of the site has not changed.
56. The revised monitoring network recommended by the Auditor should include locations that are installed to characterise the potential risks at beyond the SEC (Former Drum Storage Area and the Office) and to provide additional information on the risks posed to offsite receptors.
57. The human health risk assessment should be redesigned and repeated to include all relevant exposure pathways across the site (and those with identified and potential site-related impacts off-site) following adequate delineation and update of the CSM.
58. Additional risk modelling should rely on the existing soil vapour data and those gleaned from monitoring of the revised network, such that the soil source as well as the groundwater source is included in the modelling.
59. An assessment of how the risk profile may change with time should be conducted (including partitioning effects such as effective solubilities).
60. The risks posed to off-site workers require immediate re-assessment. This includes the collection of additional data as recommended above and additional risk modelling.
61. The SMP for on-site intrusive workers, recommended by GHD, should be implemented within one month of the date of this report. The SMP shall include measures to manage odours, acute and lifetime health risks, and should be revised as the CSM is updated.

9 AUDIT FINDINGS

9.1 Summary of Soil and Groundwater Contamination

Soil contamination was observed to varying degrees within the premises. The historical operations conducted at the site over at least the past four decades has provide for potential soil contamination at several areas of the site due to fixed infrastructure and also manual handling and loading practices. Soil contamination was most evident in the SEC, where it was contaminated by VCHs. The maximum soil contaminant concentrations were detected at the eastern and southern boundaries of the soil investigation; approximately 15 m from the eastern site boundary and adjacent to the southern site boundary. It is likely that VCH-contaminated soil extends from the site to the south and possibly also the east. However, the Auditor also notes that soil delineation in other areas of the site has not progressed with sufficient resolution to rule out with any certainty other surficial release areas (such as the Former Drum Storage Area and the TIT). As soil vapour impacts have been identified with the current low-resolution monitoring and as other source zones are possible, the Auditor has recommended a revised soil vapour monitoring network to address the above-noted issues.

LNAPL or hydrocarbon sheens were not observed on the water table. However, the Auditor notes that the USTs operated for decades and as there are no records of replacement of these USTs, there is the potential that leakage occurred over a significant period of time. Further, the continued presence of PHCs in groundwater is indicative of continuing sources within the subsurface. Therefore, there may be areas where the LNAPL has not been identified as it has migrated deep to the water table and/or that matrix diffusion into the clayey media has provided a long-term source of PHCs that is partitioning back into groundwater. As degradation of VHCs is occurring to some degree at the site, there is the potential for some of the mass of PHCs to be driving this degradation.

DNAPL has not observed at the site. As DNAPL is generally not observed, indirect lines of evidence have been used to assess the presence of DNAPL for the purpose of this audit report. The results have indicated the likely presence of DNAPL as an ongoing source of contamination at the site (and potentially off-site). The very high concentrations of VCHs (especially in the SEC) and the known DNAPL behaviour of such material, suggests the prospect for DNAPL to occur beneath the source areas. The presence of DNAPL is in non-compliance with SEPP(GoV), and contributes to detriment of beneficial uses. As site operations have included the loading, storage and handling of DNAPLs (such as PCE, TCE, CF, DCM, and TCAs) since 1949 at this relatively small site, there is a strong possibility for long-term release locations. Although data gaps exist in site historic operations (from 1949), the data compiled interviews with employees and site inspections together provide adequate documentation for such long-term DNAPL releases. The above provide adequate time and opportunity for deeper migration of DNAPL into the Brighton Group Aquifer (and potentially into the Fyansford Formation Aquifer). Subsequently, multiple suspected DNAPL source zones exist across the site (with the exception of the northern ~30m). The most significant source zone is in the SEC (former USTs and ASTs, concrete sump, decanting, drum storage in the Former Drum Shed, and refrigerant storage); with other source areas in the southwest (former UST), the Northern (Former Drum Storage Area) and North Central (former ASTs and TIT1).

Groundwater flow direction is not well defined and appears to be generally southerly, but also have westerly or easterly components (in particular within the Former Drum Storage Area that may take impacted groundwater off-site in this area). Mounding, which is occurring across the site in a few areas, is also complicating the flow pattern. The monitoring well network has been evaluated and a revised monitoring well network is considered by the Auditor to be required to

provide adequate data on groundwater flow and delineation of contamination. Due to the historical operations conducted at the site over at least the past four decades, groundwater contamination occurs throughout the site. The major contaminants are VCHs, TPH and BTEX. These contaminants were detected across the site, with the exception of the northern ~30 m of the site. The contaminant plumes overlap with plumes from adjoining source areas (this can be particularly observed for plumes from that appear to originate north of the Poisons Store that overlap with those in the SEC). There is a lack of adequate data (and data quality issues) in relation to the potential for degradation in the Brighton Group Aquifer at the site (i.e. whether one or more aquifer 'types' exist). This and the processes of biodegradation and groundwater flow issues complicate the contaminant hydrogeology at this site. Groundwater contamination extends off site to the south to at least Phillip Street. Deeper contamination by VCHs has not as yet been investigated. The Auditor has recommended a revised groundwater monitoring well network to address the above-noted issues.

Some metals are slightly elevated within groundwater at the site, which is believed to be caused by a combination of natural background and further elevated due to site activities.

9.2 Land Contamination and Risks

Following a review of the data provided by the Assessor, and having regard to the SEPP *Prevention and Management of Contaminated Land*, the Auditor has assessed the impacts on the protected beneficial uses of the land.

Maintenance of Land Ecosystems: The contamination of surface soil may be a significant impediment to this beneficial use of the land, especially in the south eastern portion of the site. Soil assessment has been focused on locations where groundwater contamination has been observed; thus a complete assessment of soil contamination across the remainder of the site is not possible.

Buildings & Structures: The Auditor has not identified soil characteristics that are clearly likely to affect buildings or structures across the site. However, the presence of residual DNAPL suspected to be present in the south east portion of the site may have a detrimental effect (related to vapour and/or groundwater impacts) on utility conduits (especially plastic pipes and insulation), which may adversely affect their integrity. This aspect may require further consideration and management.

Aesthetics: Odorous material was identified at the site during the assessment. Intrusive works will require management to avoid unacceptable aesthetic impact (i.e. odours) if and when remediation occurs or any subsurface maintenance work is conducted.

Production of Food, Flora & Fibre: This is not a protected beneficial use on industrial land and is therefore not considered further.

Human Health: The results of soil assessments indicate that the relevant investigation levels for human health criteria for petroleum hydrocarbons (mainly chlorinated hydrocarbons) in soil have been exceeded. Human health exposures due to inhalation of vapours from contaminated soil and groundwater or NAPL is a potentially significant risk pathway. The Auditor is of the opinion that the VHC impacts currently identified require further assessment to confirm the results of the assessors Health Risk Assessment for on and off-site receptors. Any change to site use involving more frequent or longer duration occupation or redevelopment of the site would represent a potentially unacceptable risk.

9.3 Groundwater and Surface Water Contamination and Risks

In accordance with the SEPP *Groundwaters of Victoria* the protected beneficial uses of groundwater in the Area of Interest (i.e. the Segment under audit) which are defined as Segment A1 groundwater have been assessed.

Maintenance of Aquatic Ecosystems: Although aquatic ecosystem protection is considered “relevant” under the policy, the contamination in groundwater seems unlikely to represent pollution with respect to aquatic ecosystems due to the attenuation opportunity in the aquifer provided by the distance to the nearest surface water body (Port Phillip Bay). However, there is considerable uncertainty in this assessment and further investigations and monitoring are required.

Potable Water: The water quality criteria for potable water are greatly exceeded. However, this beneficial use is not a relevant use due to the low likelihood of the use being realised by a bore owner pumping groundwater for consumption.

Stock Water: The water quality criteria for toxicants such as benzene default to human drinking water objectives, which are greatly exceeded. However, this use is not relevant due to the low likelihood of people keeping livestock and watering them from a groundwater bore in this vicinity.

Industrial Water Use: Similarly the groundwater contamination can be shown to preclude a number of potential industrial uses, although these are limited and the likelihood of them being realised in this vicinity is low - but still relevant..

Primary Contact Recreation: This use also defaults to human drinking water quality objectives which are clearly exceeded within the site. However, it is considered by the Auditor not a relevant use due to the low likelihood of the use being realised either by a bore owner pumping groundwater into a swimming pool, or the groundwater discharging to a surface water body used for swimming in the vicinity.

Buildings & Structures: To the extent that contaminated groundwater and NAPL at the site can impact on underground structures then this use is not protected. While this is possible and should be guarded against, it is a low risk due to the 9 m depth to the water table.

9.4 Contamination in Surrounding Areas

Chlorinated hydrocarbon contamination has been identified offsite to the south in the adjoining properties (MW26 and MW34) an up to 150 m off-site at Philip Street. BTEX compounds have been identified to the southwest of the site, but are considered to be of lower significance than the VCHs.

Groundwater flow directions are generally southerly, but also have easterly and westerly components. Thus the southern, eastern and western boundaries should be considered to be the hydraulically downgradient boundaries at the site for the purposed of further assessment or management.

9.5 Health Risk Assessment

A Health Risk Assessment (HRA) was conducted by GHD (2009) to assess the potential risk to human health associated with the inhalation of vapour emissions from contaminated soil and groundwater at the site. The assessment followed the approach outlined in the NEPM.

The HRA was conducted using the highest soil vapour and groundwater concentrations, which were typically obtained in the SEC. GHD found that there were no unacceptable risks posed to on-site or off-site workers under the current site configuration. However, risks to human health may exist for underground maintenance workers, or if the site is redeveloped. These potential risks should be managed with an SMP. The Auditor considers that additional investigation is required, especially to characterise the risks to off-site workers.

9.6 Recommended Measures

In regard to the objectives and scope of the Audit, in compliance with EPA-issued CUN the Auditor is to recommend measures to reduce and manage risks to beneficial uses at acceptable levels. These recommended measures have been made throughout the Audit report and numbered in the order of occurrence in the report. They are presented in number order in Appendix L and arranged by aspect or work in Table 9-1.

Table 9-1: Recommended Measures and Implementation Timetable

Aspect	Recommendation		Recommended Completion Timetable
General Site Investigations			
Site Plan	7	An accurate site plan be constructed and used for future reporting requirements. The site plan should be constructed by a licensed surveyor and include the location of the site boundary, roads, buildings, services and permanent sample locations.	4 Months
Hydraulic Control – Groundwater Flow Directions	28	On and offsite services be investigated to determine if they are leaking and effecting the groundwater flow pattern and contaminant transport	6 months
Groundwater Resources - Unregistered Bore Search	31	Conduct a search for unregistered bores (field event) downgradient of the site – and door knocking (if required).	6 months
Groundwater Resources – Supply Well Information	32	Seek to obtain groundwater extraction and water supply well information for the above-noted wells.	6 months
Mounding and TDS variations	30	Investigate the source(s) of the variation of TDS to show whether the site groundwater is actually other than Segment A1. This includes the areas of mounding noted at the site in the vicinity of monitoring wells MW3, MW12 and MW18.	6 months
Soil Vapour Monitoring			
Soil Vapour Data Gaps	3	Areas with impacted soil vapours (i.e. the SEC and the Former Drum Storage Area, sump in the Poisons Store, and the Area 2 USTs) require further delineation using field screening with temporary locations and analytical laboratory data at permanent monitoring locations. The Auditor notes that the preliminary soil gas survey data are indicative of surficial releases, which should be further investigated.	6 Months

Aspect	Recommendation		Recommended Completion Timetable
Soil Vapour – Monitoring Network	20	The Auditor recommends the inclusion of a revised soil vapour monitoring network to enable sufficient resolution in line with the on-site and off-site risks posed by the migration of volatile site contaminants. This should be part of an ongoing program in association with groundwater monitoring that takes into account the weathering from source zones over time and preferential pathways with high concentrations (i.e. mass flux).	Commence immediately to develop the monitoring network plan for auditor endorsement and implement within six months.
Soil Vapour Monitoring Event	54	An additional vapour monitoring event (soil vapour and indoor air) should be scheduled as soon as practicable to confirm the current data.	6 Months
Health Risk Assessment			
Soil Vapour – Intrusion Risk	21	Further consideration needs to be given to possible vapour intrusion risk to persons occupying buildings off-site (and potentially on-site depending on future investigation results) including incorporation of the recommendation for an enhanced soil vapour monitoring network.	5 Months
Human Health Risk Assessment – Short-Term	4	A detailed assessment of human health risks associated with the current use of the site and areas immediately to the south and possible future use complying with the current land use zone is required using the current data and the data to be gained in further investigations (on- and off-site risks). This must lead into OHS management measures in a Site Management Plan (SMP) for the purpose of avoiding and managing unacceptable risks due to contamination (Commence immediately and update based on additional relevant data).	9 Months
Human Health Risk Assessment – Longer-Term	57	The human health risk assessment should be redesigned and repeated to include all relevant exposure pathways across the site (and those with identified and potential site-related impacts off-site) following adequate delineation and update of the CSM.	Following delineation (upon endorsement by Environmental Auditor).
Risk Modelling	58	Additional risk modelling should rely on the existing soil vapour data and those gleaned from monitoring of the revised network, such that the soil source as well as the groundwater source is included in the modelling.	Commence within 3 months, report with risk assessment (item 4)
Risk Profile – Changing Over Time	59	An assessment of how the risk profile may change with time should be conducted (including partitioning effects such as effective solubilities).	Commence within 3 months, report with risk assessment (item 4)

Aspect		Recommendation	Recommended Completion Timetable
Risk to Off-Site Workers	60	The risks posed to off-site workers require immediate re-assessment. This includes the collection of additional data as recommended above and additional risk modelling.	Commence within 3 months, report with risk assessment (item 4)
Source Zone Investigation			
Source Zones - Investigation	1	Identify potential source zones (Former Drum Storage Area, North Central ASTs, sump in the Poisons Store, and others). Conduct targeted source zone investigations in the northern half of the site to confirm whether there are ongoing sources of contamination in these areas (nature and extents), and if so what management strategies are required.	12 Months
Delineation of VCH Impacts related to Source Zones	38	Investigate other sources of VCH impacts in the subsurface (including areas with upgradient impacts such as the northern half of the site) by soil, soil vapour and groundwater investigations (including installation of wells in the revised monitoring well network).	12 Months
Groundwater Data Gaps	2	Groundwater data gaps in the Northern and Central Areas are to be investigated to delineate sufficiently and to assist in identifying whether there are ongoing sources of contamination in these areas.	12 Months
Revised Monitoring Well Network			
Permanent Monitoring Well Network – Plan and Implementation	11	Develop a plan for and install a revised permanent monitoring network both on- and off-site to evaluate the geology and hydrogeology of the deeper portions of the BGA and into the FFA, as well as the hydraulic connection between these units, assess groundwater flow and dissolved phase contaminant migration within the aquifer(s). Designed meet the intended use and goals to be achieved (delineation and assessing risk).	9 Months
Conceptual Site Model – Delineation of Plumes	33	Use the CSM presented by the Auditor to develop a revised monitoring well network, which has been recommended by the Auditor, to delineate the groundwater plume(s).	9 Months
Delineation of Chlorinated Solvent Impacts	35	Improve the density and quality of the monitoring well network as indicated in Recommendation 11 to gain data that are suitable to be used to evaluate the depth of impact of chlorinated solvents on-site and off-site.	12 Months
Degradation of Chlorinated Solvents - Data	48	Improve the density and quality of the monitoring well network as indicated in Recommendation 11 to gain data that are suitable to be used to evaluate degradation of chlorinated solvents on-site and off-site – including aquifer 'type' and plume stability.	12 Months

Aspect		Recommendation	Recommended Completion Timetable
Risks posed by Groundwater Impacts	56	The revised monitoring network recommended by the Auditor should include locations that are installed to characterise the potential risks at beyond the SEC (Former Drum Storage Area and the Office) and to provide additional information on the risks posed to offsite receptors.	Following endorsement of the plan for the network by Environmental Auditor.
Mass Flux Approach for Monitoring	22	The Auditor recommends a mass flux plane approach for management of contaminant transport (soil vapour and groundwater). This could be accomplished using a mass flux plane approach if sufficient access becomes available down-gradient of the source or a numerical modelling approach matched to field data. The flux plane approach can include monitoring of contaminants across transects perpendicular and parallel to flow. This may require transects off-site, as possible; and will need to take into consideration the implications for monitoring near the source zones. Alternatively the modelling approach would match the groundwater flow behaviour and contaminant behaviour with calibration accomplished by adjusting source parameters to match contaminant concentrations in the monitoring wells	Commence immediately to develop the monitoring network plan for auditor endorsement and implement within 12 months.
Mass Flux Approach - Transects	23	Mass flux approach is to include: Transects (T1 to T4) with both soil vapour and groundwater depth-discrete locations. T1 (full east-west profile) south of the Former Drum Storage Area. T2 (full east-west profile) north of the SEC. T3 from Bay Road to Philip Street. T4 along the lower boundary of SEC (using telescopic methods) to identify secondary sources. Following installation of deeper wells to evaluate the continuity and potential for the silty clay layer at 20 mBGS to limit vertical migration of DNAPL.	12 Months
Mass Flux - Transects	53	Evaluate the use of mass flux from source areas (soil vapour and groundwater) and along the groundwater flow path of plumes using the four transects recommended by the Auditor (soil vapour and groundwater depth-discrete sampling locations).	12 Months
Permanent Monitoring Well Network - Requirements	12	This revised permanent monitoring network is to include the shallow, intermediate and deep portions of the aquifer(s). Based on this recommendation and the Auditor's review of site data, the remaining wells would consist of MW19, MW20, MW22, MW24A, MW24B, MW24C, and MW25 through MW42. As many of these remaining wells have water levels above the well screen, additional wells across the water table would be required (in addition to deeper wells within the aquifer).	12 Months

Aspect	Recommendation		Recommended Completion Timetable
Continuous Low Permeability Unit	13	Obtain sufficient evidence (geological, hydrogeological and geochemical) for the presence of a locally significant low permeability unit that would limit the hydraulic connection between these units (and potentially DNAPL migration).	During installation of monitoring wells, within 12 months
Monitoring Well Network – Shallow Wells	14	As many of the remaining wells have water levels above the well screen, additional wells across the water table would be required (in addition to deeper wells within the aquifer).	Ongoing during planning for well installation
Monitoring Well Network - DNAPL	15	Construction of monitoring wells will need to include consideration of presence of DNAPLs (refer to Figure 4-3) including: well location, well screening (elevation, length and slot size), the filter pack (potentially including fine mesh wire) and seal through fill layers); this is to identify DNAPL migration into the well, decrease well artefacts and provide samples representative of the aquifer. As noted above, the Auditor considers that deeper migration of DNAPL(s) at the site is likely to have occurred. Therefore, new wells would need to incorporate this issue.	Ongoing during planning for well installation
Aquifer Media Sampling	16	Collect aquifer media (soil) samples for organic carbon content, density, grain size, and other relevant physical parameters at boreholes for wells advanced in the BGA and FFA.	During installation of the revised monitoring network, within 12 months
Precautions in Source Zones - DNAPLs	36	Use appropriate pre-cautions during DNAPL investigations, including the installation of sumps at the bases of monitoring wells, where needed.	Ongoing during well installations.
DNAPL Observation - Source Zones	37	Use the above-noted methods for observing the presence of DNAPL including Flute [®] liners during installation of monitoring wells.	Ongoing during borehole advancement (for deeper soil and/or groundwater characterisation).
Assessment of Aquifer Properties			
Down-hole Geophysics	8	Conduct down-hole geophysics on any newly installed wells (refer to Auditor recommendations below) in the BGA and FFA and use this information to inform the revised CSM.	15 Months
Hydraulic Aquifer Response Testing	18	Conduct groundwater pumping tests and slug tests in the BGA and FFA to evaluate the hydraulic conductivity (K), transmissivity (T), and hydraulic connections of these aquifers.	15 Months.

Aspect	Recommendation		Recommended Completion Timetable
Groundwater Monitoring			
In-Situ Monitoring	24	As well and sampling artefacts have affected data quality at this site, in-situ measurement devices to monitor water levels and geochemistry data are required to be part of the program developed within the GQMP. This should include down-hole data loggers with water level, temperature, conductance, DO and redox (in the sandy clay and lower sandy portions of the aquifer(s) impacted by plumes and one upgradient location).	Commencing within six months
Hydraulic Control – Groundwater Flow Directions	26	Groundwater hydraulic control on-site and off-site is to be gained through the revised monitoring network and quarterly SWL monitoring (i.e. gauging) including downhole measurements of field parameters to assist in characterisation of groundwater quality.	Commencing within six months
Quarterly Static Water Level Monitoring	29	Use the quarterly water level monitoring (i.e. gauging) to evaluate the presence and nature of vertical gradients within the upper clay unit and the BGA, as well as between the BGA and FFA.	Commence immediately on the remaining wells and then ongoing for the revised network
Groundwater Monitoring Events (GMEs)	55	The revised monitoring network recommended by the Auditor should be initiated with annual monitoring and reporting to confirm that the risk profile of the site has not changed.	15 Months
In-Situ Monitoring	25	As matrix interference has affected data quality, the SMP should consider alternative sampling methods to reduce the LORs to acceptable levels. Non-detection levels (LORs) should be discussed and presented in tables and figures.	Next GME and ongoing
Elevated Limits of Reporting	5	Ensure that the data quality issues with elevated LORs are addressed and that the LOR values are plotted on summary figures and provided in summary tables, such that there is more transparency in regard to data quality and delineation resolution.	Next GME and ongoing
Addressing Matrix Interference via Partitioning	6	Collect groundwater samples for submission to the analytical laboratory, which enable partitioning to air and soil (depending upon the physical properties of the contaminants), with the intent to address the matrix interference causing elevated LORs. For example, collect half full sample jars for gas extraction at the laboratory and injection into the GC. This is to assist identification of highly volatile compounds that are vulnerable to negative sampling bias such as VC.	Next GME
Scan Sampling	17	Evaluate the use of methods such as ‘scan sampling’ (sampling during groundwater extraction) to enhance detection of chlorinated solvent plumes.	Following installation of the revised monitoring network, within 15 months.

Aspect		Recommendation	Recommended Completion Timetable
Degradation of Chlorinated Solvents – Indicators	51	Analyse groundwater samples for alcohols and fatty acids (indicators of aerobic oxidation - cometabolic) and use this as another line of evidence for the occurrence of degradation.	Following installation of the revised, monitoring network, within 15 months
Well Decommissioning			
Well Decommissioning	9	Decommission the following wells: multilevel wells (MW6 through MW17), long-screened wells MW3, MW4, MW5, MW21 and MW23, wells impacted by leakage (e.g. MW18), low recovery wells (e.g. MW2), any wells where the seal is not sufficiently protective, and finally any wells within source areas where dissolution of the PVC casing is possible (e.g. the SEC).	12 Months
Well Decommissioning	10	The replacement of wells with quality issues located in areas where high concentrations of chlorinated solvents have been detected (historic and recent) is recommended.	12 Months
Groundwater Modelling			
3D Numerical Groundwater Flow Model	27	Based on the CSM, develop a three-dimensional (3D) groundwater flow model (with water mass balance) as the basis of the flow and transport model, using suitable existing data and recommended quarterly monitoring data and the hydraulic response data. Conduct both steady-state and transient calibration for this model.	18 Months
3D Numerical Fate and Transport Model	46	Evaluate the potential for groundwater VCH impacts to reach and be captured by groundwater extraction in the local area using 3D numerical fate and transport modeling (using the recommended 3D groundwater flow model as the foundation for this work).	18 Months
Site Management Plan			
Current SMP - Implementation	61	The SMP for on-site intrusive workers, recommended by GHD, should be implemented within one month of the date of this report. The SMP shall include measures to manage odours, acute and lifetime health risks, and should be revised as the CSM is updated.	2 Months, reassessed and revised (if required) within 12 months

Aspect	Recommendation		Recommended Completion Timetable
Interim Action	41	Interim action (within six months) is recommended to: - keep the section of the site along the southern boundary in the SEC accessible to address interim measures and potentially longer-term remedial measures - cover the grassed area in the SEC to limit recharge through the uncovered and former UST excavation areas - install interim remedial measures to limit the off-site migration of contaminants in the vadose zone and below the water table (i.e. soil vapour and groundwater plumes).	To be completed within six months.
Monitoring Well Network - SMP	19	This revised monitoring network is to form part of an SMP, and is to be maintained until cessation of monitoring is approved by the EPA. The current SMP shall be: revised to include the revised network, follow EPA guidance, and be endorsed by an EPA appointed Environmental Auditor. In addition, the ongoing SMP is to be revised as further information comes to hand from studies and monitoring recommended in this audit report.	18 Months
Ongoing SMP – Long-Term Management Plan	45	Implement a long-term management plan for the site – e.g. an ongoing SMP for the current site built environment, with revisions as needed to take into account modifications and/or redevelopment.	18 Months
Evaluation and Reporting			
Conceptual Site Model - Ongoing	34	Use the CSM to develop future investigation plans, and revise and update this CSM as relevant information is gained during these future investigations.	Ongoing
Data Evaluation of DNAPL Presence	39	Conduct and report on a detailed evaluation of the presence of DNAPLs using the lines of evidence provided above.	18 Months
Shallow VCH Plumes	47	Evaluate/investigate the potential for shallow VCH plumes to intersect PHC contamination off-site in the surrounding commercial/industrial area downgradient of the site.	18 Months
Degradation of Chlorinated Solvents – Degradation Pathways	49	Provide an updated discussion on the potential degradation pathways (biotic and abiotic products) for the VCHs. Include figures showing the pathways and peer reviewed references. This is to be used for site characterisation, groundwater fate and transport modelling, risk assessment, remediation and ongoing management.	6 Months
Intrinsic Capacity of the Aquifer System	50	Further evaluate the importance of the intrinsic capacity of the aquifer system to degrade the volatile contaminants – short-term and longer-term.	15 Months

Aspect	Recommendation		Recommended Completion Timetable
Degradation of Chlorinated Solvents – Microbial Processes	52	Investigate the microbial processes (including microcosm studies) to assist in the understanding of biological degradation – to rule out or confirm the importance of intrinsic aquifer capability to degrade these contaminants (with respect to management of aquifer pollution – beneficial use).	15 Months
Remediation Feasibility Study			
RFS – Short-Term Options	40	A Remediation Feasibility Study (RFS) would be required to evaluate short-term options for interim measures (beyond those recommended by the Auditor).	To be completed within four months.
Revised RFS – Long-Term Options	42	The Auditor considers that a revised RFS would be required to evaluate the long-term clean up options and identify suitable and preferred approach. This approach will need to also contemplate the administrative tools available and effective to manage polluted groundwater to protect future groundwater users from intercepting the plume.	21 Months
Clean Up Plan			
Clean Up Plan	43	The Auditor recommends that the preparation of a Clean Up Plan subsequent to the achievement of adequate characterisation (including geochemical data and groundwater flow) and delineation.	24 Months
CUP in SEC – Consideration of Volatiles	44	The Auditor recommends that the Clean Up Plan for the SEC (e.g. remedial excavation) consider the broad list of volatile detections in soil (TPH C ₆ -C ₉ , chlorobenzene, PCE, TCE, cDCE, 1,1-DCE, 1,1,1-TCA and 1,1-DCA) and those detected in soil vapour including VC.	24 Months

9.7 Approach to Remediation

The Auditor has determined that the site presents a risk of possible harm or detriment to the environment and has made a number of recommendations to further assess several areas of uncertainty. The EPA CUN requires that Nuplex develop and implement a Clean Up Plan for the site. The auditor suggests the following general approach for addressing the Audit recommendations, complying with the remaining CUN requirements and remediating the site:

- Reassess the Health Risk Assessment to confirm that the findings still stand with the recent data and information. This will require the collection of additional data as recommended in the Audit report.
- Prepare an interim Remediation Feasibility Study to determine what interim remediation can be implemented to reduce
 - Risks to human health (depending on outcome of HRA),
 - Risks to the environment or to
 - The transport of contaminants
- Prepare and implement an interim Clean Up Plan including the following tasks:
 - Implementing any remediation tasks that have been determined to be feasible

- Review of the groundwater monitoring well network including decommissioning of non-representative wells, installation of replacement wells (where required) and installation of additional wells required for further delineation (including of the underlying aquifers)
 - Conducting further soil, groundwater and soil vapour investigations required to investigate other potential source areas
 - Any other investigation works required to prepare a detailed Remediation Feasibility Study and Clean Up Plan
- d) Prepare and implement a detailed Remediation Feasibility Study and Clean Up Plan

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Appendix A

18 Pages

Figures

Figure 1: Site Locality

Figure 2: Site Features

Figure 3: Soil Investigation Locations

Figure 4: Groundwater Well Locations

Figure 5: Soil Vapour Locations

Figure 6: Year Ground First covered / Sealed

Figure 7: Location of Historical Chemical Storage and Handling

Figure 8: Groundwater Contours

Figure 9: TDS Concentrations – March 2010

Figure 10: Field Parameters

Figure 11: Conceptual Cross Section A – A`

Figure 12: Conceptual Cross Section B – B`

Figure 13: Conceptual Cross Section C – C`

Figure 14: Conceptual Cross Section D – D`

Figure 15: Conceptual Cross Section E – E`

Figure 16: Inorganic Concentrations

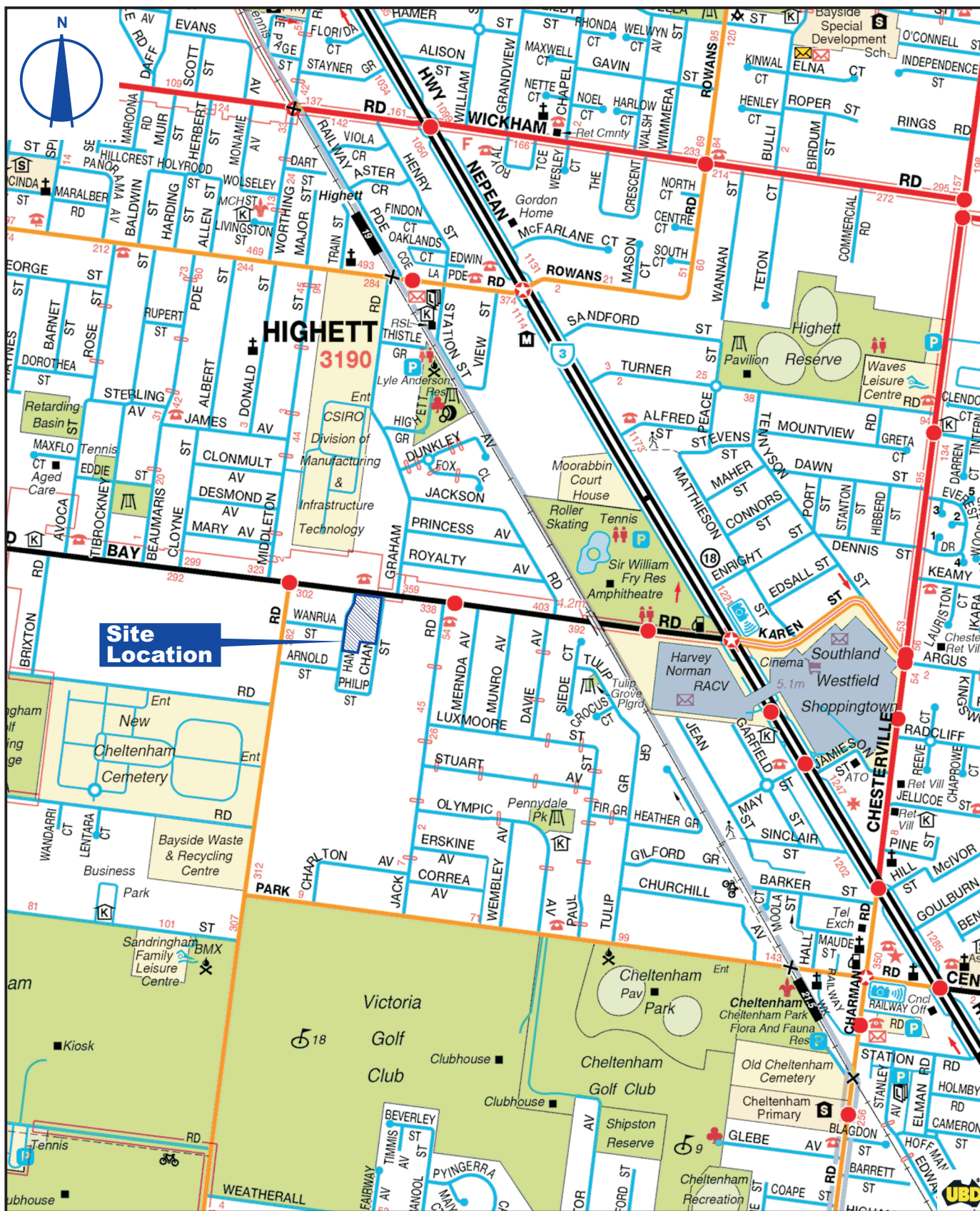
Figure 17: Metal Concentrations

Figure 18: Plume Extent – Tetrachloroethene & Breakdown Products

Figure 19: Plume Extent – 1,1,1-Trichloroethane & Breakdown Products

Figure 20: Plume Extent – Carbon Tetrachloride & Breakdown Products

Figure 21: Plume Extent – TPH and Trichloroethene



Source: UBD Australian City Streets (version 6)

0 500
Scale in Metres

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PROJECT: **s53V Environmental Audit**
18-22 Hamlet Street,
Cheltenham, Vic.

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Locality Map

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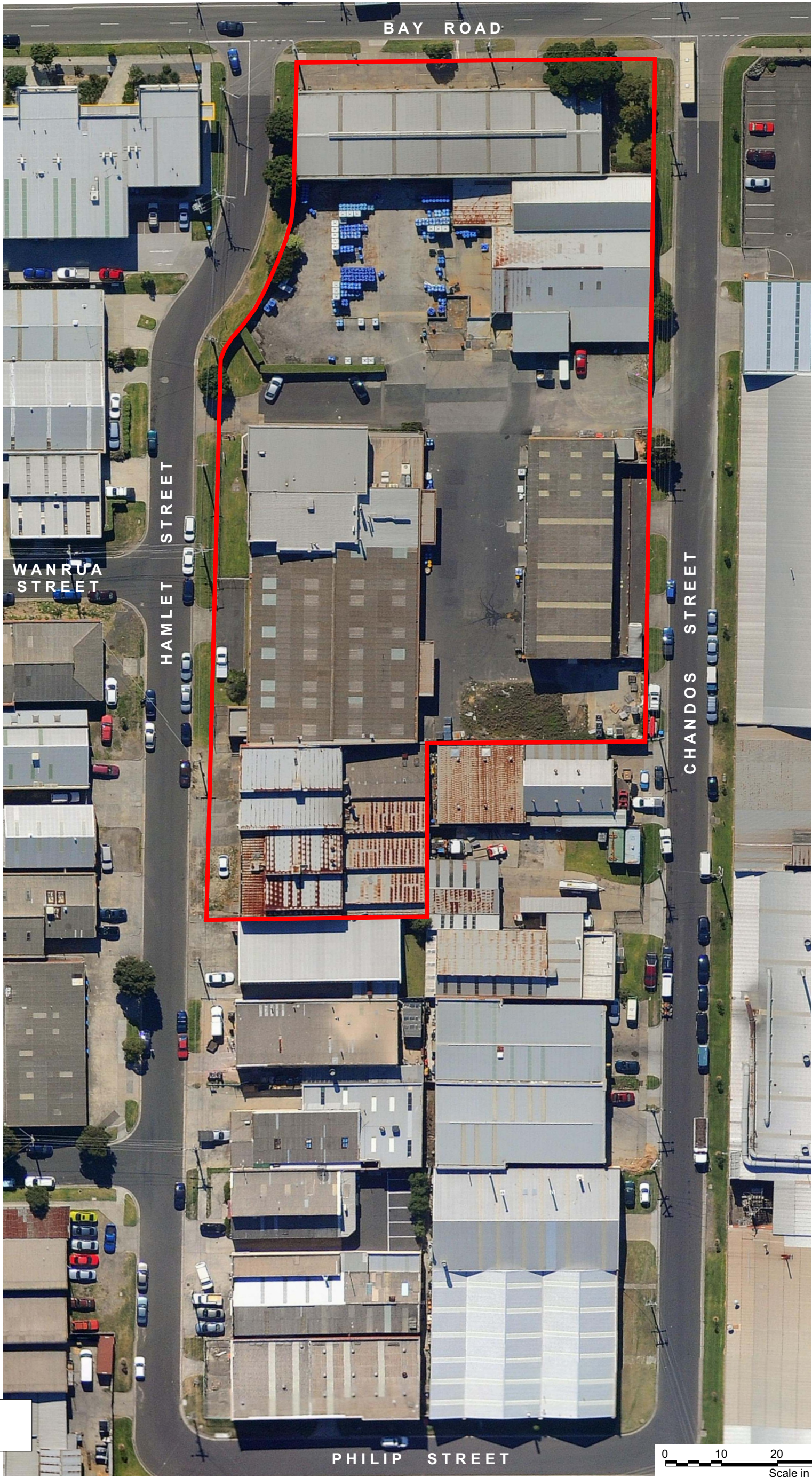
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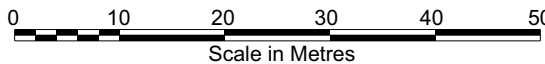
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FIG: 1



LEGEND:
 Site boundary

Source: Nearmap.com



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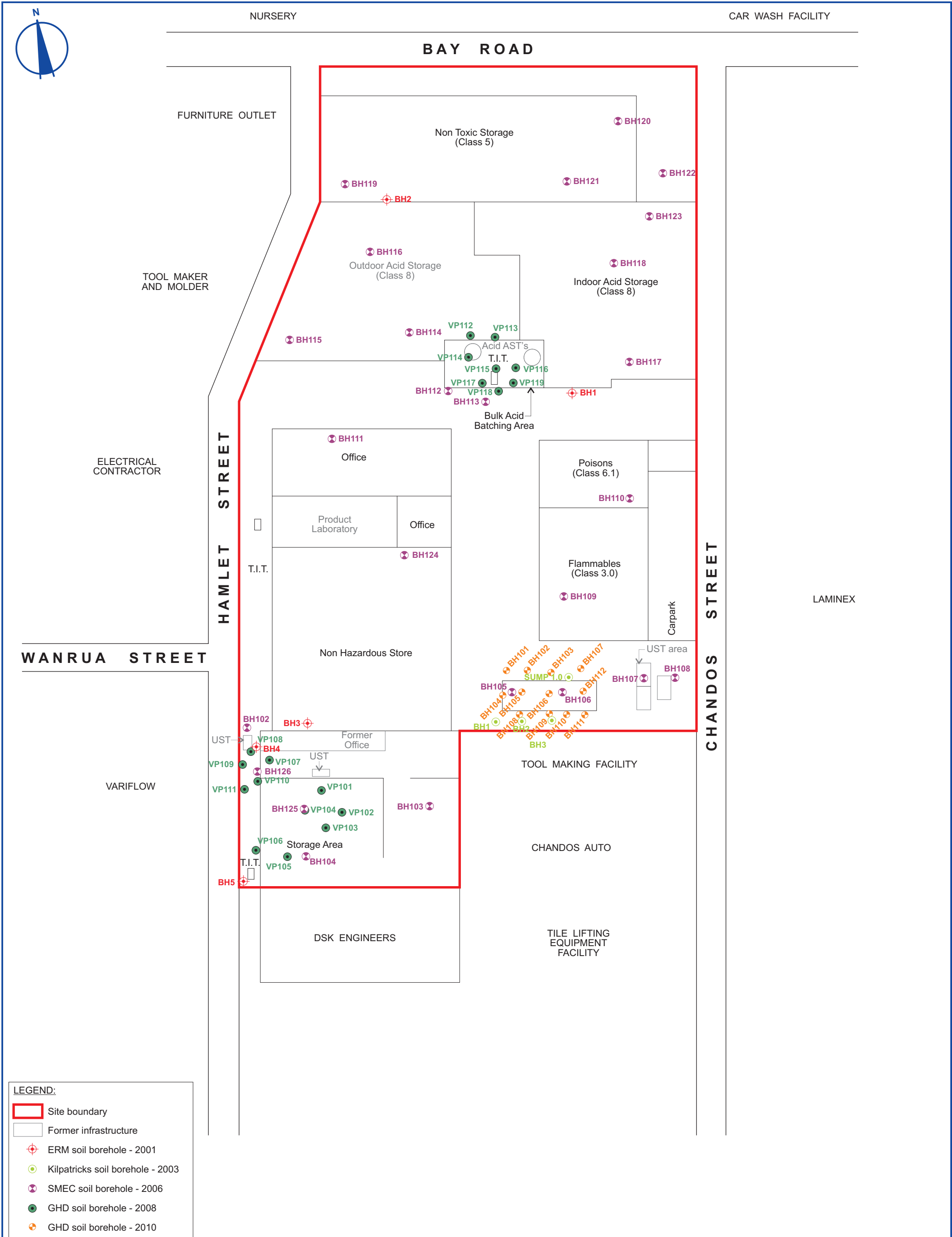
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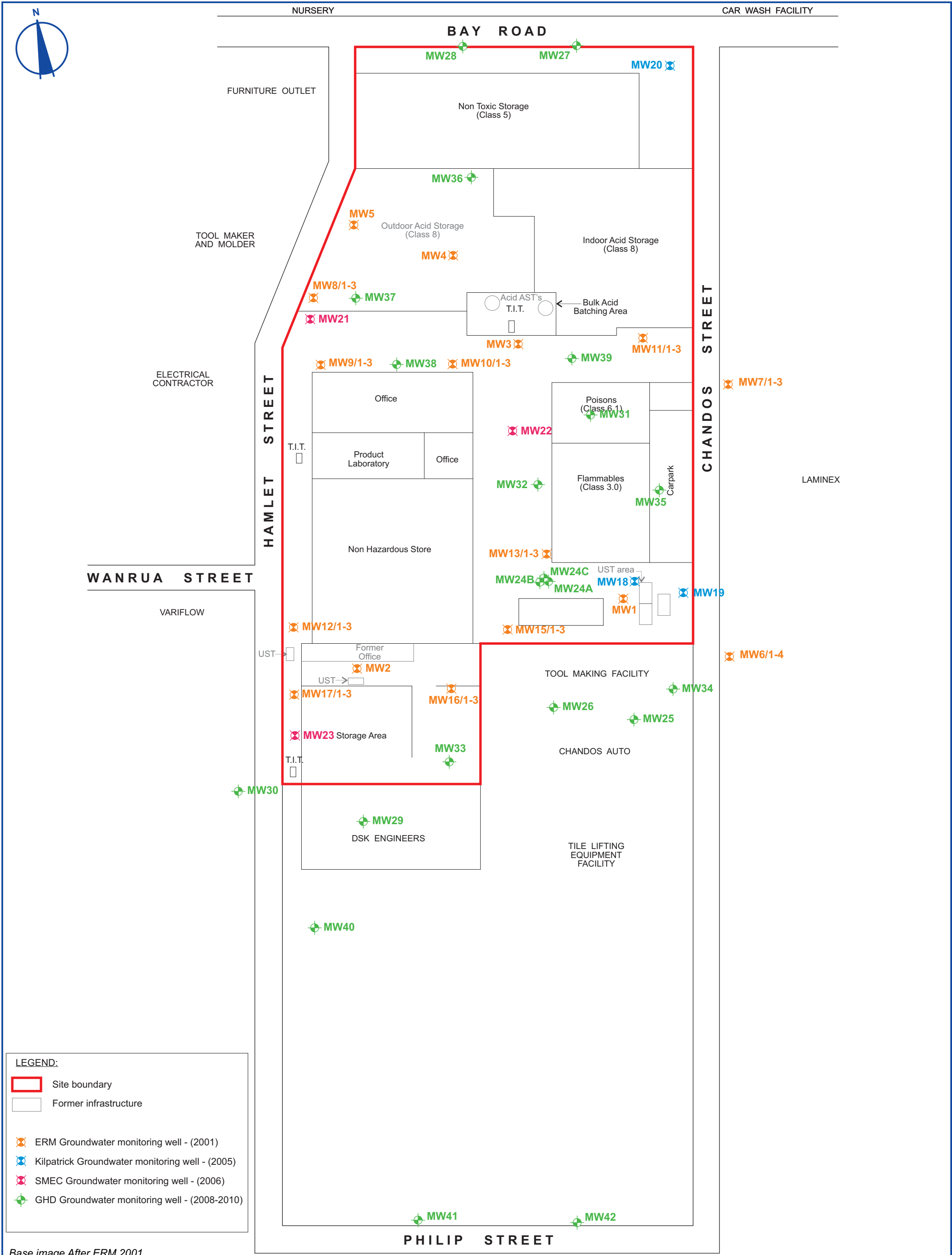
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DATE: July 2011
REV: 1

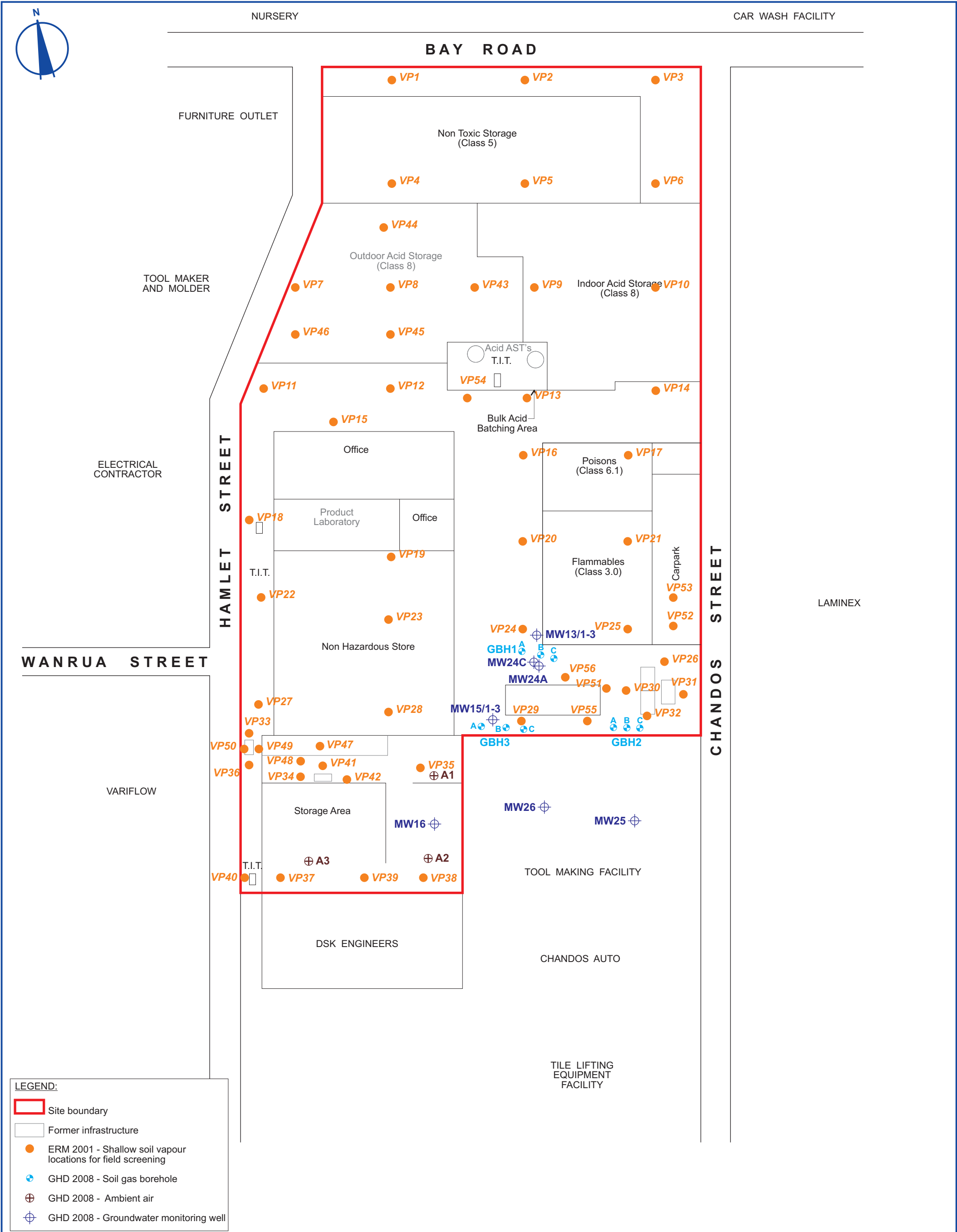
JOB No: 207214
FIG: 2



Base image After ERM 2001				
LanePiper Lane Piper Pty Ltd A.C.N. 120 109 935 www.lanepiper.com.au	PROJECT: s53V Environmental Audit 18-22 Hamlet Street, Cheltenham, Vic.		TITLE: Soil Investigation Locations	
	SCALE: No scale	DRAWN: LB	DATE: July 2011	JOB No: 207214
	REF: Figure 3.cdr		REV: 1	FIG: 3



LanePiper Lane Piper Pty Ltd A.C.N. 120 109 935 www.lanepiper.com.au	PROJECT: s53V Environmental Audit 18-22 Hamlet Street, Cheltenham, Vic.		TITLE: Groundwater Well Locations	
	SCALE: No scale	DRAWN: LB	DATE: July 2011	JOB No: 207214
	REF: Figure 4.cdr		REV: 1	FIG: 4

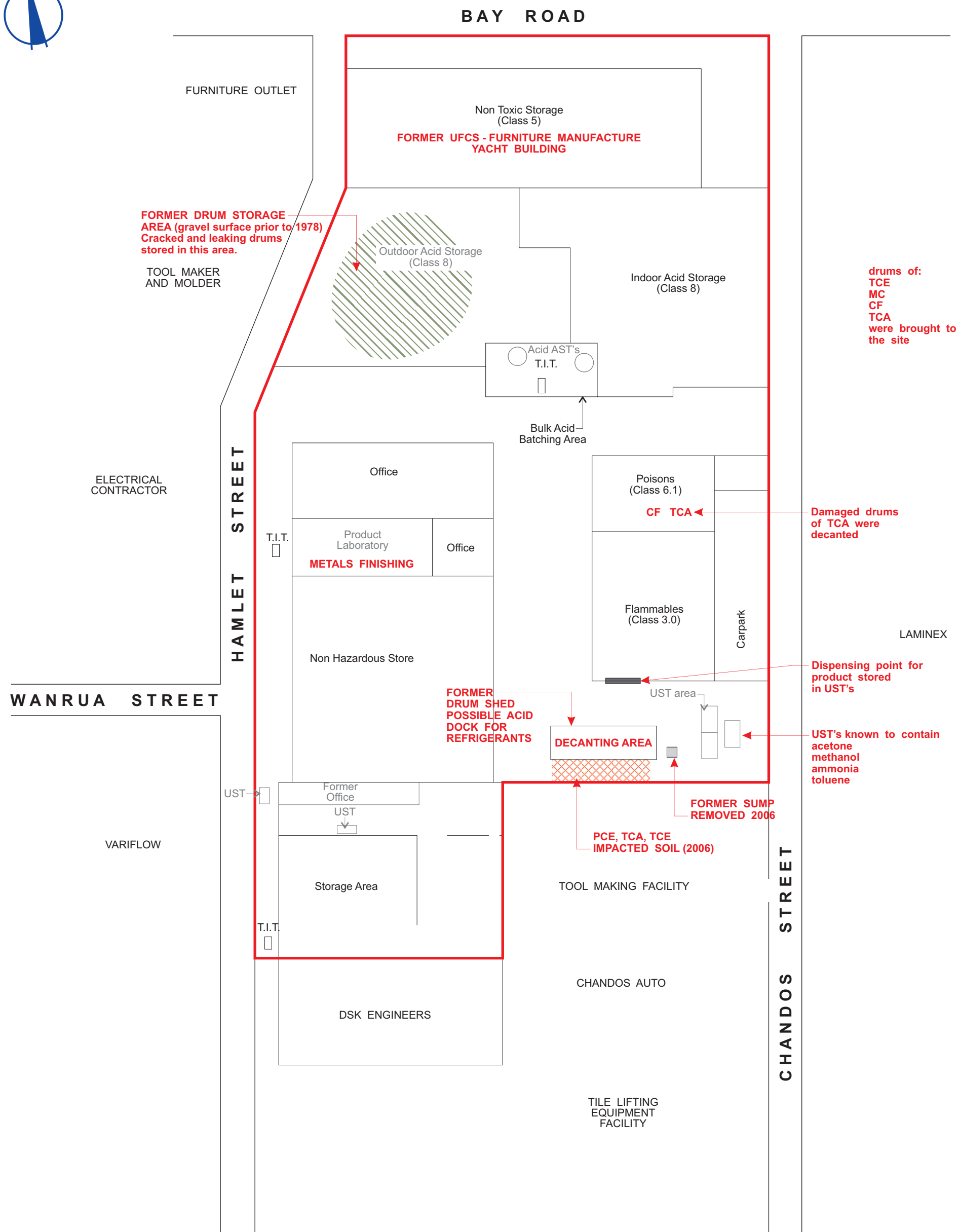


LanePiper Lane Piper Pty Ltd A.C.N. 120 109 935 www.lanepiper.com.au	PROJECT: s53V Environmental Audit 18-22 Hamlet Street, Cheltenham, Vic.		TITLE: Soil Vapour Locations	
	SCALE: No scale	DRAWN: LB	DATE: July 2011	JOB No: 207214
	REF: Figure 5.cdr		REV: 1	FIG: 5



Base image After ERM 2001

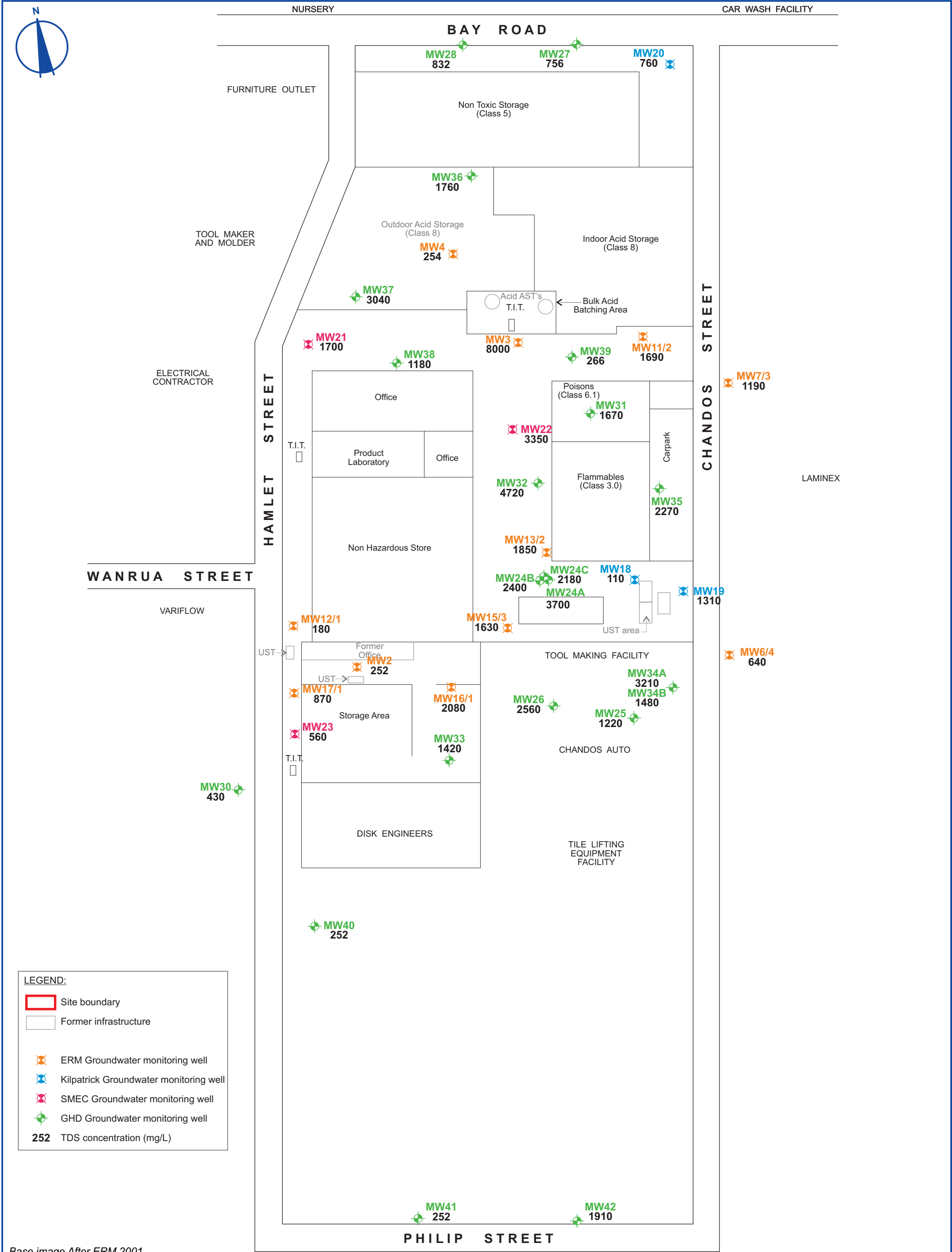
LanePiper Lane Piper Pty Ltd A.C.N. 120 109 935 www.lanepiper.com.au	PROJECT: s53V Environmental Audit 18-22 Hamlet Street, Cheltenham, Vic.		TITLE: Year Ground First Covered / Sealed	
	SCALE: No scale	DRAWN: LB	DATE: July 2011	JOB No: 207214
	REF: Figure 6.cdr		REV: 1	FIG: 6



LEGEND:

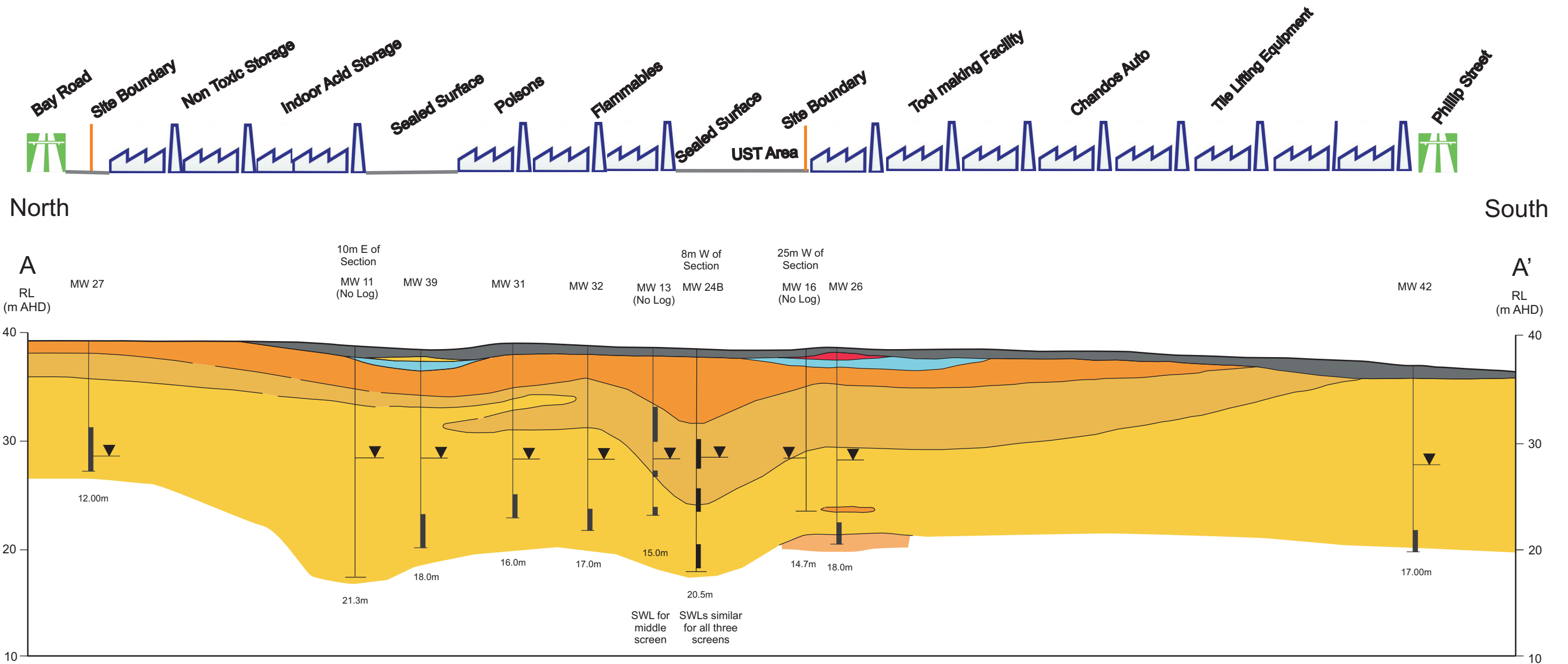
 Site boundary

 Former infrastructure

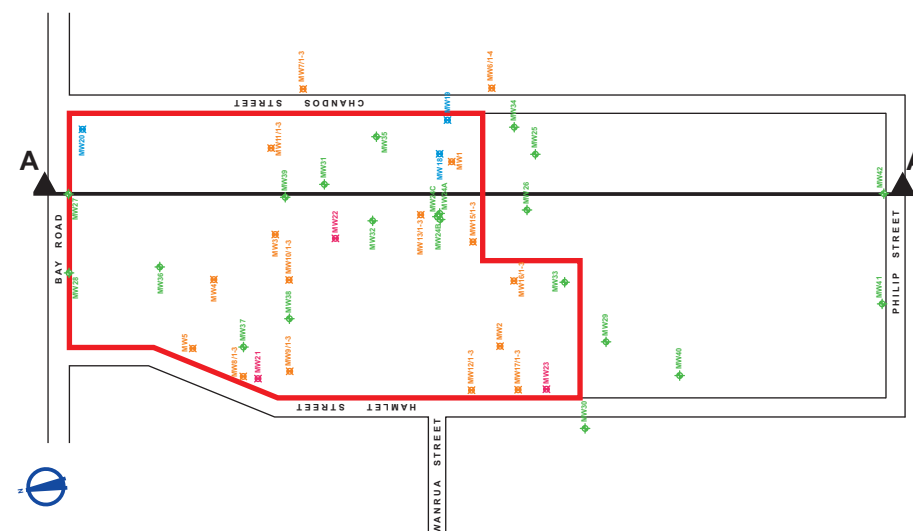
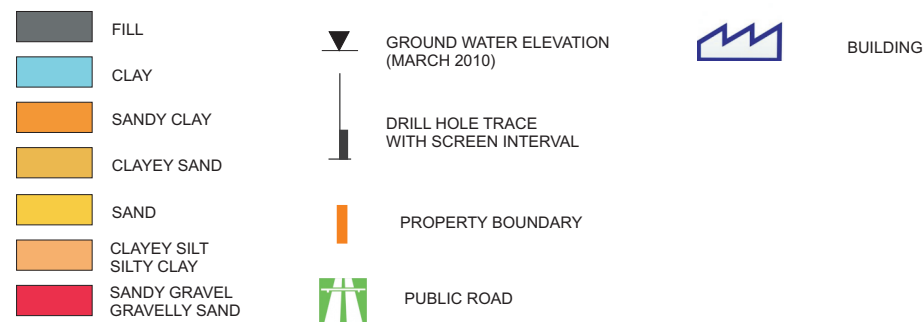


Base image After ERM 2001

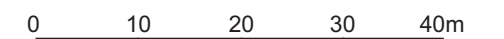
LanePiper Lane Piper Pty Ltd A.C.N. 120 109 935 www.lanepiper.com.au	PROJECT: s53V Environmental Audit 18-22 Hamlet Street, Cheltenham, Vic.		TITLE: TDS Concentrations - March 2010	
	SCALE: No scale	DRAWN: LB	DATE: July 2011	JOB No: 207214
	REF: Figure 9.cdr		REV: 1	FIG: 9

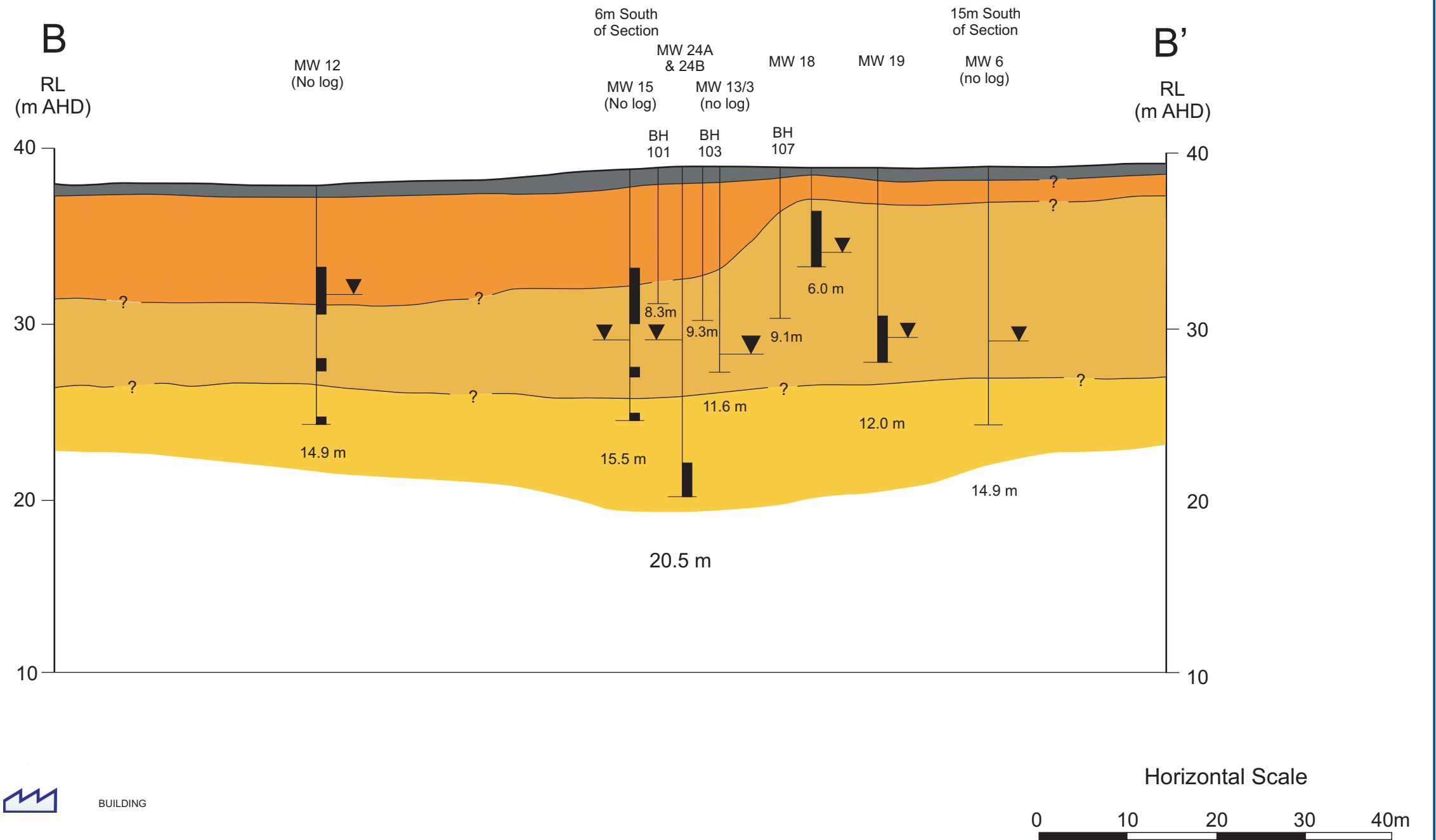
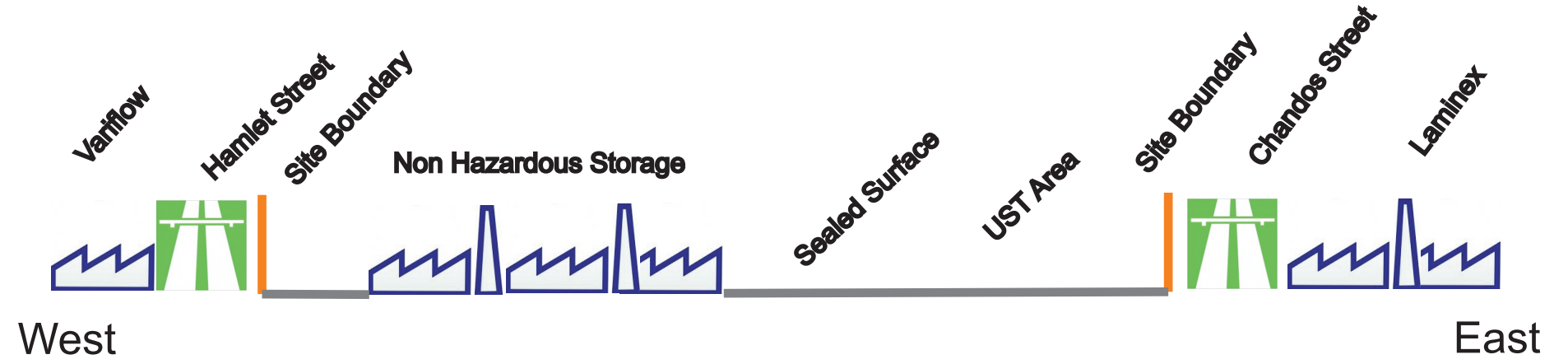


LEGEND



Horizontal Scale





LEGEND

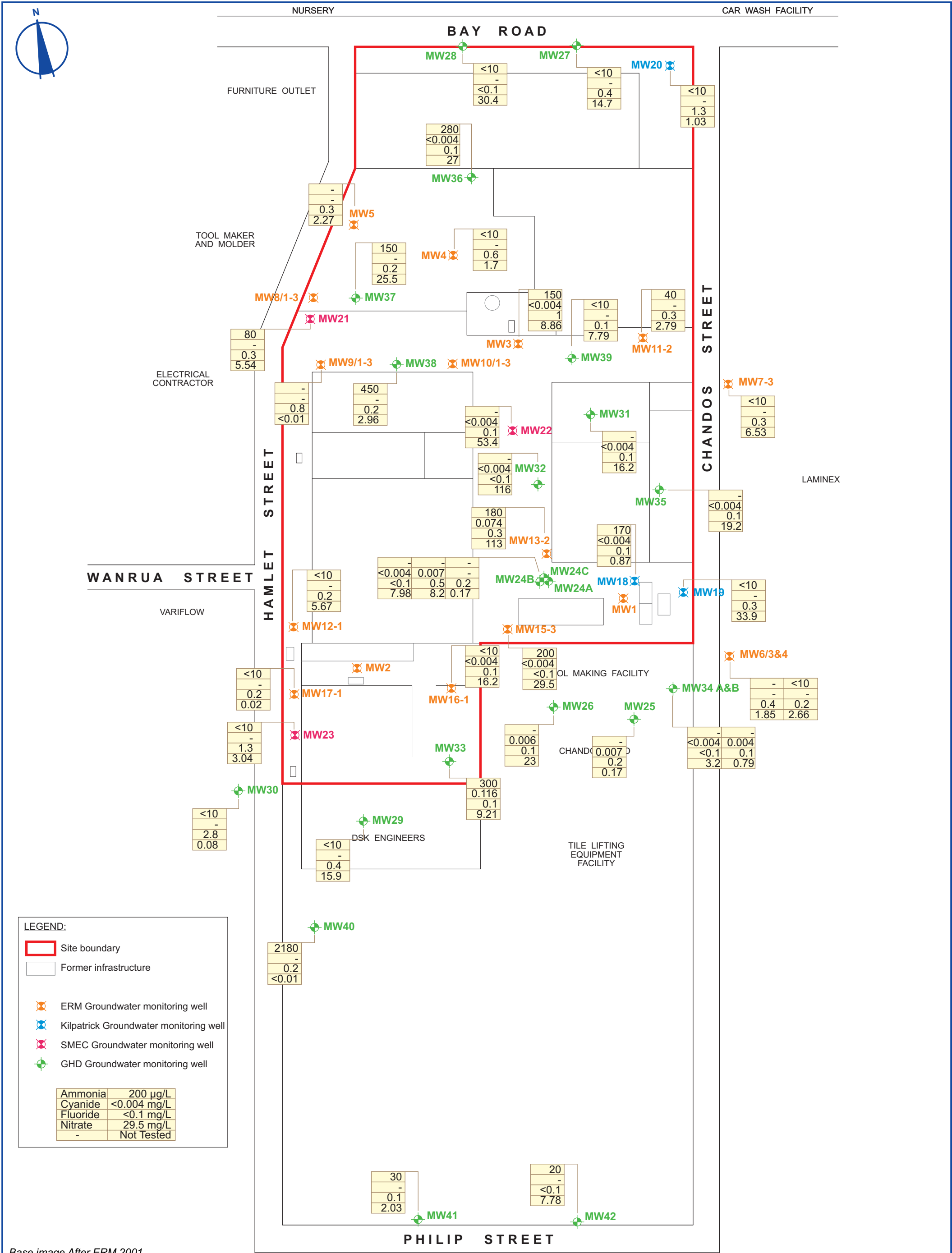
- | | |
|---|---|
|  FILL |  GROUND WATER ELEVATION (MARCH 2010) |
|  CLAY |  DRILL HOLE TRACE WITH SCREEN INTERVAL |
|  SANDY CLAY |  PROPERTY BOUNDARY |
|  CLAYEY SAND |  PUBLIC ROAD |
|  SAND | |
|  CLAYEY SILT | |
|  SILTY CLAY | |
|  SANDY GRAVEL | |
|  GRAVELLY SAND | |



BUILDING

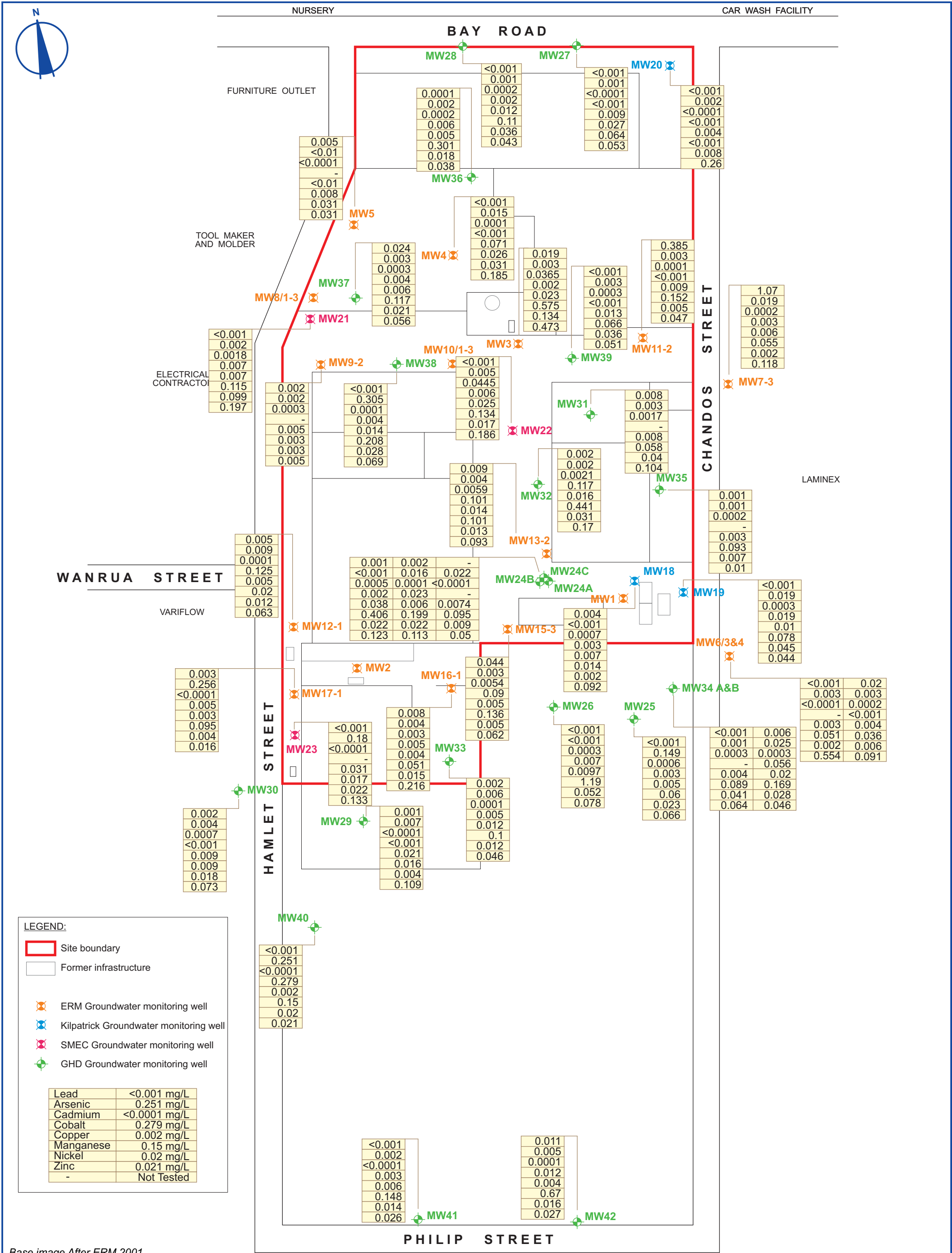
Horizontal Scale

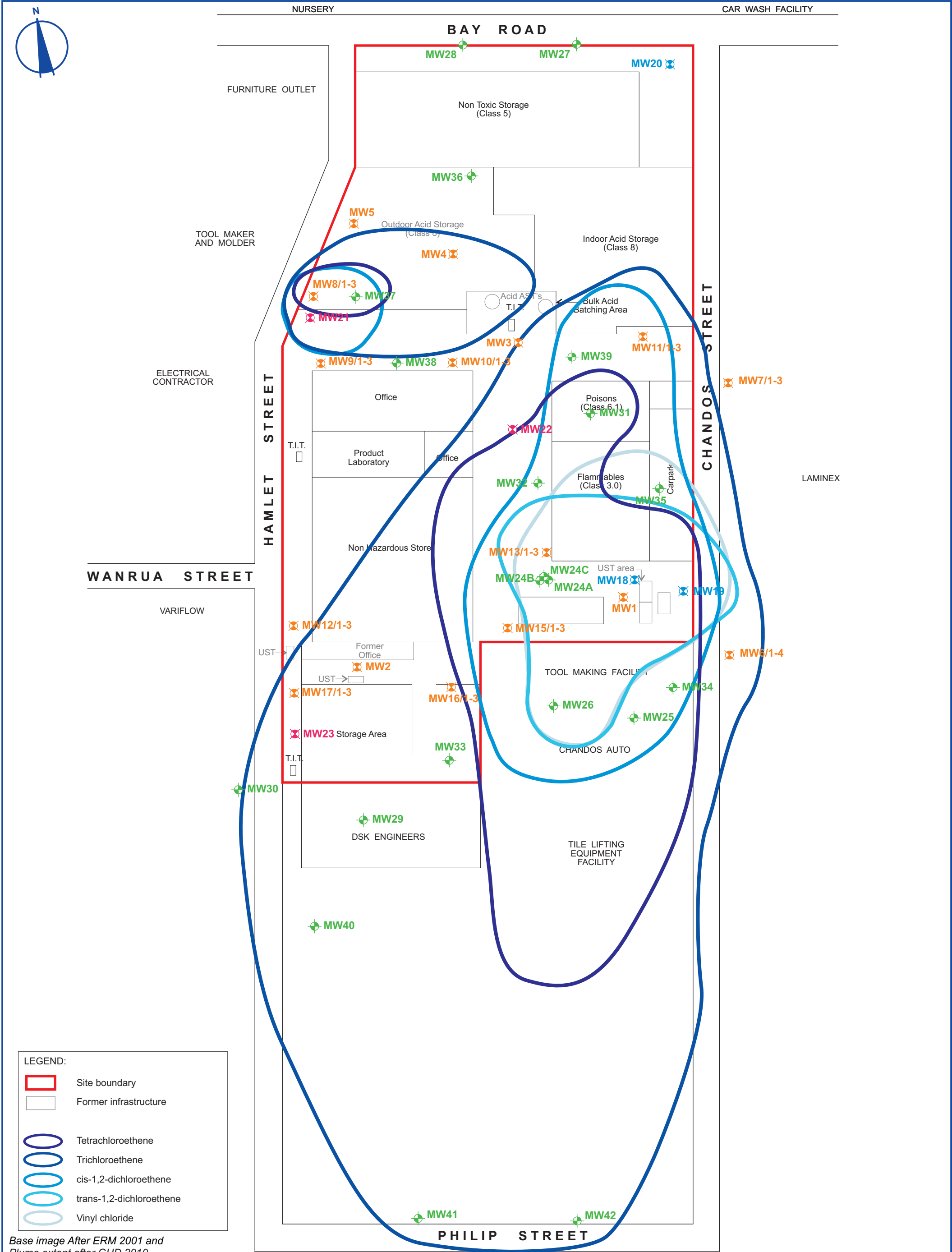




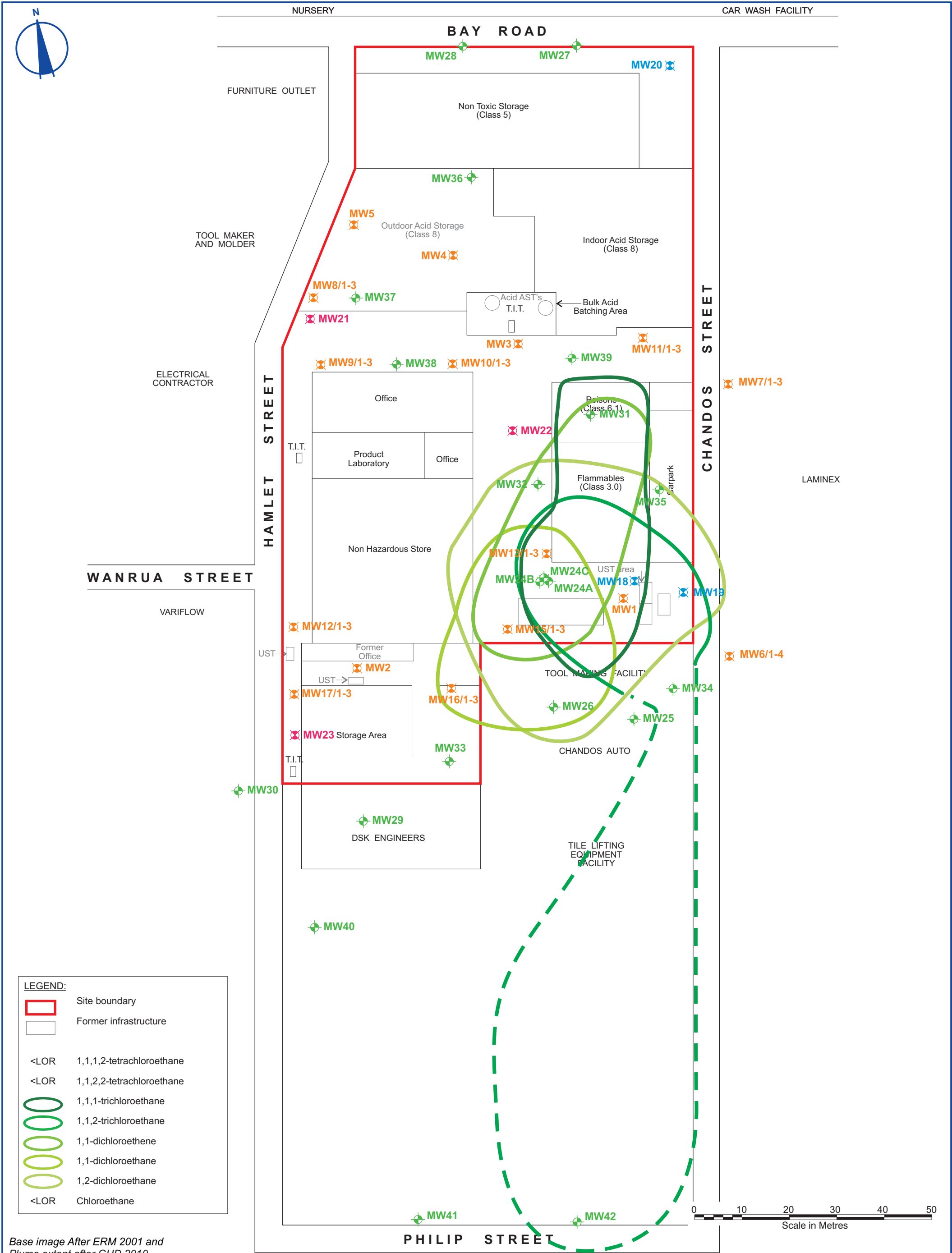
Base image After ERM 2001

LanePiper Lane Piper Pty Ltd A.C.N. 120 109 935 www.lanepiper.com.au	PROJECT: s53V Environmental Audit 18-22 Hamlet Street, Cheltenham, Vic.		TITLE: Inorganic Concentrations	
	SCALE: No scale	DRAWN: LB	DATE: July 2011	JOB No: 207214
	REF: Figure 13.cdr		REV: 1	FIG: 13

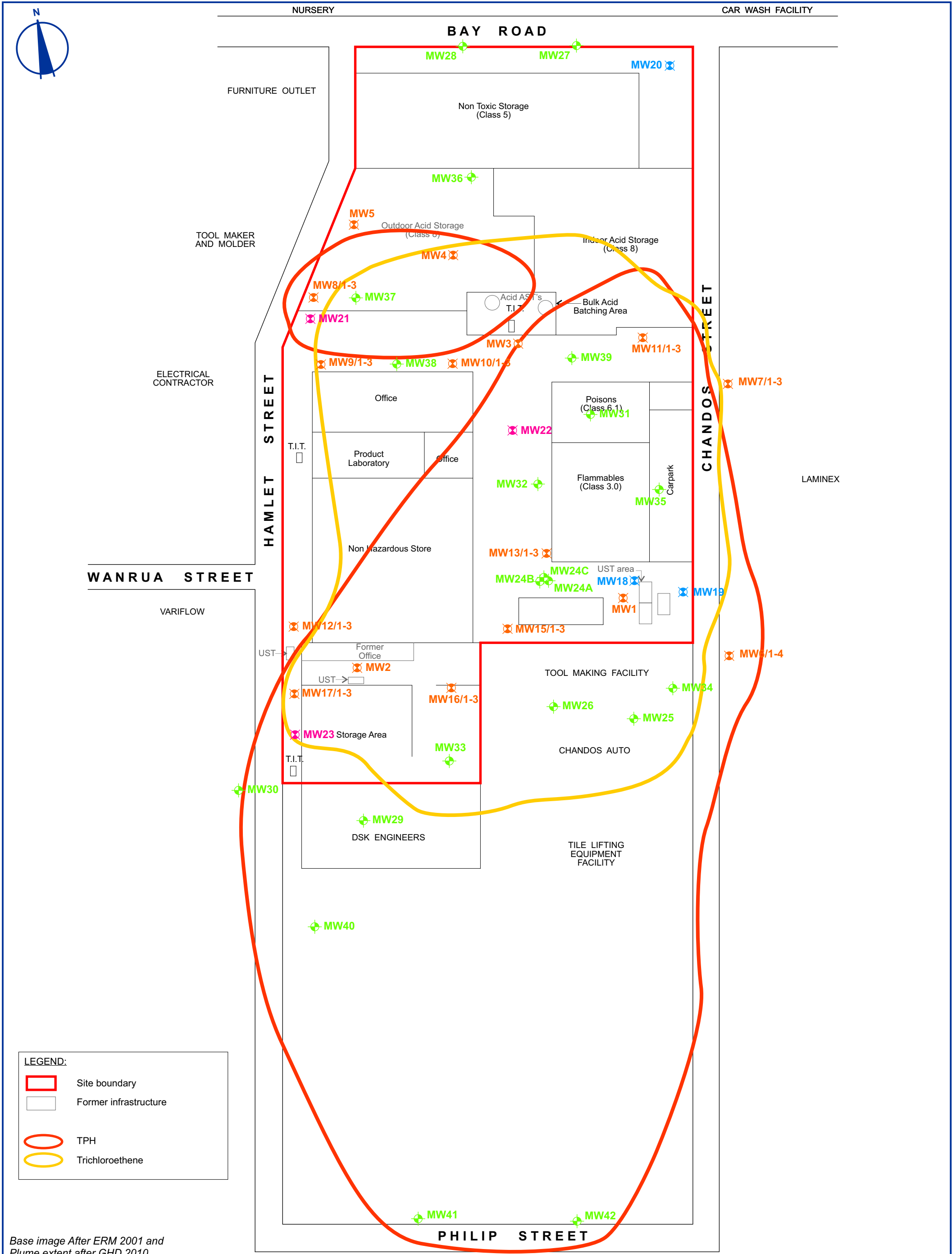




LanePiper Lane Piper Pty Ltd A.C.N. 120 109 935 www.lanepiper.com.au	PROJECT: s53V Environmental Audit 18-22 Hamlet Street, Cheltenham, Vic.		TITLE: Plume Extent - Tetrachloroethene and Breakdown Products	
	SCALE: No scale	DRAWN: LB	DATE: July 2011	JOB No: 207214
	REF: Figure 15.cdr		REV: 1	FIG: 15



LanePiper Lane Piper Pty Ltd A.C.N. 120 109 935 www.lanepiper.com.au	PROJECT: s53V Environmental Audit 18-22 Hamlet Street, Cheltenham, Vic.		TITLE: Plume Extent - 1,1,1-trichloroethane and Breakdown Products	
	SCALE: No scale	DRAWN: LB	DATE: July 2011	JOB No: 207214
	REF: Figure 16.cdr		REV: 1	FIG: 16



LanePiper Lane Piper Pty Ltd A.C.N. 120 109 935 www.lanepiper.com.au	PROJECT: s53V Environmental Audit 18-22 Hamlet Street, Cheltenham, Vic.		TITLE: Plume Extent - TPH and Trichloroethene	
	SCALE: No scale	DRAWN: LB	DATE: July 2011	JOB No: 207214
	REF: Figure 18.cdr		REV: 1	FIG: 18

Appendix B

17 Pages

Tables

Table 1: Reasonable Maximum Groundwater Concentrations (key compounds)

Table 2: Soil Data

Table 3: Groundwater Data

Table 1 : Reasonable Maximum Groundwater Concentrations (key compounds)

		LocCode	MW11/2	MW12/1	MW13/2	MW15/3	MW16/1	MW17/1	MW17/2	MW18	MW19	MW20	MW21	MW22	MW23	MW24A	MW24B	MW24C	MW25	MW26	MW27	MW28	MW29	MW30	MW31		
		Sampled_Date-Time	2008-2011 (n=5)	2008-2011 (n=4)	2008-2011 (n=4)	2008-2011 (n=4)	2008-2011 (n=4)	2008-2011 (n=3)	14/10/2008 (n=1)	2008-2011 (n=5)	2008-2010 (n=5)	2008-2011 (n=5)	2008-2011 (n=4)	2008-2011 (n=4)	2008-2011 (n=5)	2008-2011 (n=3)	2008-2011 (n=3)	2008-2011 (n=3)	2008-2011 (n=4)	2008-2011 (n=3)	2008-2011 (n=5)	2008-2011 (n=5)	2008-2011 (n=2)	2008-2011 (n=4)	2008-2011 (n=2)		
ChemName	Units	EQL																									
BTEX																											
Benzene	µg/L	0.5	<1	<1	52	9	<1	6	9	1	<1	<1	<1	<1	442	<1	23	114	<1	<50	<1	<1	<1	<1	<1		
Ethylbenzene	µg/L	0.5	<2	<2	20	<1	<1	<1	<5	2	99	<1	<1	<2	51	<2	4	138	<2	<50	<1	<1	<2	<1	<2		
Toluene	µg/L	0.5	2	11	382	871	7	16	<5	4	619	<1	<1	<2	2	<2	91	12200	3	<50	<1	<1	<2	<2	<2		
Xylene (m & p)	µg/L	1	<2	<2	66	2	<2	15	<10	5	323	<2	<2	<2	<2	<2	8	206	<2	<100	<2	<2	<2	<2	<2		
Xylene (o)	µg/L	0.5	<1	<2	39	3	<2	8	<5	4	202	<1	<1	<2	<1	<2	3	101	<2	<50	<1	<1	<2	<2	<2		
Xylene Total	µg/L		<3	<3	105	4	<3	23	<15	9	525	<3	<3	<3	<3	<4	11	307	<4	<150	<3	<3	<4	<4	<4		
Chlorinated Hydrocarbons																											
Tetrachloroethene	µg/L	0.5	<5	<5	5290	5220	<5	<5	<5	26	506	<5	36	<5	<5	327	899	5740	10	1690	<5	<5	<5	<5	25		
Trichloroethene	µg/L	0.5	<5	<5	332,000	423,000	12	<5	<5	1320	143,000	<5	585	94	<5	4830	97,300	132,000	795	94,500	<5	<5	<5	<5	3380		
cis-1,2-dichloroethene	µg/L	0.5	<5	<5	2840	2810	<5	<5	<5	2370	14,200	<5	139	<5	<5	51	9770	24,400	13	204	<5	<5	<5	<5	361		
trans-1,2-dichloroethene	µg/L	0.5	<5	<5	49	6	<5	<5	<5	<5	67	<5	<5	<5	<5	<5	20	<100	<5	<50	<5	<5	<5	<5	<5		
Vinyl chloride	µg/L	5	<10	<10	230	<10	<10	<10	<50	20	440	<10	<10	<50	<10	<50	<50	<1000	<50	<500	<10	<10	<50	<50	<50		
1,1,1,2-tetrachloroethane	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
1,1,2,2-tetrachloroethane	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
1,1,1,1-trichloroethane	µg/L	0.5	<5	<5	116	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	<5	29	216	<5	<50	<5	<5	<5	<5	12		
1,1,2-trichloroethane	µg/L	0.5	<5	<5	97	207	<5	<5	<5	<5	79	<5	<5	<5	<5	<5	73	360	<5	<50	<5	<5	<5	<5	<5		
1,1-dichloroethene	µg/L	0.5	<5	<5	193	182	9	<5	<5	7	47	<5	<5	<5	<5	<5	440	2720	<5	<50	<5	<5	<5	<5	87		
1,1-dichloroethane	µg/L	0.5	<5	<5	50	50	15	<5	<5	<5	10	<5	<5	<5	<5	<5	101	622	<5	<50	<5	<5	<5	<5	7		
1,2-dichloroethane	µg/L	0.5	<1	<1	2930	2760	<1	<5	<5	<1	581	<1	<5	<5	9	109	311	<100	<5	474	<1	<1	<5	<5	<5		
Chloroethane	µg/L	5	<10	<10	<50	<10	<50	<10	<50	<10	<10	<10	<10	<50	<10	<50	<50	<1000	<50	<500	<10	<10	<50	<50	<50		
Carbon tetrachloride	µg/L	0.5	<1	<1	47	<1	<1	<1	<5	<1	<1	<1	8	19	<1	<5	<5	<100	<5	<50	<1	<1	<5	<5	<5		
Chloroform	µg/L	0.5	<5	<5	846	803	11	<5	<5	9	1580	<5	38	69	<5	218	974	1940	15	204	5	<5	<5	<5	41		
Dichloromethane	µg/L	5	<5	<5	<110	179,000	<5	-	-	<5	466	-	12	<5	-	<5	2600	6320	-	1000	-	<5	-	-	<5		
Chloromethane	µg/L	5	<10	<10	<50	<10	<50	<50	<50	<10	<10	<10	<10	<10	<50	<50	<1000	<50	<500	<10	<10	<50	<50	<50	<50		
1,1-dichloropropene	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
1,2,3-trichloropropane	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
1,2-dibromo-3-chloropropane	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
1,2-dichloropropane	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
1,3-dichloropropane	µg/L	0.5	<5	<5	11	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
2,2-dichloropropane	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
Bromochloromethane	µg/L	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Bromodichloromethane	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
Bromoform	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
Chlorodibromomethane	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
cis-1,3-dichloropropene	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
Dibromomethane	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
Hexachlorobutadiene	µg/L	1	<1	<1	<5	<1	<1	<1	<5	<1	<1	<1	<1	<5	<1	<5	<5	<100	<5	<50	<1	<1	<5	<5	<5		
trans-1,3-dichloropropene	µg/L	0.5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<100	<5	<50	<5	<5	<5	<5	<5		
Halogenated Benzenes																											
Chlorobenzene	µg/L	0.5	<5	<5	15	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	104	1460	<5	<50	<5	<5	<5	<5	<5		
Inorganics																											
Ammonia as N	µg/L	5	40	<10	180	200	<10	<10	-	170	<10	<10	80	-	<10	-	-	-	-	-	<10	<10	<10	<10	-		
Cyanide Total	mg/L</																										

Table 1 : Reasonable Maximum Groundwater Concentrations (key compounds)

LocCode		MW3	MW32	MW33	MW34A	MW34B	MW35	MW36	MW37	MW38	MW39	MW40	MW41	MW4	MW42	MW5	MW6/3	MW6/4	MW7/3	MW9/2
Sampled_Date-Time		15/07/2008 (n=4)	2010-2011 (n=2)	2010-2011 (n=2)	2009-2011 (n=2)	2009-2011 (n=2)	17/03/2010 (n=1)	2009-2011 (n=3)	2009-2011 (n=3)	2009-2011 (n=3)	2009-2011 (n=3)	2010-2011 (n=2)	2010-2011 (n=2)	2008-2011 (n=5)	2010-2011 (n=2)	2008 (n=2)	2008 (n=2)	2008-2011 (n=3)	2008-2011 (n=5)	17/07/2008 (n=1)
ChemName	Units	EQL																		
BTEX																				
Benzene	µg/L	0.5	<1	2	<1	<1	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	0.5	<1	<2	<2	<2	<2	<10	<2	<2	<2	<2	<2	<1	<2	<1	<1	<2	<1	<1
Toluene	µg/L	0.5	58	<2	<2	<2	<5	<10	<2	<5	<2	<2	<2	<1	<2	<1	7	49	10	<1
Xylene (m & p)	µg/L	1	<2	<2	<2	5	<2	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Xylene (o)	µg/L	0.5	<1	<2	<2	3	<2	<10	<2	<2	<2	<2	<2	<1	<2	<1	<1	<2	<1	<1
Xylene Total	µg/L		<3	<4	<4	8	<4	<30	<4	<4	<4	<4	<4	<3	<4	<3	<3	<4	<3	<3
Chlorinated Hydrocarbons																				
Tetrachloroethene	µg/L	0.5	<5	81	<5	111	13	<10	<5	9	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	µg/L	0.5	18	418	31	11500	998	1140	<5	8	13	2020	37	12	5	24	<5	<5	13	<5
cis-1,2-dichloroethene	µg/L	0.5	<5	76	34	62	41	19	<5	<5	<5	179	<5	<5	<5	<5	<5	<5	<5	<5
trans-1,2-dichloroethene	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Vinyl chloride	µg/L	5	<10	<50	<50	<50	<50	<100	<50	<50	<50	<50	<50	<10	<50	<10	<10	<50	<10	<10
1,1,1,2-tetrachloroethane	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,2,2-tetrachloroethane	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,1-trichloroethane	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,2-trichloroethane	µg/L	0.5	<5	<5	<5	26	<5	<10	<5	<5	<5	<5	<5	<5	9	<5	<5	<5	<5	<5
1,1-dichloroethene	µg/L	0.5	<5	20	6	<5	<5	<10	<5	<5	<5	<5	<5	10	<5	<5	<5	<5	<5	<5
1,1-dichloroethane	µg/L	0.5	5	<5	10	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-dichloroethane	µg/L	0.5	3	58	<5	34	7	86	<5	<5	<5	<5	<5	<5	<1	<5	<1	<1	<5	<1
Chloroethane	µg/L	5	<10	<50	<50	<50	<50	<100	<50	<50	<50	<50	<50	<10	<50	<10	<10	<50	<10	<10
Carbon tetrachloride	µg/L	0.5	37	86	<5	<5	<5	34	<5	<5	<5	<5	<5	<1	<5	<1	<1	<5	<1	<1
Chloroform	µg/L	0.5	11600	498	18	221	46	22	<5	<5	32	9	<5	<5	<5	<5	<5	<5	<5	<5
Dichloromethane	µg/L	5	101	74	<5	95	<5	<35	<5	<5	<5	<5	31	<5	-	<5	-	<5	-	-
Chloromethane	µg/L	5	<10	<50	<50	<50	<50	<100	<50	<50	<50	<50	<50	<10	<50	<10	<10	<50	<10	<10
1,1-dichloropropene	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2,3-trichloropropane	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-dibromo-3-chloropropane	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-dichloropropane	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,3-dichloropropane	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
2,2-dichloropropane	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromochloromethane	µg/L	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromodichloromethane	µg/L	0.5	96	7	<5	<5	16	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chlorodibromomethane	µg/L	0.5	5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1,3-dichloropropene	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dibromomethane	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Hexachlorobutadiene	µg/L	1	<1	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<1	<5	<1	<1	<5	<1
trans-1,3-dichloropropene	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Halogenated Benzenes																				
Chlorobenzene	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Inorganics																				
Ammonia as N	µg/L	5	150	-	300	-	-	-	280	150	450	<10	2180	30	<10	20	-	-	<10	<10
Cyanide Total	mg/L	0.004	<0.004	<0.004	0.116	<0.004	0.004	<0.004	<0.004	-	-	-	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	0.01	8.86	116	9.21	3.2	0.79	19.2	27	25.5	2.96	7.79	<0.01	2.03	1.7	7.78	2.27	1.85	2.66	6.53
Nitrite (as N)	mg/L	0.003	0.03	0.03	0.09	0.06	0.08	0.03	1.22	0.03	<0.03	0.08	<0.01	0.08	0.01	0.15	0.03	0.02	<0.01	0.02
Nitrogen (Total Oxidised)	mg/L	0.01	8.8	116	9.3	3.26	0.87	19.2	28.2	25.5	2.96	7.87	<0.1	2.11	0.96	7.79	-	-	2.66	6.53
TDS	mg/L	1	9820	5000	1420	3740	2150	2270	2650	3140	1540	784	276	438	788	2020	3320	750	688	1420
Lead																				
Lead (Filtered)	mg/L	0.001	0.019	0.002	0.002	<0.001	0.006	0.001	0.0001	0.024	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	0.005	<0.001	0.02	1.07
MAH																				
Isopropylbenzene	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
n-propylbenzene	µg/L	0.5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Metals																				
Arsenic (Filtered)	mg/L	0.001	0.003	0.002	0.006	0.001	0.025	0.001	0.002	0.003	0.305	0.003	0.251	0.002	0.015	0.005	<0.01			

Table 1 : Reasonable Maximum Groundwater Concentrations (key compounds)

LocCode		Sampled_Date-Time				
ChemName	Units	EQL	Minimum Concentration	Minimum Detect	Maximum Concentration	Maximum Detect
BTEX						
Benzene	µg/L	0.5	<1	1	<5000	442
Ethylbenzene	µg/L	0.5	<1	1	<5000	138
Toluene	µg/L	0.5	<1	1	12,200	12,200
Xylene (m & p)	µg/L	1	<2	2	<10000	323
Xylene (o)	µg/L	0.5	<1	1	<5000	202
Xylene Total	µg/L		<3	3	<15000	525
Chlorinated Hydrocarbons						
Tetrachloroethene	µg/L	0.5	<5	6	5740	5740
Trichloroethene	µg/L	0.5	<5	5	423,000	423,000
cis-1,2-dichloroethene	µg/L	0.5	<5	13	24,400	24,400
trans-1,2-dichloroethene	µg/L	0.5	<5	5	<5000	67
Vinyl chloride	µg/L	5	<10	20	<50000	440
1,1,1,2-tetrachloroethane	µg/L	0.5	<5	ND	<5000	ND
1,1,2,2-tetrachloroethane	µg/L	0.5	<5	ND	<5000	ND
1,1,1-trichloroethane	µg/L	0.5	<5	5	<5000	216
1,1,2-trichloroethane	µg/L	0.5	<5	7	<5000	360
1,1-dichloroethene	µg/L	0.5	<5	5	<5000	2720
1,1-dichloroethane	µg/L	0.5	<5	5	<5000	622
1,2-dichloroethane	µg/L	0.5	<1	3	<5000	2930
Chloroethane	µg/L	5	<10	ND	<50000	ND
Carbon tetrachloride	µg/L	0.5	<1	6	<5000	86
Chloroform	µg/L	0.5	<5	5	11,600	11,600
Dichloromethane	µg/L	5	<5	12	179,000	179,000
Chloromethane	µg/L	5	<10	ND	<50000	ND
1,1-dichloropropene	µg/L	0.5	<5	ND	<5000	ND
1,2,3-trichloropropane	µg/L	0.5	<5	ND	<5000	ND
1,2-dibromo-3-chloropropane	µg/L	0.5	<5	ND	<5000	ND
1,2-dichloropropane	µg/L	0.5	<5	ND	<5000	ND
1,3-dichloropropane	µg/L	0.5	<5	11	<5000	11
2,2-dichloropropane	µg/L	0.5	<5	ND	<5000	ND
Bromochloromethane	µg/L	0.5	0	ND	0	ND
Bromodichloromethane	µg/L	0.5	<5	7	<5000	96
Bromoform	µg/L	0.5	<5	ND	<5000	ND
Chlorodibromomethane	µg/L	0.5	<5	5	<5000	5
cis-1,3-dichloropropene	µg/L	0.5	<5	ND	<5000	ND
Dibromomethane	µg/L	0.5	<5	ND	<5000	ND
Hexachlorobutadiene	µg/L	1	<1	ND	<5000	ND
trans-1,3-dichloropropene	µg/L	0.5	<5	ND	<5000	ND
Halogenated Benzenes						
Chlorobenzene	µg/L	0.5	<5	8	<5000	1460
Inorganics						
Ammonia as N	µg/L	5	<10	20	2180	2180
Cyanide Total	mg/L	0.004	<0.004	0.004	0.116	0.116
Nitrate (as N)	mg/L	0.01	<0.01	0.01	116	116
Nitrite (as N)	mg/L	0.003	<0.01	0.01	1.3	1.3
Nitrogen (Total Oxidised)	mg/L	0.01	<0.01	0.04	116	116
TDS	mg/L	1	110	110	9820	9820
Lead						
Lead (Filtered)	mg/L	0.001	0.0001	0.0001	1.07	1.07
MAH						
Isopropylbenzene	µg/L	0.5	<5	9	5000	5000
n-propylbenzene	µg/L	0.5	<5	7	5000	5000
Metals						
Arsenic (Filtered)	mg/L	0.001	<0.001	0.001	0.305	0.305
Barium (Filtered)	mg/L	0.001	0.002	0.002	0.131	0.131
Beryllium (Filtered)	mg/L	0.001	<0.001	0.001	<0.011	0.001
Boron (Filtered)	mg/L	0.05	<0.05	0.05	0.2	0.2
Cadmium (Filtered)	mg/L	0.0001	<0.0001	0.0001	0.0445	0.0445
Calcium (Filtered)	mg/L	0.1	<1	1	224	224
Chromium (III+VI) (Filtered)	mg/L	0.001	<0.001	0.001	0.02	0.02
Cobalt (Filtered)	mg/L	0.001	<0.001	0.001	0.279	0.279
Copper (Filtered)	mg/L	0.001	<0.001	0.001	0.071	0.071
Ferric Iron (Filtered)	mg/L	0.05	<0.05	0.05	6.24	6.24
Iron (Filtered)	mg/L	0.01	0.04	0.04	30.8	30.8
Magnesium (Filtered)	mg/L	0.1	1	1	322	322
Manganese (Filtered)	mg/L	0.001	<0.001	0.001	1.19	1.19
Mercury (Filtered)	mg/L	0.0001	<0.0001	0.0001	0.098	0.098
Nickel (Filtered)	mg/L	0.001	<0.001	0.001	0.134	0.134
Potassium (Filtered)	mg/L	1	0.1	0.1	28	28
Vanadium (Filtered)	mg/L	0.01	<0.01	0.01	0.07	0.07
Zinc (Filtered)	mg/L	0.005	<0.005	0.005	0.554	0.554
Organic						
Ethane	µg/L	10	<10	23	25	25
Ethene	µg/L	10	<10	ND	<10	ND
Methane	mg/L	0.005	<0.01	0.012	0.176	0.176
PAH/Phenols						
Naphthalene	µg/L	0.5	<1	8	<500	38
PAHs (Sum of total)	µg/L		<0	1	31	31
Solvents						
Methyl Ethyl Ketone	µg/L	5	<5	324	<5000	324
Acetone	mg/L	0.01	<0.05	0.11	61.4	61.4
TPH						
TPH C6 - C9	µg/L	20	<20	30	440,000	440,000
TPH+C10 - C36 (Sum of total)	µg/L	50	<50	60	139,385	139,385

Table 2: Soil Data

		Field ID	BH101 11.7	BH101 12.3	BH101 12.8	BH101 5.8	BH101 9.9	BH102 2.4	BH102 4.0	BH102 5.7	BH102 7.8	BH102 9.0	BH103 5.8-6.0	BH103 6.7	BH103 9.0	BH103 9.5	BH103 9.8	BH105 3.0	BH105 5.1	BH105 7.2	BH105 7.8	BH105 9.0	BH106 0.8	BH106 2.5	BH106 5.0	BH106 7.0	BH106 8.0	BH106 9.3	BH108 2.4	BH108 3.0
		Sampled Date-Time	16/03/2010	16/03/2010	16/03/2010	16/03/2010	16/03/2010	18/03/2010	18/03/2010	18/03/2010	18/03/2010	18/03/2010	16/03/2010	16/03/2010	17/03/2010	17/03/2010	17/03/2010	18/03/2010	18/03/2010	18/03/2010	18/03/2010	18/03/2010	17/03/2010	17/03/2010	17/03/2010	17/03/2010	17/03/2010	17/03/2010	18/03/2010	18/03/2010
		Sample Depth Range	11.7	12.3	12.8	5.8	9.9	2.4	4	5.7	7.8	9	5.8-6	6.7	9	9.5	9.8	3	5.1	7.2	7.8	9	0.8	2.5	5	7	8	9.3	2.4	3
ChemName	Units	EQL																												
aromatic solvents (Dutch)	mg/kg		<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	20.6	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	
Carcinogenic PAHs IARC (Fine Soil Calc)	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorinated hydrocarbons IWRG621	mg/kg		7.1	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	6.6	<12.5	11.35	<12.5	6.6	8.2	10.6	7.5	<12.5	15.5	<12.5	7.6	<12.5	8.1	7.7	7.8	9.1	<12.5	<12.5	143	<12.5
chlorobenzenes (Dutch Sum)	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8.7	<0.5	
chlorophenols (Dutch Sum)	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organochlorine pesticides IWRG621	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other chlorinated hydrocarbons IWRG621	mg/kg		4.35	<7	<7	<7	<7	<7	<7	3.85	<7	8.6	<7	3.85	5.45	7.85	4.75	<7	12.75	<7	4.85	<7	5.35	4.95	5.05	6.35	<7	<7	140.3	<7
Other organochlorine pesticides IWRG621	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH (Dutch 10)	mg/kg		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	
Phenols (non-halogenated) IWRG621	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenols(halogenated) IWRG621	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drins	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HCH-technical	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BTEX																														
Benzene	mg/kg	0.005	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Ethylbenzene	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	13.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4.3	<0.5
Toluene	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	17.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	<0.5
Xylene (m & p)	mg/kg	0.01	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	75.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.4	<0.5
Xylene (o)	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	19.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene Total	mg/kg		<1	<1	<1	<1	<1	<1	<1	<1	94.9	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.65	<1
Chlorinated Hydrocarbons																														
1,1,1,2-tetrachloroethane	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1,1-trichloroethane	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1,2,2-tetrachloroethane	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1,2-trichloroethane	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-dichloroethane	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-dichloroethene	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-dichloropropene	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2,3-trichloropropane	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-dibromo-3-chloropropane	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-dichloroethane	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,3-dichloropropane	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.																	

LanePiper

LanePiper

LanePiper

LanePiper

LanePiper

Table 2: Soil Data

		Field ID	TB-S	VP101	VP101	VP102	VP102	VP103	VP103	VP104	VP104	VP105	VP105	VP106	VP106
		Sampled Date-Time	16/03/2010	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008
		Sample Depth Range		0.5	2.7	1	2.5	1	2.6	0.5	2.8	0.5	2.9	0.5	1
ChemName	Units	EQL													
aromatic solvents (Dutch)	mg/kg		<0.7	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	-	-
Carcinogenic PAHs IARC (Fine Soil Calc)	mg/kg		-	<2.517	-	-	-	-	-	<2.517	-	<2.517	-	<2.517	<2.517
Chlorinated hydrocarbons IWRG621	mg/kg		-	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	-	-
chlorobenzenes (Dutch Sum)	mg/kg		-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
chlorophenols (Dutch Sum)	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-
Organochlorine pesticides IWRG621	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-
Other chlorinated hydrocarbons IWRG621	mg/kg		-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	-	-
Other organochlorine pesticides IWRG621	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-
PAH (Dutch 10)	mg/kg		-	<4.5	<0.5	<0.5	<0.5	<0.5	<0.5	<4.5	<0.5	<4.5	<0.5	<4.5	<4.5
Phenols (non-halogenated) IWRG621	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-
Phenols(halogenated) IWRG621	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-
Drins	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-
HCH-technical	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-
BTEX															
Benzene	mg/kg	0.005	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Ethylbenzene	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Toluene	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Xylene (m & p)	mg/kg	0.01	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-
Xylene (o)	mg/kg	0.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Xylene Total	mg/kg		<1	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	-	-
Chlorinated Hydrocarbons															
1,1,1,2-tetrachloroethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,1,1-trichloroethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,1,2,2-tetrachloroethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,1,2-trichloroethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,1-dichloroethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,1-dichloroethene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,1-dichloropropene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,2,3-trichloropropane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,2-dibromo-3-chloropropane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,2-dichloroethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,2-dichloropropane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,3-dichloropropane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
2,2-dichloropropane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Bromodichloromethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Bromoform	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Carbon tetrachloride	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Chlorodibromomethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Chloroethane	mg/kg	0.05	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
Chloroform	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Chloromethane	mg/kg	0.05	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
cis-1,2-dichloroethene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
cis-1,3-dichloropropene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Dibromomethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Dichloromethane	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexachlorobutadiene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Trichloroethene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Tetrachloroethene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
trans-1,2-dichloroethene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
trans-1,3-dichloropropene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Vinyl chloride	mg/kg	0.05	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
Halogenated Benzenes															
1,2,3-trichlorobenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,2,4-trichlorobenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,2-dichlorobenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,3-dichlorobenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,4-dichlorobenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
2-chlorotoluene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
4-chlorotoluene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Bromobenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Chlorobenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Hexachlorobenzene	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-
Halogenated Hydrocarbons															
1,2-dibromoethane	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Bromomethane	mg/kg	0.05	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
Dichlorodifluoromethane	mg/kg	0.05	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
Iodomethane	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichlorofluoromethane	mg/kg	0.05	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
Halogenated Phenols															
2,4,5-trichlorophenol	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4,6-trichlorophenol	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4-dichlorophenol	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
2-chlorophenol	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentachlorophenol	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Inorganics															
Cyanide Total	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Moisture	%	1	<1	9	13	13	15	7	17	10	11	16	14	9	16
pH (Lab)	pH Units	0.01	-	8.2	8	7.8	7.7	7.8	7.1	7.9	7.5	8.5	6	-	-
Lead															
Lead	mg/kg	2	-	1540	5	19	2	3	2	13	3	308	6	-	-
MAH															
Monocyclic aromatic hydrocarbons IWRG621	mg/kg		<2.2	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	-	-
1,2,4-trimethylbenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
1,3,5-trimethylbenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-

Table 2: Soil Data

			Field ID	TB-S	VP101	VP101	VP102	VP102	VP103	VP103	VP104	VP104	VP105	VP105	VP106	VP106
			Sampled Date-Time	16/03/2010	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008	16/05/2008
			Sample Depth Range		0.5	2.7	1	2.5	1	2.6	0.5	2.8	0.5	2.9	0.5	1
ChemName	Units	EQL														
Styrene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
tert-butylbenzene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Metals																
Arsenic	mg/kg	1	-	7	48	5	3	<1	7	7	12	16	5	-	-	-
Barium	mg/kg	5	-	33	5	16	<5	<5	23	<5	40	6	-	-	-	-
Beryllium	mg/kg	1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Cadmium	mg/kg	0.1	-	8.9	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	<0.1	1.7	<0.1	-	-	-
Chromium (III+VI)	mg/kg	1	-	67	22	19	11	1	10	21	12	21	17	-	-	-
Cobalt	mg/kg	1	-	79	3	3	<1	<1	<1	13	2	22	1	-	-	-
Copper	mg/kg	2	-	817	<2	11	<2	<2	<2	9	<2	175	<2	-	-	-
Manganese	mg/kg	5	-	394	<5	10	<5	<5	<5	8	<5	181	<5	-	-	-
Mercury	mg/kg	0.05	-	0.15	<0.05	0.09	<0.05	<0.05	<0.05	0.32	<0.05	0.26	<0.05	-	-	-
Nickel	mg/kg	1	-	67	5	6	2	<1	3	2	2	45	6	-	-	-
Vanadium	mg/kg	5	-	9	88	28	20	5	20	30	39	19	34	-	-	-
Zinc	mg/kg	5	-	176	<5	19	<5	<5	<5	18	<5	137	<5	-	-	-
Organochlorine Pesticides																
4,4-DDE	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
a-BHC	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aldrin	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aldrin + Dieldrin	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-
b-BHC	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlordane (cis)	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlordane (trans)	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d-BHC	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DDD	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DDT	mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DDT+DDE+DDD	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dieldrin	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endosulfan I	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endosulfan II	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endosulfan sulphate	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endrin	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
g-BHC (Lindane)	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptachlor	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptachlor epoxide	mg/kg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methoxychlor	mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH/Phenols																
Polycyclic aromatic hydrocarbons IWRG621	mg/kg		-	<7	<0.5	<0.5	<0.5	<0.5	<0.5	<7	<0.5	<7	<0.5	<7	<7	<7
2,4-dimethylphenol	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-methylphenol	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-nitrophenol	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-&4-methylphenol	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-chloro-3-methylphenol	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Acenaphthylene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Anthracene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Benz(a)anthracene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Benzo(a) pyrene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Benzo(b)&(k)fluoranthene	mg/kg	1	-	<1	-	-	-	-	-	<1	-	<1	-	<1	<1	<1
Benzo(b)fluoranthene	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Benzo(k)fluoranthene	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chrysene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Dibenz(a,h)anthracene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Carcinogenic PAHs (as B(a)P TPE)	mg/kg		-	<1.21	-	-	-	-	-	<1.21	-	<1.21	-	<1.21	<1.21	<1.21
Carcinogenic PAHs (as B(a)P TPE, PEFx3)	mg/kg		-	<3.63	-	-	-	-	-	<3.63	-	<3.63	-	<3.63	<3.63	<3.63
Carcinogenic PAHs IARC (Course Soil Calc)	mg/kg		-	<1.316	-	-	-	-	-	<1.316	-	<1.316	-	<1.316	<1.316	<1.316
Fluoranthene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Fluorene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Indeno(1,2,3-c,d)pyrene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Naphthalene	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAHs (Sum of total)	mg/kg		-	0	-	-	-	-	-	0	-	0	-	0	0	0
Phenanthrene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Phenol	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenolics Total	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrene	mg/kg	0.5	-	<0.5	-	-	-	-	-	<0.5	-	<0.5	-	<0.5	<0.5	<0.5
Polychlorinated Biphenyls																
Arochlor 1016	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arochlor 1232	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arochlor 1242	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arochlor 1248	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arochlor 1254	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arochlor 1260	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCBs (Sum of total)	mg/kg		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solvents																
Methyl Ethyl Ketone	mg/kg	0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-hexanone (MBK)	mg/kg	0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-pentanone	mg/kg	0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Methyl-2-pentanone	mg/kg	0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acetone	mg/kg	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Ethyl acetate	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
MTBE	mg/kg	0.005	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Vinyl acetate	mg/kg	0.005	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
SPOCAS																
pH (Ox)	pH Unit	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TPH																
TPH C6 - C9	mg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-
TPH C10 - C14	mg/kg	50	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	-	-
TPH C15 - C28	mg/kg	100	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-	-
TPH C29-C36	mg/kg	100	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-	-
TPH+C10 - C36 (Sum of total)	mg/kg	50	-	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	-	-
VOCs																
cis-1,4-Dichloro-2-butene	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentachloroethane	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
trans-1,4-Dichloro-2-butene	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

LanePiper

LanePiper

Table 3: Groundwater Data

[illegible]

Lane Pipes

Table 3: Groundwater Data

[illegible]

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[illegible]