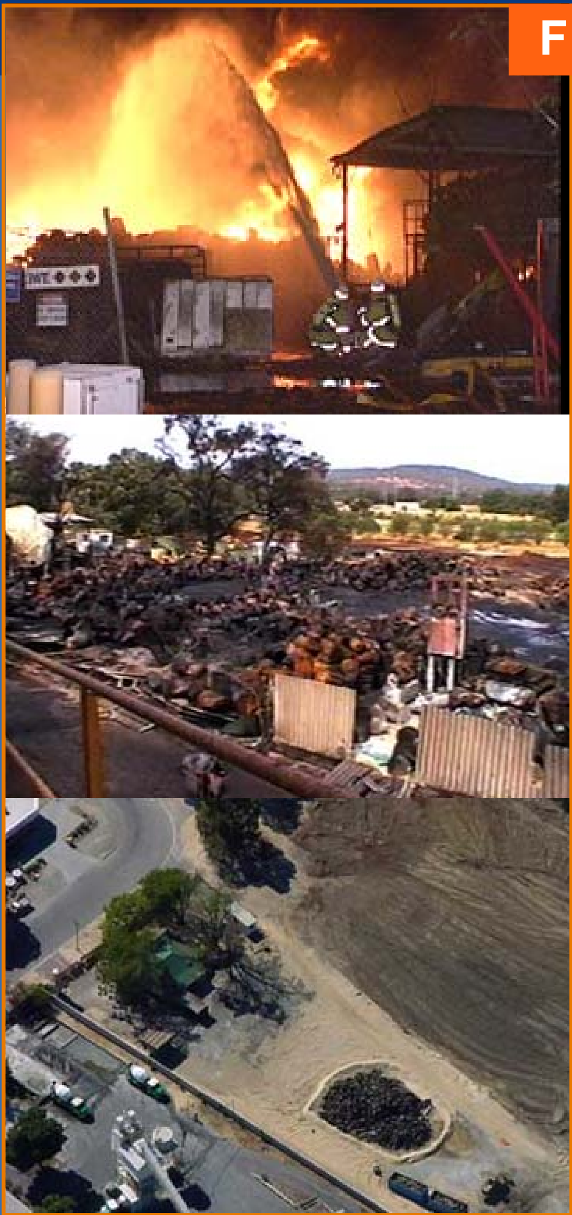
FINAL REPORT



Detailed Site Investigation

Waste Control Site
Bellevue, Western Australia

Prepared for

Department of Environmental Protection

February 2002

Ref: 20857-040-562/548-F4580.1

URS Australia Pty Ltd
Level 3, Hyatt Centre
20 Terrace Rd
East Perth WA 6004

URS

Department of Environmental Protection
Site Summary Form

(For completion by person(s) submitting report(s) for assessment by DEP as per the requirements of the *Guideline for Reporting on Site Assessments (2001).* **Please note that the certificate of title and site coordinates fields are mandatory fields.**

DEP File Number (if known)	11/90/**474**
Site Name	Waste Control
Lot No.	99
House No.	1
Street	Bulbey
Suburb	BELLEVUE
State	WA
Postcode	6056
Site Coordinates Northings	6469940 mMGA
Eastings	407230 mMGA
Circle relevant Datum Set:	1984 / 1994
Certificate of Title	Volume: 1881 / Folio: 948

List multiple certificates of titles, where applicable: ....Vol 1899, Fol. 545 (Lot 88 – Oliver Street)...

List all certificates of titles affected by site contamination: ...V 1881, F 948 : V1899, F545 : offsite properties...........................

Is hard copy of Certificate of Title attached? (Y or N)	N (on file at DEP)
Local Government Authority	City of Swan (General Industry Zonation)
Owner/Occupier Details: Site Owner (Name & address)	Waste Control Pty. Ltd. – 1 Bulbey Street, Bellevue, WA, 6009
Site Owner Company ACN/ABN	ACN 009 426 260 (In Liquidation)
Site Occupier (Name & address)	Waste Control Pty. Ltd. – 1 Bulbey Street, Bellevue, WA, 6009
Site Occupier Company ACN/ABN	ACN 009 426 260 (In Liquidation)
Site Contact Name & relationship to site (eg owner, consultant for owner/occupier)	Dr. Jeff Claflin – Managing Director of Waste Control Pty. Ltd Mr. Andrew Cooper – Environmental Consultant Project Manager (URS)/Ms. Marilyn Lauria Principal Envrionmental Geologist (URS) Retained by DEP
Site Contact Company Name	URS Australia Pty. Ltd.
Site Contact Company ACN/ABN	ACN 000 691 690 - ABN 46 000 691 690
Postal Address	Level 3, Hyatt Centre, 20 Terrace Road EAST PERTH WA 6004
Telephone	9221 1630
Fax	9221 1639

Contamination Status:

Previous activity(s) Waste Solvent Recycling through distillation, Waste collection and storage

Present activity(s) Office and minor workshop activities (eg. welding)

Future activity(s) Unknown

Identified contaminants Major : TPH, BTEX, Phenols, MEK, MIBK, various chlorinated solvents (eg. PCE), various VOCs, Naphthalene

Minor : PAH, metals

Contaminated media (eg soil, groundwater) Soil, perched groundwater, regional groundwater

History of Investigation:

Has there been previous site investigations undertaken? (Y or N, if yes, provide details below) Y

Report title, date and author:

Preliminary Environmental Site Assessment for Subsurface Contamination, May 2000, Hydrocarbon Remedial Services Pty. Ltd.

Waste Control Fire Clean-up Operations : Environmental Sampling and Methods, Bellevue, WA, May 2001, Stass Environmental and Cleanaway Technical Services.

Investigation of Dioxins, Heavy Metals and PAH, Waste Control Site, Bellevue, July 2001, URS Australia Pty. Ltd.

Preliminary Site Investigation, Sampling and Analysis Plan and Community Consultation Plan – Waste Control Site, Bellevue, WA, October 2001, URS Australia Pty. Ltd.

Declaration:

The information presented in this site summary form is a true representation of the information within the attached report(s)/document(s).

Full name (print) Marilyn E Lauria

Position held Principal Environmental Geologist – URS Australia Pty. Ltd.

Signature Marilyn Lau

Date 22/2/2002

F I N A L   R E P O R T

Detailed Site Investigation – Waste Control Site, Bellevue, WA

Prepared for

Department of Environmental Protection

Land and Water Quality Branch
Westralia Square
141 St George's Terrace
PERTH WA 6000

February 2002

20857-040-562 / 548-F4580.1

URS

Prepared By	…………………………………..	URS Australia Pty Ltd	
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	Principal Environmental Geologist		
Authorised By	…………………………………..	Date:	22 February 2002
	Marilyn Lauria	Reference:	20857-040-562 / 548-F4580.1
	Principal Environmental Geologist	Status:	Final

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Waste Control Pty Ltd (Waste Control) operated a recycling and waste treatment facility in Bellevue, Western Australia. The site comprises two joined allotments, which have frontage to both Bulbey Street (Lot 99) and Oliver Street (Lot 88). The main operation at the site was the recycling of solvents via distillation, which first began in 1987.

On the night of 15 February 2001, fire destroyed the treatment and recycling plant and a large stockpile of drummed waste chemicals. Post-fire clean-up operations were undertaken over the following months by Cleanaway Technical Services to enable the safe reoccupation of the area by residents and businesses.

Waste Control was placed in liquidation in June 2001.

In September 2001, URS Australia Pty. Ltd. (URS) were engaged by the Western Australia Department of Environmental Protection (DEP) to undertake an environmental site assessment of the Waste Control Site. The objective of the assessment was to investigate the nature and extent of contamination present ***on-site****, as a result of the fire and historical operation of the site. The first stage of this process included the completion of a Preliminary Site Investigation (PSI) in October 2001. The PSI detailed the history of activities at the site, outlined areas of potential environmental concern and proposed a sampling and analysis plan to enable further assessment of these areas through a programme of subsurface soil and groundwater investigations.*

The Detailed Site Investigation (DSI) was intended to provide an initial assessment of the soil and groundwater conditions within the confines of the Waste Control Site. This DSI comprises the initial component of a multi-staged assessment process. Information gathered during each investigation stage should be used to design subsequent investigations, thereby optimising the work required to determine the appropriate management strategies for the site.

The DSI field investigations were undertaken between 5 November 2001 and 12 December 2001. Soil bores were completed at a total of 25 locations across the site. The investigations indicated that there is a clay unit present about 5 metres below ground level (mbgl) across a large portion of the site. This low permeability unit retards the vertically downward movement of water and as a result, a shallow, perched water table has formed in the overlying sands and sandy clays about 3.5 mbgl. However, the clay unit is discontinuous and where it is not present, the shallow groundwater is able to seep slowly downwards to the regional water table, which is present approximately 9.5 mbgl.

A total of 22 soil bores were completed to a maximum depth of 8 m to investigate the shallow profile, with 8 bores converted to shallow groundwater monitoring bores (MW1 to MW8). Three bores were extended beneath the shallow clay unit to a maximum of 12.5 mbgl and converted to intermediate groundwater monitoring bores (MW21I to MW23I) to monitor the regional water table. Completion of the intermediate bores required the placement of surface casing to between 5 and 6.5 mbgl to prevent the transfer of shallow groundwater to the regional system during drilling.

Field observations from the investigations suggested a high level of contamination was present beneath the site with zones of staining and odour identified. Based on field observations, these zones included:

- *A possible former ground surface around 0.5 mbgl, predominantly on Lot 88.*
- *Directly beneath the concrete slabs on both Lot 88 and Lot 99.*
- *The former location of two separate groups of underground storage tanks (USTs) used to store waste and recycled solvents on Lot 99.*
- *An unsealed former laneway through the middle of the site (boundary of the two allotments).*
- *The saturated zone of the shallow, perched water table between 3 and 5 mbgl across the majority of Lot 99 and part of Lot 88.*
- *The areas of seepage between the shallow, perched water table and regional water table along the site boundary with a vacant lot (Lot 2) to the east, and in the northwestern area of the site near the site boundary with Pioneer Construction Materials (Pioneer).*
- *The zone of fluctuation of the regional water table.*

Laboratory analysis of 56 selected soil samples for a wide range of compounds was undertaken to assess the level of contamination identified. Concentrations above the draft DEP ecological investigation levels (EILs) were identified in samples from 8 of the 25 bores, whilst the concentrations exceeded the health investigation levels for industrial sites (HIL-F) at three locations. The main contaminants identified were generally related to the various solvents (chlorinated and non-chlorinated) previously stored on-site including but not limited to xylene, toluene and phenols, with relatively minor concentrations of various metals identified.

Elevated concentrations were generally associated with the zone of staining directly beneath the concrete slabs, or the saturated zone of the shallow, perched water table. The highest degree of contamination was reported from the saturated zone in the area of former USTs on Lot 99 (SB11_4.9-5.1), where TPH C_6-C_9, *TPH* C_{10}-C_{14}, *toluene, ethylbenzene and naphthalene were identified in excess of the EILs, xylene was in excess of the HIL-Fs and a range of volatile organic compounds including perchloroethene (PCE), trichloroethane (TCA), trichloroethene (TCE) and trimethylbenzene were identified at levels elevated above the laboratory detection limits.*

In general, the field observations indicated the presence of significant impacts, while the laboratory results, although displaying evidence of impacts, were not overly contaminated. This is likely to be associated with a number of factors associated with the differing fate and transport characteristics of the geologic materials and organic contaminants identified (eg. contaminants do not absorb easily to sand grains). In addition, discussions with the laboratory have identified that a number of the samples may have contained compounds such as cyclohexanes, which are highly aromatic and odourous. Compounds such as cyclohexanes are not included within the standard target analysis, and should be considered during future sampling programs.

Of note was the lack of detection of mercury in all soil (and groundwater) samples across the site, including six soil samples recovered from the area of an alleged mercury spill during the post-fire clean-up operations. However, it is noted that specific information in regards to the spill was not readily available prior to our investigation.

Initial screening for PCB's did not indicate concentrations above laboratory detection limits, however further detailed testing is required

The investigation of groundwater was expanded to include the water level measurement, sampling and analysis of two existing bores on-site (WCT2 and WCT3) and two existing bores just off-site (WCB11 and WCB13), as well as the 11 bores installed as part of the drilling programme. In total, 9 of the 15 bores sampled were constructed within the shallow perched water table, whilst the other 6 were constructed within the regional water table (intermediate zone).

The investigations indicate that flow within the shallow, perched water table is associated with the extent of the shallow clay unit. Groundwater flow is towards those areas where the clay becomes sandier, and the shallow, perched groundwater is able to seep down to the regional water table. Based on the current data set, the majority of flow appears to be generally towards Lot 2 to the east. However, flow within this aquifer system is not constant and is likely to vary due to various influences including seasonal affects. The shallow, perched water table appears to be absent in the eastern corner of the site and may not be present across larger portions of the site towards the end of the autumn period before receiving recharge from winter rainfall.

Groundwater flow within the regional water table is more constant. As suggested from previous regional studies, flow within this aquifer is generally towards the west or south-west resulting in flow across the Pioneer and Oliver Street site boundaries. This infers that groundwater within the two aquifer systems is moving in almost opposite directions beneath the Waste Control Site.

Preliminary aquifer testing through rising head tests suggests the sandy nature of the regional water table aquifer results in a higher permeability than the shallow aquifer system.

Laboratory analysis of groundwater samples from the 15 monitoring bores confirmed that contamination is present in both the perched and regional groundwater systems. Samples from every bore reported at least one contaminant at concentrations in excess of the assessment levels adopted. The groundwater in both aquifer systems is believed to be fresh (TDS<1,000 mg/L) however a true assessment has been difficult due to the interference caused by contamination in all 15 bores sampled. In general, slightly acidic groundwater conditions are evident.

A large variety of individual contaminants have been identified at concentrations in excess of the assessment levels. These include, but are not limited to, xylene, toluene, naphthalene, phenol, chloroform, methyl ethyl ketone (MEK), methyl iso-buytl ketone (MIBK), acetophenone, isophorone, nickel and a range of chlorinated solvents including PCE and cis-1.2-dichloroethene (cis-1.2-DCE). These compounds have differing physical and chemical properties that affect their fate when released into the environment. In addition, the combination of some compounds may also affect their ability to migrate within *groundwater (eg. contaminants that are insoluble in water may be soluble in another contaminant that is present).*

Groundwater contamination within the shallow aquifer system appears to be concentrated beneath the former distillation area (Process Area) on Lot 99 and the unsealed former laneway between the allotments. However, the distribution of the different contaminants varies, presumably due to differing source areas and differing behaviour within the groundwater once released, as mentioned above.

Groundwater contamination is present within the shallow aquifer system along the Lot 2 and Pioneer site boundaries. Off-site flow of this contaminated groundwater is most likely across the Lot 2 site boundary.

Groundwater contamination within the intermediate aquifer system is also highest beneath the Process Area and unsealed former laneway. This area corresponds to the locations where the shallow clay unit is absent, and therefore where the contaminated shallow groundwater is likely to be seeping downward and eventually recharging the regional water table. Contaminant plumes extend back beneath the site to the southwest and west in accordance with the regional groundwater flow direction. As a result, groundwater contamination is present at the Lot 2, Oliver Street and Pioneer site boundaries with off-site migration likely across all three.

Of further note, is the identification of chlorinated solvents in both the shallow and intermediate groundwater systems. Chlorinated solvents are denser than water and as such, when released into the environment, will migrate downwards until they reach a low permeability unit. The shallow clay at 5mbgl is such a unit, but as the clay is discontinuous, it appears that the chlorinated solvents have been able to continue downwards to the regional water table. As the regional water table aquifer is understood to extend to depth with generally sandy sediments, there is a possibility that chlorinated solvent contamination has migrated to the base of this aquifer, beyond the current depth of investigation. Furthermore, regional information suggests that in the Bellevue area, the regional water table aquifer may be in direct connection with the underlying Leederville Formation Aquifer, which forms an important groundwater resource for large parts of the Perth Metropolitan Area. The deeper zone within the regional water table was not investigated during this investigation phase.

The sources of the contamination identified beneath the site are likely to be many and varied, associated with both the historical operations at the site and the fire. The most likely sources on-site are the various sub-surface sumps (predominantly on Lot 99) used to collect product spillage and the unsealed former laneway between the two concrete pads that received spillage throughout the operating life of the site and contaminated water during the fire.

The investigation programme has shown soil and groundwater contamination is present beneath the Waste Control Site. However, groundwater contamination is likely to also be migrating off-site across three of the four site boundaries in two different aquifer systems. In addition, it is possible that groundwater contamination extends below the depth of investigation conducted to date in the regional water table aquifer. Furthermore, the fire-fighting activities are likely to have resulted in off-site contamination on Lot 2, which has not been assessed.

The investigation conducted was designed to get an initial understanding of the environmental setting and contamination issues on-site and should be viewed as a initial component of a multi-staged assessment process. As such, a number of issues have been identified that require further assessment before remedial and / or management requirements can be assessed. Accordingly, the following general recommendations are made in regard to further site assessment:

- *A bore search / doorknock survey to assess the presence of groundwater users (ie. residences and businesses) in the vicinity of the site, particularly to the southwest.*
- *The delineation of groundwater contamination in the shallow perched aquifer system. This would require off-site bores on Lot 2 and the Pioneer site.*
- *The delineation of groundwater contamination in the upper zone of the regional water table (intermediate zone). This would require off-site bores on Lot 2, the Pioneer site and to the southwest of the site beyond Oliver Street. This would also require access to bore WCT1, which is currently covered by a large piece of equipment that will require a crane to move.*
- *The investigation of potential DNAPL contamination associated with chlorinated solvents. This would require investigation deeper into the regional water table, potentially to the base of the aquifer. These deeper bores would be targeted in the areas where contamination is suspected to have entered the regional water table.*
- *Further evaluation of the contaminants present in soil and groundwater on-site (and off-site) through testing for additional analytes including, but not limited to, PCB and dioxin, as well as laboratory library searches for tentatively identified compounds.*
- *Investigations to better define the status of soil and groundwater conditions on Lot 2 associated with the impacts of fire fighting and clean –up issues. Such issues include the spread of the battery store, the ponding of contaminated firewater and the contaminated soil spread across Lot 2.*
- *Further evaluation of the seasonal nature of the shallow perched water table. This would require regular (possibly monthly) groundwater level gauging events.*
- *More detailed testing of the aquifer properties of the regional water table through groundwater pumping tests.*
- *A detailed evaluation of the biodegradation capacity, physical, chemical and toxicological properties of the various contaminants and the water bearing units.*
- *Predictive groundwater and contaminant transport modelling to gain an understanding of the likely fate of the contaminated groundwater plumes (particularly for the assessment of remedial options).*
- *The further assessment of potential remediation technologies. A computer model as mentioned above would be able to be used to predict the impacts of technologies such as active groundwater recovery.*
- *Potential trialing of the most likely remediation methods through the development of pilot trials.*

The completion of these tasks would be best undertaken in a staged process to optimise the overall investigation.

In addition, it is recommended that access to the site be controlled as not to allow construction works and / or groundwater withdrawal without appropriate health and safety management plans. If it appears that groundwater receptors are present, steps should be taken to assess groundwater quality in the vicinity of the receptor and, if required, restrict usage.

The community should continue to be informed and consulted regarding developments in the management of the site. The existing community consultation plan should be modified to include new results and site information, as it is obtained.

Based on the investigation results, the post-fire clean-up activities, and as the site is unoccupied and inaccessible to the general public, there does not appear to be an immediate human health risk associated with the site conditions. However, further investigation is required to assess the risk to the following potential receptors of contaminated soil, groundwater or vapour:

- *People coming in direct contact with the potentially contaminated soil spread on Lot 2.*
- *People coming in contact with transported contaminated soil associated with dust generation from the site and Lot 2.*
- *People conducting sub-surface excavations or entering underground inspection pits above or near any impacted soil or groundwater plume in the vicinity of the Waste Control Site.*
- *Occupants of buildings with areas where vapours could collect (eg. basement) above or near any impacted soil or groundwater plume in the vicinity of the Waste Control Site.*
- *The Helena River and users of the river.*
- *Any users of the groundwater resources within or near the impacted groundwater plume. Preliminary investigations indicate there is only one groundwater bore registered within a 500 m radius of the site. However, it is recommended that a survey of the properties in the immediate vicinity of the Waste Control Site be undertaken to determine if anyone is accessing potential contaminated groundwater.*

Introduction

Waste Control Pty Ltd (Waste Control) operating as Hazardous Waste Solutions, operated a chemical / oil recycling and waste treatment facility in Bellevue, Western Australia. On the night of 15 February 2001, a large fire broke out at the site. Fire fighting operations lasted until 17 February 2001.

The fire destroyed the treatment and recycling plant including a stockpile of drummed waste chemicals. Fire fighting operations included the application of considerable volumes of water, which flowed across the site prior to flowing onto adjoining properties.

The Western Australian Department of Environmental Protection (DEP) contracted Cleanaway Technical Services (CTS) to clean up contamination and waste to enable the safe reoccupation of the area by residents and businesses, and to identify the extent of significant contamination to the areas surrounding the Waste Control Site. On 7 June 2001, chartered accountants Ferrier Hodgson were appointed Official Liquidators of Waste Control by an Order of the Supreme Court of Western Australia.

Following a tender process, URS Australia Pty Ltd (URS) were engaged by the DEP to complete a staged Preliminary and Detailed Site Investigation of the Waste Control Site.

This document represents the deliverable associated with the investigation and includes the following:

- A summary of the Preliminary Site Investigation (PSI) completed and reported to the DEP in October 2001 (Ref: 548-F4338.0); and
- Results of the Detailed Site Investigation (DSI).

The Detailed Site Investigation (DSI) was intended to provide an initial assessment of the soil and groundwater conditions within the confines of the Waste Control Site. This DSI comprises the initial component of a multi-staged assessment process. Information gathered during each investigation stage should be used to design subsequent investigations, thereby optimising the work required to determine the appropriate management strategies for the site.

The objectives of the Preliminary and Detailed Site Investigations are to:

- Identify on-site soil and groundwater impacts associated with historical site operations at the Waste Control Site.
- Identify on-site potential soil and groundwater impacts resulting from the fire incident at the site in February 2001.
- Assess the possible extent of the impacts on-site.
- Based on the results of the on-site investigations, comment on the potential for off-site impacts associated with both historical site operations and the fire incident.
- Conduct all site activities in accordance with applicable sampling and health & safety protocols, DEP Guidelines and Australian Standards.
- Maintain appropriate level of contact with the surrounding community to ensure that they have been informed of site plans and progress and take appropriate steps to alleviate their concerns so that the generation of potential conflicts and misinformation is minimised.

3.1 Site Location and Ownership

The Waste Control Site is located on the southeastern edge of the suburb of Bellevue in Perth, Western Australia (Figure 1). Bellevue is a semi-industrial suburb that contains both light industrial premises and residential properties. The Waste Control Site is zoned 'General Industry" by the Local Government Authority - the City of Swan.

The site comprises two allotments (Lot 88 and 99) within Swan Location 16, both of which have street frontage but to two different streets. The site street address is generally referred to as 1 Bulbey Street, Bellevue (Lot 99 frontage), however Lot 88 is also assigned a street address of 88 Oliver Street, Bellevue. The site is legally described by two certificates of title; Volume 1899 Folio 545 (Lot 88) and Volume 1881 Folio 948 (Lot 99).

The titles state Waste Control Pty Ltd. (Waste Control) as the registered proprietor. Waste Control owned and operated the site, trading as Hazardous Waste Solutions, until approximately March 2001. On 7 June 2001, chartered accountants Ferrier Hodgson were appointed Official Liquidators of Waste Control by an Order of the Supreme Court of Western Australia.

Dr. Jeff Claflin was the Managing Director of Waste Control Pty. Ltd.

3.2 Site Description

The site is irregular in shape, roughly forming a northeast-southwest elongated rectangle that covers an area of 0.3417 ha. As identified on the certificates of title, the site is 100.6 m long and varies in width from 25.2 m (southwestern boundary) to 43.2 m (northeastern boundary).

The current site layout is shown in Figure 2.

The site is bound by the following properties:

- Northeast : Bulbey Street, then Midland Cement Products.
- Southeast : Vacant land owned by Main Roads Western Australia (Lot 2).
- Southwest : Oliver Street, then A & P Transport.
- Northwest : Pioneer Construction Materials (Pioneer).

The Pioneer site boundary is marked by a 1.8 m Flexiboard fence. The remaining site boundaries are marked by 1.8 m high chain-mesh fences. All fences, with the exception of the Bulbey Street boundary fence, were installed in 2001 due to the destruction of existing fences as a result of the fire.

Entry to the site is possible through three separate sets of double-gates providing entry from both Oliver Street (one set) and Bulbey Street (two sets).

The site is sealed with a concrete slab of varying age, thickness and condition, with the exception of the following areas:

- garden and driveway area along the Bulbey Street boundary;
- 0.5 to 1.5 m strip of sand along the Lot 2 boundary;
- 2 to 8 m strip of sand along the Pioneer boundary; and
- 14 m wide zone through the centre of the site between the Pioneer and Lot 2 boundaries.

Prior to the post-fire clean-up activities, the slab also covered an additional 8 to 9 m of the unsealed zone through the centre of the site and a 2 m wide strip between the lots on the Lot 2 boundary. These sections were removed during the post-fire clean-up activities.

There are two buildings on Lot 99, comprising:

Office:	Weatherboard house converted to an office that faces Bulbey Street. The house has a rear brick extension that has been converted into a workshop / storage area.
Laboratory:	A small demountable 'ATCO' hut is situated adjacent to the Lot 2 boundary near Bulbey Street. The hut was formerly used as a basic analytical laboratory.

Miscellaneous equipment and storage containers (steel process vessels, 205 L drums etc) are spread around the site and are generally concentrated at the southwest corner of the Lot 99 concrete pad. URS did not inspect the contents or integrity of these containers as this was reported to be the responsibility of CTS, associated with the post-fire clean-up operations.

3.3 Current Uses of the Property

In general, the site is not in use. Dr. Claflin continues to use the office on an irregular basis and at times, one of his employees is on-site undertaking minor tasks such as welding and general maintenance.

3.4 Main Previous Use of the Property

The site previously operated as a chemical recycling and waste treatment facility until destroyed by fire on 15 February 2001. A detailed description of the operations is provided in the PSI Report (URS, 2001b). In summary, the operations included:

- Receipt and storage of waste chemicals and chemical containers in bunded storage areas.
- Recycling of solvents via process distillation.
- Storage and distribution of recycled chemicals.

- Minor treatment of other chemicals (acid-base neutralisation).
- Destruction of used chemical containers via a drum crusher.

The locations of the various facilities and processes associated with the operations prior to the fire are shown on Figure 3.

The main operation on site was the recycling of solvents via process distillation. At its peak, the distillation process included four separate distillation vessels ranging in capacity from 600 L to 4,000 L. Distillation occurred in the Process Area, located towards the rear (southwest) of the Lot 99 concrete pad. Waste solvents were pumped into the distillation vessels and then heated to more than 150^{o}C. The heating process was provided by super heated oil (300 to 400^{o}C) created in a separate heating facility known as the Oil Burner.

At the completion of the distillation process, solvents were stored in underground storage tanks (USTs) or 205 L drums for subsequent re-sale, whilst waste sludge was drained from the base of the distillation vessels and stored in 205 L drums on-site. Prior to the fire it was estimated by Dr. Claflin that 1,000 drums of distillation waste sludge were stored in the Lot 88 bunded storage area. A further 300 drums of distillation sludge were stored atop a tarpaulin in the otherwise unsealed southwestern corner of the site.

Sludge from the distillation of the chlorinated solvent perchloroethene (PCE) was also stored in 205 L drums in the southwest corner of the Lot 88 bunded storage area. Less than 25 drums were believed to be present prior to the fire.

The other main function of the site was as a waste transfer station. The site received and stored waste chemicals until sufficient quantities were collected for disposal at an appropriate landfill or treatment facility off-site. A list of chemical wastes previously received at the Waste Control Site has been compiled by the DEP and is included as Appendix A. Some of the more abundant and/or toxic chemicals, including solvents for recycling, received by Waste Control included:

- acrylic and paint thinners;
- white spirit and turpentine;
- toluene and xylene;
- batteries (nickel cadmium and lead);
- various pesticides;
- Perchloroethene (PCE) also known as tetrachloroethene (-ethylene); and
- Methyl ethyl ketone (MEK) and its peroxide.

The majority of chemical storage was associated with 205 L drums, generally stored within a concrete lined and partially bunded area that covered the majority of the Lot 88 concrete pad. Approximately 2,500 chemical drums were estimated by Dr. Claflin to be present on-site prior to the fire.

3.5 Water/Wastewater/Stormwater

The site is connected to the municipal water supply, which enters the property from both the Oliver Street and Bulbey Street boundaries.

A small septic tank with a subsurface overflow seepage drain is located between the brick extension to the office and the Pioneer boundary. It is understood that only the standard toilet, bathroom and sink facilities of the office building are connected to this system.

There are currently two sumps known to be present on the site; a stormwater sump in the Bulbey Street concrete driveway and a containment sump in the northeastern corner of the Lot 99 concrete pad referred to as the Front Bund Sump.

The Bulbey Street driveway sump receives run-off from the Oil Burner area, and drains to the council stormwater system on Bulbey Street.

The Front Bund Sump is concrete lined with no drainage points. The sump was positioned to intercept run-off from the main processing area (Lot 99 concrete pad) including any solvent / chemical spillage. Since the fire, the sump has been observed to generally hold water.

A similar facility is known to have been located in the northeastern corner of the Lot 88 concrete pad that was positioned to intercept run-off from the bunded drum storage area. CTS removed this facility, referred to as the Back Bund Sump, as part of the remedial activities immediately following the fire.

The majority of stormwater across the site is not contained or channelled and flows with the general slope of land. The Bund Sumps were positioned to intercept stormwater run-off, however their capacity appears minimal, likely resulting in overflow during moderate rainfall events. This has resulted in the discharge of stormwater across the Lot 2 boundary, particularly in the area of the Front Bund Sump.

An order by the DEP in late 1998, preventing off-site stormwater discharge was actioned by Waste Control by increasing the height of the bund adjacent to the Front Bund Sump using sand. As a result, stormwater run-off was apparently diverted down the unsealed Waste Control Site driveway and onto Bulbey Street.

3.6 Adjacent Sites

Numerous industries are present in the surrounding area whose operations are likely to include the storage or use of potentially contaminating materials. Such industries include automotive wreckers, panel beaters, construction depots, the Collex Waste Treatment site and two concrete/cement plants.

A cursory visual inspection of the sites immediately bordering Waste Control (observed from the Waste Control Site), and discussions with Main Roads WA have identified three activities in the immediate area that could serve as potential sources of contamination:

- A refuelling station immediately adjacent to the Waste Control boundary on the Pioneer Site.
- A wastewater storage facility immediately adjacent to the Waste Control boundary on the Pioneer Site that receives wash down water from the cleaning of concrete truck barrels.
- An area of unauthorised landfilling that possibly included a ‘paint dump’ located between 30 and 120 m to the southwest of the Oliver Street boundary of the Waste Control Site. This area was partially remediated by consultants working on behalf of Main Roads WA in December 2000 (GHD, 2000).

URS has limited information regarding these sites or their operations.

Environmental characteristics including topography, geology, and hydrogeology were evaluated based on site observations, published literature, and maps.

4.1 Topography

The Waste Control Site slopes from the southwestern corner (Oliver Street) at an elevation of about 20 m above Australian Height Datum (AHD) towards the northeastern corner at an elevation of about 18 mAHD. About 3 m beyond the Lot 2 site boundary, the landform drops approximately 1.5 m where clean-up operations following the fire have accentuated a previously existing gradual slope. Further to the southeast (about 70 m), there is a sharp drop to about 8 mAHD onto the Helena River Floodplain.

Estimated topographic contours of the ground surface across the site developed from groundwater bore survey information are shown on Figure 2. As a specific topographic survey was not conducted, these contours should be considered indicative.

4.2 Geology

The Waste Control Site is underlain by layers of sand and clay of the Guildford Formation. A review of information from previous investigations on-site, and adjacent to the site, suggests the subsurface profile comprises 3 m of sand grading to clayey sand and the presence of a less-permeable clay unit around 5 to 7 m below ground level (mbgl). Beneath this clay layer, clayey sand is again present to varying depths. The thickness of this lower clayey sand unit was not identified in the previous subsurface investigations.

Investigations by the Water and Rivers Commission (WRC) following the fire suggest that at some locations off-site, the distinct clay layer was found to be absent. In addition, one bore intersected ‘coffee rock’ at around 13 mbgl. Investigations at the OMEX site, approximately 1 km east of the Waste Control Site, identified “coffee rock” as an upper marker to the regional Leederville Formation. Regional studies have estimated the top of the Leederville Formation to be present at a level of approximately –10 mAHD, which would represent a depth of around 30 m below the Waste Control Site.

The results of the current investigations are detailed in Section 9.

4.3 Hydrogeology

The hydrogeological system of the area is complex. Information from the three previously installed on-site bores (WCT01 to 03) and recent investigations by the WRC, indicate that the regional water table is present around 9 to 10 mbgl. Flow within this aquifer is expected to be generally towards the south, but local variations are likely. This regional flow is within the lower clayey sand unit discussed above.

Importantly, the WRC investigations identified water perched on a clay layer around 6 mbgl on Lot 2 adjacent to the site (WCB9, 11 and 13). The extent of this perched water table is unknown.

The Leederville Formation, located below the clay and clayey sand units, forms an extensive fresh water aquifer system beneath the Perth Metropolitan Area and is widely utilised for various purposes, including human consumption. In general, the aquifer is confined (i.e. water is present under pressure due to the presence of overlying low permeable layers), however regional interpretations suggest the aquifer may be unconfined in the area of the Waste Control Site. This implies that there may be direct recharge of groundwater to the Leederville Formation aquifer from the overlying Guildford Formation in the area.

Regional flow within the Leederville Formation is towards the west.

A search was undertaken of the WRC WIN database to determine the presence of any bores in the area. The search indicated the presence of one bore within a 500 m radius of the site and seven bores within a 1 km radius of the site. The recent bores installed by the WRC in the vicinity of the site, and the three existing monitoring bores on the Waste Control Site, were not identified on the database suggesting only limited numbers of monitoring bores are listed on the system.

Important observations from the data included the presence of a black clay at the base of the Guildford Formation (or possible the upper Leederville) in a number of bores, but not in the bore closest to the site. This bore, an operational deep production bore (153 m), is located 300 m to the northeast on the Midland Saleyards site. At this site, the base of the Guildford Formation was interpreted to be a coarse yellow sand, with the underlying Leederville Formation noted as a green clayey sand.

The results of the current investigations are detailed in Section 10.

4.4 Surface Water

The Helena River flows from east to west within a small floodplain to the south of the site, before discharging to the Swan River about 5 km to the west.

At its closest point to the site, the Helena River is 300 m southwest of the Waste Control Site boundary, however the floodplain extends to within 100 m of the site. This area is referred to as the ‘damplands’ in other reports. Stormwater from the industrial area that includes the Waste Control Site, is partly directed to the damplands between the Roe Highway and Military Road. This area reportedly received contaminated fire water drainage during the fire fighting efforts in February 2001.

The history of land use on and near the site was undertaken to produce a clear understanding of the potential contaminants and contaminant pathways in the area. The information was obtained from interviews, review of aerial photographs, review of property title information and review of historical site operational plans. A detailed account of the site history review is included in the PSI Report (URS, 2001b). A summary of the important findings is provided below.

5.1 History Prior to Waste Control

The site was initially part of a large grazing station (Helena Farm) that was operated from the late 1800's. In 1903, the site and surrounding area was subdivided and the house present on Lot 99 was believed to have been constructed the following year. Ownership of both allotments changed numerous times up until 1987 when Lot 99 was purchased by Austech Australia Pty Ltd and a waste recycling operation began under the operating name of Australian Chemical and Solvent Recycling (ACSR).

No information has been reviewed that would suggest either property was used for any purposes that may have resulted in soil or groundwater contamination up until 1987.

Lot 88 was not incorporated into the operations until early 1992. Between 1991 and 1992, the owner placed road base over Lot 88 and operated the site as a car park.

5.2 Waste Recycling Operations

Operations commenced on Lot 99 in 1987 as ACSR. A general description of the site operations is summarised in Sections 3.4 and 3.5 and detailed in the PSI Report (URS, 2001b). Significant changes to the operations that have occurred during the site operations until the start of 2001, include the following. The locations of the facilities referenced are shown in Figures 3 and 4.

- In 1990 – 1991, a laneway between the two allotments and the southwestern extension of Irwin Street that ran along the eastern boundary of the two allotments, was closed by gazette and incorporated into the land parcels of Lots 88 and 99.
- In early 1992, an agreement was reached with the owner of Lot 88 to lease the property and extend the waste recycling operations. The lot was purchased by Waste Control in 1996.
- A series of three sumps used to capture solvent spillage in the Process Area were removed in 1995 as they were seen as potential sources of sub-surface contamination.
- The northern bunded area along the Lot 2 boundary on Lot 99 was removed during the mid 1990's.
- A drum crusher, located near the southwest corner of Lot 88, was commissioned in about 1996.
- The Lot 88 concrete pad was extended (towards Oliver Street) in about 1996, 1998 and again in 1999-2000. The final extension involved the construction of a small bunded area in the southeastern corner of the site for laboratory chemical storage.

- Two USTs (both 4,000L) to the north of the Process Area were removed in 1998 by MS Industries (now Metric Australia). No information on the condition of the tanks or whether soil was removed during this programme is known to exist.

- The bunded area at the rear (southwest) of the Lot 99 concrete pad was removed within the last 2 years.

5.3 Fire

On the night of 15 February 2001, a fire broke out at the Waste Control Site. Fire fighting operations on and off-site lasted until 17 February 2001. The fire destroyed the treatment and recycling plant and a stockpile of more than 2000 drums. Various waste chemicals were incinerated, partially burnt and/or released to the environment. Fire fighting operations included the application of large volumes of water, which mixed with the released chemicals prior to flowing onto adjoining properties. Most of this water was directed onto Lot 2 and Bulbey Street. Water reaching Bulbey Street then entered the municipal stormwater system and discharged to areas on the Helena River Floodplain.

The main stockpile of drums was bulldozed through the Lot 2 boundary fence and spread across Lot 2. Once the fire was extinguished, large areas of contaminated water were understood to have ponded on the Waste Control Site, but more extensively on Lot 2.

5.4 Post- Fire Clean-up Activities

CTS were engaged to conduct post-fire clean-up activities to enable the safe reoccupation of the area by residents and businesses. These works included a programme of decontamination of infrastructure, equipment and vehicles on neighbouring properties and the excavation of areas of contaminated soils resulting from the flow of contaminated firewater.

On the Waste Control Site, post-fire clean-up activities included:

- The removal of the four remaining USTs ranging in size from 4,500 L to 25,000 L.

- The collection and off-site disposal of residual wastes.

- The decontamination, destruction and disposal of equipment and drums that had been destroyed by the fire.

- The dismantling, disposal and subsequent replacement of the property boundary fences along all but the Bulbey Street boundary.

- The excavation of an approximately 3 m wide strip of soil along the Pioneer and Lot 2 Site boundaries to a maximum depth of 3 m (generally 1.5m) and reinstatement with clean sand fill from Boral Quarries in Gnangara. CTS personnel noted that highly stained and odorous soils were removed from, and remained at depth, along the Lot 2 boundary adjacent to the unsealed former laneway between the two concrete pads.

- The removal and disposal of two subsurface concrete sumps containing black odorous sludge from the Lot 2 boundary adjacent to the unsealed former laneway between the two concrete pads.
- The removal and disposal of the Back Bund Sump.

Contaminated soil was spread across Lot 2 atop an area previously contaminated by ponded firewater and burning drums and batteries. As advised by CTS personnel, this soil was generated from:

- Boundary fenceline excavations on the Waste Control Site.
- The UST removal excavations on the Waste Control Site.
- Excavated and sieved material from the area of spread drums and batteries on Lot 2.
- Excavated material from the areas where contaminated firewater collected along the road verges, near the Bellevue Primary School and in the damplands.

A further summary of the post-fire clean up activities is included in the PSI Report (URS, 2001b) whilst a more detailed description is included in a report entitled *Waste Control Fire Clean-up Operations, Environmental Sampling and Methods, Bellevue, WA* (Stass, 2001).

5.4.1 Alleged Mercury Spill

In an interview, Dr. Claflin stated that during the boundary fenceline post-fire clean-up operations, a drum containing approximately 70 L of mercury was ruptured and flowed onto unsealed soil. The location of this alleged spillage was approximately on the Lot 2 boundary, adjacent to the unsealed former laneway between the Lot 88 and Lot 99 concrete pads. Dr. Claflin believed that no action was undertaken to recover the mercury at the time of the spill.

CTS reported having no knowledge of this incident or its clean-up.

5.5 Previous Environmental Site Assessments

The following assessments are known to have been completed to date associated with the Waste Control Site.

- A Preliminary Environmental Site Assessment completed by Hydrocarbon Remedial Services Pty. Ltd. (HRS) in 1994. The assessment included the installation of three groundwater monitoring bores to approximately 17 mbgl (WCT1 to 3).
- In 1997-1998, Waste Control completed a number of shallow testpits on Lot 2 immediately adjacent to the Front Bund Sump to investigate impacts from the overflow of potentially contaminated

stormwater from the site. Whilst URS did not receive a copy of the results, Dr. Claflin advised that only minimal impact of near surface soils was identified.

- A second Preliminary Environmental Site Assessment was completed by HRS in May 2000 (HRS, 2000). This included completion of sixteen hand augered holes to a maximum depth of 5 m, the analysis of three soil samples and the sampling and analysis of groundwater bores WCT1, 2 and 3. The results of the investigation confirmed that historical operations on-site had resulted in soil and groundwater contamination. The investigation identified six separate areas of surface hydrocarbon staining, a zone of reportedly solvent saturated soils from 3.5 to 5 mbgl and elevated concentrations of oil and grease in groundwater recovered from > 9mbgl in two of the groundwater bores.
- A report detailing the results of the post-fire clean-up operations by CTS was prepared in May 2001 (Stass, 2001). Soil and groundwater investigations were limited to off-site locations associated with the migration of contaminated firewater, but confirmed the presence of a variety of contaminants including cadmium, lead, phenols, poly aromatic hydrocarbons (PAHs) and chlorinated solvents.
- The WRC undertook a series of groundwater investigations following the fire in order to investigate local impacts to the shallow water table and potential discharge into the Helena River. A total of thirteen bores were installed between March 2001 and September 2001 (WCB1 to WCB13). The investigations were generally concentrated along the margins of the Helena River within the damplands. Four groundwater bores were also installed by WRC within 60 m of the site (WCB9 to WCB13). Whilst bore WCB12 was not able to be sampled in the initial monitoring programme, the results from the remaining three bores close to the Waste Control Site reported elevated concentrations of various hydrocarbons. The location of the bores is shown in Appendix G.
- An investigation into potential impacts up to 10 km west of the site associated with fall-out from the smoke plume that emanated from the fire was completed by URS in March 2001 (URS, 2001a). The location of sampling sites was determined by smoke plume modelling undertaken by the DEP. The investigation assessed the presence of dioxins, PAHs and heavy metals in different media. One sample of surface soil collected from the fire area on-site reported elevated concentrations of dioxin cogeners.

A further summary of previous environmental assessments is included in the PSI Report (URS, 2001b).

Based on the results of the PSI, the following summarises the sources, issues and areas of potential environmental concern that may have contributed to impacted soil or groundwater quality *beneath the Waste Control Site*. The location of these areas is shown on Figure 4.

On-site

- Large volumes of solvents passed through the Process Area with numerous instances of spillage and overflow reported. Heavy surface and sub-surface staining was identified in previous investigations.
- Heat for the distillation process was provided by the Oil Burner system, which included the Oil Burner, a fuel tank, holding tank, bleed tank, pump and a network of distribution pipes. Heavy staining has been previously identified adjacent to the Oil Burner.
- Six USTs were originally present on-site, some with sumps to receive overflows. All tanks have reportedly been removed but no validation of the excavations was undertaken.
- A former gravel laneway that separated the sites prior to 1990 remained unsealed throughout the site operations (noted on Figure 4 as unsealed area). Numerous spillages during operations, overflow from the Back Bund Sump and contaminated water generated during the fire fighting activities have been discharged in this area.
- Heavily contaminated soils were identified by CTS on the Lot 2 site boundary in the area of the former laneway. Contamination may remain in this area and anecdotal evidence suggests a mercury spill occurred in this area.
- An unsealed strip of land exists along the Lot 2 boundary that appears to have received stormwater and surface water discharges. Whilst this zone was excavated during post-fire clean-up operations, no validation was undertaken by CTS and zones of deep contamination were left in place.
- Contaminated surface soils were identified adjacent to a former break in the bundwall of the Lot 88 bunded drum storage area.
- Stained soils were identified on the Pioneer boundary adjacent to the drum crusher.
- Overflow of contaminated stormwater from the Front Bund Sump reportedly occurred for an extended period of the site's operation. During the fire, large volumes of contaminated firewater overflowed the Front Bund Sump onto Lot 2, the unsealed site entry driveway and ultimately to Bulbey Street.
- Groundwater with associated hydrocarbon contamination has previously been identified on-site at a depth of approximately 3.5 m, presumably perched atop a clay layer.
- The underlying regional groundwater table is present within the Guildford Formation at a depth of approximately 9 m. Historical groundwater contamination has been identified in this unit below the site.

- Chlorinated solvents, which are capable of forming dense non-aqueous phase liquids (referred to as DNAPL), have been identified in soil and groundwater off-site. Such compounds are denser than water and will therefore migrate downwards through the groundwater column until retarded by low permeability units (eg. clay). While the presence of a shallow clay layer is documented on-site, it is likely to be discontinuous off-site. Therefore, the deeper Leederville aquifer system may be at risk of DNAPL contamination.

Off-site

- The main stockpile of drums and the battery store were bulldozed from the Waste Control Site and spread onto unsealed ground across Lot 2 during the fire fighting operations.
- Contaminated water from the fire fighting operations ponded and seeped into the ground in areas of Lot 2.
- The contaminated soil from various excavations associated with the post-fire clean-up activities was spread across Lot 2.

A Sampling and Analysis Plan (SAP) was developed and approved by the DEP as part of the PSI Report (URS, 2001b) with the understanding that the scope would be subject to change based on the field observations once the investigation commenced, and that it was designed to provide a general understanding of site contamination issues. The works completed were generally in accordance with the SAP, and comprised the following:

- Sub-surface investigations using a drilling rig at a total of 25 locations.
- A total of 14 soil bores completed to depths between 4.2 and 8.0 mbgl.
- A total of 8 soil bores completed to depths between 4.5 and 7.5 mbgl, then converted to groundwater monitoring bores. These groundwater bores monitor the shallow perched groundwater system.
- A total of 3 soil bores completed to depths between 12.25 and 12.50 mbgl in a staged process that included the installation of surface casing to between 5.0 and 6.5 mbgl. These bores were then converted to groundwater monitoring bores to monitor the regional groundwater table (intermediate).
- The laboratory analysis of a total of 56 selected soil samples and 4 field duplicate samples for a range of parameters.
- The development, purging and sampling of the 11 groundwater monitoring bores installed during the investigation.
- The purging and sampling of 2 existing groundwater monitoring bores on-site and two existing off-site groundwater monitoring bores.
- The laboratory analysis of a total of 15 primary and 4 quality assurance groundwater samples for a range of parameters.
- The completion of rising head tests on 5 on-site groundwater monitoring bores.
- The position and level surveying of the groundwater monitoring bore network.

Alterations to the scope of work were required due to the extent of contamination identified, difficulties with certain drilling techniques and budgetary constraints. The following main alterations were made:

- The reduction in the number of shallow soil bores by 8 from the originally planned 22.
- The increase in the average depth of the shallow soil bores to 5.8 mbgl from the originally planned 5 mbgl.
- The reduction in the number of intermediate groundwater bores by 1 from the originally planned 4.
- The omission from the scope of a deep groundwater monitoring bore.
- The additional sampling and analysis of two off-site groundwater monitoring bores installed by the WRC (WCB11 and WCB13).

The programme of site investigations was undertaken between 5 November 2001 and 12 December 2001 with the majority of works completed by 23 November 2001.

The methodologies adopted for the programme are outlined in the following sections.

8.1 Health & Safety Plan

It is the policy of URS to provide a safe and healthy work environment for all of its employees through the prevention of occupational injuries and illnesses. Accordingly, a site-specific health and safety plan (HSP) was developed for use by all personnel working on behalf of URS at the site that would seek to ensure the health and safety of all personnel on-site and the general public.

The basis of the plan included the requirement for modified Level D Personal Protective Equipment (PPE), including nitrile gloves, tyvek coveralls, hardhat and steel-capped boots. In addition, ongoing monitoring of personal breathing space for volatile organic compounds, oxygen, carbon monoxide and ‘explosivity’ was undertaken.

Conservative trigger levels for field monitoring were adopted which were not exceeded at any stage throughout the investigations.

8.2 Community Consultation

Issues associated with the Waste Control Site have invoked strong community feeling. In order to ensure that the Bellevue community and local stakeholders were kept informed about on-site and off-site activities and developments, the following tasks were completed by URS.

A letter drop in the Bellevue area was completed approximately two weeks before the commencement of the field investigation programme. Between 120 and 140 letters were distributed to businesses and residences in an area bordered by the Midland railway lines, Roe Highway, Helena River and Military Road. In addition, the letter was forwarded to the following key interest groups identified in conjunction with the DEP.

- Bellevue Primary School
- City of Swan
- Alliance for a Clean Environment
- Bellevue Residents and Ratepayers Association
- Bellevue Hazardous Waste Fire Inquiry
- Health Department of Western Australia
- Ms. Barbara Dundas

The letter advised the community of the purpose of the investigations, what the investigations would entail and the likely duration. In addition, it provided contact details via telephone (consultation hotline), email and standard mail to enable people to provide and obtain additional information.

During the process of the investigations, only one call was received on the hotline.

In addition to those tasks undertaken by URS, it is understood that the DEP undertook another letter drop in January 2002 to provide an update of the status of the investigation process.

8.3 Soil Investigations

Sub-surface investigations were completed using a drilling rig equipped with hollow-stem augers and the split-spoon sampling technique. All drilling services were provided by J&S Drilling.

As part of the PSI, the presence of underground services on, and in the vicinity of the site was assessed through the review of utility location plans from both Dial Before You Dig WA and Waste Control, and the location of active services by a professional underground cable locating contractor.

Soil bores were generally completed using 76 mm (3”) augers with continuous split spoon sampling to enable the identification of subtle and discreet changes in lithology that may have an important bearing on the vertical migration of contaminants (e.g. confining clay layers). Soil boring logs were maintained by an experienced URS field technician or geologist and field observations such as lithology, odours and staining were recorded. The borelogs are included as Appendix B.

It was initially intended to collect and keep core tray samples from selected locations for future reference, however due to the suspected high level of contamination, particularly within the saturated zone, this was not considered appropriate. A selection of plates depicting the recovered soil samples is provided as a substitute.

Soil samples for potential laboratory analysis were collected from near surface, in areas of observed contamination, the level of the water table and at lithological boundaries. The samples were collected direct from the split-spoon by the URS supervisor using disposable nitrile gloves and placed into laboratory provided sterile glass jars with teflon seals. The samples were labelled in accordance with the bore location and the sample depth interval (eg. SB04_3.7-3.9) and then placed in chilled ice coolers.

Sample batches were then forwarded to the laboratory under standard chain of custody procedures.

Samples were also collected in the field and placed directly in resealable plastic bags. These samples were then screened within 15 minutes for volatile organic compounds using a photoionisation detector (PID) and the readings noted on the borelogs (refer to Appendix B).

At the completion of those soil bores not converted to groundwater bores, cement slurry was poured down the hollow stem augers or tremmie grouted to ensure pathways for vertical migration were not provided by the investigations. The bores were then backfilled with any visually uncontaminated cuttings, and/or cement grout to the surface.

8.4 Groundwater Investigations

Groundwater investigations included the installation and sampling of new groundwater bores, and the sampling of existing groundwater bores.

8.4.1 Groundwater Bore Installation

Two types of groundwater bores were installed as part of the investigations – shallow and intermediate.

Shallow groundwater bores were constructed following the completion of a soil bore. The drill bit was recovered from the base of the hole and 50 mm diameter Class 18 uPVC placed inside the hollow stem of the augers to the base of the hole. Screw jointed uPVC lengths were used to avoid the use of glues or solvents. Each bore comprised a basal slotted section of between 3 and 5 m with a PVC end cap at the base.

The bore annulus was then backfilled with graded gravel pack (-2 mm to +0.85 mm) to at least 0.5 m above the slotted interval. A bentonite seal up to 0.6 m was placed and the remaining bore annulus filled with a cement slurry to the surface. Final completion of the bores generally comprised a lockable steel protective upstand, with gatic covers mounted flush to the ground surface where future trafficability may have been a concern.

Due to the presence of the contaminated shallow perched water table, completion of the intermediate groundwater bores required a more complex methodology. This involved the installation of surface casing keyed into a shallow clay unit and tremmie grouted, prior to drilling at depth to prevent the potential vertical downward flow of contaminated groundwater when the confining layer was breached.

The initial 76 mm soil bores were advanced until competent clay was identified in the split –spoon samples. The bores were then reamed using 4” (102 mm) ID hollow augers to allow placement and pressure cementing of 225 mm surface casing.

At two locations, the loose nature of the upper sandy soil profile resulted in formation cave-in whenever the augers were removed, preventing the placement of the casing to the desired depth. This was overcome by the re-drilling of the hole using rotary mud drilling methods with a bentonite based drilling mud.

Once placed to the base of the hole, the surface casing was pushed (keyed) a maximum of 0.2 m into the confining clay and the annulus pressure cemented to surface. The cement seal was given at least three days to cure then the bores re-entered and completed to the desired depth (with continuous split-spoon sampling) using 76 mm and then 102 mm ID hollow stem augers.

At completion, the drill bit was recovered from the base of the drill string and 50 mm diameter Class 18 uPVC bore casing with a 4 m basal slotted section and PVC end cap was placed inside the augers. Graded gravel pack (-2 mm to +0.85 mm) was then progressively poured into the annulus between the bore casing and the hollow stem augers as the augers were gradually removed from the hole. This process ensured the effective placement of the gravel pack to at least 0.5 m above the slotted interval.

A cement slurry was then also pumped down the drill string as the augers were gradually removed from the hole. This ensured the effective placement of the cement seal from beneath the confining clay to within the surface casing.

Final completion of the bores generally comprised a lockable steel protective upstand, with gatic covers mounted flush to the ground surface where future trafficability may have been a concern.

A summary of the bore construction details is provided in Table 1.

8.4.2 Groundwater Bore Sampling

Upon completion of installation, the groundwater bores were developed using disposable bailers. Most bores were purged dry within 5 or 10 minutes and thus the development process was continued progressively over a number of days during the drilling programme. Additional development was required at those shallow groundwater bores located in the immediate vicinity of intermediate bores that required mud drilling to place the surface casing.

A minimum of six days following bore development, the depth to liquid in each of the new bores, the existing on-site bores and four close off-site bores was measured relative to the top of the PVC bore casing using an oil/water interface probe.

All on-site bores were then purged and sampled in accordance with URS QA/QC protocols, which were developed in accordance with the Australian Standards and the draft DEP Guidelines for sampling and analysis. This included the use of bore dedicated disposable bailers, the removal of a minimum of four bore volumes (or the volume required to purge the bore dry) and the measurement of field parameters, including temperature, electrical conductivity (EC), pH and Dissolved Oxygen (DO).

Groundwater recovered for sampling was poured directly into sterilised laboratory provided sample jars with appropriate preservation requirements. The samples were labelled in accordance with the bore location and the sample date (eg. MW21I_21/11/01), placed in chilled ice coolers and forwarded to the laboratory under standard chain of custody procedures.

Two off-site bores previously installed by the WRC, were also purged and sampled (WCB11 and WCB13). These bores were, however, constructed using 20 mm PVC casing which was not amenable to the sampling equipment obtained for the on-site programme. These bores were purged and sampled by WRC personnel on 28 November 2001 as part of a wider sampling programme of bores installed following the fire to assess the effects of contaminated firewater seepage off-site of the Waste Control Site.

WRC sampling procedures included the use of a low flow air bladder pump system. For the two bores of direct interest to this investigation, the samples were collected in bottles provided by URS' preferred laboratory and managed in the same manner as described above.

8.4.3 Aquifer Testing

Rising head tests were completed on selected bores in order to make an initial assessment of aquifer parameters. The tests were undertaken by measuring the aquifer response (recovery) to the removal of a slug (one litre) of water. The aquifer response was measured using a pressure transducer set to continuously record measurements every 2 seconds, thereby ensuring high quality data.

For each test, the standing water level was recorded then the decontaminated pressure transducer and bore dedicated disposable bailer were lowered to below the water level, with the transducer generally set within 0.5 m from the base of the bore. The bore was then left to equilibrate.

Once the water level had returned to the original static level, the bailer was swiftly removed from the bore and the transducer left to collect measurements for a minimum of 15 minutes.

Data from the transducer was downloaded at the completion of all tests and then analysed to produce estimates of hydraulic conductivity (K). These calculations are provided in Appendix C.

8.4.4 Position and Level Survey

A licensed surveyor, McMullen Nolan & Partners, was engaged to position and level survey all on-site bores and three of the existing WRC off-site bores (WCB 9, 11 and 13). The bores were position surveyed relative to both the old AMG84 coordinate system and the new MGA94 coordinate system. The level of the PVC bore casing and the adjacent ground surface were surveyed relative to the Australian Height Datum (AHD).

In addition, nine random points across the site and on the adjacent Lot 2 were also position and level surveyed. This information was used to produce the estimated ground topography displayed on Figure 2.

The original results of the survey are included as Appendix D.

8.5 Quality Assurance and Control Measures

8.5.1 Decontamination

A decontamination pad was constructed adjacent to the Front Bund Sump on Lot 99. All drilling equipment was decontaminated before and after each use using high-pressure hot water / steam and cleaning solution (Decon 90) with a potable water rinse. All soil sampling equipment (eg. split spoons) were washed and scrubbed in a solution of Decon 90 then rinsed in potable water between samples. In addition, three sets of split spoons were used per hole to minimise the potential for cross-contamination.

Groundwater sampling equipment was generally disposable and bore dedicated and therefore decontamination procedures were not required. Equipment such as water level probes and pressure transducers that were transferred between bores, were washed in Decon 90 and rinsed between bores. In addition, all works proceeded from least to most visually contaminated bore to further minimise the potential for cross-contamination.

8.5.2 Soil Cuttings Management

Contaminated drill cuttings were stored in a small bunded area developed on the Lot 99 concrete pad. At the completion of the programme, the results of the laboratory analytical programme were collated and conservatively used to represent the soil contained within the stockpile. This information was reviewed and approved by the Eastern Metropolitan Regional Council for disposal of the soil to the Redhill Landfill as Class IV waste.

A total of 4.6 T of cuttings was transported and disposed to the landfill on 12 December 2001 by Metric Australia.

8.5.3 Wastewater Management

All water from the wash-down pad was directed to the Front Bund Sump for temporary storage. Progressively through the field programme, water within the sump was transferred to 205 L drums using 12 V submersible pumps. In addition, purge water from the groundwater sampling programme and the liquid component of the drilling mud slurry following settlement, was transferred to 205 L drums.

Twice during the field programme, CTS were engaged to collect the wastewater using a vacuum truck for subsequent treatment off-site as “Type 7 : Solvent / Water Mix Waste”. This included the total draining of the Front Bund Sump. A total of approximately 6,500 L was collected during the programme.

8.5.4 QA/QC Sampling

A total of eight QA/QC samples consisting of duplicate soil and groundwater samples, groundwater field blanks and groundwater trip blanks were collected during the field programme to assess the quality of sampling and laboratory procedures. In addition, the laboratory used (see Section 8.6) analysed a variety of internal laboratory duplicates, matrix spikes and matrix spike duplicates.

A summary and assessment of the results is included in Section 11.

8.6 Laboratory Programme

Soil and groundwater samples were forwarded to Australian Laboratory Services Pty Ltd (ALS) in Melbourne for laboratory analysis. The analytical suite was determined from a review of the information on chemicals historically stored on-site and the results of previous testing both on and off-site.

The analytical suite utilised comprised a selection of the following:

- pH.
- Total Petroleum Hydrocarbons (TPH).
- Benzene, toluene, ethylbenzene and xylene (BTEX).
- TPH Speciation which provides a breakdown of the concentrations of aliphatic and aromatic TPH compounds (soil only).
- A suite of heavy metals and metalloids comprising arsenic, cadmium, copper, chromium, lead, mercury, nickel and zinc (soil, groundwater and soil leachate).
- Total dissolved solids (TDS) and major ions (groundwater only).
- Semi-Volatile Organic Compounds (SVOC) and PCBs.
- Volatile Organic Compounds (VOC).

The VOC and SVOC analysis includes in excess of 150 organic compounds in the following groupings:

- Phenols
- Poly aromatic hydrocarbons (PAH)
- Phthalate esters
- Nitrosamines
- Nitroaromatics and ketones
- Haloethers
- Chlorinated hydrocarbons
- Anilines and benzidines
- Organochlorine (OC) and organophosphorus (OP) pesticides
- Monocyclic aromatic hydrocarbons (MAH)
- Oxygenated and sulfonated compounds
- Fumigants
- Halogenated aromatic and aliphatic hydrocarbons
- Trihalomethanes

Included in this extensive suite are compounds such as PCE, trichloroethene (TCE), trichloroethane (TCA), vinyl chloride, naphthalene, MEK and chloroform.

ALS is NATA certified for all analyses undertaken.

8.7 Current Regulatory Framework and Criteria

Currently there is no specific legislation associated with the management of contaminated sites. Much of the legislation used to address contaminated sites is through the licencing aspects of the Environmental Protection Act (EP Act). However, there is currently draft legislation, the Contaminated Sites Bill, which is scheduled to be passed into Parliament in 2002. The draft of the Bill identifies different measures and procedures associated with the investigation and remediation of contaminated sites. This Bill identifies the usage of several guidelines that are to be used to implement the Bill. The guidelines, many of which are still in draft, provide information on things such as, sampling plan design and implementation, soil, sediment and groundwater criteria and reporting requirements.

A draft version of a guideline of *Assessment Levels for Soil, Sediment and Water* (WA DEP, 2001) was prepared by the DEP and issued in December 2001. This guideline is aimed at providing parties with a document that outlines the criteria utilised by the DEP in assessing site contamination and determining requirements for further investigation, management or remedial action. In general the guideline reflects usage of those criteria presented in the National Environmental Protection Measure (NEPM, December 1999) for the Assessment of Site Contamination.

The Waste Control Site is currently zoned ‘General Industry”. Based on this zoning and the surrounding land-uses assessment of soil and groundwater contamination has therefore been undertaken assuming ongoing industrial site usage.

On this basis, reference has been made to the draft DEP health investigation levels for commercial / industrial sites (HIL-F) to assess potential human health issues and the draft DEP ecological investigation levels (EIL) to assess potential impact to the environment. In addition, due to the lack of local available investigation levels for many of the contaminants identified on-site, reference has also been made to the following:

- Region IX Preliminary Remediation Goals (Industrial), issued by the USEPA (USEPA, 2001); and
- Dutch Intervention Guidelines, issued by the Dutch National Institute of Public Health and the Environment (RIVM, 2000).

The assessment of contaminant concentrations in groundwater is dependent on the beneficial use of the groundwater resource. Based on a review of bores identified in the WRC WIN database, it is considered that the following guideline is the most appropriate for the shallow and intermediate groundwater resources:

- the draft DEP guidelines identified for the Protection of Aquatic Fresh Water Ecosystems.

However, a detailed assessment of groundwater resources in the local area has not been completed. As the salinity of the groundwater resources indicates it could be utilised for potable supply and the draft DEP guidelines do not address many of the more diverse contaminants identified at the Waste Control Site, reference has also been made to the:

- Region IX Preliminary Remediation Goals (Tap Water) (USEPA, 2000); and
- Dutch Intervention Guidelines (RIVM, 2000).

It is also noted that these guidelines will only be used for initial comparison and to assess whether further investigation would be required. They do not necessarily reflect clean-up criteria for the site and it is likely that in the eventual interpretation of risks associated with the contaminants' fate and transport, a quantitative risk assessment may be required to determine not only the nature of the risk the contaminants pose but also the target levels for management or remediation.

9.1 Soil Profile

The drilling investigation programme involved the completion of drilling at 25 separate locations across the Waste Control Site. The majority of the bores were completed to specifically investigate the shallow soil profile. These bores were terminated when a potentially confining clay unit was encountered, or to a maximum of 8 mbgl when the clay was not encountered. Three bores were continued to approximately 12 mbgl to investigate what is referred to as the intermediate zone.

The investigations confirmed that a shallow clay unit is present beneath a large portion of the site. Figure 6 shows the location of the completed bores and the inferred extent of the shallow clay layer. The clay is inferred to be present beneath a majority of the site with the exception of the eastern corner of Lot 88, the southeastern corner of Lot 99 and the northern corner of Lot 99.

Figure 7 shows two geological cross-sections across the site and indicates that the geology beneath the site generally comprises the following depth profile:

- 0 to 3 m: Fine to medium grained, loose **Sand**, cream to pale orange.
- 3 to 5 m: **Clayey Sand to Sandy Clay**, orange to light brown, that becomes increasingly clayey with depth (fine to medium grained sands).
- 5 to 6.5 m: Tight, firm and dry grey **Clay** with minor red mottling.
- 6.5 to 11 m: **Sandy Clay to Clayey Sand**, cream to grey, that generally becomes increasingly sandy with depth (medium to coarse grained sands).
- >11 m: Medium to coarse-grained **Sand**, cream to grey.

Important variations to this generalised profile include the following:

- Whilst it was known that recent excavations had been undertaken along the site boundaries and through the unsealed central portion of the site, it was sometimes difficult to determine differences between natural sands and fill material due to backfilling with sands of similar nature.
- The zone from 3 to 5 mbgl commonly includes a variably developed laterite horizon. This is generally poorly developed, comprising red-orange mottling with no induration. However in some locations, indurated laterite nodules were encountered (eg. SB15). There does not seem to be a definable distribution pattern for this shallow laterite horizon based on the information obtained to date. Where noted, the stratigraphy was logged as ‘gravelly’.
- Generally, the sediments from 0 to 3 mbgl are unsaturated and from 3 to 5 mbgl are saturated whilst the tight, firm grey clay is dry. This confirms the presence of a perched water table and the localised confining nature of the clay.

- There is unlikely to be an ‘abrupt’ edge to the shallow clay as depicted in Figure 6. More likely, there is a gradational transformation to sandy clay.
- Beneath the clay, or the typical level of the clay if not present, the sand encountered is of a noticeably coarser grain size than the shallow surficial sands. In addition, these intervals display a crystalline appearance, resembling decomposed granite.
- In one of the intermediate bores (MW23I), a one-metre zone of ‘coffee rock’, comprising well-cemented iron stained sands was intersected at about 9 mbgl. This was not encountered in the other intermediate bores.

The discussion of results of the soil quality investigations has been divided into the following two zones :

- Shallow: comprising the unsaturated and shallow saturated zones, and the extent and inferred level of the shallow confining clay; and
- Intermediate: comprising the coarser grained sands and sandy clays from beneath the level of the confining clay to the depth of investigation.

In addition, discussions of the shallow zone have been further sub-divided to assist in data interpretation where possible.

A varied analytical programme was completed for the assessment of soil conditions. A summary of the analyses undertaken is included as Table 2 and the results are shown in Tables 3 through 6. Copies of the original laboratory reports are included as Appendix E.

Figure 8 provides a summary of those locations where contaminants were identified in excess of the adopted assessment investigation levels for both the shallow and intermediate zones.

9.2 Shallow Zone

Provided below are the results of the field and laboratory analytical results.

9.2.1 Possible Former Ground Surface

A thin (0.1-0.4 m) zone of brown sand with minor peat and commonly possessing a faint hydrocarbon odour, was identified in the unsaturated zone around 0.5 mbgl in four bores (SB01, SB07, SB08 and SB13), mainly located on the north western boundary (i.e. Pioneer Site boundary) of Lot 88. This layer may represent a former ground surface, particularly beneath Lot 88 where the concrete slab is known to have been constructed over a former car park area.

Analysis of this layer at SB08 (SB08_0.5-0.7) indicated TPH C_{15}-C_{28} fraction concentrations of 1,020 mg/kg, marginally in excess of the EILs (1,000 mg/kg).

A summary of the laboratory results is included as Tables 3 through 6.

9.2.2 Beneath Concrete Slabs (Unsaturated)

The soil encountered directly beneath the concrete slabs on both Lot 88 and Lot 99 was commonly characterised by a thin (<0.1 m) layer of sandy, clayey coarse gravel. In addition, beneath the entire Lot 99 slab and parts of the Lot 88 concrete slab, a zone of heavy staining and strong hydrocarbon odour was evident. Where present, the heavy staining was normally apparent in the upper 0.3 m.

Selected analysis of this layer beneath the Lot 88 slab was undertaken at SB04 and SB06. The concentrations of the analysed contaminants were below investigation levels for SB04_0.1-0.3, however analysis of SB06_0.2-0.4 indicated chromium, TPH C_{10}-C_{14} and TPH C_{15}-C_{28} in excess of the EILs. Subsequent analysis for TPH speciation indicated all TPH concentrations below the HIL-Fs.

At SB05 in the middle of the Lot 88 concrete slab, the concrete had been damaged to the point where it was absent. The underlying sandy soils were lightly stained and possessed a strong hydrocarbon odour indicating a probable pathway for the downwards migration of contaminants. Odours were detected throughout the soil column, including the saturated zone. Whilst no analysis of samples from the unsaturated zone was undertaken, analysis of two samples from the saturated zone (SB05_3.4-3.6 and SB05_4.8-5.0) did not indicate the presence of contaminants above the investigation levels.

Selected analysis of the stained layer immediately below the Lot 99 concrete slab was undertaken at SB10 and SB17. The concentrations of the analysed contaminants were below investigation levels for SB10_0.1-0.2, however analysis of SB17_0.4-0.5 indicated TPH C_6-C_9, TPH C_{10}-C_{14}, toluene, ethylbenzene and total phenols in excess of the EILs, and a xylene concentration of 387 mg/kg in excess of the HIL-Fs. In addition, *cis*-1,2-dichloroethene (*cis*-1,2-DCE) was detected at a concentration of 1.2 mg/kg, which is in excess of the USEPA Region IX PRG levels.

Subsequent analysis for TPH speciation indicated all concentrations below the HIL-Fs for SB17_0.4-0.5.

Beneath the Lot 99 slab, the unsaturated sandy soils beneath the zone of staining identified above, were characterised by a strong hydrocarbon odour and a variable degree of light grey staining. It is considered that in some areas beneath the slab (generally where staining is absent), this is a result of the volatilisation of volatile contaminants from the underlying shallow saturated zone.

A summary of the laboratory results is included as Tables 3 through 6.

9.2.3 Former UST Locations

The two former UST areas were directly investigated by SB03 (main tank farm removed following the fire) and SB11 (smaller tank farm).

In the area of the main tank farm, a moderate odour was encountered from 1 mbgl, which increased from 2 mbgl associated with dark grey staining. At 2.8 mbgl, black plastic sheeting was encountered and the odour and degree of staining of the sands increased. This suggests the plastic was laid following the removal of the tanks to assist in backfill activities, and the sands from 0 to 2.8 mbgl probably represent fill material. Within the saturated zone (below approximately 3.5mbgl), the hydrocarbon odour was strong and sweet, and was accompanied by dark grey-green heavy staining until 5.4 mbgl where the tight, dry, unstained shallow clay was encountered.

Despite the level of staining identified, analysis of three samples from the saturated zone did not indicate concentrations in excess of the investigation levels.

In the area of the smaller tank removed in 1998, a similar upper profile was encountered. Black plastic was encountered at 2 mbgl and the odour become very strong beneath this level. Heavily stained sand and sandy clays were evident within the saturated zone. At this location, no shallow clay was encountered and the hole was terminated at 6 mbgl in heavily stained, odorous and wet coarse-grained sandy clay typical of the intermediate zone.

Analysis of two samples from the approximate level of the water table (SB11_3.1-3.2) and the saturated zone (SB11_4.9-5.1) confirmed this zone to be impacted. Analysis of SB11_3.1-3.2 indicated TPH C_6-C_9, TPH C_{10}-C_{14}, toluene and ethylbenzene in excess of the EILs, and a xylene concentration of 804 mg/kg in excess of the HIL-Fs. Analysis of SB11_4.9-5.1 indicated TPH C_6-C_9, TPH C_{10}-C_{14}, toluene, ethylbenzene and naphthalene in excess of the EILs, and a xylene concentration of 983 mg/kg in excess of the HIL-Fs. In addition, 1,2,4- and 1,3,5-trimethylbenzene, and PCE (a chlorinated solvent) were reported at concentrations in excess of either the USEPA Region IX PRG levels or the Dutch Intervention Guidelines. A number of other volatile organic compounds including TCA, TCE and 1,2-dichlorobenzene were reported above detection limits but below investigation levels.

Other bores were completed in the general area of the USTs, however these are discussed in other sections of this report. A summary of the laboratory results is included as Tables 3 through 6.

9.2.4 Unsealed Former Laneway

A total of four bores (SB09, SB14, SB19 and SB21) were completed in this area, considered to be one of the potential main source areas, due to the overflow and subsequent seepage of contaminants which was throughout the operating history of the site as well as the seepage of contaminated firewater during the fire fighting activities.

SB14 and SB21, located on the western half of the site (on Lot 88), encountered similar profiles with stained and odorous soils only being identified at the base of the saturated zone above unstained, dry tight confining clay.

Despite the identified staining, analysis of two samples from SB14 and one from SB21 within the saturated zone did not indicate concentrations in excess of any of the referenced investigation levels.

SB09 and SB19 were located on the eastern side of the site adjacent to the Lot 2 boundary. The bores encountered similar profiles comprising a surficial zone (0.5 m) of stained debris such as concrete rubble and burnt wood. This zone overlies a sequence of sand, sandy clay and clayey sand with varying degrees of staining and odour throughout. The odour in the upper, unsaturated zone resembled landfill leachate and a smoke odour, whilst the saturated zone also possess the sweet odour also noted beneath the Lot 99 concrete pad.

The upper profile suggests the area was outside the area that was excavated and backfilled by CTS during the post-fire clean–up activities. Analysis of a sample from the zone of surficial debris and staining in SB19 (SB19_0.2-0.3) indicated TPH C_{10}-C_{14}, TPH C_{15}-C_{28}, xylene, cadmium, chromium, copper, nickel and zinc in excess of the EILs. Subsequent analysis for TPH speciation indicated TPH C_{16}-C_{35} aromatic fraction of 1,100 mg/kg in excess of the HIL-F (450 mg/kg). In addition, a number of organic compounds including naphthalene and 1,2- and 1,4-dichlorobenzene were reported above detection limits but below relevant investigation levels.

In both locations, no shallow clay was encountered and the bores were terminated in saturated materials between 7 to 7.5 mbgl, which displayed field evidence of contamination.

Despite the identified staining, analysis of two samples from the saturated zone in SB09, one sample from the saturated zone in SB19 and one sample from the lower unsaturated zone in SB19 (SB19_3.9-4.0), did not indicate concentrations in excess of any of the referenced investigation levels.

This area is also the general location of the alleged mercury spill. Analysis for metals concentrations was undertaken for a total of six samples from SB09 and SB19. The samples reported mercury concentrations below the detection limit of 0.1 mg/kg.

A summary of the laboratory results is included as Tables 3 through 6.

9.2.5 Saturated Zone

Field evidence of contamination within the saturated zone is widespread across the site. This is likely to be due to the liquid nature of the majority of chemicals of concern and their ability to migrate within the shallow perched water table. All bores with the exception of SB02 (dry) and SB15 on Lot 99 and SB08 on Lot 88 possess odour and / or staining within the saturated zone. The area beneath the Lot 99 concrete pad and the unsealed former laneway display the highest level of staining and odour, with the heaviest staining apparent at the base of the saturated zone where it is underlain by the confining clay.

The results of laboratory analysis of soils from within this zone at specific potential source areas have been discussed above. However, results of note from this zone from other bore locations around the site include:

- SB01 located adjacent to the Pioneer Wastewater Sump in the former Oil Burner area reported TPH C_{15}-C_{28} in excess of the EILs from analysis of sample SB01_3.0-3.2.
- SB16 located in the middle of the Lot 99 concrete slab reported TPH C_6-C_9, toluene and xylene in excess of the EILs from analysis of sample SB16_3.9-4.0. In addition, ethylbenzene and phenol were reported above detection limits but below relevant investigation levels.
- SB20 located in the area of the former Back Bund Sump did not report concentrations in excess of the EILs from analysis of sample SB20_5.4-5.5 from the saturated zone or SB20_2.4-2.5 from the unsaturated zone. However, a number of organic compounds including TPH C_6-C_{36} , toluene,

ethylbenzene, xylene, various PAHs, phthalate esters, dichlorobenzene and trimethylbenzene were reported at concentrations above detection limits but below relevant investigation levels.

- MW22I located at the northern edge of the Lot 99 concrete pad reported total phenols in excess of the EILs from analysis of sample MW22I_5.3-5.5. In addition, a number of organic compounds including TPH C_6-C_9 and xylene were reported above detection limits but below relevant investigation levels.

A summary of the laboratory results is included as Tables 3 through 6.

9.3 Intermediate Zone

Soil investigations intended to assess the intermediate zone were limited to the three intermediate bores, MW21I, MW22I and MW23I. All three bores were completed in areas where the shallow clay separated the shallow and the immediate zones.

Field evidence of contamination was generally only evident in bores MW21I and MW22I and comprised staining and moderate odour from 7 to 10 mbgl. This may correspond to the zone of fluctuation of the regional groundwater table.

Analysis of 3 samples from MW21I, 3 samples from MW22I and 2 samples from MW23I did not indicate concentrations in excess of any of the referenced investigation levels, with the exception of sample MW22I_7.2-7.3. Analysis of this sample of slightly stained and odorous sandy clay from the unsaturated zone reported toluene and xylene in excess of the EILs and a number of organic compounds including ethylbenzene, TPH C_6-C_9 and trimethylbenzene above detection limits but below relevant investigation levels.

Where the shallow clay was not present (SB04, SB09, SB10, SB11, SB12, SB16, SB19 and SB20), soil investigations were extended to depths identified as the intermediate zone. Soils from the intermediate zone at these locations were generally stained and odorous, and were analysed from locations SB04, SB10, SB12 and SB19. Despite the identified staining, analysis of samples from these locations did not indicate concentrations in excess of any of the relevant investigation levels.

A summary of the laboratory results is included as Tables 3 through 6.

9.4 PCB Analysis

Additional information obtained subsequent to the field investigation indicated that PCB containing materials may have been present on-site. Therefore, a total of eight samples of visually impacted soils from both the shallow and intermediate zone were screened for total PCBs subsequent to the main analytical programme. All samples reported results below the laboratory detection limits. However, it is noted that the detection limits varied from 0.1 mg/kg to 2.5 mg/kg due to laboratory dilution requirements associated with variable sample material. The EIL for PCBs is 1 mg/kg. In addition, analysis of most of the samples selected for PCB analysis occurred outside of the recommended holding time for the sample extracts. Accordingly, concentrations of PCB may be under reported for these samples.

Analysis for PCBs was undertaken to provide an initial assessment of the presence of PCBs. The results received suggest significant levels of PCBs are not present at the locations tested. However, further investigation is required to definitely confirm the absence or presence of PCBs in soil beneath the Waste Control Site.

As discussed in Section 9, the investigations confirmed that a shallow clay unit is present beneath a large portion of the site. As a result, a shallow water table has formed, perched upon the clay. At the time of the investigations, the perched water table was present at approximately 3.5 mbgl.

The regional water table aquifer was also identified beneath the site, present at approximately 9.5 mbgl.

The drilling investigations indicated that where the shallow confining clay was not identified, sandy clay is present. Given the sandy nature of the clay, it is possible that a transfer of water from the shallow perched water table to the underlying regional water table may occur.

Accordingly, the discussion of results of the groundwater investigations has been divided into the following two zones:

- Shallow: comprising the perched shallow water table; and
- Intermediate: comprising the regional water table.

It is noted that investigation of the regional water table aquifer at depth was not undertaken as part of this investigation, but will likely be required in the future.

All groundwater samples were analysed for pH, TDS, major ions, a suite of metals, TPH, BTEX, SVOC's and VOC's with the exception of the shallow WRC bore WCB11, which was not analysed for pH, TDS and major ions. The results of the analysis are shown in Tables 7 through 10 with copies of the original laboratory reports included as Appendix E.

10.1 Shallow Zone (Perched Water)

10.1.1 Groundwater Flow

The existence of the shallow perched water table is obviously associated with the presence of the shallow confining clay. Where the clay unit becomes sandier, there appears to be an increase in vertical permeability, which enables the shallow perched water to seep down to the regional water table. Accordingly, the flow of groundwater within the shallow perched aquifer will be dependent on the attitude of the underlying shallow confining clay.

The soil investigations have indicated that the shallow confining clay grades to a sandy clay or clayey sand in the northern corner of the site and the central portion of the site along the Lot 2 boundary. The inferred extent of the shallow clay is shown on Figure 9, along with the relative groundwater levels in the shallow groundwater bore network as measured on 21 November 2001. Contouring of the relative groundwater levels suggests groundwater flow is toward the areas where the shallow clay is absent. This results in a multi-directional groundwater flow regime, however the majority of flow is expected to be toward the east / southeast.

In the northeastern corner of the site, investigations at SB02 indicated the confining clay was present, but the overlying interval was unsaturated.

Flow within the shallow zone is also likely to be highly variable associated with seasonal influences. Recharge from rainfall is most likely over the winter period. Therefore, the perched water table is likely to be at its maximum saturated thickness around September in an average year, which may result in local variations to the direction of groundwater flow beneath the site. During the summer period, it appears that the perched water gradually seeps down to the regional water table at locations both on and off-site. This process, combined with the lack of recharge and increase in evaporation during summer, suggests that at some time during the summer-autumn period, the perched water table may cease to exist in places.

This interpretation appears to be further supported by an additional round of well gauging undertaken on 12 December 2001. In the 21 day period between well gauging rounds, the water level in the shallow perched aquifer decreased by an average of 20 cm (compared to 7 cm in the regional water table).

10.1.2 Aquifer Parameters

Analysis of the data collected from rising head tests completed in three of the shallow bores indicated a calculated permeability (K) ranging from 0.07 to 0.3 m/day. This is considered a moderate to low relative permeability (USDOI, 1981), typical of the general sandy clay to clayey sand nature of the saturated zone.

The estimated permeability of the shallow aquifer is likely to vary considerably depending on the time of investigation. This is due to the expected seasonal variation of the water table and the coarsening-up nature of the aquifer sediments. During periods of maximum saturated thickness (late winter) the saturated aquifer sediments will include a large proportion of sand. During periods of minimum saturated thickness (late autumn) the saturated aquifer sediments will be dominated by less permeable sandy clays that are more prevalent at the base of the shallow profile.

10.1.3 Groundwater Quality

Sampling has shown that groundwater in all of the eight on-site shallow monitoring bores and the one off-site shallow monitoring bore sampled, is impacted to some extent with concentrations of more than one contaminant in excess of the investigation levels in each sample.

An assessment on the inherent quality of the groundwater in terms of salinity (as represented by TDS) is not possible due to the interfering affects of the contaminants present. This is evident in all bores by a comparison between the calculated TDS and the sum of the reported major ions, which should be similar, but in these samples differ considerably (eg. MW2 : 3,880mg/L c.f. 464mg/L). However, based on the summation of the major ions, it seems likely that uncontaminated groundwater in the shallow zone would be considered to be fresh water (i.e. TDS <1,000 mg/L).

The pH of the shallow groundwater ranges from 5.57 (MW4) to 7.34 (MW8) indicating slightly acidic conditions. The pH recorded for bores MW4, MW5 and MW7 were below the lower range of the DEP freshwater guidelines of 6.5 pH units (Table 7).

Also of note from the analysis of major ions is the relatively high level of sodium and bicarbonate in bores MW1, MW3 and MW4. Bores MW1 and MW4 are situated in the Process Area on Lot 99 in the location of the two former UST tankfarms, and the analysis of contaminants discussed below indicates that this area shows the highest level of contamination within the shallow perched aquifer.

Metals (Table 7)

Elevated concentrations of metals in excess of the DEP fresh water guidelines were reported for all bores with the exception of MW2, MW6 and MW7. Results of note for the different metals analysis included the following:

- Cadmium and mercury were not reported above detection limits in any of the nine bores.
- Nickel was reported at concentrations above the guideline of 0.150 mg/L in bores MW1 (0.218 mg/L) and MW3 (0.161 mg/L).
- Copper was reported at concentrations above the guideline of 0.005 mg/L in bores MW1 (0.039 mg/L), MW4 (0.042 mg/L), MW5 (0.063 mg/L), MW8 (0.022 mg/L) and WCB11 (0.008 mg/L).
- A minor exceedance of zinc compared to the guideline of 0.050 mg/L was noted in MW5 (0.056 mg/L).

The highest concentrations of metals appear to be in the vicinity of the Process Area and the unsealed former laneway, with the highest concentrations consistently from bores MW1, MW4 and MW5.

TPH / BTEX Compounds (Table 7)

A number of organic contaminants have been detected within the shallow groundwater above expected background levels and available criteria. The TPH results range from 737 µg/L in MW2 to 591,875 µg/L (591.9 mg/L) in MW4. While a DEP criteria for TPH has not been published, the Dutch Intervention Guideline for TPH $C_{10} – C_{36}$ fraction are set at 600 µg/L. The results for all bores with the exception of MW2 and WCB11, are in excess of this guideline.

Toluene, xylene and ethylbenzene are present at concentrations up to two orders of magnitude in excess of the assessment guidelines in bores MW1 and MW4, and at varying concentrations in all other bores except MW2 and WCB11.

Figure 10 shows the inferred distribution of xylene within the shallow groundwater, concentrated beneath the Process Area and flowing off-site across the Lot 2 boundary and possibly the Pioneer boundary.

Benzene has been reported above the detection limit of 1 µg/L, but at concentrations less than 5 µg/L in bores MW3, MW5 and MW8. In addition, the detection limit for MW1 and MW4 was raised to 100 µg/L as the laboratory had to dilute the sample for analysis given the presence of high concentrations of other volatile organic constituents.

PAH Compounds (Table 8)

Total PAHs above the assessment guidelines of 3 µg/L were detected in bores MW1 (42 µg/L), MW3 (5 µg/L) and MW4 (236 µg/L). Naphthalene was the main individual compound identified with a highest concentration of 229 µg/L in MW4. Minor concentrations of 2-methylnaphthalene and phenanthrene were also detected in MW4.

Phenols (Table 8)

Phenols were detected in bores MW1, MW3, MW4, MW5 and MW8. The main individual compounds identified were phenol and 2-, 3- and 4-methylphenol. Phenol was present above the DEP freshwater guideline of 50 µg/L in MW1 (12,800 µg/L), MW4 (63 µg/L) and MW5 (1,550 µg/L). While DEP criteria do not exist for 2-, 3-or 4-methylphenol, USEPA PRGs for tap water were exceeded in MW1 for 2-methylphenol (3,210 µg/L) and 3- and 4-methylphenol (8,830 µg/L) and in MW3 and MW5 for 3- and 4-methylphenol (381 µg/L and 1,550 µg/L respectively). It should be noted that the detection limit/level of reporting for pentachlorophenol is greater than the assessment guidelines. However, pentachlorophenol was not detected.

Pesticides (Tables 8 and 9)

No OC or OP pesticides were reported above the laboratory detection limits. However, it is noted that the broad scale analytical scans undertaken for the groundwater investigations were not able to reach detection limits suitable for comparison of results against assessment guidelines. Ultra-trace laboratory analysis would be required to provide a greater degree of confidence in the absence of pesticide contamination.

Other Semi-Volatile Organic Compounds (Table 9)

Analysis was undertaken for a large variety of other SVOC's. Results of note included:

- Butylbenzylphthalate at a concentration of 4 µg/L was noted in MW-4. This exceeds the fresh water guideline of 0.2 µg/L.
- The presence of acetophenone in bores MW1 (1,240 µg/L), MW3 (5 µg/L), MW6 (3 µg/L) and MW8 (54 µg/L). The concentrations reported were all well in excess of the adopted USEPA PRGs for tap water (0.042 µg/L).
- The presence of isophorone at a concentration of 223 µg/L in bore MW1 which is in excess of the adopted USEPA PRGs for tap water (71 µg/L). Lower concentrations of isophorone were also detected in MW8 (36 µg/L) and MW3 (3 µg/L).

Chlorinated Aliphatic Hydrocarbons (Table 10)

There are no applicable DEP guidelines, however comparison to the USEPA and Dutch Intervention guidelines indicates the concentrations generally exceed both guideline levels for many of the identified compounds in bores MW1, MW4, MW7 and MW8.

Chlorinated aliphatic hydrocarbons were detected in all nine shallow groundwater monitoring bores. The main compounds detected in order of decreasing concentrations were cis-1,2-DCE, PCE, 1,1-DCA, TCE and TCA. Concentrations of cis-1,2-DCE ranged between 9 µg/L in MW-2 and 7,920 µg/L in MW1. All but MW2 and MW6 had concentrations above the USEPA PRG of 61 µg/L.

Concentrations of PCE ranged between <5 µg/L (MW3) to 1,040 µg/L (MW7) with results from all bores except MW3 exceeding the USEPA PRG of 1.1 µg/L and MW1, MW2, MW4, MW7 and MW8 exceeding the Dutch Intervention Level (40 µg/L).

Concentrations of trichloroethene (TCE) ranged between <5 µg/L (MW3 and MW5) and 278 µg/L (MW8). All detected concentrations exceeded the USEPA PRG of 1.6 µg/L.

1,1,1- trichloroethane (TCA) was detected in 3 wells, MW1 (351 µg/L), MW4 (375 µg/L) and MW8 (372 µg/L) above the Dutch Intervention Level (300 µg/L) but not the USEPA PRG (540 µg/L).

1,1-dichloroethene (1-,1-DCE) was present in 2 wells at concentrations of 249 µg/L (MW1) and 6 µg/L (MW5). Both concentrations exceeded the USEPA PRG of 0.046 µg/L, but only MW1 exceeded the Dutch Intervention Level (10 µg/L).

Whilst many of these compounds are individual solvents, some are typically encountered as breakdown products of other compounds. In general, the order of 'decay' of the chlorinated aliphatic hydrocarbons is evident in the names of the compounds, as shown by the first letter of the abbreviated name of the compound from P to T to D to no prefix. (eg. PCE to TCE to cis-1,2-DCE to CA (chloroethane)). However, given the likely variable nature of materials used on site, it could be difficult to assess trends in degradation.

Figure 11 shows the inferred distribution of PCE within the perched groundwater.

The distribution shown suggests that the Process Area / unsealed former laneway may not be the only source area. The highest concentration was reported from MW7. This may be a result of the migration of contaminants from the Process Area, or possibly from leakage from the Front Bund Sump.

A potentially separate contaminant plume appears to be present beneath Lot 88. This may be the result of historical spillage through the broken bund wall adjacent the PCE sludge storage area, or it could be associated with the degraded nature of the concrete slab which may have allowed the migration of fluids into the subsurface.

However, it does appear that PCE (and other chlorinated solvents) is migrating off-site across the Lot 2 boundary and potentially downwards to the regional water table aquifer.

Ketones (Table 10)

Comparatively high concentrations of two specific ketones were reported in most bores. Methyl ethyl ketone (MEK) was reported in all bores except MW2, MW6, MW7 and WCB11 at concentrations ranging from 92 µg/L to 18,600 µg/L. Concentrations above the USEPA PRG of 1,900 µg/L, were reported from bores MW1 (12,100 µg/L), MW4 (18,600 µg/L), MW5 (3,670 µg/L) and MW8 (2,160 µg/L).

Figure 12 shows the inferred distribution of MEK within the shallow groundwater.

Methyl isobutyl ketone (MIBK) was reported in all bores except MW2, MW6 and MW7 at concentrations ranging from 67 µg/L to 514,000 µg/L (514 mg/L). Comparatively high concentrations (>80,000 µg/L) were reported from bores MW1 and MW4 indicating a generally similar distribution to MEK with a extremely concentrated plume directly beneath the Process Area and relatively low concentrations elsewhere on-site. The USEPA PRG for MIBK is 160 µg/L.

Other Volatile Organic Compounds (Table 10)

Analysis was undertaken for a variety of other VOC's. Results of note included:

- Elevated concentrations of n-propylbenzene, isopropylbenzene and various isomers of dichlorobenzene and trimethylbenzene, considered to be breakdown products of other organic compounds. The highest concentrations were again reported from MW1 and MW4, with comparatively low concentrations in bores MW3, MW7 and MW8. The concentrations reported were generally in excess of the USEP PRGs for tap water, and in the case of 1,2-dichlorobenzene, were in excess of the guidelines for fresh waters for MW1, MW3, MW4 and MW8.

- Elevated concentrations of chloroform were present in all bores with the exception of MW3 and MW5. Concentrations ranged from 19 µg/L in MW6 to 865 µg/L in MW8. The highest concentrations (>200 µg/L) were reported from bores MW8, MW4, MW1 and WCB11. The USEPA PRG for chloroform is 0.16 µg/L.

- Concentrations of styrene were detected in MW1 and MW4, however, the concentrations did not exceed the USEPA PRG or Dutch Intervention Level.

It is also noted that due to the level of contamination, the detection limits were raised for MW1 and MW4 by approximately two orders of magnitude for many of the VOCs. Therefore it is possible that other compounds may be present at concentrations below the detection limits in these bores.

10.2 Intermediate / Regional Water Table Zone

10.2.1 Groundwater Flow

The intermediate zone refers to the upper zone of the regional water table aquifer. Flow within this aquifer is expected to be towards the southwest on a regional basis, with possible discharge to the Helena River. However, this requires confirmation.

The on-site investigations have shown that recharge to the intermediate zone appears to be dependent on the presence of the shallow confining clay. The inferred extent of the clay is shown on Figure 13, along with the relative groundwater levels in the intermediate groundwater bore network obtained on 21 November 2001.

Whilst the occurrence of preferential recharge zones could be expected to lead to groundwater mounding in these areas, this has not been identified beneath the Waste Control Site. This may be due to the sandy nature of the intermediate zone enabling the relatively rapid dispersion of any recharging water. Groundwater flow has been interpreted to be consistent with the regional data (Davidson, 1995), with flow towards the west or southwest.

It is noted that the WRC bore WCB9 located about 50 m east of the site on Lot 2 was used to assist in the calculation of estimated groundwater flow. Data was also collected from WRC bore WCB12 located about 40 m west along Oliver Street. However a relative water level of 10.96 mAHD was calculated (compared to a maximum of 9.66 mAHD on-site). A review of the bore construction details (refer Table 1) suggests this bore may effectively screen both the shallow and intermediate zones and therefore the data has been excluded from groundwater flow calculations.

10.2.2 Aquifer Parameters

Analysis of the data collected from rising head tests completed in two of the intermediate bores indicated a calculated permeability (K) ranging from 2 to 29 m/day, although the reliability of the upper estimate is questionable. Assuming a K of 1 to 10 m/day, this is considered a moderate relative permeability, typical of fine to medium grained sands (USDOI, 1981). This seems a fair estimate of the upper intermediate aquifer given the aquifer conditions encountered were noted to be coarse grained clayey sands.

Flow beneath the site appears relatively constant compared to the shallow zone, with a hydraulic gradient of approximately 0.008 calculated for Lot 88.

Based on these calculated parameters and an estimated porosity of 20% for clayey sands, the seepage velocity for the intermediate zone is estimated to be in the range of 14 to 140 m/year.

10.2.3 Groundwater Quality

The level of contamination present in the groundwater again restricted an assessment of the inherent quality of the groundwater in terms of salinity. However, at location WCT2, the interference was less evident and a TDS of 618 mg/L was reported indicating a potential for fresh groundwater resource.

The pH of the intermediate groundwater ranges from 6.10 (WCT3) to 9.37 (MW22I). With the exception of MW22I, the results indicate slightly acidic conditions, as identified for the shallow groundwater. The pH recorded for bores MW23I, WCT2 and WCT3 were below the lower range of the DEP freshwater guidelines of 6.5 pH units. The pH recorded for bore MW22I was above the upper range of the DEP freshwater guidelines of 9.0 pH units. It is possible that this is associated with the presence of lime from the placement of the cement/seal during construction. Resampling of the groundwater bore is required.

Sampling has shown that groundwater in all of the five on-site and one off-site intermediate monitoring bores sampled, is contaminated to some extent. The lowest level of contamination is evident in WCT2 located in the eastern (upgradient) corner of the site. The highest impact is evident in bores MW21I, MW22I and WCT3, located in the general area of the Process Area and unsealed former laneway. WCT3 located on the central eastern side of the site displayed 8 cm of a light non-aqueous phase liquid (LNAPL). Fingerprint analysis of a sample of this product identified the presence of palmitic and stearic acid as well as chlorinated solvents, gasoline and petroleum oil.

The distribution of contaminants within the intermediate zone is interpreted to be dependant on three major factors:

- the location of the zone of transfer between the shallow and intermediate groundwater resources;
- the direction of flow within the intermediate zone; and
- the physical properties of the different contaminants.

The nature and extent of the contamination identified is discussed in the following sub-sections.

Metals (Table 7)

Concentrations of metals were reported from most bores, but only exceeded the fresh water guidelines for copper. The reported concentrations were generally well below those reported in the shallow zone. Results of note for the different metals analysis included the following:

- Cadmium and mercury were not reported above detection limits in any of the six bores.
- Copper was reported at concentrations elevated above 0.005 mg/L (the freshwater guideline) in bores MW21I, MW22I, WCT3 and WCB13 with a maximum of 0.029 mg/L from WCT3.

TPH / BTEX Compounds (Table 7)

Organic contaminants have been detected within the intermediate groundwater above expected background levels and available criteria. TPH results, ranged from 1,351 µg/L in WCT2 to 128,250 µg/L (128.3 mg/L) in WCT3. The results for all bores were in excess of the Dutch Intervention Levels for TPH C_{10} – C_{36} fraction of 600 µg/L.

Toluene and xylene are generally present at comparatively high concentrations (>2,000 µg/L) in excess of available guideline levels in bores MW21I, MW22I and WCT3 and at varying and lesser concentrations in MW23I. Ethylbenzene is similarly distributed but is present at a concentration an order of magnitude less than toluene/xylene concentrations (maximum of 615 µg/L in MW21I). However, the concentration of ethylbenzene in MW21I, MW22I and WCT3 still exceed the DEP fresh water guideline of 140 µg/L.

Figure 14 shows the inferred distribution of xylene within the intermediate groundwater. This suggests concentration hot spots beneath the areas of shallow groundwater seepage, with subsequent migration down gradient towards the west-southwest. Off-site migration is likely across the Lot 2 and Pioneer site boundaries.

Benzene has been reported above the detection limit of 1 µg/L in MW23I (2.2 µg/L) only. However, the detection limit for MW21I, MW221 and WCT3 was raised to 100 µg/L due to the high level of contamination.

PAH Compounds (Table 8)

Total PAHs were detected in bores MW21I (18 µg/L), MW22I (68 µg/L) and WCT3 (27 µg/L) above the DEP freshwater guideline of 3 µg/L. Naphthalene was the main individual compound identified with a highest concentration of 58 µg/L in MW22I.

The plume of elevated PAHs appears to be concentrated around the interpreted source areas in the centre of the site.

Phenols (Table 8)

Concentrations of phenols were detected in bores MW21I, MW22I and WCT3, with lower levels also reported from MW23I and WCB13. The main individual compounds identified were phenol, 2,4-dimethylphenol and 2-, 3- and 4-methylphenol. Phenol was present above the DEP freshwater guideline of 50 µg/L in MW21I (61 µg/L) and WCT3 (9,950 µg/L). However, the concentrations do not exceed the USEPA PRG of 22,000 µg/L. While DEP criteria do not exist for 2-, 3- and 4-methylphenol, the concentrations detected do not exceed the USEPA PRGs for tap water, with the exception of WCT3. In this bore, 2,4-dimethylphenol (1,350 µg/L), 2-methylphenol (3,210 µg/L) and 3- and 4-methylphenol (12,200 µg/L) were present at one to two orders of magnitude greater than the respective USEPA PRGs.

Pesticides (Tables 8 and 9)

As for the shallow groundwater, no OC or OP pesticides were reported above the laboratory detection limits in the regional water table. It should be noted however , that the detection levels were generally higher than the individual guideline levels.

Other Semi-Volatile Organic Compounds (Table 9)

Analysis was undertaken for a large variety of other SVOC's. Results of note included:

- Elevated concentrations of bis (2-ethylhexyl) phthalate (27 µg/L), butylbenzyl phthalate (25 µg/L) and di-n-butyl phthalate (16 µg/L) were detected in excess of the guidelines for fresh water in WCT3.
- Concentrations of acetophenone in bores MW21I (70 µg/L), MW22I (25 µg/L) and WCT3 (156 µg/L) were detected in excess of the USEPA PRG of 0.042 µg/L.
- Concentrations of isophorone ranging from 2 µg/L (MW23I) to 68 µg/L (WCT3) were detected but were below the USEPA PRG of 71 µg/L.

Chlorinated Aliphatic Hydrocarbons (Table 10)

The assessment of chlorinated aliphatic hydrocarbons in the intermediate groundwater was hampered by the need to raise the detection limits by two orders of magnitude for MW21I, MW22I and WCT3. However, it appears that the same range of compounds were detected in the three remaining bores with the highest concentrations reported for cis-1,2-DCE and PCE.

Concentrations of cis-1,2-DCE ranged between 32 µg/L (WCT2) and 2,590 µg/L (WCT3) and all but WCT2 exceeded the Dutch Intervention Level of 20 µg/L. PCE was present at concentrations ranging between 11 µg/L (WCT2) and 393 µg/L (WCT3). The concentrations in MW23I and WCT3 exceeded both the USEPA PRG (1.1 µg/L) and the Dutch Intervention Level (40 µg/L).

Figure 15 shows the inferred distribution of PCE within the intermediate groundwater. The location of the core of the plume is unclear (as it would appear to be on Lot 2), but is likely to be situated in the eastern/central portion of the site. The migration of the plume to the southwest appears to be advanced with possible migration beyond the Pioneer, Oliver Street and Lot 2 site boundaries. However, further investigation would be required to assess the extent of migration.

Ketones (Table 10)

As exhibited in the shallow perched groundwater, comparatively high concentrations of two ketones were reported in most bores. MEK was reported at concentrations ranging from 150 µg/L to 14,700 µg/L with concentrations above the USEPA PRG of 1,900 µg/L reported from bores MW21I and WCT3. Figure 16 shows the inferred distribution of MEK within the intermediate groundwater. The core of the plume appears to be present in the central/eastern portion of the site, but the migration of the plume to the southwest appears to be more advanced than other contaminants and is likely beyond the Pioneer, Oliver Street and Lot 2 site boundaries.

MIBK was reported at comparatively high concentrations in bores WCT3 (3,130 µg/L), MW23I (7,160 µg/L) and WCB13 (132,000 µg/L), whilst the results for bores MW21I and MW22I were less than the detection limit of 5,000 µg/L. This distribution coupled with the highest concentration of 132,000 µg/L (132 mg/L) being recorded at WCB13 located the furthest downgradient indicates that the most concentrated section of the contaminant plume appears to have migrated off-site to the south west within the intermediate groundwater. However, a further off-site assessment would be required to assess plume migration.

Other Volatile Organic Compounds (Table 10)

Analysis was undertaken for a variety of other VOC's. Results of note included:

- Elevated concentrations of the various isomers of dichlorobenzene. The highest concentrations were reported from WCT3 (207 µg/L 1,2-dichlorobenzene) with levels in excess of the guidelines for fresh waters (2.5 µg/L) for MW21I (11 µg/L) and WCT3 (207 µg/L). 1,3- and 1,4-dichlorobenzene were also detected at concentrations in excess of the freshwater guidelines in WCT3 (22 µg/L and 91 µg/L respectively).

- Elevated concentrations of the various isomers of trimethylbenzene (1,2,4- and 1,3,5-trimethylbenzene). Concentrations ranging from 15 to 255 µg/L were reported for bores MW21I, MW22I, MW23I and WCT3 at levels in excess of the USEPA PRGs of 12 µg/L.

- Concentrations of chloroform ranging between 27 µg/L and 105 µg/L in MW21I, MW23I and WCB13. The USEPA guideline for tap water is 0.16 µg/L.

It is again noted that due to the level of contamination, the detection limits were raised for MW21I, MW22I and WCT3 by two orders of magnitude for many of the VOCs indicating that other compounds identified as not detected, may be present at lower concentrations.

Other Issues

It is also noted that the WRC completed a round of groundwater sampling and analysis of bores within two weeks of the sampling programme completed by URS. The WRC programme included the analysis of samples from WCB9 and WCB12, which intersect the regional water table within 50 m of the site to the east and west respectively.

Analysis of these samples did not report concentrations of any organic compounds above detection limits, and only trace concentrations of some metals suggesting groundwater at these locations was not impacted by the contamination identified on-site.

The data validation guidelines adopted by URS provide a consistent approach for the evaluation of analytical data. These guidelines are based upon data validation guidance documents published by the USEPA and the NEPC. The process involves the checking of analytical procedure compliance and an assessment of the accuracy and precision of analytical data from a range of quality assurance/quality control (QA/QC) measures, generated from both the sampling and analytical programs.

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

- preservation and storage of samples upon collection and during transport to the laboratory;
- holding times;
- use of appropriate analytical procedures;
- required limits of reporting;
- frequency of conducting quality control measurements;
- laboratory blanks;
- field duplicates;
- laboratory duplicates;
- matrix spike/matrix spike duplicates (MS/MSS);
- surrogates (or System Monitoring Compounds); and
- the occurrence of apparently unusual or anomalous results, eg. laboratory results that appear to be inconsistent with field observations or measurements.

Validation summary reports and tables of field duplicates, laboratory duplicates and matrix spike/matrix spike duplicates are provided as Appendix F. From this information an assessment of the quality of the soil and groundwater analytical data was made.

11.1 Soil Analytical Data

It is assessed that the accuracy and precision of the soil data, as implied from the QA/QC information available for this project, are of sufficient standard such that the data as reported by the analytical laboratory can be used as a basis of interpretation, with reference to the following points:

- Samples SB03_3.7-3.9, SB05_4.8-5.0, SB06_0.2-0.4 and SB10_0.1-0.2 were analysed by the laboratory outside of recommended holding times for one or more of the following analytical types; BTEX compounds, TPH, SVOCs and VOCs. Consequently concentrations of these analyses may potentially be under reported for these samples.

- All samples selected for PCB testing, were analysed by the laboratory outside of recommended holding times. Consequently concentrations of these analyses may potentially be under reported for these samples.

- Guidelines were lower than laboratory limits of reporting (LOR) for a number of semi-volatile and volatile analyses. This lack of definitive data should be taken into account when interpreting results.

- Field duplicate relative percent differences (RPDs) were elevated (greater than 30%) for nickel in sample MW8_5.9-6.0 and its duplicate QA6_14/11/01, and a number of SVOC / VOC analytes in sample SB11_4.9-5.1 and its duplicate QA4_7/11/01. This lack of precision can most likely be attributed to sample heterogeneity, which is not uncommon for soil samples. This would not be expected to affect the interpretation of results for the majority of analytes in question, as concentrations were generally below guidelines, but should be taken into account for samples which reported concentrations close to guidelines.

11.2 Groundwater Analytical Data

It is assessed that the accuracy and precision of the groundwater data, as implied from the QA/QC information available for this project, are of sufficient standard for interpretive use, however consideration should be given to the following points:

- Laboratory duplicates were not reported according to URS Specification, which recommends that 1 in 10 samples be duplicated. Sufficient laboratory quality control (QC) data exists for an assessment of laboratory precision however. For analytical types where no matrix spikes were reported, the accuracy of the data can still be assessed as surrogate recoveries and laboratory control sample spikes were reported.

- Guideline criteria were lower than laboratory limits of reporting (LOR) for a number of semi-volatile and volatile analyses. This lack of definitive data should be taken into account when interpreting results for these analyses.

- Rinsate blanks were not collected as dedicated sampling equipment was used for groundwater purging and sampling.

- Field relative percent differences (RPDs) were elevated (greater than 30%) for a number of analytes in sample MW3_22/11/01 and its duplicate QAW1_22/11/01. For the majority of analytes, RPDs were only marginally greater than 30% or alternatively, close to LOR (where precision is inherently low) and consequently, this apparent lack of precision would not be expected to affect the interpretation of results. For ethylbenzene and TDS however, the variation in sample and duplicate concentrations cannot be attributed to these factors and care should be taken when interpreting sample results.

12.1 General

Solvent recycling operations (via distillation) and the receipt of wastes commenced on Lot 99 in 1987. By 1992, the operations had expanded onto Lot 88, which had been operated as a carpark the previous year.

The objective of the assessment was to investigate the nature and extent of contamination present on-site, as a result of the fire and historical operation of the site. Off-site issues associated with potential off-site sources and/or contaminant migration were not assessed as part of our investigation.

The PSI completed by URS in October 2001 detailed the history of activities at the site, outlined areas of potential environmental concern and proposed a sampling and analysis plan to enable further assessment of these areas through a programme of subsurface soil and groundwater investigations.

A programme of soil and groundwater investigation was completed between 5 November 2001 and 12 December 2001. Soil bores were completed at a total of 25 locations across the site, with 11 bores converted to groundwater monitoring bores through the installation of PVC casing.

The DSI was intended to provide an initial assessment of the soil and groundwater conditions within the confines of the Waste Control Site. This DSI comprises the initial component of a multi-staged assessment process. Information gathered during each investigation stage should be used to design subsequent investigations, thereby optimising the work required to determine the appropriate management strategies for the site.

12.2 Site Stratigraphy

The investigations indicated that there is a shallow clay unit present about 5 mbgl across a large portion of the site. This low permeability unit appears to retard the vertically downward movement of water and as a result, a shallow, perched water table has formed in the overlying sands and sandy clays about 3.5 mbgl. However, the clay unit is discontinuous, and where it is not present, the shallow groundwater appears to seep downwards to the regional water table, which is present approximately 9.5 mbgl. It appears that the clay is present across the majority of the site, with the exception of an area along the central eastern portion of the site and the northern corner of the site. In these areas it appears that the clay thins or grades gradually to sandy clay/clayey sand, which allows for the vertical migration of groundwater.

Three of the bores were extended beneath the shallow clay unit to a maximum of 12.5 mbgl and converted to intermediate groundwater monitoring bores to monitor the regional water table. All other bores were completed to investigate the shallow perched water system, as this is currently serving as the contaminant source to the regional water table.

12.3 On-site Soil Quality

Field observations from the sub-surface investigations suggest that the soils are heavily impacted in many locations as various zones of staining, PID readings and odours were identified. Based on field observations, these zones of impact include :

- A possible former ground surface around 0.5 mbgl on Lot 88.
- Directly beneath the concrete slabs on both Lots 88 and Lot 99.
- The former location of two separate groups of USTs used to store waste and recycled solvents on Lot 99.
- A former unsealed former laneway through the middle of the site (boundary of the two allotments).
- The saturated zone of the shallow, perched water table between 3 and 5 mbgl across the majority of Lot 99 and part of Lot 88.
- The areas of seepage between the shallow, perched water table and regional water table along the Lot 2 site boundary, and in the northwestern area of the site near the Pioneer site boundary.
- The zone of fluctuation of the regional water table.

Laboratory analysis of 56 selected soil samples for a wide range of compounds was undertaken to assess the level of contamination identified. In general, given the sandy nature of the soil profile above the shallow clay unit, the concentrations detected in the analytical samples do not necessarily represent the extent of impact based on field observations.

Concentrations above the draft DEP EILs were identified in samples from 8 of the 25 bores, whilst the concentrations exceeded the HIL-Fs at three locations. The main contaminants identified were generally related to the various solvents (chlorinated and non-chlorinated) previously stored on-site including xylene, toluene and phenols, with relatively minor concentrations of various metals identified. Concentrations above the EILs were noted in the central portion of the Process Area on Lot 99 (phenol, toluene, xylene and other volatile organics) and in the southwestern portion of Lot 88 (toluene and chromium).

Elevated concentrations were generally associated with the zone of staining directly beneath the concrete slabs, or the saturated zone of the shallow, perched water table. The highest degree of contamination was reported from the saturated zone in the area of former USTs on Lot 99 (SB11_4.9-5.1), where TPH C_6-C_9, TPH C_{10}-C_{14}, toluene, ethylbenzene and naphthalene were identified in excess of the EILs, xylene in excess of the HIL-Fs and a range of volatile organic compounds including PCE, TCA, TCE and trimethylbenzene were elevated above the laboratory detection limits.

In general, the transport of volatile organic compounds and in particular non-aqueous phase liquids (NAPLs), through the unsaturated zone is extremely complex and is dependent on physical, chemical and biological properties such as density, water solubility, vapour pressure, Henry's constant, sorption, oxidation and biological degradation. In addition, the presence of NAPLs such as chlorinated solvents, which are denser than water (DNAPLs) and toluene, ethylbenzene and xylenes, which are lighter than water (LNAPLs) gives rise to migrating vapour plumes, which in turn partition to the water and soil phases thereby extending the zone of contamination beyond the region of the source area. Furthermore, chlorinated solvents are not always strongly sorbed onto geologic materials.

These fate and transport characteristics represent some of the reasons why field observations indicated the presence of significant impacts, while the laboratory analysis, although displaying evidence of impacts, were not overly contaminated.

In addition, discussions with the laboratory have identified that a number of the samples may have contained compounds such as cyclohexanes, which are highly aromatic and odourous. In general, cyclohexanes are used as a solvent for lacquers and resins and are found in paint and varnish removers. Compounds such as cyclohexanes are not included within standard targeted analysis.

Initial screening for PCB's did not indicate concentrations above laboratory detection limits, however further detailed testing is required.

Finally, of note was the lack of detection of mercury in all soil (and groundwater) samples across the site, including six soil samples recovered from the area of an alleged mercury spill during the post-fire clean-up operations. However, it should be noted that the exact location of the alleged spill could not be defined by Dr. Claflin.

12.4 Groundwater Flow Characteristics

The investigation of groundwater included the sampling of 15 groundwater bores, 11 of which were installed during the field programme. Of the bores sampled, 9 were constructed within the shallow perched water table, whilst 6 were constructed within the regional water table (intermediate zone).

The investigations indicate that flow within the shallow, perched water table is associated with the extent of the shallow clay unit. Groundwater flow is towards those areas where the clay becomes sandier, and the shallow, perched groundwater is able to seep down to the regional water table. Based on the current data set, the majority of flow appears to be generally towards Lot 2 to the east. However, flow within this aquifer system is not constant and is likely to be changeable or discontinuous due to influences including seasonal recharge. The shallow, perched water table was not present on the eastern corner of the site.

Groundwater flow within the regional water table is more constant. As suggested from previous regional studies, flow within this aquifer is generally towards the west or south-west resulting in flow across the Pioneer and Oliver Street site boundaries. This infers that groundwater within the two aquifer systems is moving in almost opposite directions beneath the Waste Control Site. However, this is not unreasonable given the perched nature of the upper unit.

Preliminary aquifer testing suggests the sandy nature of the regional water table aquifer results in a higher permeability than that encountered within the shallow aquifer system.

12.5 On-site Groundwater Quality

Laboratory analysis of groundwater samples from the 15 monitoring bores confirmed contamination is present in both the perched and regional groundwater units. Samples from every bore reported at least one contaminant at concentrations in excess of the investigation levels adopted. The groundwater in both aquifer systems is believed to be fresh (TDS<1,000 mg/L) however an accurate assessment of background water quality has been difficult due to the interference caused by contamination in all 15 bores sampled.

Groundwater contamination within the shallow aquifer system appears to be concentrated beneath the former distillation area (Process Area) on Lot 99 and the unsealed former laneway between the allotments. However, the distribution of the different contaminants varies, presumably due to differing source areas and differing behaviour within the groundwater once released, as mentioned above. This is particularly evident for the chlorinated solvents including PCE.

Significant groundwater contamination is present within the shallow aquifer system along the Lot 2 and Pioneer site boundaries. Off-site flow of this contaminated groundwater is most likely across the Lot 2 site boundary. A further off-site investigation would be required to assess groundwater migration and contaminant fate and transport.

In regards to comparison with DEP fresh water criteria, the predominant compounds detected above these criteria where available, included copper, nickel, ethylbenzene, toluene, total PAHs, butyl benzyl phthalate, phenol and 1,2-dichlorobenzene. It should be noted however that the flow of the shallow perched water zone to a fresh water receptor has not been identified or assessed and this use of freshwater criteria is for comparison purposes only.

Those compounds where freshwater criteria were not available were compared with USEPA PRGs for tap water or the Dutch Intervention Levels. Compounds noted to exceed these criteria included some of those detailed above, as well as xylene, naphthalene, select phenols, acetophenone (a colourless liquid with a sweet pungent odour used in specialty solvents and as a resin intermediate), isophorone (used in solvents, printing inks and lacquers), chlorinated solvent compounds, MEK, MIBK, and the various dichloro and trimethyl benzene compounds. Again, it is noted that drinking water criteria may not be appropriate comparison criteria, as the shallow groundwater is likely not being used for drinking water purposes.

Groundwater contamination within the intermediate aquifer system is also highest beneath the Process Area and unsealed former laneway. This area generally corresponds to the locations where the shallow clay unit is absent, and therefore where the shallow groundwater is likely seeping downward and eventually recharging the regional water table. Contaminant plumes extend beneath and in some cases potentially beyond the site to the southwest and west in accordance with the regional groundwater flow direction.

In regards to comparison with DEP fresh water criteria, the predominant compounds detected above these criteria where available, included copper, ethylbenzene, toluene, total PAHs, various phthalate esters, phenol and 1,2 and 1,4-dichlorobenzene. The regional water table could eventually flow to the Helena River, which would therefore become a potential freshwater receptor. As a number of compounds were detected at the downgradient property boundaries or in the case of WCB13, off-site. A further assessment of off-site migration would be required to assess whether the groundwater contamination identified could impact the Helena River or other potential surface water receptors.

Those compounds where freshwater criteria were not available were compared with USEPA PRGs for tap water or the Dutch Intervention Levels. Compounds noted to exceed these criteria included some of those detailed above, as well as xylene, naphthalene, select phenols (only in WCT3), acetophenone, chlorinated solvent compounds, MEK, MIBK, chloroform and the various dichloro and trimethyl benzene compounds. Again, it is noted that drinking water criteria may not be appropriate comparison criteria; however, the potential exists for the intermediate groundwater unit to be used for reticulation, and therefore allows potential consumption.

In general, a similar suite of compounds was present in both the shallow and intermediate groundwater zones. Of the four locations where well couplets (a shallow bore and an intermediate bore) were present (MW1/MW21I, MW3/WCT3, MW4/MW22I and WCB11/WCB13), three couplet locations showed a generally decreasing trend in all contaminants between the shallow to intermediate wells. There were two notable exceptions however. Concentrations of contaminants were higher in intermediate well WCT3 compared with shallow well MW3 located approximately 10 m to the northeast. WCT3 was not observed to be properly capped when first inspected and it is therefore possible that during the fire, firewater may have flowed directly into the well, causing the presence of higher concentrations of contaminants in this intermediate well. The other exception, is the presence of a high concentration of MIBK in intermediate well WCB13, which is three orders of magnitude higher than its shallow couplet.

Of further note, is the identification of chlorinated solvents in both the shallow and intermediate groundwater systems. Chlorinated solvents are denser than water and as such, when released into the environment, will migrate downwards until they reach a low permeability unit. The shallow clay at 5 mbgl appears to be such a unit but as the clay is discontinuous, it appears that the chlorinated solvents have been able to continue downwards to the regional water table. As the regional water table aquifer is understood to extend to depth with generally sandy sediments, there is a possibility that chlorinated solvent contamination has migrated to the base of this aquifer, beyond the current depth of investigation. Furthermore, regional information suggests that in the Bellevue area, the regional water table aquifer may be in direct connection with the underlying Leederville Formation Aquifer, which forms an important groundwater resource for large parts of the Perth Metropolitan Area. A further assessment of the vertical and horizontal migration of these compounds is required.

12.6 Contamination Summary

The sources of the contamination identified beneath the site are likely to be many and varied, associated with both the historical operations at the site and the fire. The most likely sources are the various sub-surface sumps (predominantly on Lot 99) used to collect product spillage and the unsealed former laneway between the two concrete pads that received spillage throughout the operating life of the site and contaminated water during the fire.

The investigation programme has shown soil and groundwater contamination is present beneath the Waste Control Site. However, groundwater contamination is likely to also be migrating off-site across three of the four site boundaries in two different aquifer systems. In addition, it is possible that groundwater contamination extends below the depth of investigation conducted to date.

Furthermore, during the fire-fighting activities in February 2001, burning drums of waste and batteries were spread across the site boundary onto Lot 2 and contaminated firewater was observed to pond and seep into the ground. In addition, as part of the post-fire clean-up activities, potentially contaminated soil from various locations on-site was spread across Lot 2 once the residual waste products had been removed. Whilst the residual waste products have been removed from this area, there has been no evaluation of the potential impacts to the underlying soil and groundwater resources.

Further evaluation of the vertical and lateral extent of contamination in both soil and groundwater is required.

12.7 Potential Remediation Methodologies

One of the overall objectives of the DSI was to estimate any remediation activities that would need to be undertaken at the site. Whilst the investigations were successful in identifying the nature of contaminants present, the extent of contamination goes beyond the area of investigation, which was focussed on conditions beneath the site itself.

In addition to the issues of contamination extent, the investigations have shown there is a large variety of contaminants present. Each contaminant has different physical and chemical properties that will dictate its mobility within the environment and ability to be remediated or recovered. In addition, the combination of certain chemicals will also change the behaviour of those chemicals in the environment.

Accordingly, it is not considered appropriate to provide any cost or scope estimates for the remediation of this site, without undertaking further investigations.

However, the following information can be used to guide initial discussions on potential remediation methodologies based on the information gathered to date:

- The driver for remediation will likely be groundwater. The apparent solubility of the identified contaminants and the sandy nature of the regional water table aquifer indicate that the groundwater is the main environmental media of concern. Remediation will most likely be centred around the management of the spread of the contaminant plume within the regional water table aquifer.
- Many of the contaminants identified are volatile in nature, suggesting they may be amenable to remediation via volatilisation (i.e. transferring the contaminants to a gas phase to enable recovery). Possible remediation techniques include ex-situ method such as air-stripping (aeration of extracted groundwater) and *in situ* methods such as air-sparging (a process of injecting air into the aquifer) with associated and vacuum extraction (a process of extracting air and possibly water from the ground).
- Conversely, the treatment of volatile contaminants will inevitably result in the discharge of odour during remediation activities. This is particularly the case if excavation of contaminated soils is required, which will likely require additional odour management.
- Breakdown of many of the contaminants is likely to be enhanced by oxidation of the groundwater. This could be achieved through air-sparging (as mentioned above) or the addition of oxidising agents such as potassium permanganate or hydrogen peroxide.
- If DNAPL contamination is present, the scope of remediation activities may increase significantly due to the potential need to recover / treat groundwater at depth (>30 m) and the associated increase in volume of groundwater requiring removal.

Remediation management of the soils also requires further consideration. Groundwater remediation techniques may work to reduce the level of contaminants in soil concurrently. However, isolation of the zones of contaminated soil directly below the concrete slabs and at the inferred former ground from future site occupants is likely to be required. This may be able to be achieved through capping or removal. However, this would require memorials of title, as well as confirmation that the soil was not continuing to impact groundwater.

12.8 Current Management Issues

Based on the investigation results and as the site is unoccupied and inaccessible to the general public, there does not appear to be an immediate human health risk associated with the site conditions. However, further investigation is required to assess the risk to the following potential receptors of contaminated soil, groundwater or vapour:

- People coming in direct contact with the potentially contaminated soil on Lot 2.
- People coming in contact with transported contaminated soil associated with dust generation from the site and Lot 2.
- People conducting sub-surface excavations or entering underground inspection pits above or near any impacted soil or groundwater plume in the vicinity of the Waste Control Site.
- Occupants of buildings with areas where vapours could collect (eg. basement) above or near any impacted soil or groundwater plume in the vicinity of the Waste Control Site.
- The Helena River and users of the river.
- Any users of the groundwater resources within or near the impacted groundwater plume. Preliminary investigations indicate there is only one groundwater bore registered within a 500 m radius of the site. However, it is recommended that a survey of the properties in the immediate vicinity of the Waste Control Site be undertaken to determine if anyone is accessing potential contaminated groundwater.

As previously discussed, the investigation conducted was designed to get an initial and overall understanding of the environmental setting and contamination issues associated with the site. The investigation has identified a number of issues that require further assessment before remedial and / or management requirements can be assessed.

Based on the above, the following general recommendations are made in regard to further site assessment:

- A bore search / doorknock survey to assess the presence of groundwater users (i.e. residences and businesses) in the vicinity of the site, particularly to the southwest.
- The delineation of groundwater contamination in the shallow perched aquifer system. This would require off-site bores on Lot 2 and the Pioneer site.
- The delineation of groundwater contamination in the upper zone of the regional water table (intermediate zone). This would require off-site bores on Lot 2, the Pioneer site and to the southwest of the site beyond Oliver Street. This would also require access to bore WCT1, which is currently covered by a large piece of equipment that will require a crane to move.
- The investigation of potential DNAPL contamination associated with chlorinated solvents. This would require investigation deeper into the regional water table, potentially to the base of the aquifer. These deeper bores would be targeted in the areas where contamination is suspected to have entered the regional water table.
- Further evaluation of the contaminants present in soil and groundwater on-site (and off-site) through testing for additional analytes including, but not limited to, PCBs and dioxin, as well as laboratory library searches for tentatively identified compounds.
- Investigations to better define the status of soil and groundwater conditions on Lot 2 associated with the impacts of fire fighting and clean–up issues. Such issues include the spread of the battery store, the ponding of contaminated firewater and the contaminated soil spread across Lot 2.
- Further evaluation of the seasonal nature of the shallow perched water table. This would require regular (possibly monthly) groundwater level gauging events.
- More detailed testing of the aquifer properties of the regional water table through groundwater pumping tests.
- A detailed evaluation of the biodegradation capacity, physical, chemical and toxicological properties of the various contaminants and the water bearing units.
- Predictive groundwater and contaminant transport modelling to gain an understanding of the likely fate of the contaminated groundwater plumes (particularly for the assessment of remedial options).
- The further assessment of potential remediation technologies. A computer model as mentioned above would be able to be used to predict the impacts of technologies such as active groundwater recovery.

- Potential trialing of the most likely remediation methods through the development of pilot trials.

The completion of these tasks would be best undertaken in a staged process to optimise the overall investigations.

The community should continue to be informed and consulted regarding developments in the management of the site. The existing community consultation plan should be modified to include new results and site information, as it is obtained.

In addition, it is recommended that access to the site be controlled as not to allow construction works and / or groundwater withdrawal without appropriate health and safety management plans. If it appears that groundwater receptors are present, steps should be taken to assess groundwater quality in the vicinity of the receptor and, if required, restrict usage.

URS Australia Pty Ltd (URS) has prepared this report for the use of the Western Australia Department of Environmental Protection (DEP) in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the proposal dated 1 August 2001 (Ref : 01-215 / 548-F4064.0).

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 1 November 2001 and 22 January 2002 and is based on conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This Phase 2 environmental site assessment addresses the likelihood of environmental liability resulting from past and current known uses of the property and the immediately adjacent properties.

This investigation is limited to interview(s) with personnel and a review of reports and literature, visual observation of surface conditions at the property, sampling and analysis of soil and groundwater The sampling and/or laboratory analysis undertaken as part of this investigation is confined to a limited number of surface and near surface soil samples.

Opinions and recommendations contained in this report are based upon data provided by representatives of the DEP, Cleanaway Technical Services, Waste Control and information gained during site inspection and fieldwork, employee interviews and information provided from government authorities' records and other third parties. This approach reflects current professional practice for Phase 2 environmental site assessments.

This investigation addresses the likelihood of hazardous substance contamination resulting from past and current known uses of the subject facility. Given the limited and mutually agreed scope of work, URS does not guarantee that hazardous materials do not exist at the subject property. Similarly, a property which appears to be unaffected by hazardous materials at the time of our assessment may later, due to natural phenomena or human intervention, become contaminated.

As a result, certain conditions such as those listed hereafter may not have been revealed:

- naturally occurring toxins in the sub-surface soils, rocks, water or the toxicity of the on-site flora;
- toxicity of substances common in current habitable environments such as stored household products, building materials and consumables;

- sub-surface contaminant concentrations that do not exceed present regulatory standards but may exceed future standards; and/or
- unknown site contamination such as dumping or accidental spillage which may occur following the site visit by URS.

Subsurface conditions can vary across a particular site and cannot be explicitly defined by these investigations. It is unlikely therefore that the results and estimations expressed in this report will represent the extremes of conditions within the site or the conditions at any location removed from the specific points of sampling. Subsurface conditions including contaminant concentrations can also change in a short time.

The information in this report is considered to be accurate at the date of issue and is in accordance with conditions at the site at the dates sampled.

This document and the information contained herein should only be regarded as validly representing the site conditions at the time of the investigation unless otherwise explicitly stated in a preceding section of this report.

No warranty or guarantee of property conditions is given or intended. URS makes no determination or recommendation regarding a decision to provide or not to provide financing with respect to the site.

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