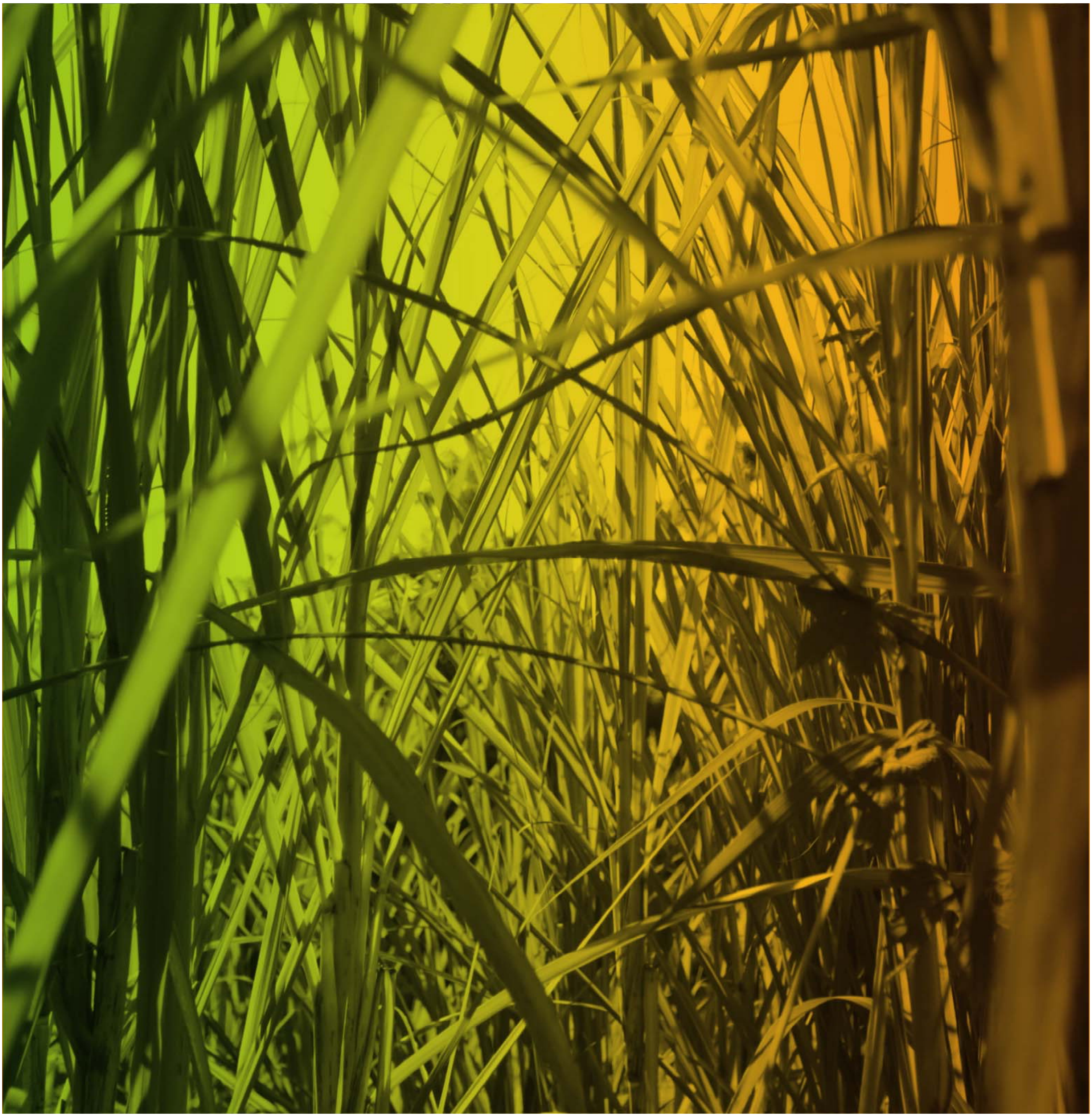
FINAL

Remedial Action Plan

2 Christina Road, Villawood, NSW



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Remedial Action Plan

2 Christina Road, Villawood, NSW

Prepared for

Orica Australia Pty Limited

Prepared by

AECOM Australia Pty Ltd
Level 5, 828 Pacific Highway, Gordon NSW 2072
T +61 2 8484 8999 F +61 2 8484 8989 www.aecom.com
ABN 20 093 846 925

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Prepared by	Andrew Rolfe Author Signature
Reviewed by	Rui Henriques Technical Peer Reviewer Signature

Distribution

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Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
1	16 April 2010	Draft report to Orica and Site Auditor	Andrew Rolfe	
2	2 June 2010	Final addressing Site Auditor comments	Andrew Rolfe	
3	5 November 2010	Final addressing DECCW comments	Andrew Rolfe	
4	10 December 2010	Final addressing Dept of Planning EA Adequacy Review	Andrew Rolfe	
5	28 February 2011	Final addressing DECCW comments (31 January 2011)	Andrew Rolfe	
6	17 March 2011	Final addressing final DECCW comments (11 March 2011)	Andrew Rolfe	

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CONTENTS

List of Tables

Body of Report

List of Figures

Back of Report

List of Plates

List of Appendices

1.0 Introduction

AECOM Australia Pty Limited (AECOM[1]), was commissioned by Orica Australia Pty Limited (Orica) to develop a Remedial Action Plan (RAP) for the former chemical manufacturing facility located at 2 Christina Road ('the Site'), Villawood, NSW (refer to **Figure 1**). The Site was formerly known as the 'Crop Care site'.

This RAP has been prepared to meet the requirements of Remediation Order (RO, No 23019, Area 3200) issued by the NSW Environment Protection Authority (EPA[2]) on 2 November 2005 (refer to **Appendix A**). The current and historical site infrastructure is presented in **Figure 2.**

This RAP supersedes and replaces the original version of the RAP prepared by HLA-Envirosciences Pty Ltd (HLA, 3 October 2007).

1.1 NSW EPA Remediation Order

On 29 July 2004, Orica notified the NSW EPA under Section 60 of the *Contaminated Land Management Act 1997* (CLM Act) that the Site is contaminated in such a way as to present a potential significant risk of harm (SRoH).

The RO states that the Site is contaminated with the following substances:

> *"Total Petroleum Hydrocarbons (TPH);*
>
> *Benzene;*
>
> *DDT (and its degradation products DDD and DDE)[3];*
>
> *1,2-dichloroethane (1,2-DCA)[4];*
>
> *Trichloroethene (TCE);*
>
> *Chlorobenzene (MCB);*
>
> *1,4-dichlorobenzene (1,4-DCB)*
>
> *Hexachlorobenzene (HCB);*
>
> *Lindane (a-BHC);*
>
> *Polycyclic Aromatic Hydrocarbons (PAHs), including Benzo(a)pyrene (BaP); and*
>
> *Cyanide".*

It should be noted that AECOM Phase 1 and 2 Remedial Investigations (RIs) undertaken across the Site did not identify any significant cyanide sources in soil and the analysis of groundwater samples collected from the well network generally reported non-detectable cyanide concentrations. Consequently, cyanide is not considered to be a Contaminant of Potential Concern (CoPC) at the Site.

The EPA has considered that the Site is contaminated in such a way as to present a SRoH to human health and the environment. The risk of harm arises principally from the interaction and mobilisation of these contaminants, resulting in the potential for off-site migration of contaminants via groundwater into adjacent industrial sites and nearby waterways. There is also some risk of direct exposure of workers to the contaminated soil, although there are protocols in place to protect workers working with soil.

On 22 April 2005 the EPA declared the site to be a remediation site, and issued a proposed RO on 11 July 2005. The RO (No 23019, Area 3200) was subsequently issued to Orica on 2 November 2005.

---

[1] *Previously known as HLA-Envirosciences Pty Ltd and ENSR Australia Pty Ltd*

[2] *NSW EPA is part of the NSW Department of Environment, Climate Change and Water (DECCW)*

[3] *DDT and its degradation products will be referred to as DDX throughout this report*

[4] *1,2-dichloroethane will be referred to as EDC throughout this report*

The RO requires Orica to have undertaken a specified number of activities within a defined timeframe, including:

- A remediation technology assessment, including Site Auditor review (Conditions 4E, 4F, 4G, 4H, 4I and 4J) by 30 September 2006; and
- Preparation of a Remedial Action Plan including Site Auditor review (Conditions 4K, 4L, 4M, 4N and 4O) by 31 December 2006. The timeframe for the original RAP (HLA, 2007) was extended by Orica and approved by DEC.

This RAP addresses the requirements of Conditions 4K, 4L, 4M, 4N and 4O of the RO which are detailed as follows:

Condition K. Prepare a RAP for soil impacted by the site contaminants.

Condition L. Prepare a RAP for groundwater impacted by the site contaminants.

Condition M. The RAPs referred to in conditions 4K and 4L must include the following:

- A summary of all investigations carried out in relation to the site contamination, including all investigations carried out in relation to the migration of contamination off the site.
- A clear statement of the scope of work to be undertaken.
- A re-evaluation of options to prevent the migration of contaminated groundwater off the site, the preferred option and reasons for that preference.
- A re-evaluation of options to remediate contaminated site soils that are providing a source of continued groundwater contamination, including reasons for a preferred option.
- A re-evaluation of options to remediate contaminated groundwater at the site, including reasons for choosing a preferred option.
- A re-evaluation of options to remediate contaminated soil and groundwater that has migrated off the site, the preferred option and reasons for that preference.
- A review and revision, if required, of the proposed remediation criteria for soil and groundwater referred to in Condition 4G(vi) that ensure the remediated site will be suitable for its current and approved use(s) as defined in the CLM Act and to the maximum practicable extent for the proposed use(s) of the land.
- If site-specific remediation criteria are proposed, a risk assessment associated with the development of the criteria, being an assessment done in accordance with the NEPM with all site-specific assumptions used in the risk assessment clearly defined.
- Detail of any environmental safeguards required to complete the remediation in an environmentally acceptable manner.
- Detail of validation and ongoing site monitoring and reporting procedures.

Condition N. Engage a Site Auditor accredited under the CLM Act to review the RAPs referred to in conditions 4K and 4L. Orica must ensure that the Site Auditor comments on whether implementation of the RAPs will make the Site suitable for its current and approved use(s) as defined in the CLM Act and to the maximum practicable extent for the proposed use(s) of the land.

1.2 Proposed Future Landuse

At this stage, the future landuse of the Site has not been determined. However, based on the predominantly commercial / industrial landuse in the area surrounding the Site, this RAP anticipates a commercial / industrial landuse for the Site.

1.3 Project Objectives

The key objectives for the proposed remediation works are:

- To ensure that the Site is suitable for the anticipated ongoing commercial / industrial use;
- To protect the environment by ensuring that the identified areas of soil contamination are remediated to the maximum extent practicable such that they do not constitute a contamination source for the Site and the surrounding properties; and
- To comply with legislative requirements and the appropriate requirements from Bankstown City Council, the NSW Department of Planning (DoP)and the NSW Department of Environment, Climate Change and Water (DECCW).

1.4 Scope of Works

The RAP outlines the rationale for remediation works and the proposed methods of excavation of contaminated soils and the on-site ex-situ treatment of these soils for beneficial reuse on-site.

Based on the findings of groundwater modelling (A.D. Laase, 2007,**Appendix B**), it was concluded that the groundwater contamination at the Site is static and is unlikely to migrate to Byrnes Creek due to the effects of retardation, matrix diffusion and biodegradation. Based on these factors and the Site's continued commercial/industrial land use, the Human Health and Environmental Risk Assessment (HHERA) conducted by URS (2011, refer to **Appendix C**) concluded that groundwater did not present an unacceptable risk to human health or the environment. Consequently, remediation of the Site's groundwater is not considered to be required.

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2.0 Assessment and Approval Processes

The proposed remediation project is likely to be declared by the Minister for Planning as a 'major project' under the provisions of the *Environmental Planning and Assessment Act 1979* (EP&A) and *State Environmental Planning Policy (Major Projects) 2005* (SEPP 2005). Project approval is therefore being sought under Part 3A of the EP&A Act.

2.1 Legislation Relevant to Remediation Works

The DECCW administers a number of Acts and legislative instruments relevant to the proposed remediation works at the Site. These include:

- The Contaminated Land Management Act 1997 (CLM);
- The *Protection of the Environment Operations Act 1997* (POEO), in particular, licensing obligations under that Act; and
- The *Environmentally Hazardous Chemicals Act 1985* (EHC), in particular the Chemical Control Order (CCO) for Scheduled Chemical Waste (SCW) and polychlorinated biphenyls (PCBs) under that Act.

2.1.1 Contaminated Land Management Act

The CLM Act is the primary Act under which contaminated land is regulated by the DECCW.

This section addresses the following aspects of the Act:

- Determination and suitability of a contaminated site for a proposed use including the generation of remediation criteria;
- Existing orders and regulatory instruments applicable to the remediation area; and
- Voluntary remediation agreements.

The *Guidelines for the NSW Site Auditor's Scheme* (DEC, 2006) describe a decision process for assessing urban redevelopment sites that should be followed by contaminated land consultants. The Guidelines prescribe soil investigation levels (SILs), which are the concentration levels of particular contaminants above which further investigation and evaluation are required. SILs are arrived at using appropriate sampling, analytical and data interpretation techniques.

However, the substances for which SILs have been prescribed do not include all of the CoPC identified at the Site. The Guidelines make the following provision for such circumstances:

> *"…where SILs are not available for particular contaminants, or assessment of contaminants against SILs at a particular site is inconclusive… The auditor must check whether the risk assessment is in accordance with the NEPM* [National Environmental Protection (Assessment of Site Contamination) Measures] *and any relevant guidelines made or approved by DEC. The auditor must also check that any human health risk assessment satisfies all the requirements in the checklist in Appendix VII. The auditor must check that all site-specific risk assessments are scientifically valid and that the site-specific criteria recommended by the consultant are appropriate to protect public health and the environment."*

Since SILs are not available for all CoPC identified at the Site, it is necessary and appropriate to adopt a health-based risk assessment approach in determining suitable criteria for these chemicals and the level of remediation required for the proposed future use of the Site, which is commercial/industrial. The risk assessment process, by which the site-specific criteria were derived, is summarised in **Section 7.2**.

2.1.2 Protection of the Environment Operations Act

Section 48 of the POEO Act requires a person to obtain a licence from the DECCW before carrying out any of the premises-based activities described in Schedule 1 of that Act.

Schedule 1 includes the following activity:

> *"Contaminated soil treatment works for on-site or off-site treatment (including, in either case, incineration or storage of contaminated soil but excluding excavation for treatment at another site) that:*

- Handle more than 1,000 cubic metres per year of contaminated soil not originating from the site on which the works are located; or
- Handle contaminated soil originating exclusively from the site on which the works are located; and
- Incinerate more than 1,000 cubic metres per year of contaminated soil, or
- Treat otherwise than by incineration and store more than 30,000 cubic metres of contaminated soil, or
- Disturb more than an aggregate area of 3 hectares of contaminated soil."

The current Environment Protection License (EPL) allows for the certain activities at the Site under the POEO Act (refer to **Appendix E**). The remediation works will involve the treatment of approximately 25,000 m^3 of contaminated soil. Accordingly, an application to DECCW to obtain a new license specific to the remediation works will be required.

2.1.3 Environmentally Hazardous Chemicals Act

Under Division 5, Part 3 of the EHC Act (1985), the DECCW can make a Chemical Control Order (CCO) in relation to an environmentally hazardous chemical or a declared chemical waste.

The *Guidelines for the NSW Site Auditor's Scheme* published by the DEC (2006) state that:

> *"CCOs set out requirements for manufacturing, keeping, using, processing, storing, selling, transporting or disposing of chemicals and declared chemical wastes. A site auditor must not endorse a management strategy proposed for a site which involves chemicals or chemical wastes subject to a CCO, unless they are satisfied it complies with the requirements set down in the CCO. For example, certain chemicals occurring above the prescribed concentrations are prohibited from being disposed of at any landfill.*
>
> *There is a program of national management plans for Schedule X wastes (ANZECC 1994b). The program includes wastes associated with HCB (hexachlorobenzene) (ANZECC 1996a), PCBs (polychlorinated biphenyls) (ANZECC 1996b), and OCPs (organochlorine pesticides) (management plan proposed). The national management plans set timelines for the destruction and disposal of Schedule X wastes. The relevant authorities implement regulatory aspects of the plans. Site auditors should be aware that CCOs either have been or will be revised by the EPA* (now DECCW) *as part of implementing the national management plans."*

CCOs are a primary regulatory tool under the EHC Act and are used by the DECCW to control particular compounds, and their potential or actual impact on the environment. The following Scheduled Chemical Waste (SCW) compounds have been detected at the Site:

- Aldrin;
- a-Benzene Hexachloride (BHC);
- b-BHC;
- d-BHC;
- g-BHC (lindane);
- Dieldrin;
- Endrin;
- Endrin aldehyde;
- Hexachlorobenzene (HCB);
- 4,4-dichlorodiphenylethylene (DDE);
- 4,4-dichlorodiphenyldichloroethane (DDD); and
- 4,4-dichlorodiphenyltrichloroethane (DDT).

The CCO in relation to SCW dated 11 June 2004 (the SCW CCO, NSW EPA, 2004a) prohibits the manufacturing, processing, keeping, distributing, conveying, using, selling or disposing of SCW, or any act related to any such act, unless it is otherwise permitted by, and carried out in accordance with the conditions of, the SCW CCO. The SCW CCO (NSW EPA, 2004a) requires a licence for various activities, including treatment. It is understood that DECCW intends to remove the using provision from the CCO but this change has not currently been formalised with an amendment of the CCO.

Material in some localised Site areas is considered HCB waste under the HCB Waste Management Plan (ANZECC, 1996a).

On 29 May 2003 Orica lodged an application to obtain a License from the NSW EPA under the EHC Act, to store scheduled chemical wastes at the Site under the provisions of the SCW CCO (NSW EPA, 2004a). The application was approved for a five year period from 19 August 2003 and was renewed in 2008 (refer to EHC Act License Number 85, EPA file number HO7795 in **Appendix E**). This license was obtained to appropriately manage impacted soils excavated during the remediation works undertaken on the Pharmaceuticals Site. A total of 9,990 cubic metres of impacted fill, clay, weathered shale and shale was excavated from the Pharmaceuticals Site and moved to a secure storage facility (SSF) located on the Crop Care Site (historically referred to as 'Packing Store No. 5', refer to **Figure 2**). Refer to **Section 3.3.9** for further detail regarding these remediation works.

2.1.4 Existing Orders and Regulatory Instruments

The primary regulatory instrument for remediating the Site is the CLM Act (as discussed in **Section 2.1.1**). Prior to the enactment of the CLM Act, the DECCW regulated sites by orders under sections 35 and 36 of the EHC Act. The transitional arrangements for the commencement of the CLM Act repealed these sections of EHC Act, but preserved the operation of orders made under the EHC Act.

CCOs are a primary regulatory tool under the EHC Act and are used by the EPA to selectively and specifically control particular chemicals of concern, and their potential or actual impact on the environment. The nature of the contaminated materials at the Site is such that they are considered to be SCW under the SCW CCO (NSW EPA, 2004a) and HCB waste under the HCB Waste Management Plan (ANZECC, 1996a).

2.2 Regulation of the Remediation and Validation Process

The proposed treatment technology will be reviewed and licensed by the DECCW separately under the appropriate provisions of the EHC Act based on a future Technology Assessment to be completed by Orica in accordance with the National Protocol for Schedule X wastes. The Technology Assessment will include treatability trials on contaminated material from the Site to assist with the optimisation of treatment plant design.

The DECCW regulation and requirements of post-remediation, long term groundwater monitoring to be undertaken at the Site and in off-site areas is detailed in **Section 20.0**. These requirements will be detailed in the Long Term Site Management Plan (SMP) to be finalised for the Site.

The remediation works are to be undertaken in accordance with the existing Environment Protection License (EPL 2149) which will require modification prior to commencement of any remediation works. The current version of EPL 2149 is provided as **Appendix E.**

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3.0 Site Identification and History

3.1 Site Details

A summary of the Site details is provided in **Table 1** (refer to **Figure 1** and **Figure 2**).

Table 1: Site Details

Item	Details
Site Owner	Orica Australia Pty Limited
Site Address	2 Christina Road, Villawood, NSW 2163
Lot and DP Numbers	Lot 1 in Deposited Plan (DP) 634604
City, County and Parish	City of Bankstown, Parish of Liberty Plains, County of Cumberland
Local Government Authority	Bankstown City Council
Site Area	Approximately 12.6 hectares (ha)

3.2 Site History

The Site was initially part of a larger chemical complex owned by the Commonwealth of Australia and used for the manufacturing of munitions, including trinitrotoluene (TNT), in 1941. The Site was subsequently purchased by Taubmans in 1946, who manufactured a range of chemicals including chlorobenzene and DDT until the southern portion of the facility (the Site) was purchased by ICIANZ Pty Limited (ICIANZ) in 1953. ICIANZ (and later Orica) continued to manufacture a wide range of agricultural and pharmaceutical chemicals until the site was closed in 2000.

A detailed review of the site history was undertaken by SHE Pacific (2000), and was summarised in the Phase 1 RI report (HLA, 2005).

3.3 Previous Investigations

To prepare this RAP, the following sources of previous investigation data from the Site were collected and reviewed:

- SHE Pacific Pty Limited, 2000, *Site Historic Review*;
- URS 2000, Stage 1 Phase 2 Environmental Site Audit (Draft);
- CH2MHill, January 2004, *Additional Stage 2 ESA*;
- CH2MHill, April 2005a, *Conceptual Site Model.* Reference 32177*;*
- CH2MHill, September 2005b, Preliminary Report (Draft Version) Voluntary Investigation Part 1A – Groundwater and Soil;
- HLA, 2005, Phase 1 Remedial Investigation (RI), 2 Christina Road Villawood. Report S4056125_RPTFinal_22Dec05;
- HLA, August 2006a, *Phase 2 Remedial Investigation, 2 Christina Road Villawood*. Report S4060632_RPTFinal_30August06;
- HLA, December 2006b, Remedial Technology Assessment (Soil)*, 2 Christina Road Villawood*. Report S4066001_Final_22Dec06;
- HLA, December 2006c, Remedial Technology Assessment (Groundwater)*, 2 Christina Road Villawood*. Report S4066001_Final_22Dec06;
- HLA, 2007, Phase 3 Data Gap Investigation, 2 Christina Road Villawood. Report S4075424_RPTFinal_29May07;
- HLA, 2007, Remedial Action Plan (original version), 2 Christina Road, Villawood, NSW. Report S4066001_Final_RPT_3Oct07;

- CH2M Hill, May 2007a. Pharmaceuticals Site, Villawood Under Building Investigation (Reference 359640.T1.02);
- CH2M Hill, June 2007b. Validation Report Pharmaceuticals Site, Christina Road, Villawood (Reference 359640.T1.01);
- A.D. Laase Hydrologic Consulting, June 2007. Groundwater Flow and Contaminant Transport Modelling;
- URS, 2007. HHERA, Orica Villawood site, 22 June 2007. Ref. 43217484 (original version);
- AECOM, 2010. Round 1 Groundwater Monitoring Event, 2 Christina Road, Villawood, NSW. Report S41070_RPT_Final_01Mar10;
- AECOM, July 2009. Remedial Action Plan Addendum, 2 Christina Road Villawood, S4063810_RAPaddendum_09July_2009; and
- URS, 2011. HHERA, Orica Villawood site, February 2011.

Data generated in previous AECOM RIs are the main sources of information available relating to contamination at the Site. This information is summarised in **Section 8.0** and in the soil summary tables provided in **Appendix D** while a summary of historic groundwater results is provided in **Appendix F**.

The main site investigation works undertaken at the Site is summarised in the following sections.

3.3.1 SHE Pacific (2000) – Site Historic Review

SHE Pacific Pty Limited (SHE Pacific) undertook a review of available site historical information in 2000 to assist in '*the planning of an initial site Assessment*'. The review included interviews with staff from AstraZeneca, located on the part of the site referred to as the Pharmaceuticals Site, Crop Care Australasia as well as former employees of Orica/ICI Australia. The review included a summary of the various production processes undertaken at the site and the historic use of each of the site buildings, which is summarised in Appendix 13 of the SHE Pacific report. this report includes the identification of Site areas where '*past occurrences, practises or physical features, combined with the materials involved, suggest there may possibly be ground contamination*'.

3.3.2 URS (2000) – Stage 1 Phase 2 Environmental Site Audit

The Phase 2 Environmental Site Assessment (ESA) involved a Stage 1 investigation to identify the main site contaminants and areas of concern, based on the findings of the SHE Pacific (2000) report, and a detailed soil and groundwater investigation to assess the nature and extent of any soil and groundwater contamination. The work was undertaken to assess whether there is a significant risk of harm related to the presence of contaminants at the Site and to assess locations requiring further (Stage 2) investigations.

Based on the above works, URS recommended additional site investigation works in various parts of the site to delineate the source of the impacted soils and groundwater. In addition, it was also recommended that a site specific risk assessment be undertaken with the objectives being:

- To identify the requirement to undertake remediation;
- To develop remediation goals for individual contaminants of concern; and
- To allow assessment of remediation technologies.

3.3.3 CH2M Hill (January 2004) – Additional Stage 2 ESA

The CH2M Hill (2004) investigation involved the drilling of 58 boreholes to facilitate the collection and analysis of soil samples. Ten of the borehole locations were converted to groundwater monitoring wells *'to address the conclusions of the previous investigation undertaken at the site by URS in 2000'*. Soil samples were also collected from five trenches excavated across Area B.

Following a review of the criteria used to assess the potential for the site to pose a SRoH to the environment, CH2M Hill concluded that based on available data, it was not possible '*to adequately determine whether the site posed a SRoH pursuant to s 9 of the Contaminated Land Management Act (1997)*'.

Recommendations for additional works included undertaking further detailed assessment:

- For contaminants of concern in areas 'immediately adjacent to former above and underground structures';
- For contaminants of concern in areas 'that were not known to CH2M Hill at the time of the investigation but which have subsequently been identified by past and present Orica personnel';
- For contaminants of concern in areas 'which the current Pharmaceuticals Site Remediation Project is demonstrating as susceptible to containing contamination (e.g. garden beds, landscaped features etc)'; and

- To further assess 'the identified impacts to confirm their distribution'.

A groundwater monitoring program was also recommended to involve:

- 'Installation of additional monitoring wells in off-site locations to assess whether the identified on-site impacts have migrated off-site';
- 'Installation of monitoring wells to delineate the extent of the groundwater impacts identified'; and
- 'Continued monitoring of the groundwater passing through the site on an estimated six-monthly basis to assess the distribution of the identified impacts'.

3.3.4 HLA (2005) Phase 1 Remedial Investigation

This investigation involved the excavation of 46 testpits (TP1 to TP46) across the Site to further delineate identified areas of concern and the installation of 14 bundled piezometers (BP101 to BP114) in on-site and off-site locations to further delineate the vertical and horizontal nature of the identified groundwater plumes. A study was also undertaken to assess the likely fate and transport of contaminated groundwater at the Site.

3.3.5 HLA (2006a) Phase 2 Remedial Investigation

The objectives of the Phase 2 RI soil investigation program were to:

- Meet the requirements of condition 4A and 4C of the RO;
- Further delineate identified impacted areas to assist in the preparation of the RAP;
- Further investigate the source area of the B-S1 groundwater plume (Area C at the Pharmaceuticals Site);
- Investigate potential impacts from the Trade Waste Line (TWL); and
- Investigate identified data gap areas to provide a suitable level of assessment for each of the nine site sub-areas and to provide an adequate data set for the preparation of the RAP and HHERA.

A total of 46 testpits (TP47 to TP92) were excavated across the Site to assess the Site based on the above objectives. Air emission testing from Site soils was also undertaken for input into the original HHERA (URS, 2007).

The objectives of the Phase 2 RI groundwater investigation program were to:

- Assess groundwater conditions on the eastern Site boundary and the eastern extent of off-site groundwater impacts to address concerns raised by the DEC;
- Assess the nature and extent of MCB and DDX contamination in off-site groundwater monitoring well BP107, which may be related to off-site storage; and
- Further assess the lateral and vertical extent of identified on-site and off-site groundwater plumes.

The groundwater investigation works generally involved the installation of bundle piezometers with sampling ports placed at 2.0 m intervals to vertically characterise groundwater conditions. A total of 16 bundle piezometers (BP201 to BP216) and one shallow/deep monitoring well pair (MW217A/B) were installed as part of the Phase 2 RI works.

3.3.6 HLA (2007) Phase 3 Data Gap Investigation

The objectives of the soil investigation component of the Phase 3 DGI were to:

- Address the Site Auditor's request for additional investigation for Impacted Soil Zone (ISZ) 1a and also evaluate bulk DDX concentrations for remedial operational purposes;
- Gather sufficient data to allow delineation of the extent of remediation required within ISZ 1b (MCB impacts) as part of the RAP preparation process and address the Site Auditor's additional investigation requirements for this area; and
- Gather sufficient data to allow delineation of the extent of remediation required within ISZ 2, 7, 8 and upgradient of Plume 4.

The objectives of the groundwater investigation component of the Phase 3 DGI were to:

- Further delineate selected plumes at the Site as requested by the DECC and the Site Auditor; and
- Confirm various on-site and off-site groundwater contaminant concentrations exceeding Australian and New Zealand Environment Conservation Council (ANZECC, 2000) water quality guidelines.

The Site Auditor's request for additional site investigations, following an audit of the Phase 1 and 2 RIs, was detailed in the following report:

- C.M. Jewell & Associates Pty Limited (CMJA, 2006). Site Audit, 2 Christina Road, Villawood – Section 4D Audit. Ref: J1196.2R-rev0.

The Scope of Work for the Phase 3 DGI included the following:

- Excavation of 23 trenches (TP93 to TP115) across Areas B, H and I to facilitate the collection of soil samples; and
- Installation and sampling of four off-site groundwater monitoring wells MW301 to MW304) to address identified data gaps.

3.3.7 A.D. Laase Hydrologic Consulting (2007) Groundwater Flow and Contaminant Transport Modelling

The objectives of the groundwater flow and contaminant transport modelling (A.D. Laase, 2007, refer to **Appendix B**) was to develop a better understanding of groundwater movement and contaminant migration in the fractures and block matrix of the shale underlying the Site. A.D. Laase (2006) (see Appendix B of the Phase 2 RI, HLA 2006a) presented the initial modelling study, which was revised to account for issues raised by the site auditor (CMJA 2006). A.D. Laase (2007) provides the revised modelling study.

A.D. Laase (2007) used Groundwater Vistas Version 4 (Rumbaugh 2004) to create MODFLOW (McDonald and Harbaugh 1988), MODPATH (Pollack 1994) and MT3DMS (Zheng 1999) input files, launch the models and post-process the resultant model output files. In addition to these software, PEST (Doherty 1999) and PEST-SVD (Doherty 2004), both parameter estimation codes, were used during model calibration to determine the best-fit parameter values and hydraulic conductivity distributions for the model as configured. Trial-and-error calibration was employed during transport model calibration.

The Orica Villawood modelling exercise included the development of four regional flow models calibrated to differing recharge scenarios. In addition, 36 cross-sectional flow models having differing recharge, hydraulic conductivity and anisotropy ratios were developed and analysed to develop a better understanding of the groundwater flow. A three-dimensional contaminant transport model based on the regional flow model was also configured, calibrated and used to evaluate future plume movement of dissolved phase contamination originating at the Site. Sensitivity analysis was performed using the transport model to evaluate how parameter uncertainty could affect model predictions, specifically whether or not the plume would reach Byrnes Creek within 100 years of present day.

The following conclusions were based on the results of the above modelling study:

- Based on approximating Byrnes Creek daily discharge volumes and more closely replicating plume flow paths, recharge scenario 2, corresponding to a parkland recharge rate of 5% annual precipitation (55 mm/yr), is likely the most representative of the four recharge scenarios.
- Cross-sectional flow modelling demonstrates that, except for when the horizontal to vertical anisotropy ratio is 100: 1 or greater, all groundwater beneath the Site ultimately discharges to Byrnes Creek. Given that many of the fractures are oriented nearly vertical, it is unlikely that horizontal to vertical hydraulic conductivity ratios would exceed 100:1.
- Cross-sectional flow modelling suggests that contamination, if present at depths greater than -10 m AHD, will not migrate significant distances within 100 years. Flow model sensitivity analysis shows that even for hydraulic conductivity values as high as 10^{-2} m/d at depths below 0 m AHD, groundwater travel times to Byrnes Creek will be in excess of 200 years. Because of plume attenuation, primarily through matrix diffusion, contaminant migration to Byrnes Creek will be even slower.
- Three-dimension contaminant transport modelling simulating matrix diffusion effects predicts relatively rapid plume expansion flowed by a decrease in plume migration rates. Once the "slow" migration period is reached plume concentrations and extent become relatively static. It is believed that the plumes originating from the Site are no longer rapidly expanding and are now relatively static with respect to concentrations and extent.
- Sensitivity analysis shows that while varying transport input parameters produces plumes of different configurations than the calibrated plumes, none of the plumes reaches Byrnes Creek within 100 years of present day. Thus, it is unlikely, even considering the uncertainties, that dissolved contamination from the Site (EDC being the most mobile) will reach Byrnes Creek within 100 years of present day.

- While the modelling results alone demonstrate that it is unlikely that groundwater contamination will reach Byrnes Creek within the next 100 years, it is important to note that the observed plume configurations support this conclusion. Although Site groundwater velocities have been calculated to be as high as 200 m/year, HLA (2006a) the plumes have migrated less than 100 m. Clearly the plumes are being significantly attenuated, which has been replicated by the transport model.

3.3.8 CH2M Hill (May 2007a) Pharmaceuticals Site, Under Building Investigation

In November 2004, CH2M Hill conducted an investigation to assess whether soil beneath the Pharmaceuticals Building had been impacted by previous Site activities. The scope of work for the investigation was as follows:

- Documentation of the site description and historical practices for the purpose of identifying potentially contaminating activities, particularly filling activities where impacted fill material from the Crop Care Site was potentially used prior to and during the construction of the Pharmaceuticals Building;
- Sampling of soil beneath the concrete slab of the Pharmaceuticals Building using push tubes or a hand auger;
- Analysis of a total of 33 surface samples and 38 deeper soil samples for identified CoC; and
- Comparison of the laboratory analytical results to relevant regulatory guidelines.

The results of the investigation indicated that some impacted fill material was used during the construction of the Pharmaceuticals Building, with elevated DDX concentrations detected in fill material at 3 locations beneath the concrete slab.

3.3.9 CH2M Hill (June 2007b) Pharmaceuticals Site, Validation Report

From November 2003 to December 2004, CH2M Hill conducted remediation and validation on the Pharmaceuticals Site, which incorporates all of Area A, most of Area C (with the exception of the northeast portion), the southwest corner of Area B and the western end of Area D (refer to **Figure 2**). The scope for the remediation and validation works can be summarised as follows:

- A total of 9,990 cubic metres of impacted fill, clay, weathered shale and shale was excavated from areas previously identified as being impacted with chemicals of concern (predominately DDX) and moved to a secure storage facility (SSF) located on the Crop Care Site (historically referred to as 'Packing Store No. 5', refer to **Figure 2**);
- Additional areas were investigated following evidence that fill material sourced from the Crop Care site, potentially impacted with CoC, was used during construction of infrastructure in Area A and Area C;
- Validation of remaining soil via soil sampling and laboratory analysis following removal of impacted material; and
- Reinstatement of remediated areas using imported validated virgin excavated natural material (VENM).

The validation and remediation scope also included a groundwater investigation incorporating an on-site and limited off-site assessment to identify potential sources and/or migration pathways, the delineate impacts identified during previous investigations and to provide data for the determination of risks to human health and/or the environment. The groundwater assessment incorporated the following scope:

- The installation of angled groundwater monitoring wells (MW41 and MW42) beneath Christina Road to determine whether service trenches were acting as preferential pathways for contaminated groundwater migrating off site;
- The installation of 4 additional nested wells (MW43A/B/C, MW44A/B/C, MW46A/B/C, MW53A/B/C) to provide data on the vertical distribution of previously identified groundwater impacts;
- The installation of 7 additional monitoring wells (MW45, MW47 – MW52) downgradient of inferred source zones to delineate previously identified groundwater impacts;
- Sampling and analysis of groundwater from 48 monitoring wells;
- Excavation of a 5 metre long trench adjacent to the redundant trade waste line (OTWL) to a depth of 5.7 mbgs to assess whether the trade waste line was a potential source of identified EDC impacts previously identified in groundwater down gradient of this location;
- Excavation of 5 test pits (TP12-TP16) adjacent to Christina Road to assess whether service trenches along the Site's southern boundary are providing preferential pathways for impacted groundwater. Trenches were excavated until groundwater was observed (approximately 5 - 6 mbgs). Groundwater seeping into the excavation was sampled and analysed;

- An assessment of accessible service pits and trenches along Christina Road. The investigation comprised a vapour assessment using a PID to measure organic vapours to determine whether service trenches have been providing preferential pathways for the migration of impacted groundwater; and
- A visual assessment of the old trade waste line under the Pharmaceuticals Building using a closed circuit television (CCTV) camera.

Results from the validation program indicated the following:

- The Pharmaceuticals Site has been validated for the CoCs identified in soil on the Site with the exception of a section of soil underneath the Pharmaceuticals Building and some residual impact in validation areas VA4 and VATW;
- Results from the trench excavated adjacent to the old trade waste line (OTWL) indicated that no impacts are present at that location;
- The CCTV assessment indicated that breaks in the trade waste line are present beneath the Pharmaceuticals Building, which may be providing a source for the impacts detected in groundwater down gradient of this location;
- The vapour assessment along Christina Road indicated that no evidence was found to suggest that the service trenches along Christina Road are providing a preferential pathway for impacted groundwater; and
- Groundwater monitoring indicated that impacted groundwater is present in three areas on the Pharmaceuticals Site with EDC impacts detected on the northern boundary, EDC, TCE and MCB impacts detected on the southern boundary and EDC, BTEX, TCE, MCB and OCP impacts detected on the western boundary, down gradient of the former Crop Care ETP.

3.3.10 URS (2011) Human Health and Environmental Risk Assessment

A HHERA (URS 2011, refer to **Appendix C**) was prepared to assess the risks to human health and the environment due to exposure to contaminants present at the Site. The approach adopted during the HHERA was to assess the analytical results obtained during the discussed site investigations (including soil, soil gas and groundwater data) to derive Risk-Based Site Wide Criteria (RBSWCs) for soil concentrations across the Site and to enable assessment of whether remediation works would be required in identified areas of concern (the RBSWC are presented in **Table 21**, **Section 7.1**)**.** In adopting this approach, the HHERA considered the cumulative effect of CoPC present within soils across the Site. The soil analytical data obtained from the ISZs are compared to the RBSWC in **Tables D1 to D8**, **Appendix D** while all site-wide data is presented in **Table D9**.

It should be noted that the RBSWC have not considered leaching to groundwater. However, groundwater has not been identified as presenting unacceptable risks to human health or the environment, therefore there are no risk-based requirements to consider further.

The HHERA and RBSWC are discussed further in **Section 7.2**.

4.0 Site Conditions

4.1 Topography

The Site lies within the geomorphic region of the Sydney basin known as the Cumberland Plain and is categorised as Blacktown landscape type (Bannerman & Hazelton, 1990), which is characterised by gently undulating rises on Wianamatta Group shales with relief ranging up to 30 m and slopes generally less than 5%.

The highest natural elevation of the Site at the north-east corner is approximately 36 m AHD and generally slopes towards the south-west corner of the site where the elevation is approximately 18.5 m AHD. The Site has been progressively cleared and filled over the years and the highest relief at the Site is the remnants of a blast mound (approximately 39 m AHD) located at the northern boundary of the Site.

4.2 Regional Geology

The Site is underlain by the Bringelly Shale, a formation within the mid-Triassic Wianamatta Group (NSW Dept of Mineral Resources [DMR], 1980). The Bringelly Shale sequence comprises interbedded and interbanded shales, carbonaceous claystones, laminite, fine grained lithic sandstones and, rarely, coal horizons. The upper portion of the Bringelly Shale is deeply weathered, usually giving rise to several metres of mottled clay. The mineralogy of the Bringelly Shale is dominated by kaolin-illite and smectite. The Bringelly Shale forms the upper part of the Liverpool Sub-group of the Wianamatta Group. The Bringelly Shale is underlain by the Minchinbury Sandstone, which is in turn underlain by the Ashfield Shale. Structure contours for the Wianamatta Group (DMR, 1980) indicate that the Liverpool Sub-group extends to a depth of -60 m AHD in the vicinity of the Site (refer to Figure 6.3, HLA 2006a).

The Sydney Basin, including the sedimentary sequence of the Wianamatta Group has been gently folded by a series of tectonic events and is characterised by large-scale lineaments (vertical and sub-vertical faults) and associated fractures. The Site lies within a large regional fold structure referred to as the Fairfield Basin (DMR, 1980).

A regional geological cross-section extending from the Byrnes Creek catchment divide to Prospect Creek is shown on Figure 6.3 of the Phase 2 RI (HLA 2006a). The outcrop of the Minchinbury Sandstone and Ashfield Shale as well as the thickness of the Liverpool Sub-group was derived from DMR (1980). Records of deep regional stratigraphic bores were unable to be obtained to determine the approximate thickness of each of the formations beneath the Site. However, it is inferred that the Bringelly and Ashfield Shale are approximately 40 m thick in the Villawood area.

4.3 Local Geology

The geology on-site and off-site comprises four principal elements, which include fill material, residual clay on-site, alluvial clay off-site, and basal Bringelly Shale (refer to cross-sections presented in Figures 6.4 to 6.6, HLA 2006a).

The uppermost unit on-site and off-site comprises fill material of reworked clay.

Residual clay on-site is likely to be weathered Bringelly Shale. The clay is mottled orange/grey, moist and of moderate to high plasticity. Cross section A-A' (Figure 6.5, HLA 2006a) illustrates a relatively uniform thickness of residual clay from north to south (Christina Road), which follows the topographical profile. A slight thickening of clay at the southern boundary of the Site in the vicinity of BP106 (Figure 6.5, HLA 2006a), is likely to represent colluvial deposits eroded from the more elevated part of the Site.

Highly weathered shale, as observed during test-pitting, underlies the Site at depths of greater than 1 m. Sub-vertical fractures are identified at approximate 1 m spacings, which are orthogonal in nature (90° intersections) with individual fracture planes trending 330° and 60° with respect to true north.

Clay material identified off-site, south of the railway corridor, and illustrated in the discussed geological cross-sections, thickens significantly, attaining a thickness of up to 6 m. This clay material is likely to represent fine grained overbank alluvial deposits associated with the Byrnes Creek flood plain. Underlying the alluvial clay is the Bringelly Shale.

4.4 Regional Hydrology

The Site lies within the catchment for Byrnes Creek, which is essentially a concrete lined drain. Byrnes Creek is a tributary of Prospect Creek which is located approximately 4.5 km downstream of Christina Road. The invert level of Byrnes Creek at several locations upstream and downstream of the Site is summarised in the table below.

Table 2: Byrnes Creek Invert Levels

Location	Creek Invert Elevation (m AHD)
Miller Road	17.9
Christina Road	13.0
Woodville Road	10.8

Byrnes Creek receives stormwater discharge from several other open concrete lined drains including one located to the north of the Site and another located in the industrial area to the south of Christina Road.

4.5 Site Hydrology

Historically all surface water run-off from the Site was collected in open earthen drains and discharged to an open surface water drain (No 9 Branch Drain) to the south of Christina Road. These earthen drains were reportedly replaced with pipe drains in the early 1970s.

The practice of off-site discharge of stormwater ceased in approximately 1990, at which time rainfall run-off from the Site was segregated into “clean” stormwater and potentially contaminated stormwater run-off from manufacturing areas. Clean stormwater is discharged to Byrnes Creek to the south. Run-off from the former manufacturing areas is retained on-site for testing prior to discharge.

4.6 Soil Conditions

Based on the results of historic site investigations and AECOM RIs at the Site, ISZs were identified where chemical concentrations in soil was considered to be a potential concern in terms of human health and environmental risk. These ISZs are shaded yellow in **Figure 4** and **Figure 7** to **Figure 10**. All available soil analytical results obtained for each of the ISZs are provided in **Appendix D**.

As discussed in **Section 3.3.9**, remediation works have previously been conducted in ISZ 4 and 6 (refer to **Figure 4**. For detailed reporting on the site remediation and validation works conducted in this area refer to the CH2MHill report (2007b).

A summary of each of the ISZs is provided in the following sections and includes:

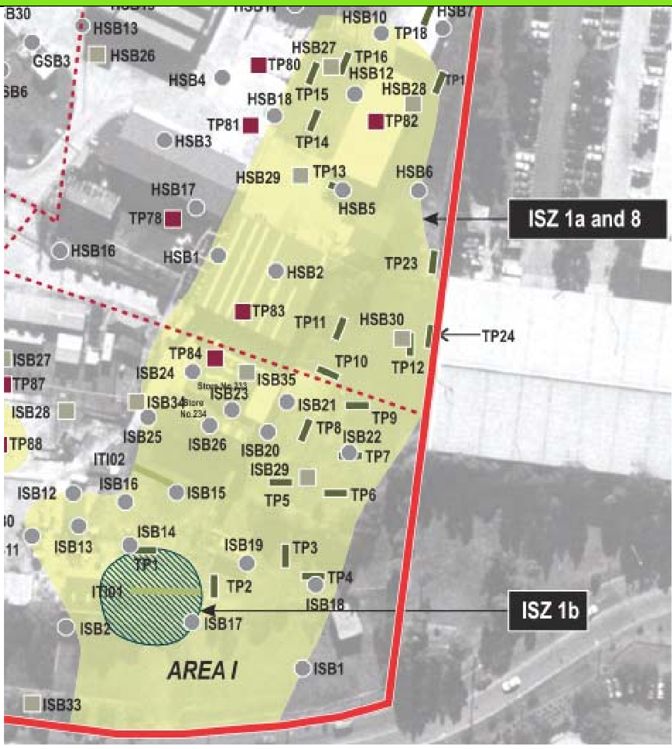
- A description of the historical site activities undertaken in the area;
- A visual representation of the ISZ (shaded yellow) to illustrate the relevant soil sampling locations;
- Cross referencing of tabulated summary analytical data for each of the ISZs (refer to **Table D1** to **D8**, **Appendix D**) and the relevant figure where this data is spatially presented; and
- A summary of those CoPC present in the ISZs.

Tabulated summary analytical data for the whole Site is provided as **Table D9**, **Appendix D**.

It is noted that based on the available soil analytical data, the Site history and the Site’s topography in Area H and I, for the purposes of remediation and validation, ISZ 1a and 8 are considered to be adjoined (refer to **Figure 18** and **Section 8.2**).

4.6.1 Impacted Soil Zone 1a

Table 3: Summary of historic site activities and CoPC in ISZ 1a

ISZ 1a **AREA H/I (surficial pesticide impacts within fill material)**	
	**Relevant presentation of analytical results for this** ISZ Soil concentrations in **Figure 7**. Analytical data is compared to the RBSWC in **Table D1, Appendix D**.
Summary of Former Plant Infrastructure and Site History (refer to Figure 2) **Store No. 233** formerly housed the original mononitrotoluene plant and was later used for animal remedies filling and the manufacture of sheep dip (likely to have handled arsenic, OCPs and DDT). **Store No. 234** formerly used to isolate DDT and was later used for the formulation of insecticides and fungicides.	**Anecdotal Evidence of Spills/Leaks** Possible leaks from the DDT production plant and inappropriate disposal of production wastes across surface soils in the area. Some impacts also related to deeper impacted fill material rather than surface spills.

In addition to the discrete sampling from various materials encountered across Area I, bulk samples were also collected in areas where DDX crystals were observed to be present within the fill materials (HLA 2007). This sampling was undertaken to replicate the homogenisation of materials which will occur during the process of remedial excavation and stockpiling works.

The reported DDX analytical results are as summarised below.

Table 4: Average DDX Concentrations for ISZ 1a Bulk Samples (HLA, 2007)

Bulk Sample Location	Depth range (mm)	DDX concentration (mg/kg)
RBSWC		**2,000 mg/kg**
TP105E	0-300	55,375
TP105S	0-300	4,124
TP105W	0-300	5.79
Average concentration		19,835
TP106E	0-300	25,400
TP106N	0-300	13,822
TP106W	0-300	91,276
Average concentration		43,499
TP108E	0-300	5,832
TP108N	0-300	3,941
TP108W	0-300	84,853
Average concentration		31,542

The results indicate some variability in DDX concentrations exists which is likely to be attributable to the nature of the fill material and the relatively simple homogenisation process undertaken in the field. However, the results do indicate that the levels of DDX contamination in surface materials in ISZ 1a would be in the order of 20-50,000 mg/kg if they were to be excavated.

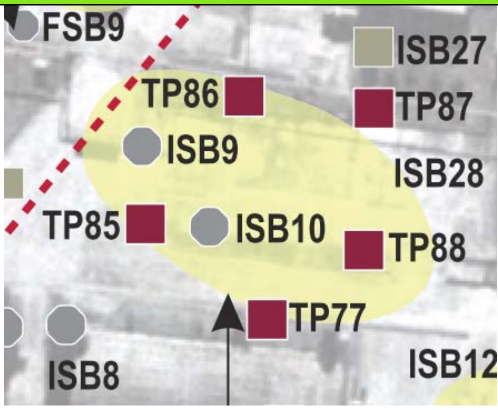
4.6.2 Impacted Soil Zone 1b

Table 5: Summary of historic site activities and CoPC in ISZ 1b

ISZ 1b **AREA I (MCB & DDX impacts at depth)**	
	**Relevant presentation of analytical results for this ISZ** Soil concentrations for this ISZ are presented in **Figure 7**. Analytical data is compared to the RBSWCs in **Table D1, Appendix D**. This ISZ is considered to join with ISZ 8 located directly to the north.
Summary of Former Plant Infrastructure and Site History **An underground storage tank (UST)** was previously located to the east of the DDT formulation plant and initially stored benzene (associated with the TNT production process) and later MCB for the formulation of DDT. An associated underground pipeline (detailed in 1944 service plan) was used for refuelling from the railway corridor to the southeast. **A former tank farm** was located to the southwest of the discussed UST and stored DDT, endosulfan, toluene and CTC.	**Anecdotal Evidence of Spills/Leaks** Aerial photos suggest potentially contaminated surface water ponding – may have flowed overland towards the stormwater drain on northern side of Christina Road. Solvent odours were noted during demolition works in 1989.

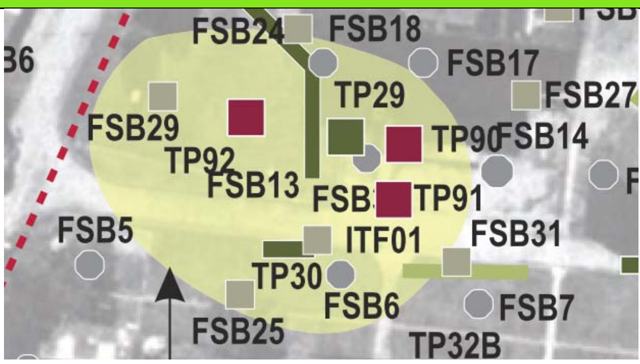
4.6.3 Impacted Soil Zone 2

Table 6: Summary of historic site activities and CoPC in ISZ 2

<table>
<tr><td colspan="2">ISZ 2
AREA I (former Tetramisole Plant)</td></tr>
<tr><td>
</td><td>Relevant presentation of analytical results for this ISZ
Soil concentrations for this ISZ are presented in Figure 7.
Analytical data is compared to the RBSWCs in Table D1, Appendix D.</td></tr>
<tr><td>Summary of Former Plant Infrastructure and Site History
Former Tetramisole Plant was used for the production of the final tetramisole product (for sheep and cattle worm treatment).</td><td>Anecdotal Evidence of Spills/Leaks
Plant floor was noted to be in poor condition before demolition works.</td></tr>
</table>

4.6.4 Impacted Soil Zone 3

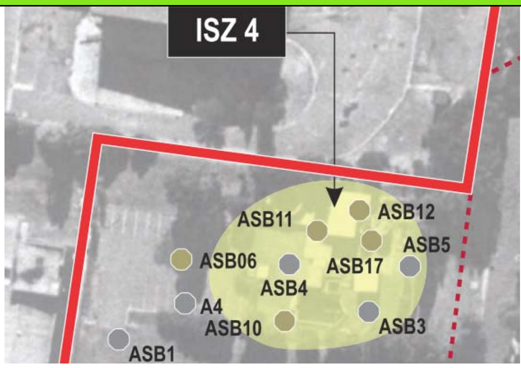
Table 7: Summary of historic site activities and CoPC in ISZ 3

<table>
<tr><td colspan="2">ISZ 3
AREA F (former IHPT Plant)</td></tr>
<tr><td>
</td><td>Relevant presentation of analytical results for this ISZ
Analytical data summarised in Table D2, Appendix D. As there are no exceedances of the RBSWC in this area, the analytical data is not presented on a figure.</td></tr>
<tr><td>Summary of Former Plant Infrastructure and Site History
IHPT process building, tank farm and EDC recovery plant - in association with the Tetramisole Plant, produced tetramisole (for sheep and cattle worm treatment).
Effluent Stripping Plant (ESP) received aqueous waste from IHPT and Tetramisole plants. EDC was recovered, tars produced and the stripped waste moved to the TWL.</td><td>Anecdotal Evidence of Spills/Leaks
Possible EDC leaks.

Possible EDC leaks.</td></tr>
</table>

4.6.5 Impacted Soil Zone 4

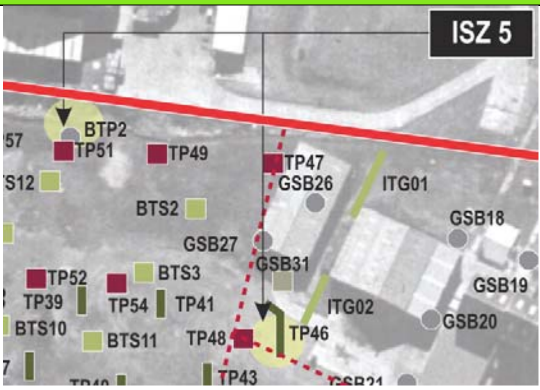
Table 8: Summary of historic site activities and CoPC in ISZ 4

ISZ 4 **AREA A (former Effluent Treatment Plant)**	
	**Relevant presentation of analytical results for this ISZ** Analytical data is compared to the RBSWCs in **Table D3, Appendix D**. Area A and C validation areas are detailed in **Figure 11**. For detailed reporting on the site remediation and validation works conducted in this area refer to the CH2MHill report (2007b).
Summary of Former Plant Infrastructure and Site History **Effluent Treatment Plant (ETP)** - a former pentagonal settling pit located to the west of the Pharmaceuticals Building. Caustic and acid storage was undertaken to facilitate pH adjustment in a pit upstream of the ETP. Waste discharges to the ETP ceased in 2000. Remediation of the upper soils has been completed but residual DNAPL sources remain.	**Anecdotal Evidence of Spills/Leaks** Old pits (dating back to 1944), possibly leaked. Impacts identified around the underground TWL entering the ETP and the discharge line from the ETP - noted during the remediation works in this area.

ISZ 4 does not require remediation works based on the Area A remedial works previously undertaken as detailed in CH2MHill (2007b). Based on the information in that report, 3,057 m^3 of material was removed from ‘validation areas 3 and 4’ to the extent practicable. This involved excavation into the shale bedrock at a maximum depth of 4 m bgl. The excavated material was subsequently stored in the Secure Storage Facility (SSF, historically referred to as ‘Packing Store No. 5’ [refer to **Figure 2**]). Sampling of the excavation walls and base was undertaken to validate the residual material for the CoC and the excavation was backfilled using validated VENM.

4.6.6 Impacted Soil Zone 5

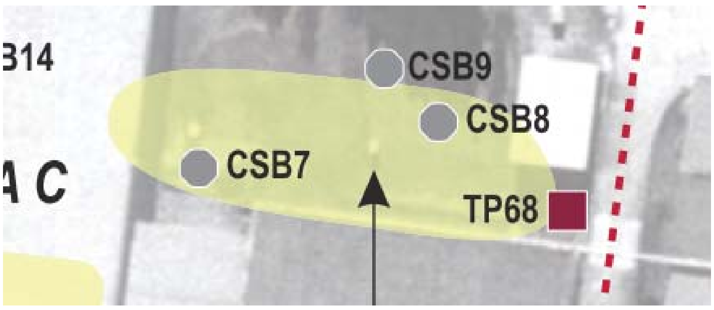
Table 9: Summary of historic site activities and CoPC in ISZ 5

ISZ 5 **AREA B/G (former drum storage area)**	
	**Relevant presentation of analytical results for this ISZ** Soil concentrations for this ISZ are presented in **Figure 8**. Analytical data is compared to the RBSWCs in **Table D4, Appendix D**.
Summary of Former Plant Infrastructure and Site History **Potential EDC tar drum storage area**	**Anecdotal Evidence of Spills/Leaks** The drum storage area is visible in the 1969 & 1984 aerial photographs (refer to Figure 9.3 in the Phase 1 RI report (HLA 2005)).

It is noted that 3 potential source areas have been identified in the HHERA (URS 2011) in Area B as comprising ISZ 5. However, based on concentrations of CoPC in soil in these areas, the western-most area (as identified in Figure 3 of the HHERA) does not require remediation and is not considered further in this RAP.

4.6.7 Impacted Soil Zone 6

Table 10: Summary of historic site activities and CoPC in ISZ 6

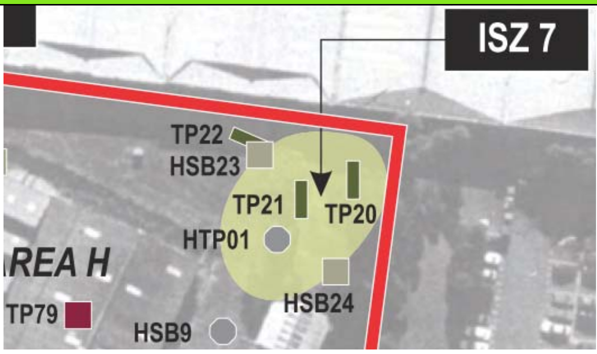
ISZ 6 **AREA C (Trade Waste Line east of Pharmaceuticals Building)**	
	**Relevant presentation of analytical results for this ISZ** Analytical data is compared to the RBSWCs in **Table D5, Appendix D**. Area A and C validation areas are detailed in **Figure 12**. For detailed reporting on the site remediation and validation works conducted in this area refer to the CH2MHill report (2007b).
Summary of Former Plant Infrastructure and Site History **Trade Waste Line** – the TWL system was present at the Site prior to 1944. The TWL from this Area was removed as part of the 2004 remediation works and a new TWL constructed beneath the Pharmaceuticals Building.	**Anecdotal Evidence of Spills/Leaks** No comments noted.

ISZ 6 does not require remediation works based on the remedial works previously undertaken as detailed in CH2MHill (2007b). Based on information detailed in that report, 700 m^3 of material was excavated from the 'Finished Goods and Trade Waste' areas to the extent practicable (i.e. the shale bedrock was encountered at a maximum depth of 1 m bgl) and the excavated material was stored in the SSF. Sampling of the excavation walls and base was undertaken to validate the residual material for the CoC and the excavation was backfilled using validated VENM.

4.6.8 Impacted Soil Zone 7

Table 11: Summary of historic site activities and CoPC in ISZ 7

<table>
<tr><td colspan="2">ISZ 7
AREA H (far northeast corner)</td></tr>
<tr><td>



</td><td>Relevant presentation of analytical results for this ISZ

Soil concentrations for this ISZ are presented in Figure 9.

Analytical data is compared to the RBSWCs in Table D6, Appendix D.</td></tr>
<tr><td>Summary of Former Plant Infrastructure and Site History

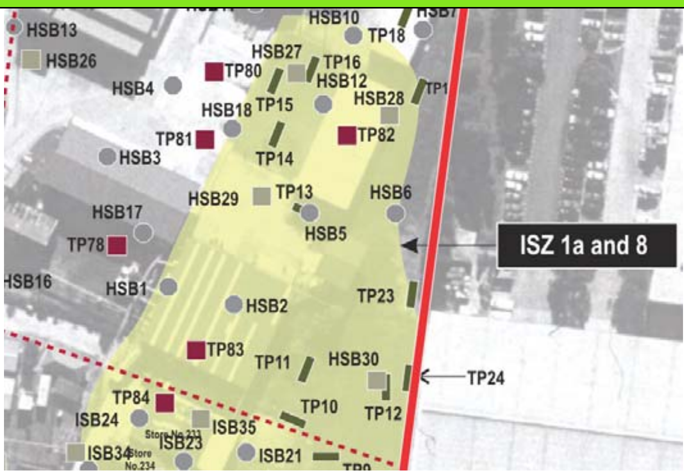
Possible 'buried formulation vessel' - a formulation vessel was originally thought to have been buried in this area but further enquiries confirmed that only wastes from the vessel were buried. No tank has been encountered during test pitting in this area.</td><td>Anecdotal Evidence of Spills/Leaks

A possible 'buried formulation vessel'</td></tr>
</table>

4.6.9 Impacted Soil Zone 8

Table 12: Summary of historic site activities and CoPC in ISZ 8

<table>
<tr><td colspan="2">ISZ 8
AREA H (eastern area)</td></tr>
<tr><td>



</td><td>Relevant presentation of analytical results for this ISZ

Soil concentrations for this ISZ are presented in Figure 7.

Analytical data is compared to the RBSWCs in Table D1, Appendix D.

This ISZ is considered to join with ISZ 1a located directly to the south.</td></tr>
<tr><td>Summary of Former Plant Infrastructure and Site History

Drum store No 7 and 8 (flammable liquids)

Drum store No 8 – the 1944 service plan indicates that pesticides and herbicides were produced in the old ‘Sydney Williams Hut’.

TWL – the TWL piped aqueous wastes from this area to the south (refer to Figure 3).</td><td>Anecdotal Evidence of Spills/Leaks

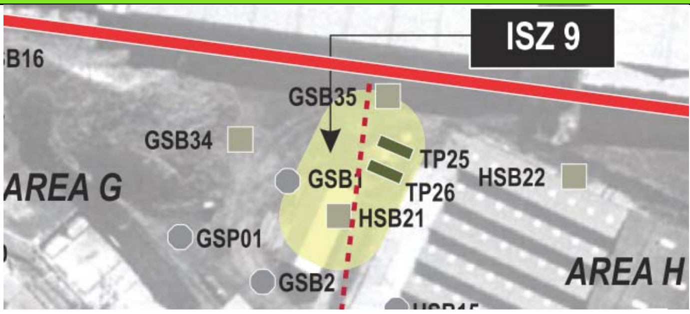
No comments noted.

BHC and hormone weed killers were stored in this area. No evidence of possible spills/leaks.

No comments noted.</td></tr>
</table>

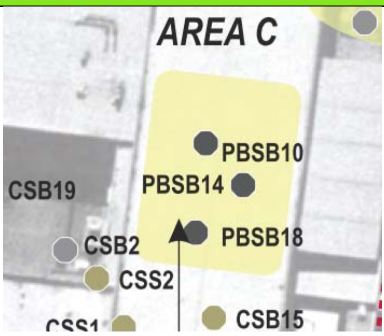
4.6.10 Impacted Soil Zone 9

Table 13: Summary of historic site activities and CoPC in ISZ 9

<table>
<tr><td colspan="2">ISZ 9
AREA G/H (northwest of SSF building)</td></tr>
<tr><td>
</td><td>Relevant presentation of analytical results for this ISZ
Soil concentrations for this ISZ are presented in Figure 10.
Analytical data is compared to the RBSWCs in Table D7, Appendix D.</td></tr>
<tr><td>Summary of Former Plant Infrastructure and Site History
Known area of localised dumping of formulation wastes (TP25 and TP26 area)</td><td>Anecdotal Evidence of Spills/Leaks
Localised dumping of formulation wastes at western end of access road.</td></tr>
</table>

4.6.11 Impacted Soil Zone 10

Table 14: Summary of historic site activities and CoPC in ISZ 10

<table>
<tr><td colspan="2">ZONE 10
AREA C (beneath Pharmaceuticals Building)</td></tr>
<tr><td>
</td><td>Relevant presentation of analytical results for this ISZ
Analytical data is compared to the RBSWCs in Table D8, Appendix C.
Site investigation areas are detailed in Figure 3.
For detailed reporting on the site assessment conducted in this area refer to the CH2M Hill report (May 2007).</td></tr>
<tr><td>Summary of Former Plant Infrastructure and Site History
Possible impact from treatment of DDX wastes in the Pharmaceuticals Building area</td><td>Anecdotal Evidence of Spills/Leaks
Ash from the former boiler house in this area is thought to have been used to treat DDX wastes as the alkaline material was considered to break down DDX compounds. The DDX wastes may have been brought to the area from the eastern end of the Site. The ash was spread in broad areas but was excavated prior to the laying of the concrete slabs for the Pharmaceuticals building.</td></tr>
</table>

4.6.12 Remainder of Area A and C (Excluding ISZ 4, 6 and 10)

The analytical data relating to validation works undertaken across the remainder of Area A and C (excluding ISZ 4, 6 and 10) is summarised in **Table D9, Appendix C** and the validation areas are presented in **Figure 11** and **12**. The remediation and validation works undertaken in this area is detailed in the CH2M Hill (June 2007b) validation report.

A PAH (benzo(a)pyrene equivalent) concentration of 58.7 mg/kg (0.05-0.4 m bgl at validation location VA12/94) was reported in the far north east corner of validation area 12 (refer to **Figure 12**). Based on PAH and benzo(a)pyrene analytical data obtained for the area surrounding this location and across the Site, these impacts are considered to be localised and are not considered to present a significant risk to human health or the environment. Consequently, remediation works are not proposed for this area.

All other CoC concentrations in Area A and C were reported to be less than the relevant RBSWC. For further detail relating to the remediation and validation works undertaken across Area A and C, refer to the Area A and C Validation report (CH2MHill, June 2007).

4.6.13 Site-Wide Trade Waste Line

While the findings of previous investigations have not identified the Site-wide Trade Waste Line (TWL) as a significant source of soil or groundwater contamination, AECOM considers it prudent to remove this infrastructure prior to commencement of the main remedial excavation works. The removal of the TWL will serve to validate the soils in this potential area of concern and prevent potentially contaminated surface waters flowing through the TWL and re-contaminating validated areas.

4.6.14 Previously Excavated Materials

Approximately 10,000 m^3 of SCW is stored within the Secure Storage Facility (SSF), originating from remediation and validation works previously undertaken in Areas A and C (refer to the CH2M Hill validation report, June 2007b). DDX concentrations within the SCW material are understood to range from 500,000 mg/kg (present within white DDX crystals) to less than 1,000 mg/kg. Other CoPC likely to be present in the material and which are related to the excavation of deeper clays and shales adjacent to the former Area A ETP, are anticipated to be EDC, TCE, benzene and toluene.

Orica advises that the SSF materials comprise predominantly excavated natural clays and shales. While the material is not uniform in nature, it is understood that the material in the southeast corner of the SSF comprises predominantly clay material from the earlier stages of the remediation works, while the material in the northwest corner of the building comprises predominantly shale material from the excavation works advanced to greater depths. The shale material is likely to be impacted with EDC, TCE, benzene and toluene.

It is understood that some bonded asbestos containing materials (BACM) were observed to be present within fill materials excavated during the removal of old stormwater drains, water pipes and pits from Area A and C. Should BACM materials be encountered during the handling of the SSF materials, they will be managed as per **Section 23.1.4**).

Some ash material was also excavated from around a former boiler house which was located in validation area 7 and 8, Area A (CH2M Hill, 2007b).

4.6.15 Contaminated Materials from the Former Orica Chester Hill Site

Contaminated materials were brought to the Site from the former Orica site located at 127 Orchard Road, Chester Hill during the remediation works undertaken at that site (completed between mid October 2008 to late March 2009). These materials had been tested and were deemed to be unsuitable for reuse at the Chester Hill site as CoC concentrations exceeded the potential DNAPL criteria derived for that site. Further detail relating to this material is provided in the Combined Validation Report prepared for the Chester Hill remediation works (AECOM, July 2009).

The total volume exceeding the DNAPL criteria was surveyed to be 1,428.14 m^3 identified as 'VSP01 [5]'. A license variation application for Environmental Protection License (EPL) 2149 was approved by DECC on 14 September 2007 to allow storage of the Chester Hill materials at the Site (refer to **Appendix E**). This variation allows for the storage of 'industrial, hazardous and Group A waste' at the Site. This material was stored appropriately within a heat-welded high-density polyethylene (HDPE) liner. The HDPE encapsulated soil stockpile has been placed on a level concrete slab in the eastern part of the Site with perimeter stormwater controls. This material will be treated during the proposed remediation works at the Site.

Surplus materials which were tested at the Chester Hill and met the Risk Based Concentrations (RBCs) derived for that site, but were not required for backfilling, were also stored at the Site. This material had a total volume of 332.81 m^3 and was identified as 'VSP02'. This material was placed on a HDPE liner at the Site (adjacent to the HDPE encapsulated material) and securely covered with a heavy duty tarpaulin.

In summary, material stored at the Site from the Chester Hill site was stored under the following conditions:

- Hazardous material - 1,428.14 m^3 appropriately stored in a HDPE liner in accordance with the discussed Villawood EPL 2149 (approved storage capacity of 'more than 500 tonnes a year'); and

- Non-hazardous material (CoPC concentrations less than the Chester Hill RBCs) - 332.81 m^3 securely covered with a heavy duty tarpaulin.

A summary of the analytical data obtained for the Chester Hill material is provided below.

Table 15: Chester Hill 'Remediation Areas 1 & 2' - Summary of Soil Analytical Results

Statistical Summary	EDC	1,1-DCA	1,1-DCE	TCE	1,1,1-TCA	CTC	Chloroform
Number of Results	52	52	52	52	52	52	52
Number of Detects	24	19	7	12	5	9	19
Minimum Concentration (mg/kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Maximum Detect (mg/kg)	251	42.9	21.9	228	1160	1160	174
Average Concentration (mg/kg)	13.51	1.87	1.01	5.48	23.67	23.53	8.71

Chester Hill 'Remediation Area 3' is generally defined by the presence of TCE and cis-1,2-DCE. A summary of the analytical data obtained within this area is provided in Table 16.

Table 16: Chester Hill 'Remediation Area 3' – Summary of Soil Analytical Results

Statistical Summary	EDC	1,1-DCA	1,1-DCE	cis-1,2-DCE	trans-1,2-DCE	TCE	1,1,1-TCA
Number of Results	53.0	53.0	53.0	53.0	53.0	53.0	53.0
Number of Detects	0.0	0.0	1.0	29.0	2.0	38.0	0.0
Minimum Concentration (mg/kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Maximum Detect (mg/kg)	ND	ND	0.6	90.9	2.6	6,020.0	ND
Average Concentration (mg/kg)	-	-	0.3	5.3	0.3	147.3	-

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5.0 Groundwater Conditions

5.1 Regional Hydrogeology

The shales are characterised by partings along bedding planes and fracture sets, which are oriented sub-vertically. The bedding plane partings and fractures provide pathways for the preferential migration of fluids. The regional groundwater flow direction within the Wianamatta Group is strongly influenced by the catchment topography and surface water features.

Groundwater flow in the upper Bringelly Shale is likely to be localised and discharge directly to Byrnes Creek and associated tributaries. Groundwater flow in the lower Ashfield Shale is likely to represent the broad regional groundwater flow system and discharge to Prospect Creek. This conceptual flow regime was confirmed by the numerical groundwater model.

5.2 Groundwater Flow Direction

Water levels across the investigation area have been measured since 2000 in a number of field investigations (Woodward-Clyde, 2000; CH2MHill, 2003, 2004 and 2005, and AECOM, 2005, 2006 and 2008) and are presented in **Appendix F**. The water level elevation data for up to 6 discrete monitoring periods has been assessed. In general the variation in the groundwater elevation (i.e. fluctuations) at most locations is less than 1 m over the 6 year period, with the exception of MW11, MW28, MW44C, MW77 and OS04A. In all instances where the water level fluctuation has been greater than 1 m, it appears to be related to an anomalous measurement.

A majority of the wells installed across the Site and in off-site areas intersect the upper water table and have been used to prepare shallow water level contours for the Bringelly Shale (refer to **Figure 6**). The water table elevation reflects the regional and local topography and indicates that groundwater in the northern and western portion of the Site flows in a westerly direction and groundwater from the southern and eastern portion of the Site generally flows in a southwesterly direction towards Byrnes Creek, where it is inferred to discharge. The hydraulic gradient is generally steeper underlying the more elevated northern areas and is in the order of 0.05. This is compared to a hydraulic gradient in the order of 0.01 for approaching the southern boundary of the Site and in the off-site Byrnes Creek floodplain.

The groundwater flow direction in the deeper portion of aquifer is similar to that of the shallow portion and indicates the groundwater in the northern and western part of the Site is in a westerly direction and groundwater in the southern and eastern portion of the Site is in a southwesterly direction towards Byrnes Creek, where it is inferred to discharge. The Byrnes Creek channel, located adjacent to bundle piezometers BP109 and BP110, has an invert level ranging between 15 and 16 m AHD, which is below the potentiometric surface, and as such is the likely receptor for groundwater. The overall hydraulic gradient is similar to that noted for the shallow portion of the shale aquifer noted above.

5.3 Porosity

Fractured rock aquifers, particularly shales, have dual porosity consisting of:

- Primary porosity within the rock mass, comprising intergranular voids, which for shales is low because of the fine grained nature of the clay particles that comprise the rock and various a degrees of cementation between the grains; and
- Secondary porosity resulting from interconnected bedding plane partings and fractures, which may be moderately high if these features are relatively open.

Groundwater flow in the Bringelly Shale occurs within the fractures and bedding plane partings (secondary porosity). The advective flow within the rock matrix is considered to be negligible; however, the matrix porosity is important in the fate and transport of dissolved phase contaminants (i.e., matrix diffusion).

The primary (matrix) and secondary (fracture) porosity for the Bringelly Shale is likely to be very heterogeneous. In the case of primary porosity (matrix) the variability reflects the range of lithologies present within the bedded shale. In the case of the secondary porosity, it is likely that this will decrease with depth due to a decrease in fracture spacing and apertures.

No site-specific data have been collected with respect to the primary and secondary porosity of the Bringelly Shale. The latter is difficult to measure in the field, since while cores can provide an indication of fracture and bedding plane spacing, in practice the fracture aperture cannot be determined with reliable precision. Based on published data (Freeze and Cherry, 1979; Domenico and Schwartz, 1990) the total secondary porosity for the Bringelly Shale is estimated to range from 1% to 10%, with and effective porosity ranging from 0.5% to 5%.

The porosity of the sandstone core (MW29_7.0-7.28) ranged from 8.4% to 9.6%, which is consistent with the limited published data on the porosity of the Bringelly Shale. William (2002) reported on the porosity of block samples obtained from seven quarries in the western part of Sydney, which ranged from 5% to 12%.

5.4 Hydraulic Conductivity

Based on the testing of 30 monitoring wells, the bulk hydraulic conductivity of the Bringelly Shale at the Site is estimated to range between 0.0004 m/day and 0.57 m/day. As expected there is a large variability in the reported values (3 orders of magnitude) and is consistent with a lognormal distribution for hydraulic conductivity as noted by Domenico and Schwartz (1990). The geometric mean (an approximation of the mean for the lognormal distribution) for the data set is 0.02 m/day.

5.5 Groundwater Flux and Velocity

The groundwater flux in the Bringelly Shale at the Site can be calculated using Darcy's Law as follow:

$Q = KiA$:

Where: K = Hydraulic conductivity (m/day);

i = Hydraulic gradient (dimensionless); and

A = Cross-sectional Area (m^2).

Assuming a conservative estimate of the upper range of the hydraulic conductivity (0.57 m/day), and a hydraulic gradient of 0.01, the total daily groundwater volume migrating across the Site boundary to a depth of 20 m (i.e., a cross-sectional area of 20 m x 500 m) is estimated to be approximately 60 m^3/day.

The groundwater velocity is also a function of Darcy's Law and is calculated as follow:

$v = Ki/Ø$: where,

K = Hydraulic conductivity (m/day);

i = Hydraulic gradient (dimensionless); and

Ø = porosity (%).

Using the same parameters for the hydraulic conductivity and the hydraulic gradient and assuming a fracture porosity of 10%, the average linear pore water velocity in the shale is estimated to be approximately 0.06 m/day (20 m/year). Lower fracture porosity (i.e., 1%) would yield a significantly faster groundwater velocity in the order of 200 m/year.

5.6 Nature and Extent of Groundwater Contamination

The various stages of site investigation discussed in **Section 3.3** are considered to have appropriately delineated the vertical and lateral extent of groundwater impacts in on-site and off-site areas. Five separate dissolved phase plumes have been identified at the site and are associated with Impacted Soil Zones (ISZ's) and/or the presence of Dense Non-Aqueous Phase Liquids (DNAPLs).

An additional investigation was undertaken to address data gaps related to the offsite extent of Plumes 1, 2 and 3 (HLA, 2007), which concluded:

- Groundwater results from the DGI generally support previous investigation results detected across the Site;
- The downgradient extent of **Plumes 1** and **2** has been delineated along Christina Road and south of the railway easement. No further delineation of Plumes 1 and 2 is required; and
- The DDX concentration in groundwater reported at the newly-installed MW304 (**Plume 3**) is of a similar order of magnitude to the adopted guidelines.

The nature and extent of the plumes are summarised in the following table and are shown on **Figure 13**.

Table 17: Summary of Groundwater Plumes

PLUME 1	
Inferred Source/s	**DDX formulation plant and adjacent benzene/MCB UST** **DNAPL - Surface spills/drainage from DDX formulation plant and MCB plant/UST -** DNAPL identified underlying this area (BP106/6) and appears to have pooled at the interface between residual clay and underlying weathered shale (6 m bgl). However, given the vertical extent of the dissolved phase contamination (>100,000ug/L @ 18 m bgl) – DNAPL mix is suspected at depth within the fractured shale
Principal COC	MCB & DDX (as mobilised by MCB solvent carrier).
Secondary - COC	Benzene, Toluene, and TCE. Elevated EDC is related to overprint from Plume 2.
Extent of Offsite Migration	Plume 1 extends south from ISZs 1a/1b crossing Christina Road in the vicinity of OS02 and subsequently extending in a westerly direction in the area of the former No 9 Branch Drain along Christina Road for approximately 300 m. The toe of Plume 1 is identified in OS05A. Plume 1 is not identified south of the railway corridor and is not considered to impact Byrnes Creek. The offsite extent of Plume 1 is controlled by an historical onsite surface water drainage system and subsequent Sydney Water stormwater/sewer conversion of parts of this network. The network comprised east-west drains along the Site's southern boundary which intercepted surface runoff (from DDX formulation plant). These drained into north-south cross drains which discharged across Christina Rd into the No 9 Branch Drain which runs parallel to the railway corridor. This drain was subsequently converted into the current stormwater system which drains Christina Road. DDX identified in OS01, OS08, OS09, and BP203 is likely mobilised by MCB as the solvent carrier related to ISZs 1a/1b.
Round 1 GME (September 2008)	MCB concentration generally lower on-site near the source of Plume 1 (BP206). BP106 indicated slight decrease in MCB at 5.5 m bgs. In general DDX concentrations variably increased and decreased. Plume 1 extent was similar to previous datasets with no significant change. Chloroform concentrations have generally decreased.
PLUME 2	
Inferred Source/s	**IHPT process building, tank farm and EDC recovery plant** - in association with the Tetramisole Plant, produced tetramisole (for sheep and cattle worm treatment). **Effluent Stripping Plant (ESP)** - received aqueous waste from IHPT and Tetramisole plants. EDC was recovered, tars produced and the stripped waste delivered to the Effluent Treatment Plant (ETP). **TWL** - delivering stripped waste from ESP to ETP.
Principal COC	EDC & DDX
Secondary - COC	TCE, Toluene and Benzene Elevated MBC is likely to be related to overprint from Plume 1

Extent of Offsite Migration	Plume 2 extends in a southerly direction from ISZ 3 to the southern boundary of the Site. As with Plume 1, it appears to be controlled by the historical surface water drainage system with Plume 2 crossing Christina Road in the vicinity of OS03/OS04 and subsequently extending in a westerly direction for approximately 200 m. The toe of Plume 2 is identified in OS05A. Plume 2 is not identified south of the railway corridor and is not identified to impact Byrnes Creek. Elevated EDC in OS10A may indicate the offsite migration of source material. DDX identified in OS10A, BP108 and BP112 is likely mobilised by EDC as the solvent carrier identified in ISZ 3 and NAPL likely in the drainage system in the vicinity of OS10A.
Round 1 GME (September 2008)	The EDC concentration was generally lower on-site near the source of Plume 2 (BP/208) and similar off-site and 'down-plume' (OS03A). DDX concentrations variably increased and decreased but with no significant change.
PLUME 3	
Inferred Source/s	**ETP** – a former pentagonal settling pit to the west of the Pharmaceuticals Building. Caustic and acid storage was undertaken to facilitate pH adjustment in a pit upstream of the ETP. Waste discharges to the ETP ceased in 2000. Remediation and validation of the upper soils has been completed. **DNAPL** – DNAPL identified underlying ETP (in existing MW46A and in abandoned MW24, MW25 & MW29) within the fractured shale.
Principal COC	EDC, TCE, Toluene, Benzene, MCB & DDX
Secondary - COC	NA
Extent of Offsite Migration	Plume 3 extends in a westerly direction with a plume front of approximately 90 m crossing the Site's western boundary. The plume length is in the order of 180 m (BP216 TCE – 1,180 ug/L). Migration of Plume 3 appears to be controlled by fracture pathways within shale bedrock and not high permeability preferential pathways associated with historical/current utilities. Plume 3 is not identified to impact Byrnes Creek.
Round 1 GME (September 2008)	Plume front defined by concentrations of MCB, EDC and Chloroform less than limit of reporting in MW303 and MW304. TCE and cis-1,2-DCE in MW304 related to contamination issues down gradient of the Site. Isolated concentrations of DDT in off site wells MW302, MW303 and MW304 potentially not likely part of a "plume" based on previous results in OS06 and OS07.

PLUME 4	
Inferred Source/s	**Former drum storage area/and various unknown practises** - drums containing EDC tars from the IHPT plant are thought to have been stored in this open, grassed area (adjacent to MW217S/D). However, groundwater concentrations at this well indicate that this former storage area is not the identified source for Plume 4. The source of Plume 4 is currently unidentified, however the given the confined extent of both EDC and DDX within the plume (< 30 m width) the source is suspected to be within the current array of monitoring wells or just up-gradient of MW48. It is also suspected that other potential sources and associated groundwater plumes exist with the general ISZ 5 area given the random and small scale nature of waste disposal practices.
Principal COC	EDC
Secondary - COC	DDX and TCE
Extent of Offsite Migration	Plume 4 extends in a west/southwesterly direction with a plume length in the order of 100-150 m with the toe of the plume identified in MW77 (less than LOR in current round of sampling). Plume 4 is not identified to migrate significantly off-site. Migration of Plume 4 appears to be controlled by fracture pathways and not high permeability preferential pathways associated with historical/current utilities and this migration mechanism would also explain the narrowness of Plume 4. Plume 4 is not identified to impact Byrnes Creek.
Round 1 GME (September 2008)	The overall extent of Plume 4 is considered to be similar to the previous datasets .
PLUME 5	
Inferred Source/s	**TWL** - TWL system was present at the Site prior to 1944. An unknown portion of TWL backfill material north of the Pharmaceutical Finished Goods Warehouse was removed as part of 2004 remediation works and a new TWL constructed beneath the Pharmaceutical Store**.** Remediation/excavation of the soils in this area was undertaken in 2004 - however analytical data pertaining to the extent of contamination of insitu material is unknown as the data has not been reviewed by AECOM. However, residual MCB, EDC, TCE and toluene soil impacts were noted during validation testing. The validation testing for these works has not been reported formally and will need to be detailed in the future.
Principal COC	EDC, MCB & DDX
Secondary - COC	NA
Extent of Offsite Migration	Plume 5 is limited in extent to BP211 (MCB – 34 ug/L/DDX – 2.088 ug/L), BP213 (EDC – 34 ug/L) and MW35 (6 ug/L) and is likely sourced from residual materials not removed during the 2004 remediation works. Plume 5 is not identified to migrate offsite.
Round 1 GME (September 2008 (AECOM, 2010).	Plume 5 related monitoring wells were not sampled as part of the Round 1 GME.

5.7 Risk Associated with Groundwater Contamination

Based on the groundwater data obtained at the Site, the findings of the groundwater modelling and the HHERA, it is concluded that groundwater conditions do not represent a significant risk to human health or the environment. However, URS has derived Risk Based Groundwater Criteria (RBGC) in the HHERA (URS 2011) which will be used as trigger levels for the proposed long term groundwater monitoring program (refer to **Section 20.0**). These RBGCs will be detailed in the Long Term SMP to be finalised for the Site.

NSW DEC (2007) states that restoration of contaminated groundwater to natural conditions "*is particularly important for pristine or near-pristine groundwater systems of high yield*". Previous investigations at the Site have demonstrated that the groundwater system underlying the Site and surrounding area is neither pristine or near-pristine nor high yielding.

NSW DEC (2007) also recognises that clean up of groundwater contamination to natural background concentrations "*can be technically difficult and extremely costly*". As discussed in HLA (2006c) *Remedial Technology Assessment (Groundwater)*, effective groundwater clean-up at the Site is limited by the following constraints:

- The contaminants of concern have a wide range of chemical and physical properties, with some being volatile with low boiling points, whereas DDX compounds are non-volatile and have high boiling points. This in turn limits the applicability of available technologies;
- Technologies for remediation of DNAPL source zones at the Site (namely Thermal Conductive Heating [TCH]) would be limited in terms of the ability to effectively delineate the boundaries of the DNAPL source zones;
- TCH may not be suitable for application over broad areas due to the requirements for closely spaced heater and vapour collection wells and the large amount of energy required to heat the subsurface to the required temperature;
- The contaminants removed from the subsurface would require subsequent destruction using an ex-situ technology that would require approval and licensing for Schedule X Wastes;
- In terms of the dissolved phase contamination, remediation technologies are effectively limited by the mass diffused in the rock matrix and would be required to operate for many decades; and
- Many technologies are unsuitable due to the properties of some of the contaminants of concern.

When it is not practical to restore groundwater contamination to natural background conditions, NSW DEC (2007) allows for interim clean-up goals that protect environmental values and prevent potential risks to human health and the environment.

6.0 Conceptual Site Model

The various stages of site investigation discussed in Section 3 have delineated the vertical and lateral extent of groundwater impacts in on-site and off-site areas. Five separate dissolved phase plumes have been identified at the Site and are associated with ISZs and/or the presence of DNAPL.

A Conceptual Site Model (CSM) that characterises groundwater contamination (nature and extent) is presented below. This information and a subsequent discussion of management issues (source zone delineation and remediation limitations) support the SMP for ongoing monitoring of groundwater contamination and thereby demonstrate clean-up to the extent practicable (DECC, 2007).

6.1 Environmental Setting

The following information on the relationship between various forms of contamination at the Site uses the results of previous site investigations including the Groundwater Monitoring Event (GME) conducted in September 2008 (AECOM, 2010).

6.1.1 Topography and Hydrology

The Site lies within the geomorphic region of the Sydney basin known as the Cumberland Plain and is categorised as Blacktown Landscape (Bannerman & Hazelton, 1990), which is characterised by gently undulating rises of Wianamatta Group shales. The highest elevation at the Site is the remnants of a blast mound (approximately 39 m AHD) located at the northern boundary. The Site generally slopes towards the southwest corner of the Site where the elevation is approximately 18.5 m AHD.

The Site lies within the Byrnes Creek catchment near the topographic divide between the Duck River and Byrnes Creek catchments. Byrnes Creek is essentially a concrete lined drain and a tributary of Prospect Creek, which is located approximately 4.5 km downstream of the Site. The Byrnes Creek concrete lined channel receives stormwater discharge from several other open concrete lined drains including one located to the north of the Site and another located in the industrial area south of Christina Road. A preliminary inspection of the channel between Miller Road (to the east and upstream) and Christina Road (to the northwest and downstream) was conducted in June 2009 (refer to the **Plates** section). The inspection did not identify the presence of flows or seeps that indicate that significant volumes of groundwater are entering the Creek. It is noted that the inspection was conducted during a rainfall event and an additional inspection will be conducted following prolonged dry weather.

Historically all surface water runoff from the Site was collected in open earthen drains and discharged into an open surface water drain on the southern side of Christina Road (the Old No. 9 Branch Drain, refer to **Figure 14**). This practice ceased in 1990 when rainfall runoff from the Site was contained as ‘clean’ stormwater and potentially contaminated stormwater runoff from manufacturing areas was contained separately. Clean stormwater is discharged into the Byrnes Creek concrete lined channel to the south. The Old No. 9 Branch Drain has also been replaced with a buried concrete stormwater pipe in the same alignment.

6.1.2 Geology and Hydrogeology

The Site is underlain by Bringelly Shale, a formation within the mid-Triassic Wianamatta Group (NSW Department of Mineral Resources [DMR], 1980). The Bringelly Shale sequence comprises inter-bedded and inter-banded shales, carbonaceous claystones, laminate, fine grained lithic sandstones and coal horizons (although rarely). The upper portion of the Bringelly Shale is deeply weathered, usually giving rise to several metres of mottled clay.

The Sydney Basin, including the sedimentary sequence of the Wianamatta Group has been gently folded by a series of tectonic events and is characterised by large scale lineaments (vertical and sub-vertical faults) and associated fractures. The Site lies within a large regional fold structure referred to as the Fairfield Basin (DMR, 1980).

The geology on-site and off-site comprise of four principle elements; fill materials, residual clay on-site, alluvial clay off-site and basal Bringelly Shale.

The uppermost unit on-site and off-site comprises fill material of reworked clay. Residual clay on-site is likely to be weathered Bringelly Shale. The clay is mottled orange/grey, moist with moderate to high plasticity. Highly weathered shale underlies the Site at depths greater than 1 metre. Sub-vertical fractures have been identified at an approximate 1 metre spacing, which are orthogonal in nature (90˚ intersection) with individual fracture planes trending 330˚ and 60˚ with respect to true north. Clay material, that was identified off-site south of the railway corridor, thickens significantly up to 6 metres. The clay material is likely to represent fine grained over bank alluvial deposits associated with the Byrnes Creek floodplain. Underlying the alluvial clay is Bringelly Shale.

The shales are characterised by partings along bedding planes and fractures sets, which are oriented sub-vertically. The bedding plane partings provide pathways for preferential migration of fluids. The regional groundwater flow is strongly influenced by catchment topography and surface water features. Groundwater flow in the upper Bringelly Shale is likely to be localised and discharge directly into Byrnes Creek and associated tributaries. Groundwater in the lower Ashfield Shale is likely to represent the broad regional groundwater flow system and discharge to Prospect Creek.

6.2 Groundwater Flow Direction

Water levels across the investigation area have been measured since 2000 in a number of field investigations including the GME conducted in September 2008 (AECOM, 2010). The majority of wells installed across the Site and in off-site areas intersect the shallow portion of the aquifer. The water table elevation reflects the regional and local topography and indicates that groundwater in the northern and western portion of the Site flows in a westerly direction. Groundwater from the southern and eastern portion of the Site generally flows in a south-westerly direction towards the Byrnes Creek concrete lined channel.

The general variation in the groundwater elevation at most locations is less than 1 m over the last 3 years. In all instances where the water level fluctuation is greater than 1 m, it appears to be related to an anomalous measurement. The hydraulic gradient is generally steeper underlying the more elevated northern areas and is in the order of 0.05. This is compared to a hydraulic gradient in the order of 0.01 near the southern boundary of the Site and in the off-site Byrnes Creek floodplain.

The groundwater flow direction in the deeper portion of aquifer is similar to that of the shallow portion.

6.3 Porosity

Fractured rock aquifers, particularly shales, have dual porosity consisting of:

- Primary porosity within the rock mass (matrix porosity), comprising intergranular voids, which for shales is low because of the fine grained nature of the clay particles that comprise the rock and various degrees of cementation between the grains; and
- Secondary porosity resulting from interconnected bedding plane partings and fractures, which may be moderately high if these features are relatively open.

Groundwater flow in the Bringelly Shale occurs within the fractures and bedding plane partings (secondary porosity). The advective flow within the rock matrix is considered to be negligible; however, the matrix porosity is important in the fate and transport of dissolved phase contaminants (i.e., matrix diffusion).

The primary (matrix) and secondary (fracture) porosity for the Bringelly Shale is likely to be very heterogeneous. In the case of primary porosity (matrix) the variability reflects the range of lithologies present within the bedded shale. In the case of the secondary porosity, it is likely that this will decrease with depth due to a decrease in fracture spacing and aperture.

No site-specific data has been collected with respect to the primary and secondary porosity of the Bringelly Shale as the latter is difficult to measure in the field. While cores can provide an indication of fracture and bedding plane spacing, in practice the fracture aperture cannot be determined with reliable precision. Based on published data (Freeze and Cherry, 1979; Domenico and Schwartz, 1998) the total secondary porosity for the Bringelly Shale is estimated to range from 1% to 10%, with an effective porosity ranging from 0.5% to 5%.

The porosity of a core sample from MW29 (7.0-7.28 m BGS) ranged from 8.4% to 9.6%, which is consistent with the limited published data on the porosity of the Bringelly Shale. William (2002) reported on the porosity of block samples obtained from seven quarries in the western part of Sydney, which ranged from 5% to 12%.

6.4 Hydraulic Conductivity

Based on the testing of 30 monitoring wells, the bulk hydraulic conductivity of the Bringelly Shale at the Site is estimated to range between 0.0004 m/day and 0.57 m/day. As expected there is a large variability in the reported values (3 orders of magnitude) and is consistent with a lognormal distribution for hydraulic conductivity as noted by Domenico and Schwartz (1998). The geometric mean (an approximation of the mean for the lognormal distribution) for the data set is 0.02 m/day. The use of a method (Connecticut Department of Environmental Protection [CT DEP], 2000) to calculate the 95% upper confidence limit (UCL) of these data, results in a UCL of 0.125 m/day.

6.5 Groundwater Flux and Velocity

The groundwater flux in the Bringelly Shale at the Site can be calculated using Darcy's Law as follow:

$Q = KiA$:

Where: K = Hydraulic conductivity (m/day);

i = Hydraulic gradient (dimensionless); and

A = Cross-sectional Area (m^2).

Assuming a conservative estimate of the upper range of the hydraulic conductivity (0.125 m/day), and a hydraulic gradient of 0.01, the total daily groundwater volume migrating across the Site boundary to a depth of 20 m (that is, a cross-sectional area of 20 m x 500 m) is estimated to be approximately 12.5 m^3/day.

The groundwater velocity is also a function of Darcy's Law and is calculated as follow:

$v = Ki/Ø$: where,

K = Hydraulic conductivity (m/day);

i = Hydraulic gradient (dimensionless); and

Ø = porosity (%).

Using the same parameters for the hydraulic conductivity and the hydraulic gradient and assuming a fracture porosity of 10%, the average linear pore water velocity in the shale is estimated to be approximately 0.06 m/day (20 m/year). Lower fracture porosity (i.e., 1%) would yield a significantly faster groundwater velocity in the order of 200 m/year.

6.6 Soil Contamination

Remediation of those ISZs (and appropriate management of any perched water that discharges into the excavations) that exceed the RBSWCs will effectively remove a significant source of groundwater contamination. This will, in-turn, essentially eliminate the mass of contamination migrating to the watertable in the dissolved phase and enhance the quality of deeper groundwater.

6.7 DNAPL Contamination

Previous studies confirmed DNAPL presence at several locations and inferred its presence at several others (HLA, 2006a):

- Measurable DNAPL was reported by CH2MHill (2004) in MW25, MW26 and MW29 down-gradient of the former effluent treatment plant (southwest corner of the Site). These wells were subsequently decommissioned. Although DNAPL was not found during installation of MW46 (located up-gradient of the former Effluent Treatment Plant), it was reported during groundwater sampling in April 2006 (HLA, 2006b. HLA also identified DNAPL at BP106, down-gradient from the former chlorobenzene (MCB) tank (southeast corner of site, HLA, 2006a). DNAPL has not been observed in other monitoring wells.
- DNAPL, if present in the past, was likely to have migrated off-site via former open surface water drains on the southern side of Christina Road, particularly near MWOS10 as indicated by the high concentrations of dissolved phase contamination. Geometry of the groundwater plumes, flow direction and groundwater modelling suggests rapid migration through surface flow in a southwest direction on site then a more westerly direction, aligning with the former Old No. 9 Branch Drain. Rapid migration in the subsurface through unidentified preferential pathways (e.g. fractures, bedding planes, etc) is not supported by the dataset. This is further discussed below.

DNAPL was not detected during the Round 1 GME conducted in September 2008 (AECOM, 2010). However, a sheen was noted on samples taken from the following monitoring wells: BP106/8, BP106/10, BP208/6, MW27, MW33 and MW46A.

6.8 Dissolved Phase Contamination

The current extent of dissolved phase groundwater plumes that have developed at the Site was assessed in the Round 1 GME (AECOM, 2010) and is shown in **Figure 13**. In summary:

- Five plumes of groundwater contamination were delineated historically;
- Three plumes extend off-site – Plumes 1 and 2 follow the paths of the historic surface drains and Plume 3 has migrated from the former Effluent Treatment Plant area; and
- The plumes are now generally stable and unlikely to migrate significantly in the future.

The recent GME (ENSR, 2008) demonstrated a general decrease in EDC and MCB concentrations. The related groundwater contaminant plumes either did not change or contracted.

DDT, DDD and DDE (DDX) concentrations were found to vary, with both increases and decreases in concentration detected across the Site and off-site. Changes that were observed in the related DDX groundwater contaminant plumes were not significant.

Table 17 provides a summary of each of the identified plumes and provides a discussion on groundwater samples that either exhibited a sheen during sampling or where high concentrations of contaminants of concern were detected. The ISZs and area of the Site that corresponds to each plume is also discussed.

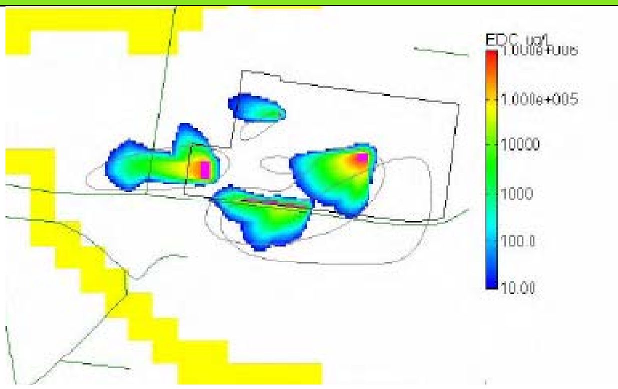
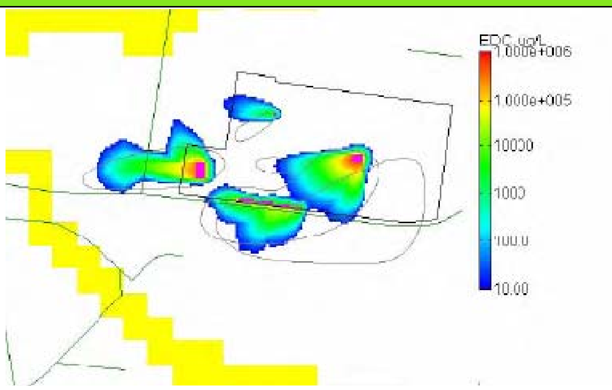
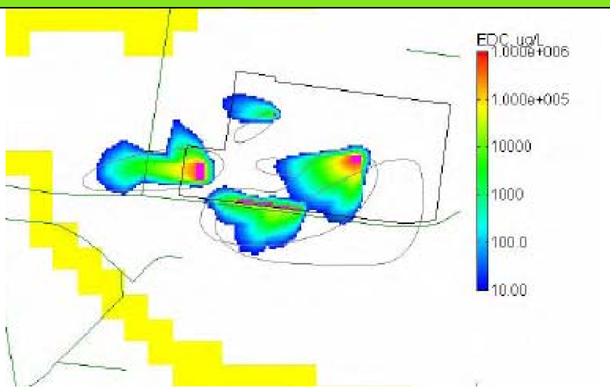
6.9 Groundwater Flow and Contaminant Transport Modelling

The following groundwater flow and contaminant transport modelling information relates to work reported in Laase (2007). The modelling exercise utilised relevant information from previous studies at the Villawood site to develop a better understanding of how groundwater moves and contaminants migrate in the fractures and block matrix of the shales underlying the Site. The groundwater flow and contaminant transport modelling included the following approach:

- Four regional flow models were calibrated to differing recharge scenarios;
- Thirty-six cross-sectional flow models with varied recharge, hydraulic conductivity and anisotropy ratios were developed to understand regional conditions;
- A three-dimensional contaminant transport model based on the regional flow model was configured, calibrated and used to evaluate future plume movement of dissolved phase contamination originating at the Orica Villawood site; and
- Sensitivity analysis used the transport model to see whether or not the plume would reach the Byrnes Creek concrete lined channel within 100 years.

The following groundwater modelling figures (refer to **Table 18** below) show development of the EDC plumes (EDC being the most mobile of the contaminants) at 5 years, 100 years and 140 years. They show rapid plume development followed by very little change after 5 years. The plumes do not reach Byrnes Creek (yellow model boundary below). It is important to note that without source along the former Old No. 9 Branch Drain, there is essentially no plume development on the southern boundary, further supporting the CSM of lateral surface migration of contaminants followed by vertical subsurface migration.

Table 18: EDC groundwater plume development (Laase, 2007)

Year 5 EDC Plume

Year 100 EDC Plume

Year 140 EDC Plume


The following information provides the conclusions of the groundwater flow and contaminant transport modelling conducted by Laase (2007).

Recharge is between 1 and 5 percent of rainfall, depending on land usage.

Based on approximating Byrnes Creek daily discharge volumes and more closely replicating plume flow paths, recharge scenario 2, corresponding to a parkland recharge rate of 5% annual precipitation (55 mm/yr), is likely the most representative of the four recharge scenarios.

All groundwater beneath Villawood is likely to discharge to the Byrnes Creek concrete lined channel.

Total daily groundwater discharge to the length of Byrnes Creek extending from Chester Hill to Villawood is relatively small (approximately 262 m^3/d). It is probable that all groundwater beneath Villawood discharges to Byrnes Creek and underflow and subsequent discharge to distant Prospect Creek does not occur.

Both cross-sectional flow and transport modelling results suggest that contamination, if present, at depths greater than -10 m AHD will not migrate significant distances within 100 years.

Cross-sectional flow suggest that contamination, if present, at depths greater than -10 m AHD will not migrate significant distances within 100 years. Flow model sensitivity analysis shows that even for hydraulic conductivity values as high as 100 m/d at depths below 0 m AHD groundwater travel times to Byrnes Creek will be in excess of 200 years. Because of plume attenuation, primarily through matrix diffusion, contaminant migration to Byrnes Creek will be even slower…the simulated travel times to Byrnes Creek for Villawood groundwater at elevations deeper than 0 m AHD (approximately 25 m below land surface) were 240 years or more.

Both matrix diffusion (dominant process) and biodegradation significantly retard plume migration.

Three-dimension contaminant transport modelling simulating matrix diffusion effects predict relatively rapid plume expansion flowed by a dramatic decrease in plume migration rates. Once the "slow" migration period is reached plume concentrations and extent are relatively static.

It is believed that the plumes originating from the Orica Villawood site are no longer rapidly expanding and are now relatively static with respect to concentrations and extent.

Sensitivity analysis shows that while varying transport input parameters produces plumes of different configurations than the calibrated plumes, none of the plumes reach Byrnes Creek within 100 years of present day. Thus, it is unlikely, even considering the uncertainties, that dissolved contamination from the Orica Villawood site (EDC being the most mobile) will reach Byrnes Creek within 100 years of present day.

While the modelling results alone demonstrate robustly that it is unlikely that groundwater contamination will reach Byrnes Creek within the next 100 years, it is important to note that the observed plume configurations support this conclusion.

Site groundwater velocities are reported to be as high as 200 m/year yet the plumes have migrated less than 100 m. Clearly the plumes are being significantly attenuated, a phenomenon replicated by the transport model.

6.10 DNAPL Fate and Transport

The following information is based on Reynolds (2005). David Reynolds (formerly of the University of Western Australia) is an expert in the fate and transport of DNAPL in clay and fractured rock environments. As discussed in Section 3 of the RAP, the geology of the Villawood site is predominantly residual clay underlain by fractured rock. Reynolds (2005) summarised key issues related to DNAPL migration that constrain and limit source zone characterisation and remediation.

The fate and transport of DNAPL in the subsurface is complex and is influenced by many factors, including but not limited to the following:

- Geological properties of the media;
- Hydrogeological properties of the media;

- Physical and chemical properties of the DNAPL, including but not limited to:
  - Viscosity;
  - Density;
  - Solubility;
  - Interfacial tension, and
  - Nature of the DNAPL release (i.e. slow leak versus large spill or loss of containment).

6.11 DNAPL Migration

DNAPL migration would have involved pathways through the fill, clay and shale bedrock under the Villawood site and adjacent areas (that is, beneath the former off-site drains). The primary historic pathway for DNAPL migration off the Site would have been through surface swales and drains into the former Old No. 9 Branch Drain (**Figure 14**). The fill contamination would exist in several phases and forms: vapour, residual DNAPL, DNAPL pools/ganglia, dissolved in pore water, sorbed to soils and diffused into the fine grained matrix.

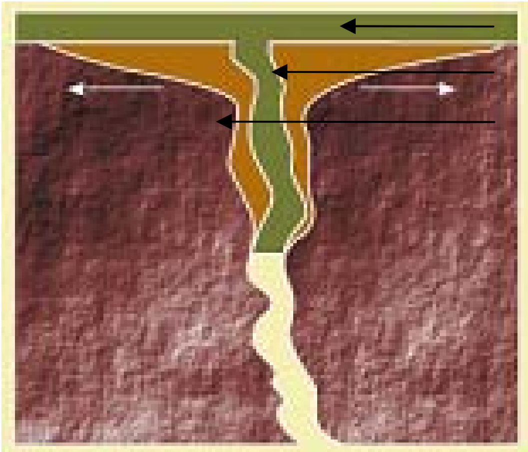
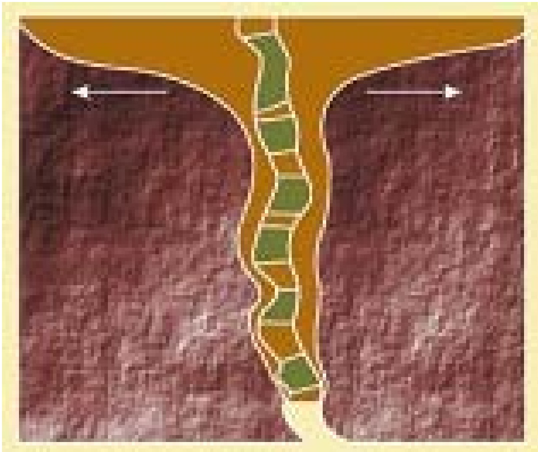
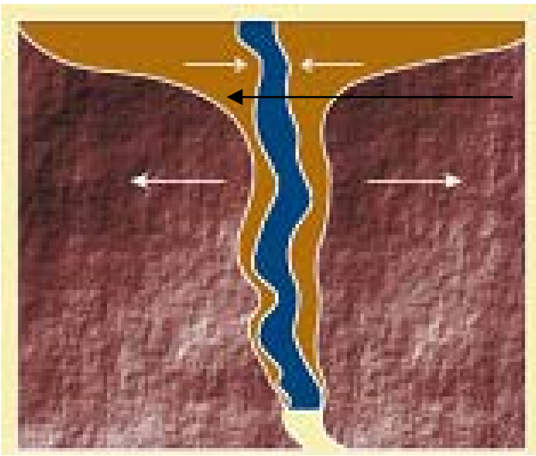
Deeper migration into the clay and weathered bedrock would be via open fractures (secondary porosity – relic fractures from the underlying bedrock) and/or other pathways (such as tree roots). Some DNAPL can be trapped at the fill/clay interface. The majority of contamination would be contained (by diffusion) in the clay matrix (primary porosity) and pose a long-term source of contamination. While the source would be long term, diffusion back into the fracture and the flow system is a very slow process, as discussed below.

Primary porosity within the bedrock is significant (estimated to range between 5 and 12 per cent, refer to **Section 5.3**. Shale exposed to DNAPL or aqueous dissolved phase contamination will present a long-term source of contamination to the system due to back diffusion of compounds from the matrix into soil gas or groundwater.

The mechanism for contamination to have migrated to the shallow groundwater system under the Site is as presented in **Table 19** overpage and summarised as follows.

- **Stage 1** - the DNAPL migrates down the fracture and diffuses away from the fracture into the matrix;
- **Stage 2** - the DNAPL drains to residual and both dissolves into the groundwater in the fracture and diffuses away from the fracture into the matrix; and
- **Stage 3** - the DNAPL is completely dissolved, clean water moves through the fracture and diffusion then occurs in two directions. If the water flowing through the fracture has a lower concentration than the water in the surrounding matrix, the diffusion process reverses, migrating contaminant mass from the matrix to the water flowing through the fracture. However, the concentration gradient within the matrix still causes forward diffusion (i.e., away from the fracture and further into the matrix) until the concentration gradient reaches equilibrium.

Table 19: Mechanism of DNAPL migration through fractures

Stage 1

Stage 2

Stage 3


It is important to note that the contaminant mass diffused into the matrix is likely to be relatively large compared to what remains in fractures.

McKay et al (1991) calculated the distribution of contaminant mass associated with DNAPL within a fractured rock system and reported the following:

- DNAPL mass in fractures: 0.32 kg/m^3;
- Dissolved phase (in solution) mass in matrix: 2.0 kg/m^3; and
- Sorbed mass (sorbed onto solid matrix) in matrix: 0.38 kg/m^3.

The above distribution of contaminant mass highlights that the DNAPL mass is not the most important consideration in fractured bedrock environments. The distribution of contaminants will be even more skewed with decreased fracture density, and for deposits such as clays, which are characterised by higher matrix porosities.

6.11.1 DNAPL Release Summary

Figure 15 through **Figure 17** illustrate the relationship between soil, DNAPL and dissolved phase contamination at the Site. The figures also show the influence that the Old No. 9 Branch Drain system (including connecting drains that flowed from the Site [**Figure 14**] had on plume development. The following stages of on-site and off-site contamination can be identified:

- **Early Time (less than two years from initial contaminant release)** – **Figure 15**. Initial contamination stage. Direct leakage from contamination sources into the surrounding soil, surface water drainage system and underlying groundwater. Surface runoff of contaminants into the surface water drainage system, transport of contaminants from the drainage system into the surrounding soil and underlying groundwater, and commencement of movement of contamination off-site.
- **Late Time (greater than five years from initial contaminant release)** – **Figure 16**. Site operation/decommissioning stage. The off-site open drains were replaced with pipes and infilled during the site operating period. The off-site plumes generally stabilised. Following closure of the surface water drainage system and on-site water treatment, there were no additional releases into drains and off-site.
- **Post Remediation Stage (near future)** – **Figure 17**. Excavation and treatment of soils which do not meet the Remediation Goals (Remediation Areas as defined in **Section 7.0**) will adopt a conservative strategy for the remediation of the Site and thereby removal of a significant source of groundwater contamination. Migration and degradation of residual DNAPL, retardation of dissolved phase groundwater plumes due to diffusion of contamination into the shale matrix. Ongoing monitoring to determine plume dynamics and related risks.

6.12 CSM Verification

To verify the key parameters and assumptions of the CSM it is proposed that the following site-specific data/information will be obtained before/during/after remediation works:

Table 20: Key CSM Parameters/Assumptions

Key CSM Assumption/Parameter	Site-Specific Data to be Obtained	Timing
Fracture alignment and density	The fracture alignment and density will be documented during excavations into the Bringelly Shale in the Remediation Areas as well as logged in cores.	During remedial works
Groundwater flow direction	As detailed in the SMP, gauging of groundwater elevations will be undertaken regularly.	Pre- and post-remediation
Matrix porosity	Core samples from the Bringelly Shale will be collected in or adjacent to identified source areas.	During remedial works
Hydraulic conductivity	As detailed in the SMP, groundwater monitoring will be undertaken regularly.	Pre- and post-remediation
Soil contamination	Review of validation soil data from the excavated Remediation Areas will be conducted to confirm that CoPC concentrations are not significantly greater than previously reported.	During remedial works
Presence of DNAPL in excavations	In excavated Remediation Areas where potential DNAPL bearing materials may be present, a hydrophobic dye test (Sudan IV) will be conducted in the field on basal soil and/or shale samples.	During remedial works
Total Organic Carbon (TOC) in the Bringelly Shale	Samples of the basal shale from the remedial excavations will be analysed for TOC to verify the groundwater model input data.	During remedial works
Contaminated groundwater is not reaching Byrnes Creek	As detailed in the SMP, groundwater and Byrnes Creek surface water monitoring will be undertaken regularly.	Pre- and post-remediation

The above information will be presented in the validation report(s) prepared for the remedial works and/or as part of future GMEs at the Site.

7.0 Remediation Goals

7.1 Soil Remediation Goals

The current generic assessment criteria used in NSW to evaluate soil analytical results are based on the NSW DEC (2006) "Guidelines for the NSW Site Auditor Scheme", NSW DEC (2006) "Guidelines for Assessing Service Station Sites" and the "National Environment Protection (Assessment of Site Contamination) Measure" (NEPC, 1999a). These guidelines present a range of Health-Based Soil Investigation Levels (HILs), sensitive land use thresholds and expected background concentration ranges for urban redevelopment sites in NSW.

As discussed in **Section 2.1.1**, since HILs are not available for all contaminants identified at the Site, it is necessary and appropriate to adopt a site-specific health-based risk assessment approach in determining safe Remediation Goals for these chemicals and the level of remediation required for the proposed future use of the Site. Accordingly, Remediation Goals have been developed using this approach.

The discussed Remediation Goals will apply to all remedial activities at the Site that involve beneficial reuse or retention of materials, including the treatment process. This approach is contemplated in Section 28 of the SCW CCO (NSW EPA 2004) and is espoused by the provisions of clause 9 and 28:

> *"9. The manufacture of scheduled chemical wastes is permitted by:*
>
> *9.3 works associated with the remediation of contaminated Sites; and…"*
>
> *"28. The use of scheduled chemical waste manufactured in accordance with clause 9.3 and not covered by clauses 26 and 27 is permitted where the use is:*
>
> *28.1 onsite and is not in an environmentally sensitive area (see Schedule B); or*
>
> *28.2 onsite in an environmentally sensitive area (see Schedule B) and:*
>
> *28.2.1 the EPA forms the opinion that the basis for the Site being an environmentally sensitive area has been satisfactorily addressed in determining the proposed use;*
>
> *or*
>
> *28.2.2 the appropriate consent authority provides specific approval for the use having had regard to the requirements of this order.*
>
> *Note: Use includes use of soil containing scheduled chemical waste in a manner which does not necessitate the employment of barriers or other engineering structures which may be associated with the keeping or disposal of waste".*

7.2 Risk-Based Site Wide Criteria

As noted previously, a HHERA (URS 2011, refer to **Appendix C**) was prepared to assess the risks to human health and the environment due to exposure to contaminants present at the Site. The approach adopted during the HHERA to develop RBSWCs was generally in accordance with the health risk assessment protocols/ guidelines recommended by enHealth (Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards, June 2002). These guidelines draw on and are supplemented by those provided by Australian and New Zealand Environment and Conservation Council (ANZECC) and National Health and Medical Research Council (NHMRC) and detailed in the documents:

- Contaminated Soil Monograph Series (CSMS, 1991, 1993, 1996 and 1998) and enHealth (2002). *The Health Risk Assessment and Management of Contaminated Sites;*
- ANZECC/NHMRC (1992) Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites; and
- National Environment Protection (Assessment of Site Contamination) Measure (1999b). Schedule B(4), Guideline on Health Risk Assessment Methodology.

ANZECC and NHMRC currently provide only general guidance and, as such, the more detailed protocols and guidelines developed by the United States Environmental Protection Agency (USEPA, 1989 and 2001) are referred to for supplementary guidance. The derivation of RBSWCs for the contaminants present at the Site has been based on assumptions relevant to potential for human exposure to the chemicals using guidance recommended and endorsed by Australian regulators in particular the DECCW and NSW Health.

In following this approach and in accordance with these types of risk assessments, the HHERA is not an epidemiological study (which is a study of the distribution and causes of existing health related issues in the community), nor does the assessment provide a statistical analysis of the existing health status of the community. Rather, the assessment provides an evaluation of the potential impact of exposure to contaminants at the Site on risks to human health using guidance recommended and endorsed by Australian regulators, in particular the DECCW and NSW Health.

The aims and objectives of the HHERA report were to:

> *"Provide a quantitative assessment of potential risks to human health associated with the presence of site-related chemicals in soil and groundwater beneath the site and in off-site areas;*
>
> *Provide a qualitative assessment of potential risks to the environment associated with the presence of site-related chemicals in soils and groundwater, particularly within off-site areas; and*
>
> *Develop risk-based soil, groundwater and/or vapour concentrations that can be used at a screening level for further investigation or as remediation end-points (if required)".*

Human health risks are the combination of the toxicity or hazard of a chemical substance and the amount of exposure by people. The greater the exposure or dose, the higher the risk. Under circumstances where there is no exposure then there is no associated risk. The risks to human health have been calculated following methodology that is representative of best industry practice in accordance with both Australian and international guidance as summarised below.

CoPC were identified following review of data (soil, soil gas and groundwater data) collected from the investigations undertaken at the Site. The maximum contaminant concentrations previously identified to be present in the identified areas of concern were assessed against existing screening guidelines. Those contaminants that exceeded the screening guidelines were considered to be Contaminants of Concern (CoC, refer to Section 3 in the HHERA, **Appendix C**). The HHERA identified the areas of concern (referred to as 'ISZs' in the Phase 2 RI, HLA 2006a) and considered the cumulative effects of those CoC being present in the soils across the Site.

The derivation of RBSWC at the Site has assumed that CoC identified at any depth may be brought to the surface during excavation and construction works. Hence the RBSWC are relevant for all soil depths at the Site. The calculation of the RBSWC also adopted the most conservative methodology for the calculation of intake derived from dermal exposures using the maximum intake derived from either inhalation, ingestion or dermal exposure to soils (refer to Section 5.3.1 of the HHERA). Furthermore, the RBSWC have been derived to allow the excavation, validation and movement of materials across the Site should the developer require bulk excavation works in parts of the Site to achieve final development levels. More detail regarding the required validation works for such works is provided in **Section 19.9**.

The relevant analytical data for each of the ISZs with comparison to the RBSWC is detailed in **Tables D1 to D10**, **Appendix D**.

The RBSWC will be adopted as 'Remediation Goals' during the remediation works.

The Remediation Goals for the Site, as derived in the HHERA are provided in **Table 21**. Detailed information relating to how the RBSWC were calculated is provided in the URS (2011) report.

Table 21: Soil Remediation Goals

Contaminant of Concern	Proposed Risk-Based Site Wide Criteria (mg/kg)
Major Risk Contribution	
1,2,3-trichloropropane	0.5
1,4-dichlorobenzene	15
a-HCH (a-BHC)	30
b-HCH (b-BHC)	15
Benzene	5
DDX (DDT + DDE + DDD)	2,000
Endosulfan II	100
g-HCH (g-BHC or lindane)	15
Hexachlorobenzene (HCB)	5
Minor Risk Contribution	
1,2-dichloroethane (EDC)	700
Vinyl chloride	10
Chloroform	80
Carbon tetrachloride	10
Trichloroethene (TCE)	400
Tetrachloroethene (PCE)	5
Chlorobenzene	2,500
Toluene	200
Ethylbenzene	200
Xylenes	800
PAHs (BaP equivalent)	10
Bis(2-chloroethyl)ether	1
d-HCH (d-BHC)	1.2
Dieldrin	15
Mercury (as total organic)	75

NOTES: Additional table notes to Table 7-1 of the HHERA are provided in that report.

7.3 Risk-Based Groundwater Concentrations

The HHERA assessed the potential risk to human health of groundwater concentrations at the Site and in off-site areas. The only exposure pathway considered to be potentially complete was the inhalation of volatile chemicals from the top of the groundwater table from the migration of vapours through the overlying soils and into buildings, outdoor air and excavations. The identification of CoPC in groundwater considered relevant to human health was therefore identified using soil gas and flux emissions rather than chemical concentrations in groundwater.

The soil gas and flux emissions data was collected from the most impacted areas of the Site and in the central portion of the plumes in off-site areas to present the worst case scenario.

The soil gas concentrations were compared to screening levels based on ambient air guidelines which are protective of human health for all people in the population associated with inhalation over a lifetime. Furthermore, it was estimated that actual chemical concentrations in indoor air would be at least 100 to 1,000 times lower than in soil gas directly beneath the building due to diffusion through soil and concrete and dispersion within the building. Concentrations in outdoor air will be even lower due to diffusion and dispersion outdoors. Consequently, the adopted guidelines were considered to be conservative in assessing risk to human health in the context of a commercial/industrial area.

Based on the soil gas and flux emissions data, the assessment of inhalation exposure off-site indicated "*a low and essentially negligible risk for offsite commercial premises that may located above inferred groundwater plumes 1, 2 or 3*". Consequently, the HHERA concluded that groundwater did not present a significant risk to human health at the Site or in off-site areas. However, URS has derived RBGCs in the HHERA (URS 2011) which will be used as trigger levels for the proposed long term groundwater monitoring program (refer to **Section 20.0**). The RBGCs will be detailed in the Long Term SMP for the Site.

7.4 Water Quality Criteria

All seepage water collected within excavated areas on the Site will be treated on-site in a waste treatment plant (WTP) to a standard suitable for discharge to sewer as per **Section 16.0** or beneficial reused during the excavation, remediation and reinstatement works, where possible.

Surface waters captured on building roofs at the Site will be considered to be free from contamination and will be discharged directly to the stormwater system during the remediation works. Surface water collected from within and adjacent to Remediation Areas, and the Soil Treatment Area (STA), including stockpiling areas, will be recovered and captured in the Site's stormwater pits, which are sealed from the external (outside the Site boundary) stormwater system and have a total capacity of 360 kilolitres (KL, refer to **Section 23.1.5** for further details). Testing of this water will be conducted and if this testing indicates that it is contaminated it will be directed to the WTP for treatment.

Based on field observations during the AECOM RIs, only minor seepage waters were noted to be generated when the upper surface of the unweathered shales was excavated. Consequently, it is unlikely that significant volumes of seepage water will accumulate within excavations during the course of the proposed remedial works. These works will also be undertaken in a controlled manner so surface waters will be appropriately managed (if required).

No other surface waters are proposed to be recovered during the works.

A Trade Waste Licence will be obtained (or an existing one will be modified) from Sydney Water for the disposal of treated waters into the sewerage system. This licence will nominate the appropriate types and concentrations of any contaminants that are permitted for discharge. Site water will not be discharged from the Site unless tested and in full compliance with the licence water quality criteria. All discharges will be documented in terms of quantity and quality, and compliance with the licence criteria will be recorded.

8.0 Extent of Proposed Remediation Works

8.1 Extent of Remediation

As noted previously, based on the findings of the groundwater modelling report (A.D. Laase, 2006), it was concluded that the groundwater plumes are static and are unlikely to migrate to Byrnes Creek due to the effects of retardation, matrix diffusion and biodegradation. Based on these factors and the Site's continued commercial land use, the HHERA (URS 2011) concluded that groundwater did not present an unacceptable risk to human health or the environment. Consequently, the primary driver for the remediation works will be the risk to human health from CoC identified within the Site soils. Excavation and treatment of soils which do not meet the Remediation Goals will adopt a conservative strategy for the remediation of the Site with the benefit of also removing impacted soils which have the potential to impact the shallow groundwater system.

Based on the data from previous investigations and a comparison of chemical concentrations to the Remediation Goals (refer to **Table 21**), various ISZs have been identified as requiring remediation. For the purposes of this report, these ISZs will be referred to as 'Remediation Areas' and are denoted as such with light blue shading in **Figure 18**. A summary of the nature and extent of the Remediation Areas is provided in the following sections while full analytical results for the Remediation Area and adjacent areas is provided in the relevant summary tables (refer to **Appendix D**).

Remedial excavations will be undertaken in the Remediation Areas to the depths indicated in the following sections. However, if validation testing of the excavation walls and base indicate that CoPC concentrations exceed the Remediation Goals, additional excavation will be conducted to greater depths based on the Maximum Practicable Depth of Remedial Excavations (MPDoRE). The MPDoRE for areas around the Site was assessed during the Phase 1 RI (HLA 2006a) and from various stages of drilling works required for the installation of groundwater monitoring wells.

Remedial excavations will also be undertaken to ensure visual signs of DDX crystals are removed and the area appropriately validated.

8.2 Remediation Area 1a

Remediation Area 1a includes ISZ 1a and 8 which, based on the available soil analytical data obtained across the areas, the history of land use at the Site and the topography of Area I and H, is considered to be adjoined for the purposes of the required remediation and validation works.

Table 22: Remediation Area 1a summary

CoC which Exceeds the Remediation Goals	Remediation Goal (mg/kg)	Maximum Concentration (mg/kg)	Average Concentration (mg/kg)	Number of Guideline Exceedances
1,2,3-trichloropropane	0.5	0.6	0.34	2
1,4-dichlorobenzene	15	165	2.4	10
a-BHC	30	17,400	140	6
b-BHC	15	14,200	123	6
Benzene	5	21.4	0.43	2
d-BHC	1.2	753	20	4
DDT+DDE+DDD	2,000	98,8000	6,740	24
Dieldrin	15	542	18	5
g-BHC (Lindane)	15	8,000	88	4
Hexachlorobenzene	5	15.5	15	3
PAHs(as B[a]P)	10	31.9	0.5	1

Tetrachloroethene	5	603	3.1	3
Toluene	200	1,500	8.9	1
Vinyl chloride	10	13	3.4	1
Estimated depth of remedial excavations: 0.5 m bgl		**Estimated volume to be excavated:** 4,000 m^3		

8.3 Remediation Area 1b

Table 23: Remediation Area 1b summary

CoC which Exceeds the Remediation Goals	Remediation Goal (mg/kg)	Maximum concentration (mg/kg)	Average concentration (mg/kg)	Number of guideline exceedances
MCB	2,500	3,040	63	1
DDX	2,000	988,000	6,740	24
Estimated depth of remedial excavations: To the Maximum Practicable Depth of Remedial Excavations (MPDoRE) - approximately 4.0 m bgl		**Estimated volume to be excavated:** 2,000 m^3		

Given the MCB and DDX concentrations reported at a depth of 3.5 m bgl in this area (sampling location IT101-F, refer to **Figure 7**), remedial excavations will be undertaken to the MPDoRE of 4.0 m bgl. This depth is based on the maximum practicable depth of excavations identified during the excavation of trench TP2 which was located approximately 10 m to the east (HLA 2006a). Continued excavation further into the weathered shales beyond 4.0 m bgl at this location was not possible using a conventional 20T excavator due to the presence of 'very, very hard' shales (refer to the Trench Logs, HLA 2006a). The depth of these hard shales has been confirmed during the following previous site investigations:

- soil sampling using a Geoprobe drill rig reported refusal on hard shales in the ISZ 1b area at depths of 1.4 m and 2.1 m bgl (ISB14 and ISB02 respectively, URS [2000]); and
- the BP206 drilling works (located adjacent to Remediation Area 1b) which also encountered the hard shale referred to in the trench logs at a depth of 4.0 m bgl (HLA 2006a).

8.4 Remediation Area 5

Table 24: Remediation Area 5 summary

CoC which Exceeds the Remediation Goals	Remediation Goal (mg/kg)	Maximum concentration (mg/kg)	Average concentration (mg/kg)	Number of guideline exceedances
DDX	2,000	16,183	638.7	2
1,2,3-trichloropropane	0.5	0.5	0.26	1
Estimated depth of remedial excavations: 1.5 m bgl		**Estimated volume to be excavated:** 500 m^3		

8.5 Remediation Area 7

Table 25: Remediation Area 7 summary

CoC which Exceeds the Remediation Goals	Area-specific Remediation Goal (mg/kg)	Maximum concentration (mg/kg)	Average concentration (mg/kg)	Number of guideline exceedances
1,4-dichlorobenzene	15	39.4	3.1	1
a-BHC	30	598	48	3
b-BHC	15	571	83	1
d-BHC	1.2	29.9	4	1
DDT+DDE+DDD	2,000	5,390	622	2
Dieldrin	15	67.2	6.2	1
Endosulfan II	100	181	12	1
g-BHC (Lindane)	15	951	138	1
Hexachlorobenzene	5	250	19	4
Mercury	75	187	21	1
Tetrachloroethene	5	48.1	6.4	2
Estimated depth of remedial excavations: 1.5 m bgl		**Estimated volume to be excavated:** 1,000 m^3		

8.6 Remediation Area 9

Table 26: Remediation Area 9 summary

CoC which Exceeds the Remediation Goals	Remediation Goal (mg/kg)	Maximum concentration (mg/kg)	Average concentration (mg/kg)	Number of guideline exceedances
Benzene	5	5.8	0.54	1
DDX	2,000	22,265	1248	2
Dieldrin	15	562	29	2
Endosulfan II	100	15,900	943	2
Estimated depth of remedial excavations: 1.0 m bgl		**Estimated volume to be excavated:** 1,000 m^3		

8.7 ISZs not Requiring Remediation

Those ISZs which, based on site conditions and the outcomes of the HHERA (URS 2011), do not require remediation, are as follows:

8.7.1 ISZ 2

CoPC concentrations marginally exceeded the RBSWC at ISZ 2 at the following sampling locations (refer to **Figure 7** and Table D1):

- Soil location ISB09 (0.3 m bgl) - 13 mg/kg vinyl chloride (RBSWC of 10 mg/kg); and
- Soil location TP88 (1.0 m bgl) - 15.2 mg/kg 1,4-dichlorobenzene (RBSWC of 15 mg/kg).

However, based on the analytical data obtained for the surrounding areas in ISZ 2 and the soil vapour monitoring undertaken at this location, these impacts are considered to be localised in vertical and horizontal extent and do not represent an unacceptable risk to human health. The HHERA (URS 2011) also concluded that all risks were less than the target risk in relation to workers in ISZ 2 (i.e. commercial/industrial and intrusive workers). Consequently, remediation of the soils in ISZ 2 is not considered to be warranted.

8.7.2 ISZ 3

All CoPC concentrations within ISZ 3 were reported to be less than the RBSWC (refer to **Table D2**). Consequently, no remediation is considered to be required in this area.

8.7.3 ISZ 4 and 6

As discussed in **Section 3.3.9**, remediation works have previously been undertaken in ISZ 4 and 6 (refer to **Figure 4**. For detailed reporting on the site remediation and validation works conducted in this area refer to the CH2MHill report (2007b).

CoPC concentrations within ISZ 4 and 6 were generally reported to be less than the RBSWC (refer to **Table D3** and **D5**) with the exception of the following validation area (refer to **Figure 4** and **11**):

- Soil location VA4/138 (0.3 m bgl) in the southern portion of validation Area 4 (CH2 validation works, 2004) - 3.04 mg/kg d-BHC (RBSWC of 1.2 mg/kg).

Based on review of the soil data surrounding sampling location VA4/138, additional remediation of the soils in this area is not considered to be warranted for the following reasons:

- The reported low d-BHC concentrations in 3 analysed soil samples (maximum concentration of 0.09 mg/kg) from sampling points surrounding sampling location VA4/138 (i.e. VA4/136, VA4/141 and VA4/142), confirms that the exceedance in this area is localised. d-BHC concentrations across the remainder of validation Area 4 were also generally reported to be non-detect;
- The calculated 95% upper confidence limit for all d-BHC concentrations in the top 0.5 m of the ISZ 4 soil profile (i.e. at a depth representing a possible risk of exposure via dermal contact and ingestion) is 0.04 mg/kg which is significantly less than the RBSWC of 1.2 mg/kg; and
- It is likely that future development of the Site will involve construction of a concrete slab/paving or warehouse over the discussed area thus mitigating opportunities for dermal contact and/or ingestion.

8.7.4 ISZ 10

DDX concentrations exceed the RBSWC beneath the Pharmaceuticals Building concrete slab. The HHERA (URS 2011) concluded that risks are negligible in this area while the building remains and therefore the RBSC are relevant to future developments only where the building is removed.

8.7.5 Other Site Areas

Based on a review of all data across the Site, d-BHC concentrations also exceeded the Remediation Goals at the following locations outside the identified ISZs (refer to **Figure 4** and **11**):

- Soil location BTP04 (1.0-1.1 m bgl) in the middle of Area B (URS, 2000) - 3.7 mg/kg d-BHC (RBSWC of 1.2 mg/kg).

Based on review of the soil data surrounding sampling location BTP04, remediation of the soils in this area is not considered to be warranted for the following reasons:

- The non-detectable d-BHC concentrations in 10 analysed soil samples from sampling points surrounding BTP04 (i.e. BTS4, BTS9, TP52 and TP55), confirms that the exceedance in this area is localised horizontally. d-BHC concentrations across the remainder of Area B are also generally non-detect;
- The d-BHC exceedance at sampling location BTP04 is considered to be localised vertically as the samples analysed above and below (0.2-0.3 and 1.1-1.2 m bgl) the depth of the exceeding sample (1.0-1.1 m bgl) were both reported to be non-detect for d-BHC; and
- There is no risk of exposure via dermal contact and ingestion related to the d-BHC impacted soil at BTP04 (1.0-1.1 m bgl) due to the depth of this material. It is also likely that future development of the Site will

involve construction of a concrete slab/paving or warehouse over the discussed area further mitigating opportunities for dermal contact and/or ingestion.

8.8 Summary of Remediation Requirements

Based on the findings of the above sections, the following remediation works will be required at the Site.

Table 27: Summary of Remediation Requirements

Remediation Areas	CoC	Excavation Depth (m bgl)	Estimated Remediation Volume (m^3)
Remediation Area 1a and 8	Various - refer to **Table 3** and **Table 12**	Between 0.5 and 1.5 m	9,400
Remediation Area 1b	MCB and DDX	4.0 m	1,000
Remediation Area 5	DDX & 1,2,3 trichloropropane	1.5 m	500
Remediation Area 7	Various – refer to **Table 11**	1.5 m	1,000
Remediation Area 9	Benzene, DDX, dieldrin & Endosulfan II	1.0 m	1,000
Site-Wide Trade Waste Line	TBC	-	-
Secure Storage Facility	DDX, EDC, TCE, benzene and toluene	-	10,000
Chester Hill Contaminated Materials	EDC, TCE, 1,1,1-TCA, CTC & CFM	-	1,800
ESTIMATED TOTAL (m^3)			**24,700**

8.9 Summary of Waste Types and Estimated Volumes

Based on preliminary estimates provided by Thiess Services, the following waste types and estimated volumes are likely to be generated during the remediation works and will require waste classification and offsite disposal:

Table 28: Summary of Waste Types and Estimated Volumes

Waste Type	Estimated Volume/Tonnage	Likely Storage Area
Excavated Materials		
Concrete slabs from Remediation Areas 1a, 1b and 8	approx. 1,200 m^3	Central Stockpile Area (Item 1, **Figure 18**)
Asbestos pipes from TWL	approx. 85 T	Central Stockpile Area (Item 1, **Figure 18**)
Asbestos impacted soil from TWL removal works	approx. 60 T	Central Stockpile Area (Item 1, **Figure 18**)
Non-contaminated concrete pipe suitable for recycling	approx. 40 m^3	Central Stockpile Area (Item 1, **Figure 18**)
Waste from Feed Soil Building (FSB) & Thermal Plant		
FSB carbon	approx. 500 T	Licensed storage area in FSB (Item 8, **Figure 18**)
Thermal plant solids and sludge	approx. 300 m^3	Licensed storage area in FSB (Item 8, **Figure 18**)
Thermal plant carbon, gravel and High Efficiency Particulate Air (HEPA) filters	approx. 500 T	Licensed storage area in FSB (Item 8, **Figure 18**)
WTP oil	approx. 40 m^3	Licensed storage area in FSB or WTP tanks (Item 8, **Figure 18**)
WTP carbon and sand filter media	approx. 200 m^3	Licensed storage area in FSB(Item 8, **Figure 18**)
WTP sludge	approx. 100 m^3	Licensed storage area in FSB (Item 8, **Figure 18**)

9.0 Remedial Options

Orica engaged AECOM to undertake a Remedial Technology Assessment (RTA [HLA, 2006b]) for the remediation of the contaminated soils identified at the Site. The purpose of this assessment was to carry out an initial review of a wide range of possible remedial options and recommend a set of three preferred options for more detailed evaluation.

9.1 Assessment of Technology

The assessment detailed in the RTA (HLA, 2006b) was focused on the contaminated soils identified within the ten ISZs and the excavated soils stockpiled within the SSF outlined in **Section 8.0**. The assessment assumed that any remedial treatment works would be carried out either on-site or at an alternative location off-site. Based on the range of contaminants identified at the Site and the estimated volume of materials to be treated, the initial assessment considered that on-site treatment of the materials was the most favourable.

9.1.1 Determination of Technology Options

The assessment was undertaken in three stages. The initial stage involved a review of primary information sources to identify a list of twenty-five remedial technology options that were potentially applicable to the remediation of the identified contaminated soils at the Site. These options were selected for further review in the first stage of assessment.

9.1.2 First Stage of Assessment

The first stage of assessment involved carrying out a screening of the technologies against the following four specified parameters:

- **Applicability** - an assessment of the potential applicability of the technology at the Site giving consideration to the following:
  - lithology;
  - the chemical and physical properties of the contaminant including the physical ability to reduce contaminant concentrations to below clean-up goals;
  - distribution in the subsurface (vadose/saturated zone);
  - access and space constraints;
  - efficacy; and
  - Occupational Health & Safety (OH&S) issues.
- **Technology Status** - acceptance of technology locally and internationally by remediation practitioners (consultants/academics/regulators) as being proven or innovative as well as availability of remedial equipment/infrastructure;
- **Secondary Treatment Requirements** - identification of additional treatment requirements including the disposal of wastes;
- **Monitoring** - short-term and long-term monitoring requirements for implementation of technology to assess remediation performance and/or adverse impacts;

The technologies were ranked on the basis of an overall rating from 1 (low) to 5 (high) for each criteria. These ratings were used to determine the highest ranking technologies, and the following technologies were selected for further screening:

- Ex-situ Direct Thermal Desorption (DTD);
- Ex-situ Plasma Arc Centrifugal Treatment (PACT);
- Ex-situ Startech;
- Ex-situ Mobile High Temperature Incineration;
- Ex-situ Cement Kilns;
- In-situ Vitrification;
- Ex-situ Vitrification;
- In-situ Electrical Conductive Heating;
- Ex-situ Indirect Thermal Desorption (ITD), with treatment of condensate by another technology;

- In-situ/Ex-situ Biodegradation;
- Base Catalysed Decomposition (BCD); and
- Plascon.

While not one of the ranked technologies, biodegradation was included since some of the impacted soils identified at the Site could have potentially been treated using this method. Likewise, BCD and Plascon were included in the second stage of assessment since these technologies are often successfully used in combination with ITD for the treatment of condensate.

9.1.3 Second Stage of Assessment

The second stage of assessment involved conducting a more detailed screening of the highest ranking technologies identified in the Stage 1 assessment. The second stage of assessment involved carrying out a screening of the technologies against the following eight specified parameters:

- **Risk and Controls** - limitations or constraints posed by technology which may require additional controls prior to implementation to ensure appropriate containment of contaminants and/or chemicals added to the subsurface in the case of groundwater remediation;
- **Site Specific Issues** - additional factors that may pose constraints that may limit ability to implement technology or efficacy of treatment;
- **Bench/Pilot Scale Trial Requirements** - need for additional testing of technology for site specific conditions;
- **Timing (Technology Implementation)** - timeframe required to complete feasibility assessments and design of remediation system;
- **Timing (Treatment)** - timeframe required to reduce contaminant mass following implementation of technology, including the time required to achieve cleanup goals or period over which management is likely to be required for groundwater remediation technologies;
- **Regulatory Approvals** - likelihood of regulatory acceptance giving consideration to current policies including emissions, energy requirements and sustainability;
- **Community Acceptance** - likelihood of technology being acceptable to local community including adjacent industrial/commercial properties and nearby residents; and
- **Relative Costs** - including the capital costs such as equipment and its installation/commissioning, coupled with ongoing costs such as for maintenance and waste treatment/disposal.

9.2 Remedial Technology Assessment Summary

The ratings from the first stage of assessment were carried over and added to the ratings from the second stage to determine the three technologies with the highest rating as tabulated below.

Table 29: Summary of Second Stage of Assessment Ratings

Process Name	Ratings								
	Stage 1 Final Rating (P1)	Risk and Controls	Site-specific Issues	Bench/ Pilot Trials	Timing (Tech Implement)	Timing (Treatment)	Regulatory Approval	Community Accept	Relative Costs	Total Rating
Primary Treatment Technologies										
Ex-situ DTD	**20**	4	3	4	4	4	4	4	5	**52**
Ex-situ PACT / Startech	**15**	3	3	3	3	2	3	3	2	**37**
Ex-situ Mobile High Temperature Incineration	**20**	4	3	5	2	4	1	1	3	**43**
Ex-situ Cement Kilns	**18**	3	3	3	2	3	1	1	5	**39**
Ex-situ/In-situ Vitrification	**17**	3	3	3	2	3	2	2	2	**37**
In-situ Electrical Conductive Heating	**17**	5	3	3	4	4	4	4	4	**48**
Ex-situ ITD	**19**	4	3	4	5	4	5	4	4	**52**

Based on the information gathered as part of the RTA the following technologies had the highest ratings and were considered to be the preferred remedial technology options to treat contaminated materials at the Site:

- DTD;
- Ex-situ ITD coupled with separate treatment of the condensate (by BCD or Plascon); and
- In-situ ECH with separate treatment of the condensate (by BCD or Plascon).

The RTA concluded that the use of ECH to treat materials previously excavated and held in the secure storage facility (SSF) does not appear practical given that this is an in-situ based process. Combined with the fact that ECH technology is not as well developed as ITD or DTD, this would imply that ITD and DTD are the technologies of choice for the Site. However, it was noted that the benefits inherent in in-situ treatment from an operational perspective and reduced complexity from a regulatory perspective supported further study of ECH in the context of the Site. Accordingly, it was recommended that all three technologies be assessed in greater engineering detail for application at the Site as a single or combined solution. It was also intended to consult stakeholders in the assessment process to assist in the technology selection and risk management.

10.0 Remediation Works Overview

10.1 Selection of Preferred Remediation Option

Based on the findings of the RTA and further evaluation of the two ex-situ technologies (DTD and ITD), DTD was selected as the preferred remediation technology for the following reasons:

- Degree proven
  - DTD is considered to be a proven technology as it has been in use since the mid-1980s. The technology has been applied to around 120 remediation projects, treating approximately 3.5 million tonnes of contaminated material. DTD is suitable for treating the CoC at the Site.
  - A DTD treatment process was used at the former Allied Feeds site (completed in August 2009) and was used to treat to treat 81,000 m3 of contaminated soils at the Lednez site on the Rhodes Peninsula (completed May 2010). The successful local demonstration of the technology at full scale at the above projects provides confidence in the technology and will assist in achieving planning approvals and community acceptance.
- Simplicity of design and operation
  - DTD is a relatively 'simple' technology when compared to ITD. Put simply, it is considered that DTD is more robust and easier to operate and maintain compared with ITD - meaning that the likelihood of operational success for DTD is greater than for ITD.
- Stack Emissions
  - Emissions to air for the ITD and DTD technologies are anticipated to be comparable, but ITD has marginally lower emissions than DTD. If designed and operated properly in accordance with the best practice guidance of the Stockholm Convention, emissions from either technology are not anticipated to cause appreciable health or environmental risks.
- Residues
  - As DTD utilises a destructive Emission Control System (ECS) to treat the off-gases, there are no residues generated. Consequently, secondary treatment systems are not required. ITD is, by contrast, a technology that requires extensive secondary treatment processes such as BCD or plasma arc to destroy the concentrated residues that are produced. For DTD there is no requirement for treatment, storage and transport of residues, as there is for ITD.
- Project Timeframe
  - DTD is anticipated to be faster in treating the Site's contaminated material than ITD. The reduced timeframe of the DTD operations would directly translate into a shorter overall project duration with corresponding reduction in associated impacts for the local community.
- There is sufficient space on the Site to establish the required plant and treatment infrastructure.
- Ex-situ DDT is suitable for treating the SCW stored in SSF (refer to **Section 4.6.12**).
- Ex-situ DTD is suitable for treating the CoC present in the contaminated material which is proposed to be transported to the Site from the former Orica Chester Hill site (refer to **Section 4.6.15**).

10.2 Proposed Remediation Methodology

The DTD process is an ex-situ remedial treatment method, and as such, excavation of the Remediation Areas will be required prior to treatment. The excavated materials will be assessed upon excavation and sampled for classification. Excavated materials requiring treatment will be transported from the Remediation Area to a Feed Soil Building (FSB), where they will be readied for treatment in the adjoining DTD Plant. The FSB will be equipped with an Emission Control System (ECS) to control and regulate emissions from the material handling processes prior to treatment. After treatment, the material will be validated and temporarily stockpiled adjacent to the FSB (refer to **Figure 19**). Once treatment of each of the Remediation Areas has been completed and the areas have been suitably validated, the treated material will be beneficially reused as backfill material at the Site.

Specific information on the individual plant, site facilities and treatment processes are outlined in the appropriate sections of this RAP. The proposed remedial works will involve the following general operations:

- Preliminary activities including project planning and licensing;

- Site establishment, including:
  - Set-up of site offices, fencing, decontamination stations, environmental control measures, Water Treatment Plant (WTP) and other associated facilities;
  - Set-up of various safety zones and Remediation Areas to be excavated (the sequencing is yet to be determined);
  - Installation of DTD Plant and equipment;
  - Construction of the FSB and associated ECS and the sealed hardstand adjacent to the FSB (as required); and
  - Construction of internal haul roads (as required).
- Progressive excavation of contaminated soils from the first Remediation Area;
- Proof of Performance (PoP) testing period for the DTD Plant and associated ECS for the FSB;
- Screening of oversize excavated materials (as required);
- Transport of the excavated materials from the Remediation Area to:
  - The FSB if the initial testing finds that the excavated materials require remedial treatment; or
  - A second soil stockpile if initial testing indicates that the excavated materials are suitable for beneficial reuse without remedial treatment; or
  - An off-site licensed waste facility where excavated materials are considered unsuitable for remedial treatment, but are suitable for disposal/recycling at such a facility.
- Treatment of soils within the DTD Plant;
- Progressive validation of the treated soils and placement in temporary stockpile areas;
- Progressive validation of the Remediation Areas (against the Remediation Goals) after the excavation and removal of the contaminated materials;
- Dismantling and reestablishment of Remediation Area for each stage of excavation works;
- Backfilling of the validated Remediation Areas after completion of the excavation and remedial treatment works;
- Final reinstatement and finishing of the Remediation Areas; and
- All necessary OH&S, environmental protection works and monitoring.

These project tasks and other remediation requirements are detailed in the following sections of this report (refer to **Table 30** below).

Table 30: Overview of Remediation Tasks Detailed in this Report

KEY REMEDIATION TASK	RELEVANT REPORT SECTION
Public Consultation	**Section 11.0**
Preliminaries	**Section 12.0**
Excavation Works	**Section 13.0**
Materials Handling	**Section 14.0**
Treatment Operations	**Section 15.0**
Management of Water	**Section 16.0**
Removal and Disposal of Materials from the Site	**Section 17.0**
Placement of Reinstatement Materials	**Section 18.0**
Validation Plan	**Section 19.0**
Groundwater Monitoring Program	**Section 20.0**
Environmental Management Plan	**Section 21.0**
Occupational Health and Safety	**Section 22.0**
Contingency and Emergency Response Plan	**Section 23.0**

10.3 Project Schedule

The remediation process is expected to take approximately 58 weeks to complete, including site establishment, pre-treatment, treatment, validation, decommissioning and reinstatement.

The estimated breakdown of this program is generally as follows:

- Site establishment and construction (including DTD Plant commissioning and PoP testing) - approximately 26 weeks;
- Excavation and treatment - approximately 20 weeks;
- Decommissioning and demobilisation - approximately 12 weeks; and
- Reinstatement of excavated areas - approximately 12 weeks (concurrent with demobilisation).

A more detailed project schedule will be prepared once the DTD Plant has been selected.

It is anticipated that construction and demobilisation hours would be between the hours of 7am and 6pm Monday to Friday, and 7am to 1pm Saturdays. No construction work would occur on Sundays and Public Holidays.

Operation hours for the excavation activities would be between 7am to 5pm, six days per week. Operation hours for the FSB and the DTD Plant would be 24 hours per day, seven days a week, with the seventh day scheduled for maintenance.

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11.0 Public Consultation Strategy

11.1 Background

Given the nature of the remediation works, the issues involved and potential for community interest and concern, an open communication and consultation system with all stakeholders will be established. This section outlines the various methods of communication proposed between the contractors undertaking the remediation works and members of the community surrounding the works.

In preparing the proposed consultation process, the following factors have been considered:

- the location of the Site and the surrounding workers and communities; and
- the need for the general public to be informed of the progress of the remediation works and to have their questions or concerns responded to in a timely manner.

11.2 Consultation Objectives, Scope and Duration

It is essential to the overall success of the project that open consultation occurs during all stages of the project. Open communication, allowing all stakeholders access to information is necessary during the course of the remediation works, and it is essential that all stakeholders have a means of airing any concerns and having any questions responded to in a timely manner.

The key goal of the consultation process for this project is to disseminate clear and factual information that meets the needs of the various stakeholders in order to minimise the generation of false information, to encourage and respond to feedback and to reduce the potential for uninformed objections to the works. The following objectives have been identified:

- To help the local community develop an understanding of the project objectives, benefits and works proposed;
- To provide up-to-date information on the progress of the project on a regular basis;
- To provide opportunities for all stakeholders to provide feedback and air concerns during the course of the project;
- To respond to comments and requests for information in a clear and timely manner; and
- To pass on information relating to stakeholder issues and concerns to the remediation team so that they can be adequately addressed.

The form of consultation and information tools need to be developed with consideration of stakeholder needs. The scope of information released in the consultation process needs to include the following:

- Progress of remediation works;
- Any changes in key components of the site works proposed during the course of the remediation works
- Any changes in the timetable and timeframes proposed over the course of the remediation works;
- Expected effects of the proposed works on other site workers (as required) and the surrounding community;
- Measures to be taken to manage and mitigate these effects;
- Potential risks to other site workers (as required) and the community;
- Measures to be taken to manage and minimise these risks and
- Realistic project outcomes.
- The consultation process should span the duration of all activity on the Site (including site establishment, remediation and decommissioning.

11.3 Consultation Methods and Tools

Over the course of the remediation works, continued and ongoing consultation will be undertaken to inform stakeholders of the progression of the project and to provide an avenue to receive feedback and respond to questions or concerns. This will largely be done by holding targeted meetings with specific interest groups.

The frequency, scope, location and attendance of meetings will be determined in consultation with interested parties. The following methods will be used to ensure effective and efficient consultation with stakeholders over the duration of the remediation works.

11.3.1 Consultation Database

A database will be prepared to identify all stakeholders for the proposed remediation works. The key parties identified to date are the DECCW, Bankstown City Council, other government agencies and surrounding community groups, neighbouring businesses, local MPs, National Advisory Body on Scheduled Wastes.

Over the course of the project, the database will be updated with new or changed contacts as required and will be regularly used to document communications with stakeholders.

11.3.2 Contact Letter

A letter to identified stakeholders with an interest in the project will be prepared and distributed prior to commencement of the remediation works at the Site. The letter will contain information relating to the proposed remediation works, a project programme showing the anticipated duration of works, appropriate contact details and the planned opportunities available for stakeholder feedback and participation. This letter will ask for stakeholders to provide feedback on their consultation requirements so that the methods used can be updated to meet their needs and for the recipients to pass on contact details of other parties whom they think may be interested in the remediation works.

11.3.3 Newsletters

At defined stages throughout the project, newsletters will be prepared and distributed to stakeholders to communicate project information and to remind stakeholders of feedback contact details. The newsletters will provide an avenue for communicating specific information on the progress of the remediation works as appropriate. Feedback will be collected via the dedicated telephone number and recorded in the consultation database.

11.3.4 Information Board

A notice board will be established at the main entrance to the Site. The notice board will present recent newsletters, contact information and inform interested parties on the methods of communication with the remediation team available to them.

12.0 Preliminaries

12.1 Background

Prior to establishment of the Site, all plans, programs, licences, certificates and other documents necessary for the commencement of work will be completed. These documents will include the following:

- Management Plan and Work Procedures for :
  - OH&S;
  - Environmental management;
  - Project management;
  - Quality management; and
  - Emergency response and contingency management.
- Studies relating to potentially hazardous on-site operations and processes (HAZOP);
- Community Liaison Plan;
- Detailed work program and logic diagram;
- All necessary licences and approvals from regulatory authorities;
- Insurance certificates;
- Submission of all WorkCover NSW (WorkCover) notifications; and
- Any additional documentation required.

All assessment and design work for the excavation and remediation works, including the design of site buildings, processes and equipment used, will be completed by appropriately qualified and experienced engineers. All assessment and design will be documented in the form of plans and drawings that are properly certified for use on the Site.

12.2 Licences and Approvals

12.2.1 Occupational Health and Safety

Prior to site establishment, all appropriate OH&S planning activities will be completed, i.e. an OH&S Plan (OHSP) will be prepared, documented and approved, where necessary. An overview of OH&S activities is provided in **Section 22.0**.

12.2.2 Environmental Management

Prior to site establishment, all appropriate environmental management activities will be completed, i.e. an Environmental Management Plan (EMP) will be prepared, documented and approved, where necessary. An overview of environmental management activities is provided in **Section 21**.

The current EPL allows for the certain activities at the Site under the POEO Act (refer to **Appendix E**). An application to DECCW to obtain a new EPL specific to the remediation works will be required. The environmental provisions of the EMP will need to be reviewed to ensure that they comply with the new (remediation) EPL.

An application will need to be lodged to the NSW EPA to update the existing EHC Act License (Number 85, EPA file number HO7795, refer to **Appendix E**) to allow treatment of scheduled chemical wastes during the proposed remediation works.

12.2.3 WorkCover NSW Notification

Prior to site establishment, WorkCover will be notified of the proposed commencement date for site works.

12.2.4 Commissioning and Mobilisation of Plant and Equipment

All equipment and plant used on-site during the remediation works must:

- Be suited to the work intended and meet all operational requirements;
- Be in good condition, in sound working order and have a current documented maintenance logbook;
- Be reliable and have low-maintenance requirements;

- Comply with all regulatory requirements;
- Comply with the design and manufacturer's standards; and
- Be operated by a suitably trained and licensed operator.

Plant and equipment that does not comply with these requirements will not be permitted on-site. In the event of a break down on-site or inactivity due to routine maintenance requirements, additional equipment and plant complying with these standards may be brought to Site in the interim.

12.2.5 Utilities and Resources

Utilities and resources required for the proposed remediation works include:

- Natural gas - required for the rotary dryer and thermal oxidiser of the DTD Plant. Gas will be supplied to the DTD Plant via an underground pipe from a reticulation system which will need to be established at the Site. No alternative or back-up fuels are proposed and a loss of gas supply would automatically initiate a controlled shutdown of the DTD Plant.
- Electricity - during normal operation all power for the plant will be supplied from the existing grid. The DTD Plant will be fitted with a back-up power supply to enable controlled shutdown and restart in the event of a power outage.
- Diesel - Diesel is required for the back-up generator fitted to the DTD Plant as well as for the operation of equipment to be used on-site such as excavators, loaders and trucks. All re-fuelling will be by mini-tanker in a dedicated bunded area. No diesel storage will be provided on-site.
- Potable Water - required for the cooling process within the quench and the acid gas scrubber within the DTD Plant. Recycled water will be used wherever possible. The water will be supplied to a break tank at the DTD Plant and then pumped from the break tank to the quench and acid gas scrubber. A back-up water tank will be provided for the quench, pressurised by air cylinders to cater for loss of mains water flow.
- Mains sewer and telecommunications – required for site facilities, etc.

The installation and commissioning of temporary site services (gas, electricity, water, sewer and telecommunications) required for the duration of the remediation works will be undertaken by qualified and experienced personnel in accordance with the specifications and requirements of the appropriate regulatory authorities. All approvals in respect to the installation, operation and eventual removal of temporary services will be obtained.

There may be services located within the vicinity of the proposed remedial excavation works. In order to confirm this, a cable/pipe location survey will be conducted of the Remediation Areas and adjacent areas to identify and locate any underground services that may be affected by the excavation and reinstatement works.

Any existing utilities located within materials requiring excavation would be temporarily bypassed and removed so as not to hinder excavation activities. These services and utilities would be re-established as required as part of the Site reinstatement works.

12.3 Site Facilities and Procedures

12.3.1 Contractor's Facilities

Site accommodation and facilities required for the remediation works will be established in compliance with relevant regulations. These facilities will be connected to appropriate utilities as required.

The following facilities will be established at the Site:

- FSB and the DTD Plant;
- Site Offices located adjacent to Gate 1;
- Air lock and wheel wash zones at the entrance and FSB exit point;
- ECS for the FSB (refer to **Figure 18** and **Figure 19**);
- Stores, work sheds, lunchrooms and changing areas for the use of subcontractors and consultants;
- Temporary site sheds, first aid and emergency facilities, bathroom facilities and decontamination units; and
- Any additional site facilities to facilitate work in other areas of the Site, or in areas requiring additional safety measures.

12.3.2 Exclusion Zones

Exclusion Zones are areas of the Site outlined in the OHSP that either require additional protective measures or may require the adoption of additional OH&S requirements and work practices. Exclusion Zones may also include other areas affected by emissions from the works being undertaken at any point in time. All Exclusion Zones will incorporate a buffer area along the boundary of the zone.

The boundaries of all Exclusion Zones will be defined by fencing (or other solid barriers) and safety signs erected at regular intervals around each Exclusion Zone warning of the boundary of the Exclusion Zone, the nature of the hazard associated with it and access restrictions that apply for entry into the zone. Access of personnel into and out of Exclusion Zones will be controlled at Decontamination Stations and will depend on the personnel classification. The location and extent of Exclusion Zones will be detailed in the OHSP and addressed in the Site-Specific Safety Induction. The following Exclusion Zones have been nominated at the Site:

- The Remediation Area and its immediate surrounds;
- The FSB and its immediate surrounds; and
- The DTD Plant area and its immediate surrounds.

12.4 Site Access and Security

12.4.1 General

Only authorised personnel and equipment will be allowed on to the Site. Entry to the Site will be strictly controlled throughout the course of the remediation works.

12.4.2 Site Haul Roads & Parking Areas

Existing access roads at the Site will be utilised as haul roads to the extent practicable. However, extensions and diversions of existing roads will need to be undertaken to serve as haul roads for the transport of materials between the Remediation Areas and the FSB. **Figure 18** illustrates the proposed haul roads for transport of materials between the Remediation Areas and FSB.

Any newly constructed haul roads will be built to a suitable industrial standard, and finished with a bitumen-sealed surface. Sediment and erosion control measures, drains or barriers will be erected adjacent to all haulage roads to control drainage and run-off during rainfall events, where necessary.

All designated haul roads will be regularly inspected for the presence of BACM to prevent the possible crushing and spreading of these materials to other site areas.

12.4.3 Site Access

The primary access route to the Site would be via the main entry gate on Christina Road (Gate 1). A security gate will be patrolled at this entry point during the operational hours of the remediation works.

Vehicles travelling to and from the Site will be limited to employees, delivery of plant and equipment and deliveries of consumables.

The likely primary routes to the Site would be:

- Inbound from the west (only) – drive along Woodville Road turning onto Christina Road and accessing the Site via Gate 1;
- Outbound to the west – exit via Gate 1 along Christina Road and turn onto Woodville Road; and
- Outbound to the east – exit via Gate 1 along Christina Road and turn onto Miller Road at the roundabout. Proceed in northerly or southerly direction.

The primary traffic routes to and from the Site utilise arterial roads to access the Sydney metropolitan area, therefore minimising the impact on the local road network.

12.4.4 OHS Signage

OHS Signage will be installed at the Site entrance off Christina Road, detailing directions to key areas (including to the various site areas, offices, decontamination units, haul roads, first aid facilities and parking). The existing security gate will be patrolled to limit access further into the Site and ensure the safety of site visitors and to restrict off-site vehicles from disrupting site operations. The signage at the main access points will include after hours contact details.

As detailed in **Section 12.3.2**, additional signage will be erected along Exclusion Zone boundaries to restrict access to these areas to authorised personnel only.

12.4.5 Fencing

Security fencing will be established around the Soil Treatment Area (STA, refer to **Figure 18**). Additional fencing will be erected where necessary to secure portions of the Site, in particular areas such as the Exclusion Zones.

12.4.6 Control of Site Entry and Exit

Entry and exit to and from the Site will be controlled through the use of a sign-on/sign-off log system at the entry to the Site. The following site entry controls will be implemented:

- Only authorised personnel will be allowed on-site;
- Personnel will gain access to the Site only after they have:
  - Undertaken the required medical examination;
  - Signed on in the sign-on/sign-off logbook;
  - Attended and completed a site safety induction briefing (applicable to all site workers and visitors);
  - Are wearing all applicable personal protective equipment (PPE) as detailed in the OHSP; and
  - Signed the OHSP acceptance form (applicable to all site workers and visitors).
- All construction vehicles and delivery vehicles will enter the Site through the main security gate via Gate 1 (Christina Road). When a vehicle enters the Site, it will proceed along the designated vehicle route to the pre-arranged rendezvous area where an authorised person will meet the vehicle and provide the driver with further instructions.

In the event of an emergency on-site and the need for emergency services personnel to access the site works, the site access process may be expedited. In these situations, which require the need to minimise delays in accessing injured site personnel or critical areas of the Site, prior arrangement will be made for special site access procedures. However, given the nature of the remediation works, all PPE and decontamination protocols will remain in effect at all times. An Emergency Response Plan (ERP) will be developed prior to site establishment detailing the specific procedures relating to site emergencies. The local emergency services will be notified of the ERP, Site procedures and protocols prior to site establishment.

12.4.7 Parking

Sufficient parking for private vehicles will be provided in the existing parking area adjacent to Gate 1 (Christina Road, refer to **Figure 18**).

12.5 Site Preparation and Maintenance

All surplus materials, off-cuts, construction plant, other clean waste items and personnel-generated rubbish will be disposed off-site. Bins for the disposal of low level contaminated PPE will be placed within the decontamination station. Additional rubbish bins for personnel-generated rubbish will be provided adjacent to Site buildings and facilities. The bins will be regularly emptied by licensed waste disposal contractors.

13.0 Excavation Works

13.1 Background

This section addresses works associated with the excavation of the identified Remediation Areas. This includes the following activities:

- All stages of the establishment and disestablishment;
- Control and minimisation of emissions from the excavation area;
- Control and treatment of water from the remedial excavations;
- Excavation of the Remediation Areas; and
- Loading of excavated materials for transport to the STA.

It is likely that the remediation works will start with the excavation and removal of the TWL (as discussed in **Section 4.6.12**). The staging of the main excavation works within the Remediation Areas has not been determined at this stage.

13.2 Soil Excavation

Excavation of the materials within the Remediation Areas will be undertaken within areas segregated from the remainder of the Site by fencing. All excavated material will be transported to the FSB for stockpiling and, if required, fed to a coarse vibrating screen (“Grizzly”) located in the FSB by a front end loader to remove oversized materials, such as bricks, pipes, concrete, crushed drums, etc. Any grossly oversized materials will be separated during the initial excavation works and transported directly to the Central Stockpile Area for stockpiling. Consequently, at the end of each day’s excavation works, no potentially contaminated stockpiles will remain within the Remediation Area.

If the temporary stockpiles in the Central Stockpile Area are odorous or likely to generate excessive dust levels, this material will be covered or treated with an appropriate emission or dust control technique (i.e. clean soil, spray grass, odour suppressant sprays or foams). Further details regarding mechanisms to control odour and dust emissions will be detailed in an Air Quality Management Plan that will be submitted to DECCW for approval prior to any remediation works commencing.

13.3 Excavation Staging

It is likely that the remedial works will commence with the removal and validation of the Site-wide TWL. While this infrastructure has not been identified as being a significant source of soil or groundwater contamination, AECOM considers it prudent to remove this infrastructure prior to commencement of the main remedial excavation works. The removal of the TWL will serve to validate the soils in this potential area of concern and prevent potentially contaminated surface waters flowing through the TWL and re-contaminating validated Remediation Areas.

It is likely that once excavation works are underway at the first Remediation Area to be excavated, the segregation of the next Remediation Area will commence to avoid possible delays associated with construction time. Once the excavation works at the first Remediation Area are completed, the excavation equipment will be transported to the second excavation area, and the process repeated for the other Remediation Areas across the Site. This sequence will be undertaken for all stages of the excavation works.

Emmissions from excavated areas will be minimised by undertaking the works as follows:

- Excavating only one Remediation Area at any time;
- Excavating at a slow rate;
- Minimising the exposed surface of contaminated soil during excavation;
- Covering exposed surfaces of contaminated soil at the end of each day;
- Minimising stockpiles of excavated contaminated soil;
- Covering loads during transport of contaminated soil;
- Undertaking pre-treatment of contaminated soil in an enclosure with an ECS;
- Operating the ECS noted above to minimise emissions from the building;

- Treating the contaminants in a plant with a high inherent destruction efficiency;
- Operating the ECS of the plant to maximise destruction efficiency of contaminants; and
- Progressive validation works and revisiting if necessary prior to the commencement of the scheduled reinstatement works. This will assist in minimising the length of the reinstatement works, reducing the duration and limiting the extent of exposure of the validated areas and minimising erosion, surface water infiltration and dust generation.

If excavation walls and/or bases are considered to generate excessive odours and/or dust levels they will be temporarily covered at the end of the working day and as soon as possible following completion of the required validation works. The site auditor will be required to provide sign off on validated areas and validated stockpiles to enable the required progressive backfilling and compaction works.

13.4 Excavation Planning

All excavation works will be undertaken in accordance with the following procedures (in sequence):

- Prior to commencement of excavations on each work shift, all necessary environmental and OH&S measures and equipment, truck access and vehicle decontamination processes, vapour monitoring equipment, truck haul roads, and all worker PPE and respiratory controls will be in place and in full working order in accordance with the OHSP;
- All excavation plant operators, haulage operators and supervisors will be made familiar with the excavation strategy and their responsibilities prior to the commencement of each shift;
- Stockpile areas within the FSB and Central Stockpile Area will have been prepared with adequate capacity to receive the contaminated materials after excavation (where possible, on the same day of the initial excavation);
- Designated signage will be placed around the boundary of the active Remediation Area and along haulage roads specifying that the area is an exclusion zone;
- All truck haulage roads will be suitable for transportation and haulage of the excavated materials;
- All haulage trucks will be covered, followed by decontamination prior to exiting the Remediation Area or FSB in accordance with the EMP; and
- All personnel, vehicles and equipment leaving the Remediation Area will be properly decontaminated in accordance with the OHSP and EMP.

13.5 Excavation Operations

The materials to be excavated comprise fill materials (generally clay based fill), natural clays and weathered shales as outlined in **Section 8.0**. Remediation works will be conducted six days per week. The plant operating within the Remediation Area will include a tracked excavator and a front end loader (refer to **Figure 21**).

Prior to excavation works within the active Remediation Area, any seepage water (free water) present, will be removed (by pump) for treatment at the WTP. Should uncontrolled seepage water leak into the open excavation area, the impacted material will be tested and if required excavated and treated in the DTD Plant. The residual soil will be validated as per **Section 19.0**.

Excavation operations will commence within any Remediation Area by the removal and temporary stockpiling of the overlying materials if the results of available data indicates that these materials are likely to be unimpacted. This material will be taken (on the day of excavation) to the Central Stockpile Area where it will be temporarily stockpiled and classified to determine if it can be beneficial reuse on-site, or whether treatment or off-site disposal will be required. If off-site disposal of materials is required, the material will be sampled and analysed to assess its suitability for disposal to landfill or a recycling facility in accordance with the *Waste Classification Guidelines* (DECC 2008). The proposed flow process for excavated material is summarised in **Figure 22**.

The excavated material requiring treatment will be transported directly to the FSB for stockpiling. If required, this material will be fed to a coarse vibrating screen (Grizzly) within the FSB by a front end loader to remove oversized materials (greater than 100 mm in size). Any oversized material from the screening works will be sampled and analysed to assess its suitability for treatment in the DTD Plant, disposal to an appropriate waste facility in accordance with *Waste Classification Guidelines* (DECC 2008) or transfer to a recycling facility.

Any grossly oversized materials will be separated during the initial excavation works in the Remediation Area and will be transported to the Central Stockpile Area for stockpiling. No stockpiles would remain within the Remediation Area at the end of each day's excavations.

The stockpiled, oversized material in the Central Stockpile Area will be tested for contamination before being either disposed to an appropriate waste facility, recycled where possible or transported to the FSB for treatment (as required). If the material is to be treated in the DTD it will require crushing and size reduction. If the material is odorous or likely to generate excessive dust levels, these temporary stockpiles will be covered or treated with an appropriate emission or dust control technique (i.e. clean soil, spray grass, odour suppressant sprays or foams). Further details regarding mechanisms to control odour and dust emissions will be detailed in an Air Quality Management Plan that will be submitted to DECCW for approval prior to any remediation works commencing.

The depth of excavations within each of the Remediation Areas will be based on the available data (as summarised in **Section 8.0**). Excavation will continue until the base and walls of the excavation have been validated to comply with the Remediation Goals (refer to **Section 15**).

Bogie drive tip trucks will operate on a daily basis to haul materials from the Remediation Area to the FSB (via the air-lock) in the case of materials destined for treatment, and for haulage of materials suitable for beneficial reuse without treatment directly to the Central Stockpile Area. Once inside the Remediation Area, the trucks will be loaded, covered and driven through a high pressure wash in a fully automated spray system or through a wheel wash (refer to **Figure 26**). Once decontamination is completed the trucks will transport the excavated materials directly to the required destination along the designated haul roads.

Water that may be present within the remedial excavation and wash water from the decontamination area will be recovered and treated in a WTP (refer **Section 16.2.4** for discussion). The water will be treated to a standard to enable reuse in the wheel wash system, reuse as grey water on-site, or alternatively for disposal to sewer subject to compliance with licence criteria.

13.6 Excavation Support

At all times, the sides of excavations will be maintained in a stable and safe condition. Soil will generally be excavated with batters set at an angle of repose of no greater than 1 in 1. Steeper batter angles may be used in instances where the safe angle of repose of the soil is greater than 45° or where additional reinforcement such as woven geotextile can be utilised to stabilise and support the slope.

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14.0 Materials Handling

14.1 Background

This section specifies the proposed materials handling procedures. The materials handling procedures have been designed to provide "cradle-to-grave" control and management of excavated materials at all times and are necessary to ensure that the each Remediation Area is suitable for the proposed land use with a high level of confidence.

14.2 Classification of Excavated Materials

If required, materials excavated from each Remediation Area will be screened in the FSB to separate oversize material (greater than 100 mm) from materials suitable for remediation treatment.

Oversize material will be temporarily stockpiled within the FSB or Central Stockpile Area, and subsequently sampled and analysed to assess their suitability for disposal to landfill or recycling facilities in accordance with *Waste Classification Guidelines* (DECC 2008). Materials considered unsuitable for off-site disposal or re-use on-site will be transported to the FSB for further processing (refer to **Figure 22**).

If available data indicates that materials overlying contaminated materials may be unimpacted, the overlying materials will be temporarily stockpiled in the Central Stockpile Area where it will be sampled and analysed, and the results compared against the Remediation Goals. Where the results indicate that the material may be beneficially reused on-site, it will be transported directly to soil stockpiling areas. Alternatively, where the results indicate that the material is unsuitable for beneficial reuse and treatment is required, it will be hauled to the FSB for processing and treatment in the DTD Plant (refer to **Figure 22**).

14.3 Materials Tracking System

Due to the scale and nature of the earthworks program to be undertaken, a Materials Tracking System will be developed to monitor and control excavation of all materials and their movements at the Site. The main objective of the system will be to ensure traceability of the remediation process and to track materials through the duration of the project from excavation through to treatment and stockpiling, for subsequent use as backfill during the reinstatement process.

The Materials Tracking System will monitor and control each of the different phases of material handling that will occur during the project including:

- Excavation;
- Screening;
- Transport of the excavated materials from the Remediation Area;
- Classification of overlying materials suitable for beneficial reuse without treatment;
- Classification of oversize materials in accordance with the *Waste Classification Guidelines* (DECC 2008);
- Transport of oversize materials for licensed off-site disposal or recycling;
- Transport of oversize material to the FSB;
- DTD treatment of suitable materials;
- Stockpiling of the treated materials in preparation for beneficial reuse;
- Transport of the validated stockpiled materials from the stockpile to the validated Remediation Areas for beneficial reuse; and
- Placement and compaction of the material as backfill within the validated Remediation Areas.

The system will provide detailed information about the treatment, location and quantity of all materials on the Site from the time of excavation until their beneficial reuse on the Site.

14.4 On-site Transportation of Materials

Materials at the Site will be excavated, handled, moved, treated and stockpiled in a manner designed to minimise exposure to the environment. The following materials handling requirements have been developed for trucks transporting materials within the Site:

- Trucks carrying excavated materials will be covered and decontaminated in the wheel wash facility within the Remediation Area before exiting the area;
- Trucks will proceed directly to the FSB or soil stockpile areas as appropriate along the predetermined haul roads as shown in **Figure 18**;
- Trucks carrying contaminated materials will not be permitted to drive over areas of the Site which have previously been excavated, validated or reinstated;
- Trucks carrying contaminated materials will remain covered until authorised to unload within the FSB. The trucks will be decontaminated at the FSB and the truck body covered before exiting the building;
- Empty trucks will return directly to the Remediation Area along predetermined haul roads, as shown in **Figure 18**; and
- Validated Remediation Areas will be effectively isolated from contaminated areas of the Site by the use of physical means such as the placement of clean material bunds, temporary fences and by use of signage.

14.5 Stockpiling of Treated and Validated Materials

14.5.1 Stockpile Locations

Treated and validated soil materials will be stockpiled within the STA as shown in **Figure 18** (Item 5). It is anticipated that the reinstatement of the Remediation Areas will commence progressively once validation testing is complete and the Site Auditor has endorsed the validation of each Remediation Area. The stockpiled soil will then be transported directly from the STA to the validated Remediation Area(s) for beneficial reuse and compaction as backfill. Consequently, validated materials are anticipated to be stored within the STA for relatively short periods (approximately 4-6 weeks) with progressive works conducted to validate separate stockpiles and to facilitate the progressive backfilling of validated Remediation Areas.

14.5.2 Stockpile Area Preparation

During site establishment, stockpile areas will be prepared using the following methods:

- Works will be undertaken initially to clear the area of rubbish, rubble, structures and vegetation. The area will then be graded, to remove local depressions and to create a smooth and even surface;
- The STA will be constructed with hardstand surfaces;
- Diversion drains and bunds will be constructed around the perimeter of the stockpile areas. Additional sediment and erosion control measures including silt fencing and hay bales will be installed where necessary;
- Signs will be erected at the entrance to the stockpile area and at locations around the stockpile specifying individual stockpile numbers and the type of materials stored; and
- Buffer zones will be established around each stockpile area to enable access to the stockpiles and minimise impacts of the stockpile area on the surrounding facilities.

14.5.3 Stockpile Construction and Maintenance

The drainage, sediment and erosion control measures installed within stockpiling areas at the commencement of the project will be maintained, repaired and replaced where necessary for the duration of the stockpiling activities. All long term soil stockpiles on-site will be covered or treated (as required) to reduce dust generation and erosion by spray grass seeding or coating materials such as polyvinyl acetate (PVA) spray.

The maximum height of stockpiles within the STA will be approximately 5 m high which will enable storage of approximately 12,000 m^3 of treated, validated material. Based on the estimated DTD treatment rate of 165 m^3/day, this stockpiling capacity is considered suitable for facilitating timely validation and site auditor sign off of the treated, validated stockpiles (i.e. approximately 12 weeks of storage capacity based on 6 days continuous operation of the DTD plant).

All stockpiles will be maintained in a tidy and safe condition with stable batter slopes.

14.6 Storage of Waste Materials

Waste materials generated during the remediation works will be stored in four designated areas of the Site as follows:

- **Support/Office Area**: refuse and non-contaminated debris generated from the project will be stored adjacent to the support areas and site offices located adjacent to the Gate 1 in clearly marked bins and containers (refer to **Item 13**, **Figure 18**);
- **Plant Maintenance Area**: The maintenance area adjacent to the DTD will store oil, oil filters, and other materials generated during the servicing of plant used during the remediation works. Plant will be decontaminated before being serviced to minimise potential contact with contaminated materials during servicing. These materials will be stored in drums in a bunded area and will be disposed of off-site at oil recycling facilities or landfill (refer to **Item 6**, **Figure 18**);
- **WTP**: Oils and oily sludges pumped or collected from dewatering of excavations will be held in the WTP storage tanks or drums pending analysis and assessment of the required treatment (refer to **Item 3**, **Figure 18**);
- **FSB**: Oils requiring treatment from the DTD plant will be stored within the FSB in a licensed bunded area. Solids and sludges that require DTD treatment will also be stored within the FSB (refer to **Item 8**, **Figure 18**).

14.6.1 Waste Minimisation

Where practicable and in accordance with the implementation of good site management practices, a key objective of the remediation works will be to minimise the volumes of waste generated and, where possible, to implement the following recycling strategies:

- Segregation and storage of materials to reduce the potential for cross contamination. I.e. contaminated materials will be excavated in a manner that allows segregation of the different layers of material, which will then be stockpiled separately with control measures adopted to avoid cross contamination;
- Recycling and beneficial reuse on site whenever possible. I.e. re-use of crushed demolition material for the construction of haul roads (as required), and the recycling of waste oil from plant maintenance and recycling of waste paper, glass and aluminium cans generated at the Site;
- Maximising soil and water treatment processes to obtain the most efficient operational outcomes that reduce the amounts of filter media and treatment residues, which then require management and possible offsite disposal;
- Using water management practices to minimise sediments and contaminated water from contacting clean materials and potentially contaminating them;
- Decontamination of various items including solid debris or construction rubble, plastic liners, excavated rock, and contaminated soil in rubble in a manner to allow for beneficial reuse on-site or result in a reduction in the volume of material requiring classification and offsite disposal; and
- Ongoing evaluation and revision of site waste management protocols with an aim at reducing the overall generation of materials that cannot be beneficially reused on site, and increasing the amount of recycling possible.

14.7 Screening of Materials

Excavated contaminated material will be screened within the FSB (if required) using a Grizzly screen. In addition to the primary screening, a “powerscreen” with a nominal capacity of 100 tonnes per hour will be used in the FSB for secondary screening to prepare the soil for DTD treatment. Subject to the characteristics of the feed system of the DTD Plant, a maximum particle size of 50 mm may be required in the feed material. Oversize materials (greater than 50 mm diameter) will be crushed in the FSB prior to treatment.

Both screens will be equipped with appropriate control measures to reduce noise emissions.

14.8 Crushing/Shredding of Materials

The crushing of oversize excavated materials may be necessary to ensure that the excavated materials can be treated in the DTD Plant. If required, it is anticipated that conventional mobile crushing and shredding equipment will be used within the FSB, minimising the potential for dust generation.

14.9 Reinstatement of Materials

Once the excavation works within the Remediation Areas are completed and the base and batter slopes of each excavated area have been validated, it is anticipated most of the treated and validated materials will be used to backfill the excavation. Backfill materials will be placed and compacted in 300 mm layers. The final reinstatement levels will be consistent with the area surrounding each Remediation Area.

15.0 Treatment Operations

15.1 Background

The materials excavated from the Remediation Areas will have different treatment requirements in terms of their workability, management, range of CoC present and contaminant concentrations. This section describes the methodologies to be employed for preparing and treating the excavated materials for beneficial reuse on-site, and stockpiling of surplus materials.

15.2 Pre-Treatment of Materials

The pre-treatment of excavated materials requiring treatment will be undertaken via screening works within the FSB. The material will be stockpiled in the FSB using a front end loader before undergoing further screening and testing for contaminant levels and other characteristics which will be required for the DTD treatment process. The material will then be blended to achieve a relatively homogenous feed material prior to being loaded into the feed hopper of the DTD Plant. Activities within the FSB, including screening and testing will take place 24 hours per day, seven days per week.

15.3 Feed Soil Building and Emission Control System

The purpose of the FSB is to control emissions during pre-treatment activities and ensure these emissions are vented to atmosphere through an ECS. Operation of the FSB and associated ECS will be in accordance with operation and maintenance management systems developed on completion of the final design. An overview of the controls to be designed into the system is provided below.

The FSB will be constructed of a steel frame with metal sheeting. It will include doors, lights, electrical and other ancillary facilities that are required for safe and efficient operation. The building will contain an approximate seven day working inventory of feed soil plus a sufficient buffer for soil drying and other pre-treatment activities. This inventory volume is designed to provide adequate storage capacity to feed the thermal treatment plant during periods when unforeseen conditions interfere with normal excavation activities.

The FSB will be fitted with an air-lock and automated wheel wash, louvers and an ECS for air quality control.

The FSB will be equipped with personnel entrances and truck entrances. The truck entrances will include an air-lock consisting of a small structure internal to the enclosure. The air-lock will be equipped with two doors. When a truck enters the air-lock, the outer door will open while the inside door is closed. Once the truck enters the air-lock, the outer door will close, the inner door will open and the truck will enter the enclosure. The procedure will be reversed when a truck exits the enclosure.

An ECS will be constructed and operated to preserve air quality within the building and minimise emissions (dust and organic vapours) to the atmosphere. The ECS will be operated to ensure the flow of air into the FSB (i.e. air pressure within the FSB will be slightly lower than ambient air pressure). Conceptually, the ECS will comprise an induced draft fan, duct work system, particulate control device (dust filters), two stage carbon beds and a stack. The actual capacity of the ECS will be determined through detailed design studies, to satisfy OH&S considerations. The ECS will be located directly adjacent to the FSB at each of the Remediation Areas.

The air exhausted from the FSB will first pass through a particulate control device to remove fugitive dust. Dust removed will be collected in enclosed drums or hoppers. When the dust collection container is taken off-line, the dust will be taken to the STA for treatment.

After the exhaust gas exits the particulate control device, it will pass through an activated carbon adsorption system. The activated carbon system will be equipped with a number of monitoring ports. A monitoring protocol will be developed for the various ports along the activated carbon adsorption system. This protocol will form the basis for deciding when activated carbon beds need to be replaced.

Air will be exhausted to the atmosphere via a stack. Periodic stack testing will be undertaken in accordance with license requirements.

15.4 Directly-heated Thermal Desorption

15.4.1 DTD Plant Commissioning and Testing

Upon establishment at the Site, the DTD Plant will undergo a commissioning and testing program to:

- Ensure the satisfactory mechanical operation of each individual plant unit operation;
- Ensure the integrated operation of the process;
- Check the operation of the instrumentation and controls;
- Process an amount of soil and to sample process streams to ensure the safe operation of the plant and ability to meet the Remediation Goals;
- Provide the monitoring data required to control the plant operations and demonstrate protection of human health on-site and off-site during the process; and
- Demonstrate regulatory compliance under conditions that are required during ongoing operations, by undertaking a full stack test.

The DTD Plant test program will be implemented in the following three phases:

- Mechanical/electrical shakedown/clean soil startup – after all DTD Plant equipment, auxiliary equipment, monitors, instruments, data acquisition systems and utilities are determined to be operational, the clean soil startup will commence. Clean soil testing would typically be conducted for 8 hours, and does not involve processing of contaminated material or monitoring of air emissions and treated materials, except to show that on line continuous equipment monitoring (CEM) is functioning normally. The automatic soil feed shut off (ASFSO) interlocks will be checked followed by a normal shutdown sequence. This sequence will be repeated to the extent necessary to determine that the DTD Plant controls are operating properly. Clean soil shakedown would continue until the DTD Plant is determined to be fully operational;
- Optimisation trials – optimisation trials will be undertaken for approximately one week to enable steady state conditions to be reached and maintained, and to allow for collection of the appropriate samples and analyses. Monitoring during this stage will be undertaken using the CEM system, to demonstrate that combustion efficiency in the afterburner is within control limits. During this stage stack gas monitoring will also be undertaken under a range of possible operating conditions. The performance of the afterburner would be monitored using the automated CEM system to record levels of carbon monoxide (CO), (CO_2) and oxygen (O_2) in the stack gas emissions. These parameters are routinely monitored to provide evidence of efficient combustion in the afterburner. During the stack tests an independent, mobile CEM system will be used to monitor CO, CO_2, O_2, nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) in the stack gas emissions. Further sampling will be undertaken for analysis of particulates, hydrogen chloride (HCL) and chlorine (CI_2), dioxins and furans and other selected volatile and semi-volatile compounds in stack gas emissions to confirm compliance with DECCW criteria; and
- Compliance testing – the duration of the compliance test may take up to five days, allowing one day for setup, up to three days for testing and one day for demobilisation of the sampling crew and equipment. The compliance test will be undertaken under operating conditions required for subsequent routine processing, based on the results of the optimisation trials. Subsequent compliance testing would be undertaken on an annual basis, during routine processing.

15.4.2 DTD Plant

The DTD Plant will be located within the STA as shown in **Figure 19**. After pre-treatment in the FSB, the excavated materials will be fed into the feed hopper located inside the FSB. The materials will be transported via a conveyor to the DTD Plant for treatment.

The DTD Plant will operate 24 hours a day, seven days a week with the seventh day typically scheduled as down-time for maintenance. The nominal maximum rate of treatment through the DTD Plant is anticipated to be up to 35 tonnes per hour.

The DTD Plant will have a footprint of approximately 50 m square. It will be established within a concrete paved and bunded area having its own internal surface water drainage control measures. Electrical power to the DTD Plant will be provided by mains power, with a diesel powered generator used as a back-up. Natural gas sourced from the mains supply, will be used to fire the heating burners of the plant. A typical thermal process area layout is shown in **Figure 20**.

There are two main types of DTD plants currently used to treat contaminated material including volatile and semi-volatile compounds (VOCs and SVOCs). They differ principally in terms of the direction of gas and soil flow in the rotary dryer (co-current and counter current), with consequent differences in gas temperatures and the sequence of unit operations used to treat the off-gas. Both types of plants produce similar outcomes in terms of soil treatment levels and air emissions when treating material that contains VOCs and SVOCs. As indicated, the detailed design for the DTD Plant and associated equipment/plant would be completed following any project approval. For convenience the co-current type of DTD plant is described herein.

A typical process flow diagram for the DTD Plant is shown in **Figure 23**. Brief descriptions of typical key unit operations in the process are presented below.

Rotary dryer

The first step in the DTD treatment process involves the volatilisation or separation of contaminants from the material in the rotary dryer.

The rotary dryer utilises natural gas as fuel to heat the contaminated material to a temperature of approximately 300ºC to 450ºC.

In a co-current system, the contaminated material enters the rotary dryer at the end where the burner is located and the combustion gas and treated soil move in the same direction to where they exit at the opposite end of the dryer.

Contaminants desorb and volatilise as they pass through the dryer. Soil is heated in the first third of the dryer with most desorption and volatilisation occurring in the next third as contaminants reach their boiling points.

Once it has passed through the rotary dryer, the heated soil material passes to a pugmill where it is sprayed with water for cooling and rewetting. The treated material is then transferred to temporary treated soil stockpiles awaiting validation.

Cyclone

The off-gases flow from the rotary dryer through a cyclone, where large dust particles are removed, to the thermal oxidiser. The dust from the cyclone is directed to the pugmill where it is mixed with the treated soil for rewetting and validation.

Thermal Oxidiser

The thermal oxidiser is used to treat the gases produced through the heating of the soil material in the rotary dryer and would be designed to be Stockholm compliant, i.e. with appropriate residence time, temperature and turbulence.

The thermal oxidiser operates at a temperature of about 1,000ºC using natural gas fuel. At this temperature, the contaminants present in the gas (from the feed material) oxidise or decompose forming CO_2, water vapour and HCl with small amounts of other by-products such as Cl_2 and sulphur compounds.

In order to maintain the correct temperature to maximise destruction efficiency and minimise the formation of by-products, the thermal oxidiser would be fitted with a sophisticated temperature control system which would be consistently monitored.

Quench

Once gases have passed through the thermal oxidiser they must be rapidly cooled to minimise the potential for dioxin formation and allow further treatment before release to the atmosphere – as required by the Stockholm Convention.

To achieve this, the hot gases are drawn into the quench by an induced draught (ID) fan. In the quench, water is injected to rapidly cool the gases to a temperature which is suitable for further treatment.

Baghouse

The cooled gas from the quench is combined with steam from the pugmill and drawn into the baghouse by an ID fan. The baghouse contains a series of fabric filters which remove particulates. If required, activated carbon may also be blown into the baghouse to coat the fabric filters and assist with removal of mercury which is present in the feed soil. The need for this additional control technology would not be known with certainty until commissioning trials have been completed, but provision would be made for the necessary hardware.

The design of the baghouse would also take into account other factors such as the high moisture and acidity of the gas stream and suitable materials of construction and insulation would be used as required. These are matters of detail that will be addressed in the plant design, HAZOP study and Technology Assessment that will be part of the technology licence application to be submitted to the DECCW under the provisions of the EHC Act.

Acid Gas Scrubber

The final step in the treatment process involves the removal of acid gases from the exhaust gas.

The acid gas scrubber consists of a packed tower with a re-circulating caustic solution that reacts with any HCl and Cl_2 in the exhaust gas to form a salt solution.

Following this, the 'clean' treated gas is vented to the atmosphere via the scrubber stack which is some 30 m in height.

Treated Soil

Treated soil would be stockpiled adjacent to the STA with drains and bunds provided to manage runoff (refer to **Figure 25**). Stockpiles would be stabilised with spray grass or other such treatment and would be wetted when necessary to control dust. Stockpile management is illustrated in **Figure 25**.

The treated, stockpiled soil will be transported (by truck) to the Remediation Areas for progressive backfilling of the excavations.

15.4.3 Soil Treatment Standards

The soil treatment standard achieved by the DTD Plant will depend on:

- The starting concentration of the contaminants of concern in the feed soil; and
- The soil treatment temperature in the rotary dryer.

A best practice soil treatment temperature (and resulting removal efficiency) will be established during the optimisation trials by running a matrix of tests with different starting concentrations and soil treatment temperatures. The results will be analysed to identify the point of diminishing returns in terms of contaminant removal and energy use. The potential for accelerated plant wear and tear and possibility of catastrophic failure (e.g. due to metal fatigue in the dryer) will also be considered particularly in terms of operating at the high end of the soil treatment temperature scale (around 500^{o}C).

The treatment standard will be below the Remediation Goals. Whether it meets the criteria in national standard for HCB and the NSW CCOs for SCW will depend on the factors above as well as the number of SCW compounds present and the achievable laboratory detection limits. Materials will be treated to as close as possible to the NSW CCOs for SCW.

15.4.4 DTD Plant Air Emissions Standards

Air emission standards to be adopted for the DTD Plant will be based on the POEO (Clean Air) Regulation 2002 concentration standards for Group 6 plant operating at scheduled premises. The POEO (Clean Air) Regulation also sets out additional performance provisions for afterburners that are in Group 6, and treating Principal Toxic Air Pollutants. They are:

- A residence time of more than 2 seconds;
- A combustion temperature of more than 980 ^{o}C; and
- A destruction efficiency of more than 99.9999% based on a one hour rolling average for the mass in the air emission as a percentage of the mass in the feed soil.

15.4.5 Reclassification and Post Treatment Storage

Treated material outputs from the DTD Plant will be transferred to the temporary treated soil storage area via a radial conveyor (refer to Item 8 and 9, **Figure 20**). Treated materials stored in this area will undergo validation testing and reclassification. This is to determine whether the process has been effective and whether or not the materials are ready for beneficial reuse at the Site.

Materials that have been treated to the Remediation Goals will then be moved to the validated treated soil stockpiles shown as Item 5, **Figure 19**. Materials that have not been treated to an acceptable level will be transported back to the FSB and subjected to further treatment via the DTD Plant. Stockpiled material will be kept moist using a sprinkler system or similar to prevent the generation of dust.

15.5 Hazard and Operability Operation Studies

HAZOP studies of the DTD Plant will be conducted prior to establishment to the Site.

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16.0 Management of Water

16.1 Background

Over the course of the remediation works, contaminated water will be encountered in the forms of potential free water (seepage water) into excavated areas, water used for truck and plant decontamination and rainfall on the STA. A Water Management Program will be implemented at the Site to minimise the volume of contaminated water generated, and to manage the water in the most efficient manner possible in compliance with regulatory requirements.

The types of water encountered during the remediation works are likely to comprise:

- Clean water - water that is not contaminated. Clean water is likely to collect in areas of the Site that remain undisturbed by site works, such as in areas upgradient of site works and water collected from the roof of the FSB;
- Contaminated water - water that is considered to be impacted and which requires recovery, treatment and recycling or disposal. Contaminated water will likely be encountered from seepage associated with rainfall events, within the materials at the base of the remedial excavations, within the treatment area bunds and the truck washes;
- Grey water – water on-site which has been untreated or has been treated and which is acceptable for being recycled on-site in truck wheel wash facilities or for dust suppression; and
- Sewer quality water – is defined as water that has been either treated or untreated and which meets the Trade Waste Criteria, as detailed in the Sydney Water Trade Waste Licence.

Water recycling will be undertaken on-site where possible but it may be necessary to discharge site water into the sewer system. A Trade Waste Licence will be modified or obtained for the Site in consultation with Sydney Water prior to the commencement of Site works. Detailed records of the quantity and quality of all water recycled and discharged from the Site will be kept and made available to the regulatory authorities as required.

16.2 Water Management Methods

This section outlines a hierarchy of four methods, from most preferred to least preferred, to be implemented for the management, treatment or disposal of water encountered during the remediation works. A schematic water management diagram is provided as **Figure 24**.

16.2.1 Water Management Method 1 – Minimise Contaminated Water

The preferred approach to managing contaminated water at the Site is to minimise the volume of contaminated water during the works wherever possible. To achieve this goal, clean surface water will be directed away from excavations, depressions, pits and stockpiles, where possible, by the construction of the FSB and other drainage works such as bunds and diversion drains. These measures will minimise the flow of clean water into other areas of the Site that contain contaminated materials.

16.2.2 Water Management Method 2 – Recycle Water

Wherever possible, measures will be implemented to maximise the volume of water that can be recycled on-site. All recovered and/or treated water that complies with the established reuse criteria is to be recycled on-site. Where possible, water will be recycled using the following methods:

- Use of recycled water for dust control during earthworks activities; and
- Use of recycled water for other site operations including wheel washing, truck washing (refer to **Figure 26**) and soil re-moisturisation in excavation areas.

To ensure that the use of recycled water does not impact on surrounding areas, the following data will be obtained prior to undertaking these activities:

- Chemical data which demonstrates that the water to be recycled complies with the reuse criteria, including consideration of potential for odour generation;
- Definition of the area where the water is to be discharged;
- Details of environmental protection measures installed to ensure that the use of recycled water will have no adverse environmental impact; and

- Appropriate tracking of recycled water reused at the Site.

16.2.3 Water Management Method 3 – Discharge to Sewer

The next preferred method involves discharge to sewer, with or without treatment, as per the guidelines specified in the Sydney Water Trade Waste Licence.

An appropriate sewer water discharge point will be determined in consultation with Sydney Water. Any water that is to be discharged to sewer is likely to be pumped to a designated storage pit located in the northern portion of Area E (refer to **Figure 18**), for testing prior to discharge.

16.2.4 Water Management Method 4 – Water Treatment

The least preferred management method involves treatment of water in the on-site WTP (refer to Area E in **Figure 18**). The following sources of contaminated water potentially require on-site treatment:

- Surface water falling on areas such as the external bunded areas of the STA;
- Water purged during the acid gas scrubbing phase of the DTD treatment process;
- Small volumes of free water (seepage) accumulating in active excavations within the Remediation Areas; and
- Water from personnel and plant decontamination processes.

A WTP will be established adjacent the STA. The conceptual design of the WTP comprises coagulation, flocculation, sedimentation, multimedia/sand filtration and granular activated carbon (GAC) adsorption stages, as discussed below:

- Chemical coagulant addition will consist of aluminium sulphate (or similar) dosing with sodium hydroxide (or similar) dosing for alkalinity and pH control. Coagulated suspended solids and oils will be flocculated for particle growth in a flocculator. The agglomerated particles will then be settled out in a clarifier. Clarified supernatant will be transferred through multimedia/sand filters to remove floc carry over from the clarifier. Multimedia/sand filtered water will be transferred to an intermediate storage tank;
- Settled suspended solids and oils in the clarifier will be withdrawn from the bottom of the clarifier as a dilute sludge. The sludge will be transferred into a storage vessel from where, if required it will be processed through a plate and frame filter press. Filtrate will be returned to the contaminated water storage tank for reprocessing and the dewatered cake will be disposed to the FSB for thermal treatment;
- Multimedia/sand filtered water will be passed through granular activated carbon (GAC) filters to remove residual dissolved organics. Treated water will be routed to a treated water storage tank. Spent GAC will be transferred to the FSB for thermal treatment; and
- Water from the treated water storage tank will be discharged to sewer or to watercarts for reuse on-site and will be used as backwash water for the multimedia/sand and GAC filters. Backwash water will be returned to the contaminated water storage tank for treatment.

17.0 Removal and Disposal of Materials from the Site

It is anticipated that the off-site disposal of materials may be necessary during the course of the remediation works to remove foreign material such as crushed drums, steel reinforcement, scrap steel, pipework and timber. These materials (if they do not require treatment in the DTD Plant) and low level contaminated clothing and PPE from Site workers, will be transported off-site for disposal at an appropriately licensed landfill or recycling facility. This section of the RAP details the procedures to be adopted for the disposal of materials from the Site. This may also include BACM which may be present in the form of stormwater pipes and drains. If BACM materials are encountered during excavation works they will be managed as per **Section 23.1.4**.

The procedure for off-site waste disposal will be as follows:

- Material requiring off-site disposal will be stockpiled separately in the Central Stockpile Area and will be tracked using the Materials Tracking System (refer to **Section 14.3**);
- The liquid or non-liquid material will be classified in accordance with the NSW EPA (2004) Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes;
- Notification of the waste facility organised to receive the waste to confirm that the facility is licensed to accept the material;
- If the waste facility is licensed to accept the class of waste, the material will be transported under the appropriate licence to the designated receiving facility. Every load of waste removed from the Site will be recorded; and
- A copy of the waste depot weighbridge docket will be collected and retained for each load of waste delivered.

Waste material from the remediation works will be disposed only at appropriately licensed landfill and recycling facilities. Waste destined for off-site disposal will be hauled from the Site in semi-trailers or truck-trailer combinations. All loads will be secured prior to leaving the Site with appropriate covers. Trucks wheels and bodies will be washed to ensure that site materials are not tracked onto local roads.

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18.0 Placement of Reinstatement Materials

At the conclusion of the excavation and validation works, treated and validated soil material stockpiled within the STA will be beneficially reused within Remediation Areas to the original levels. This section of the RAP outlines the processes and methodologies involved in the reinstatement of the Remediation Areas.

The remediated materials will be transported from their respective stockpile areas to the Remediation Areas. The materials will be placed and compacted in successive layers for the full width and length of the excavation. The compacted layer thickness will not exceed 300 mm and will be compacted to produce a field dry density of at least 98%. At the time of compaction of each layer, the moisture content of the material will be such that the specified compaction is achieved. Where necessary, water will be sprayed on the material by watercart in sufficient quantity to ensure that the appropriate moisture content is achieved for each layer.

The distribution and compaction of backfill materials will be undertaken by appropriately sized rollers for the main excavation areas, and by mini-rollers or mechanical hand tampers for perimeter areas that cannot be accessed by the larger plant.

Compaction testing will be conducted for each layer to confirm that the desired compaction standard is achieved. The testing will be undertaken at a frequency of at least 1 test per 1,000 m^3 (placed) distributed reasonably evenly throughout the full depth of the material and across the backfilling area. Testing will be conducted using density index and field density tests. Should the testing results indicate that the specified degree of compaction is not being achieved, the necessary modifications will be made to the compaction methodology or equipment to obtain the specified results. The finished surfaces will be smooth, compacted as specified, and free from irregular surfaces.

All testing will be undertaken by a qualified geotechnical engineer using NATA certified methods.

At the completion of each day’s work and at anytime during a working day when a delay to work appears to be imminent due to rain, all materials being compacted will be spread, graded and lightly rolled to direct surface flows towards surface drains. Upon resumption of the works, those areas not fully compacted will be ripped for their full depth and processed as newly deposited fill.

The excavation will be reinstated to levels which are consistent with the area surrounding each Remediation Area.

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19.0 Validation Plan

19.1 Validation Team

A suitably qualified consultant will undertake the validation of the remedial works under the direction of a Validation Project Director (VPD). The VPD is responsible for ensuring that all required validation systems are fully functional, and that staff are trained in the requirements of the Validation Plan (VP).

Daily validation management will be from an on-site project office. A site-based administrative system will be established to ensure that the project is fully documented. A daily fieldwork summary will be prepared and filed. All job-related incoming and outgoing communications will be logged in a register.

Decisions related to validation will be made in accordance with relevant guidelines endorsed by the DECCW. Copies of relevant guidelines will be kept in the site office. All fieldwork will be undertaken by qualified environmental engineer(s)/scientist(s) with experience working on contaminated sites.

A member of the Consultant's field team will be the Site Validation Manager (SVM) responsible for making all validation decisions and directing all routine site fieldwork. Prior to commencement of the project, the SVM will prepare a project manual containing all required procedures and forms. The manual will be updated, in conformance with the VP, on an as needed basis. It is the responsibility of the SVM to ensure that the VP is followed.

Site meetings will be convened as required to discuss fieldwork procedures. At least one meeting per week will be held with Orica and the Remediation Contractor to plan work for the following week and to resolve outstanding issues.

Where, because of an unforseen circumstance, the SVM considers that a departure from the VP is required, this must be discussed with the VPD before any other related action is taken. If the departure is approved it will be documented in on-site files. If urgent action is required, the VPD will be responsible for deciding the particular issue. The Site Auditor will be sent written confirmation as soon as practicable, but in any case within 10 working days of the reasons for making the changes to the VP procedures and feedback and endorsement of the changes will be requested in writing from the Site Auditor.

19.2 Validation Principles

All soil materials to be retained on-site must satisfy the Remediation Goals detailed in **Section 7.1**. The sampling and analysis program is described below.

The requirements of the *Guidelines for the NSW Site Auditor Scheme* (DEC, 2006a) will be implemented for continued commercial/industrial land use. Given that the Site will be used for commercial/industrial land use, aesthetic considerations are not anticipated to be significant. However, where the field team considers that material appears, because of aesthetic issues (including odours and discolouration), to be incompatible with the requirements of the nominated land use, guidance will be sought from Orica and the Site Auditor on an appropriate location for the ongoing management of the offensive material.

Validation data will be assessed in accordance with the *National Environment Protection* (Assessment *of Site Contamination) Measure*, *National Environment Protection Council, 1999*. This will involve checking that:

- Each individual sample concentration does not exceed the adopted criteria by more than 2.5 times; and
- The standard deviation of the sample set, is not more than 50% of the adopted criteria.

For the validation data to satisfy the relevant criterion, the upper 95% confidence limit on the arithmetic average concentration (95% UCL_{AVG}) for each CoC must be less than the criterion. A site or sampling area cannot be considered suitable for a specified land use or successfully remediated if the 95% UCL_{AVG} concentration exceeds the criterion. Further remediation is required where validation fails to meet the Remediation Goals for each CoC.

19.3 Material Sampling Frequencies

Materials that will require validation sampling during the remediation works will be as follows:

- Residual, unexcavated material beneath the TWL. This will comprise the base and walls of the final excavated surface;

- Residual, unexcavated material within the Remediation Areas. This will comprise the base and walls of the final excavated surface; and
- Excavated and treated material which has been treated via the DTD Plant.

In all cases, before collecting any surface samples from excavated areas, the SVM, or an appropriately trained team member, will inspect the entire validation surface area to ensure that there are no visible, or other, indications of contamination. Therefore, all validation surfaces will at least appear suitable before any validation samples are collected.

As discussed previously, the remediation works will involve the excavation of materials in the Remediation Areas (as detailed in **Section 8.0**). The excavation depths for the Remediation Areas are based on the analytical results obtained from previous investigations. Therefore, the excavation works will provide a significant level of confidence that materials not meeting the Remediation Goals will be removed. Further, where visible or other evidence of contamination is present, the impacted material will be removed and managed as required under this RAP, leaving a suitable surface for validation. The design of sampling frequencies nominated in this section incorporates the above remediation approach.

Where there is a justifiable reason for reducing the proposed sampling grid size, the SVM may do so but must seek approval for this action from the VPD. The sampling grid size, as defined below, cannot be increased unless authorised in writing by the Site Auditor.

The sampling regime for the above validation scenarios is detailed in the following sections.

19.4 Trade Waste Line

As discussed previously, the initial remediation works will involve the removal of the TWL and validation of the residual soils. It is proposed that validation works will be undertaken in site areas where a TWL junction is present. This validation approach is based on a higher risk of ruptures or leakages occurring in TWL junction areas due to the settling and movement of connected pipes.

It is proposed to collect validation samples from the excavated trench of the TWL at 5 m lineal metres in the discussed junction areas. Samples will be collected from a depth interval of 20 to 100 mm after scraping the overlying 20 mm of material away. The walls of the trench will also be validated at 5 m lineal at depths of 20 to 100 mm into the walls. This sampling regime will also be adopted should field observations indicate that contaminated soil or seepage waters may be present in non-junction areas. Should significant contamination be identified and additional lateral excavation is required, validation samples will be collected on a 10 m square grid.

Once validation of the TWL areas has been undertaken, it is likely that progressive backfilling of the excavated trench will be undertaken using validated virgin excavated natural material (VENM). This will prevent the possible ingress of surface waters into validated trenches and enable site haul roads to be re-established.

All validation soil samples will be analysed for VHCs and OCPs.

19.5 Remediation Areas

As discussed previously, the remediation works will involve the excavation of materials in the Remediation Areas to the depths detailed in **Section 8.0**. As these depths are based on the analytical results obtained from previous investigations, the excavation works will provide a significant level of confidence that material not meeting the Remediation Goals will be removed. Further, where visible or other evidence of contamination is present (including any visual signs of DDX crystals), the impacted material will be removed and managed as required under this RAP, leaving a suitable surface for validation.

If validation testing of the excavation walls and base indicate that CoPC concentrations exceed the Remediation Goals, additional excavation will be conducted to greater depths based on the MPDoRE. The MPDoRE for areas around the Site was assessed during the Phase 1 RI test pitting works (HLA 2006a) and from various stages of drilling works required for the installation of groundwater monitoring wells.

Given the MCB and DDX concentrations reported at a depth of 3.5 m bgl in Remediation Area 1b, remedial excavations will be undertaken to the MPDoRE of 4.0 m bgl in this area (refer to **Figure 7**). This depth is based on the maximum practicable depth of excavations achieved using a 20 T excavator during the excavation of the adjacent trench TP2 (located approximately 10 m to the east [HLA, 2006a]).

The design of sampling frequencies nominated in this section incorporates the above remediation approach.

Where there is a justifiable reason for reducing the proposed sampling grid size, the SVM may do so but must seek approval for this action from the VPD. The sampling grid size, as defined below, cannot be increased unless authorised in writing by the Site Auditor.

It is proposed to collect validation samples from the base of the excavations using a 10 m square grid. Samples will be collected from a depth interval of 20 to 100 mm after scraping the overlying 20 mm of material away. The walls of the excavation will be validated at 10 m lineal intervals around the wall of the excavation areas at depths of 20 to 100 mm into the walls. The validation approach is based on the results of previous investigations and is considered suitable for assessing whether CoC concentrations are less than the Remediation Goals following the remedial excavations. However, should field observations during the remedial excavations indicate that localised areas are more impacted, it may be required that a smaller validation sampling grid (i.e. 5 m square grid) be adopted. Such an approach will require authorisation in writing by the Site Auditor.

All validation soil samples will be analysed for VHCs and OCPs.

19.6 Treated Material

Treated material validation samples will be collected from the exit conveyor at the rate of one sample per eight hours of DTD Plant operation. This will result in approximately one sample being collected per 160 m^3 of treated material. This treated soil will be combined individually into tracked 500 m^3 stockpiles. The three sub-samples (one per 160 m^3) collected over a 24 hours period of production and representing approximately 500 m^3 will be composited for analysis using National Association of Testing Authorities (NATA) accredited (or equivalent) methods. Consequently, one composite sample will be analysed per 24 hours of DTD Plant operation.

All validation soil samples will be analysed for VHCs and OCPs.

The 95% UCL for the CoPC will be calculated for each of the 500 m^3 stockpiles to assess whether contaminant concentrations are less than the Remediation Goals. This approach will follow Method 2 of Section 6 of the *Sampling Design Guidelines* (NSW EPA, 1995).

Materials that are to be disposed off-site will be sampled and analysed in accordance with *Waste Classification Guidelines* (DECC 2008).

19.7 Sample Location Surveying

A registered surveyor will survey all validation sample points located in the remedial excavations. Proposed validation sampling will be based on square grid patterns. An initial grid cell will be selected (randomly on the validation area boundary) to mark the start of the relevant square grid that covers the entire validation area. The initial grid cell will be aligned and coincident with the validation area boundary, and the samples will be obtained from the centre of the grid cell.

19.8 Treatment Area and Stockpiling Areas

Activities within the treatment area, including treated soil storage and WTP, will be undertaken on appropriately sealed hardstand areas, with diversion drains and bunding constructed around the perimeter of the area (refer to **Section 14.5.2**). Consequently, the soil beneath the concrete slabs is unlikely to be impacted by the stockpiling activities and subsequently, validation testing of these areas, once the concrete slabs are removed, is not proposed.

As a precautionary measure, before removal of concrete slabs is commenced, a careful inspection of these will be undertaken to identify the presence of contamination. If this inspection indicates the visual presence of any contamination relating to treatment operations, validation of the soil beneath the concrete slabs will be undertaken as outlined in **Section 19.5**.

Waste materials that do not require treatment but require temporary storage to enable waste classification testing and offsite disposal, will be stockpiled in the Central Stockpile Area (approximately 1,400 m^2, refer to Item 1 in **Figure 18**). Materials will be stockpiled in the Central Stockpile Area for relatively short durations only (i.e. 3-4 weeks) to enable offsite disposal and to allow additional stockpiling to be undertaken in this area.

19.9 Validation of Excavated Materials for Onsite Beneficial Reuse

As discussed in **Section 6.11.1,** the RBSWC have been derived to allow the excavation, validation and movement of materials across the Site. Should such material require validation for onsite beneficial reuse, the following works must be undertaken:

- All materials excavated for onsite beneficial reuse must be inspected by a qualified environmental engineer/scientist with experience working on contaminated sites. This inspection should confirm that the excavated material is free of any asbestos containing materials (ACMs) and is free of visual or olfactory signs of contamination;
- For stockpiles less than 500 m^3, soil samples will be collected and analysed at a sampling density of 1 sample per 50 m^3;
- For stockpiles greater than 500 m^3, soil samples will be collected and analysed at a sampling density of 1 sample per 100 m^3;
- All validation samples will be analysed for the CoC and asbestos using NATA accredited (or equivalent) methods;
- The 95% UCL for the CoC will be calculated for each of the stockpiles to assess whether contaminant concentrations are less than the Remediation Goals;
- All materials validated for onsite beneficial reuse will be tracked using the Materials Tracking System (refer to **Section 14.3**); and
- The above works will be reported appropriately in the Site Validation Report.

19.10 Delineation Testing Adjacent to Former Validation Area 12, Pharmaceuticals Site

As discussed in **Section 3.3.9**, the CH2M Hill (2007b) report noted that residual PAH impacts were present on the Site boundary (in the vicinity of sample location VA12/94) with the Pharmaceuticals site at the completion of the validation works. Additional excavation works could not be undertaken due to the proximity with the Site boundary. Consequently, to assess the significance of the reported PAH impacts it is recommended that additional delineation testing of the surface soils be undertaken in this area. The findings of these works and any required remediation works will be detailed in the Validation Report to be prepared for the Site.

19.11 Analytical Methods

Two laboratories will analyse original and duplicate soil samples using NATA registered methods. Both laboratories must undertake the required analytical testing in accordance with the requirements of the *National Environment Protection (Assessment of Site Contamination) Measure (NEPC, 1999a)*. Details regarding the analytical methods to be used will be discussed with the Site Auditor and the appropriate analytical laboratory engaged to undertake the works.

19.12 Sampling Methodology

Fieldwork will be conducted in accordance with written standard operating procedures, copies of which will be maintained in a register on Site during the remedial works. This will ensure that representative samples of materials are collected and the sampling methodology remains consistent throughout the duration of the remedial works.

Sample collection will be by:

- EnCore™ piston samplers or trowel from excavation or trench bases and walls;
- Grab samples directly from the centre of an excavator bucket from the centre of stockpiles for validation of excavated material; and
- Grab samples from the exit conveyor for treatment plant materials.

Materials will be described in accordance with the Unified Soil Classification System (USCS), with soil type, descriptive properties (colour, particle size, moisture content, sorting), as well as discolouration, staining, odours and other indications (if any) being noted. The information will be recorded on field logs completed for each location.

On-site screening of samples for volatile organic compounds (VOCs) in the field will be undertaken using a portable photoionisation detector (PID). The PID will be calibrated at least once daily (at the start of each sampling day) with a known concentration of isobutylene.

Water quality meters will be calibrated prior to the commencement of field activities with relevant solutions (as required). The calibration will be in accordance with manufacturers instructions or NATA publications *General Requirements for Registration: Supplementary Requirement: Chemical Testing (NATA 1993) and Technical Note N0. 19* (NATA 1994). Where satisfactory calibration can not be achieved, the equipment will not be used.

Soil samples will be placed into laboratory supplied glass jars as soon as practicable after collection. The jar size will be sufficient to meet the laboratory requirements for the requested analysis. All sample containers will be filled completely using a method such that volatile components are not lost from the sample. Sample containers will be filled in the order of VOCs and SVOCs (including OCPs). Water samples will be placed into laboratory-supplied bottles and/or VOC vials depending on the requested suite of analysis. All sample containers will be clearly labelled with information such as sample number, sample location, depth, date collected and sampler's identification. After filling, sample containers will then be transferred to a chilled esky for sample preservation prior to and during shipment to the testing laboratory. The sample preservation requirements are listed in **Table 31** and **Table 32**.

Table 31: Soil Sample Preservation and Storage

Analyte	Preservation	Storage
VHCs	Unpreserved, glass jar with Teflon lined lid	Store at $<4^{\circ}$C, nil headspace, extraction within 14 days, analysis within 40 days
OCPs	Unpreserved, glass jar with Teflon lined lid	Store at $<4^{\circ}$C, extraction within 14 days, analysis within 40 days

Table 32: Water Sample Preservation and Storage

Analyte	Quantity (ml)	Preservation	Storage
VHCs	2 x 40	Glass vials, Teflon lined lid, preserved with pH<2 HCl	Store at $<4^{0}$C, nil headspace, analysis within 7 days
OCPs	1000	Glass container, Teflon lined lid, unpreserved	Store at $<4^{0}$C, extraction within 7 days, analysis within 40 days

A sample register will be updated daily to manage and track the validation process.

Equipment decontamination will be undertaken as described below. The following equipment will be needed for the detergent wash and water rinse decontamination process:

- Laboratory (phosphate-free) detergent or Decon 90;
- Tap water and deionised water;
- Buckets or tubs (sufficient for size of equipment to be cleaned); and
- Stiff brushes for cleaning.

The following procedures will be followed for decontamination of sampling equipment, by detergent wash and water rinse methods:

- Buckets or tubs used for decontamination will be cleaned with tap water and detergent and rinsed with tap water before sampling commences;
- Fill first bucket or tub with tap water, and phosphate-free detergent;
- Fill second bucket or tub with tap water;
- Clean equipment thoroughly in detergent water, using brushes;
- Rinse equipment in tap water;
- Dry equipment with disposable towels;
- Rinse equipment by thoroughly spraying with tap water and/or deionised water (as appropriate);

- Allow equipment to thoroughly air dry; and
- Change water and detergent solution after each sampling site.

Used wash water will be taken to the WTP. Equipment that cannot be thoroughly decontaminated using the detergent wash and water rinse should be steam cleaned, or if a steam cleaner is not available, not used for further sampling (and marked clearly "not decontaminated") or discarded. Equipment decontaminated using the high pressure steam cleaner will be further decontaminated as described above.

Any equipment that cannot be decontaminated to the satisfaction of the sampling team will be discarded (to an appropriate facility) and replaced. Such sampling equipment will be collected and stored on-site in appropriately marked drums. When a sufficient number of items has been collected these will be disposed of in an approved manner, in accordance with this RAP and DECCW requirements.

19.12.1 Quality Control samples

The following quality control (QC) samples will be collected as part of the field quality control procedures:

- Intra-Laboratory Duplicates – are identical to field samples, but both samples are sent anonymously to the primary laboratory. Blind duplicates provide an indication of the analytical precision of the main testing laboratory, but may also be affected by sampling techniques and inherent heterogeneity in the sample medium;
- Inter-Laboratory Duplicates – are identical to blind duplicates, but the duplicate sample is sent to the second (check) laboratory. Split duplicates provide an indication of the accuracy of the main testing laboratory;
- Equipment Blanks – are prepared in the field (at the sampling site) using empty bottles and the distilled water used during the final rinse of sampling equipment. After completion of the decontamination process fresh distilled water is poured over the sampling equipment and collected. The distilled water is exposed to the air for approximately the same time the sample would be exposed. The collected water is then transferred to an appropriate sample bottle and the proper preservative added, if required. Equipment blanks are a check on equipment decontamination procedures;
- Trip Blanks/Spikes – are samples of soil or water prepared by the laboratory with either zero or known anolyte concentration. Trip blanks/spikes are a check on the sample contamination originating or lost from sample transport and handling, and shipping; and
- Field Blanks – are similar to trip blanks except the water is transferred to sample containers on-site. Field blanks are a check on sample contamination originating from sample transport, handling, shipping, site conditions or sample containers.
- Rinsate blanks - one rinsate blank sample (from an item of sampling equipment) will be collected per day of sampling by running distilled water over the selected item and decanting directly into the sample bottle. The rinsate will be taken from the final rinse of the equipment after decontamination.

Procedures for duplicate sampling will be identical to those used for routine sampling and duplicate samples will be despatched for analysis for the same parameters using the same methods as the routine sample. Duplicate soil samples will be collected from directly adjacent to original samples (i.e., from the adjacent area of the excavation base or wall). No homogenisation of samples will occur to reduce the loss of volatile compounds.

Duplicates and equipment blank samples will be collected as follows:

- Intra-Laboratory duplicate samples will be collected at a rate of approximately 1 in 10 soil samples and analysed for the full analyte suite. At least one blind duplicate sample will be included in each batch of samples;
- Inter-Laboratory duplicates samples will be collected at a rate of approximately 1 in 20 soil samples and analysed for the full analyte suite. At least one split duplicate sample will be included in each batch of samples; and
- One equipment blank of soil sampling equipment will be collected for every day of sampling and analysed for the full analyte suite. At least one equipment blank will be included in each batch of samples.

19.12.2 Laboratory QA/QC

The laboratories will undertake the analyses utilising their internal procedures and their test methods (for which they are NATA, or equivalent, registered) and in accordance with their quality assurance (QA) system which forms part of their registration.

Laboratory quality control procedures, which will be used during the project, will comprise the following:

- Laboratory Duplicate Samples – these are sub-samples taken from one sample submitted for analytical testing in a batch. A laboratory duplicate provides data on analytical precision. The rate of duplicate analysis will be according to the requirements of the laboratory's accreditation but will be at least one per batch;
- Matrix Spiked Samples – the purpose of the matrix spike is to monitor the performance of the analytical methods used, and to determine whether matrix interferences exist. A sample is spiked by adding an aliquot of known concentration of the target analyte(s) to the sample matrix prior to sample extraction and analysis. A spike documents the effect of the sample matrix on the extraction and analytical techniques. These will be analysed at a rate of approximately 5% of all analyses. At least one per batch will be reported;
- Laboratory Blank – this is usually an organic or aqueous solution that is as free of analyte as possible and contains all the reagents in the same volume as used in the processing of the samples. The reagent blank must be carried through the complete sample preparation procedure and contains the same reagent concentrations in the final solution as in the sample solution used for analysis. The reagent blank is used to correct for possible contamination resulting from the preparation or processing of the sample. Blanks will be analysed at a rate of once per process batch, and typically at a rate of 5% of all analyses;
- Laboratory Control Samples – these comprise either a standard reference material or a control matrix fortified with analytes representative of the analyte class. Recovery check portions should be fortified at concentrations that are easily quantified but within the range of concentrations expected for real samples. These will be analysed at a rate of one per process batch, and typically at a rate of 5% of analyses; and
- Surrogates – surrogate spikes are known additions to each sample, blank and matrix spike or reference sample analysis, of compounds which are similar to the analytes of interest in terms of:
  - Extraction;
  - Recovery through clean-up procedures; and
  - Response to chromatography or other determination;

  But which:

  - Are not expected to be found in real samples;
  - Will not interfere with quantification of any analyte of interest; and
  - May be separately and independently quantified by virtue of, for example, chromatographic separation or production of ions of different mass in a GC/MS analyser.

Surrogate spikes are added to the analysis before extraction. The purpose of surrogates is to provide a means of checking, for every analysis, that no gross errors have occurred at any stage of the procedure leading to significant analyte losses. Other internal laboratory quality control procedures, as required for NATA, or equivalent, registration, will also be performed.

Results of the QC analyses for both laboratories will be reported with each batch.

19.13 Data Quality Objectives

The Data Quality Objectives (DQO) process is a systematic, seven-step process that defines the criteria that an investigation should satisfy. DQOs for the validation works have been developed based on the iterative DQO process developed by the USEPA (2000) Guidance for the Data Quality Objectives Process – EPA QA/G-4 and adopted by NSW DEC (2006). The guidelines incorporate field quality control and laboratory analysis, methods and information on laboratory quality control data and have been used to validate the field and analytical data for the validation works.

The DQO approach adopted by AECOM for this project follows guidance set out in NSW DEC (2006), which in turn generally follows the USEPA approach. The USEPA DQO approach is designed to be flexible with the assessor defining acceptable limits for quality that are required to achieve the specific objectives of the validation works.

The DQO approach follows the general guidance provided in Appendix IV of NSW DEC (2006) with respect to setting the DQOs and assessing their achievement by reference to the Data Quality Indicators (DQIs) set out in Appendix V of NSW DEC (2006). The approach has been modified to focus on setting appropriate objectives and ensuring the reliability of data from both field and laboratory procedures. The approach puts more emphasis on Step 5 (Developing the analytical approach to assessing data), which assesses the reliability of both the field and laboratory data and on demonstrating achievement of the objectives of the validation works. The approach assesses achievement of Step 6 (Performance or acceptance criteria that data need to achieve) by reference to DQIs for both field and laboratory procedures.

The DQOs are detailed in the following Sections.

19.13.1 Step 1 – State the problem

The historic use of the Site as an explosives and pesticides manufacturing facility has caused OCP and VHC contamination in the soils and shallow groundwater in some areas of the Site. The HHERA has concluded that these chemicals are present in the Site soils at concentrations which pose a significant risk to human health in the context of the proposed commercial/industrial landuse. Consequently, remediation of soils in some areas of the Site is required.

19.13.2 Step 2 – Identify the decisions

These decisions will be achieved by meeting the objectives of the remedial works which are:

- To ensure that the Site is suitable for the anticipated ongoing commercial / industrial use;
- To protect the environment by ensuring that the identified areas of soil contamination are remediated to the maximum extent practicable such that they do not constitute a contamination source for the Site and the surrounding properties; and
- To comply with legislative requirements and the appropriate requirements from BCC, the DoP and the DECCW.

19.13.3 Step 3 – Identify the decision inputs

Inputs to the decision that need to be made with respect to the proposed remediation works at the Site are identified to be:

- The results of previous investigations;
- The results of the HHERA;
- The results of the groundwater modelling report;
- The development and implementation of remedial options;
- The data to be obtained during soil sampling during the validation testing discussed in earlier in this Section;
- The use of appropriate validation field methods, including sampling and preservation of samples;
- The use of NATA registered methods for all analysis; and
- Use of appropriate remediation validation assessment criteria (the RBSWC, refer to **Section 7.2**; and
- Confirmation that the DQIs have been achieved.

19.13.4 Step 4 – Definition of the boundaries of the remedial works

This is clearly defined by reference to the Site address (refer to **Section 3.1** and **Figure 2**) while the approximate boundaries of the proposed Remediation Areas (including estimated volumes and excavation depths) is described in **Section 8.0** and illustrated in **Figure 7** to **Figure 10**. The vertical boundaries with some of the Remediation Areas will be limited by the presence of the underlying, unweathered shale. Consequently, remedial excavations in some areas will be undertaken to the MPDoRE.

19.13.5 Step 5 – Develop decision rules

The quality of data from field and laboratory procedures will be achieved by assessing data with reference to DQIs. The criteria will be as follows:

Data	Data Quality Indicators
Field	
Field Personnel	Use appropriately trained field personnel.
Field data collection	Site conditions and sample locations properly described. Soil sample locations will be surveyed. Information to be recorded in field notes. Field notes are appropriately completed.
Sample handling (storage and transport)	Soil and water samples will be collected will be collected in accordance with **Section 19.12**.
Field duplicates	Duplicate (including inter-laboratory duplicates) soil samples will be collected in the field at a rate of one in every 10 primary samples. The duplicate samples will be obtained from locations suspected of being impacted. Duplicated samples will be labelled so as to conceal their relationship from the laboratory. RPD's to be less than 30% for inorganic and 50% for organic analyses.
Field blanks	Acceptable quality of field blanks. One field per day to be collected.
Field	
Rinsate Blanks	One rinsate blank sample (from each item of sampling equipment) will be collected per day of sampling by running distilled water over the selected item and decanting directly into the sample bottle. The rinsate will be taken from the final rinse of the equipment after decontamination.
Calibration of Field Equipment	On-site screening of samples for volatile organic compounds (VOCs) in the field will be undertaken using a portable photoionisation detector (PID). The PID will be calibrated at least once daily (at the start of each sampling day) with a known concentration of isobutylene. Water quality meters will be calibrated prior to the commencement of field activities with relevant solutions. The calibration will be in accordance with manufacturer's instructions or NATA publications *General Requirements for Registration: Supplementary Requirement: Chemical Testing (NATA 1993) and Technical Note N0. 19* (NATA 1994). Where satisfactory calibration cannot be achieved, the equipment will not be used. Calibration details will be recorded on field sheets, which will be included in the final report.
Laboratory	
Sample Analysis	All sample analyses to be conducted using National Association of Testing Authorities (NATA) certified laboratory using NEPM procedures. Use NATA certified check laboratory.
Holding times	Maximum acceptable sample holding time is 14 days for organic analyses and 6 months for metal analyses (28 days for mercury).
Laboratory Blanks	Laboratory blanks to be analysed at a frequency of 1 in 20, with a minimum of one analysed per batch. Laboratory method blank analyses to be below the laboratories Practical Quantitation Limits (PQLs).

Laboratory Duplicates	Laboratory duplicates to be analysed at a frequency of 1 in 20, with a minimum of one analysed per batch.
Laboratory Control Samples (LCS)	LCSs to be analysed at a frequency of 1 in 20, with a minimum of one analysed per analytical batch.
Surrogates	Surrogate compound concentrations will be required to be spiked at similar concentration to sample results, at a rate of 1 in 20. The acceptance criteria for quality control measurements employed are based on USEPA guidelines (5) which are: • < 10% - Unacceptable low recovery, which may result in negative detections. • 10% to 70% - Recoveries are sufficiently low that results provide only an estimate of analyte concentration. • 70% to 130% - Acceptable recovery. • > 130% - Unacceptable high recovery, which may result in false high detection.
Practical Quantitation Limits (PQLs)	All PQLs to be less than the assessment criteria.
Laboratory Relative Percentage Difference (RPD)	The RPDs of replicates will be determined and compared to the following criteria (from tender brief) for acceptability: • Less than 20 percent for laboratory duplicates where the detection is greater than 20 times the PQL; • Less than 50 percent for laboratory duplicates where the detection is greater than 10 times the PQL and less than 20 times the PQL; and • No limit where concentration less than 10 times PQL
Control Spike Duplicate RPDs	RPDs for Control Spike Duplicates will be compared to an acceptable limit of 20% and undertaken at 1 in 20 samples or a minimum of 1 per batch.
Matrix Spike Duplicates RPD	RPDs for Matrix Spike Duplicates will be compared to an acceptable limit of 20% and undertaken at a minimum of 1 in 20 samples.
Control Spike and Matrix Spike Recoveries	Percent recoveries of control spikes and matrix spikes will be compared to an acceptable range of 75–130 % and/or the laboratories internal DQI limits. Lower recoveries may be acceptable for OCPs, OPPs, PCBs and phenols and will be assessed according to USEPA protocols.

Corrective Actions

Analytical data that fails to meet the predetermined DQOs and DQIs listed above will be managed using the following corrective actions on a case-by-case basis:

- Inspect samples to determine heterogeneity;
- Reanalyse suspect samples;
- Evaluate and amend sampling and/or analytical procedures;
- Re-sampling and re-analysis;
- Accept the data with an acknowledged level of bias and imprecision; and
- Discard the data.

In the event that data of questionable reliability are used, then it is essential that any restrictions and limitations associated with the use of such data are clearly identified. Failure to meet the DQIs will be reported and the implications to data quality will be assessed.

If the DQIs are considered to have been achieved satisfactorily then it will be concluded that the data is suitable for use for validation purposes. If the DQIs are not achieved, the significance of possible errors will be assessed to decide whether the data is useable.

19.13.6 Step 6 – Specification of the acceptable limits on decision errors

Specification of the acceptable limits on decision errors will be achieved by reference to the DQIs outlined below:

Precision

Precision measures the reproducibility of measurements under a given set of conditions. The precision of the laboratory data and sampling techniques will be assessed by calculating the Relative Percent Difference (RPD) of duplicate (laboratory and field) samples. The criteria to be used for the assessment of RPD will be based on guidelines given in AS4482.1 1997. These criteria listed in **Table 33**.

Table 33: RPD Assessment Criteria

Sample Type	Typical Acceptable RPD[(a)]
Intra-Laboratory Duplicate	30-50%[(b)]
Inter-Laboratory Duplicate	30-50%[(b)]

Notes: The significance of RPDs of results should be evaluated on the basis of sampling technique, sample variability, absolute concentration relative to criteria and laboratory performance.

This variation can be expected to be higher for organic analysis than for inorganics and for low concentrations of analytes.

If duplicate results are not within the acceptable RPD range, investigation into the cause will be initiated. The results of the investigations will be written up and filed, and followed up with the laboratories to achieve resolution. Thus the precision of the laboratory will be assessed by the acceptability of the RPD of laboratory duplicate samples, which should be within the acceptable RPD limits as established for intra-laboratory and inter-laboratory duplicates.

Accuracy

Accuracy measures the bias in measurement. Accuracy can be impacted by factors such as field contamination of samples, poor preservation of samples, poor sample preparation techniques, poor selection of analytical techniques by the analysing laboratory and improper analyses.

The accuracy of the laboratory data that will be generated during the project is a measure of the closeness of the analytical results obtained by a method to the 'true' value. For reference laboratory methods (e.g., USEPA methods), the following levels of accuracy should generally be achievable within ± 15 % of:

- The expected value of a certified reference material of similar matrix; or
- The value obtained by a separately validated and recognised quantitative method for the sample matrix.

Accuracy will be assessed by:

- Reference to the analytical results of laboratory control samples;
- Use of trip, equipment and field blanks to check the accuracy of sampling techniques; and
- Evaluating the results of laboratory spikes and analyses against reference standards.

Analytical results of these should be sufficient to establish that accuracy has been achieved in the work of the sampling team.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents a characteristic of a population or an environmental condition. Representativeness will be achieved by collecting samples on a grid basis across validation areas from an adequate number of sample locations, to characterise the area to the required accuracy and ensuring that an appropriate number of reliable analyses have been reported for each population or environmental condition, and that the CoPC concentrations have been maintained in the samples during and after their collection. Regular collection and analysis of treated soil samples at the specified sampling density will also ensure the analytical data is representative of the treated material for the duration of DTD treatment operations.

Consistent sampling techniques and methods, with reference to written procedures, will be utilised throughout the sampling program to ensure consistency.

Completeness

The completeness of data is defined as the percentage of analytical results that are considered valid. Valid chemical data are values that have been identified as acceptable or acceptable as qualified during the data validation process. The completeness is a comparison of the total number of samples accepted against the total number of samples, calculated as a percentage. The project goal for completeness is typically 90%. Completeness also includes checking that all entries in the database are correct, properly entered, and that any typographical errors in the database are corrected and the data are re-entered properly. Completeness is defined as:

$$\text{Completeness} = \frac{\textit{number of acceptable items}}{\textit{total number of items}} \times 100\%$$

Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This will be achieved through maintaining a level of consistency in techniques used to collect samples, and ensuring the selected laboratories use consistent analytical techniques and reporting methods. Reporting of results will be done in consistent units and nomenclatures, and comparability will be achieved by ensuring that precision and accuracy objectives are met.

19.13.7 Step 7 – Optimisation of the design of the collection of data

This will be achieved by the preparation of a Sampling, Analytical and Quality Plan (SAQP) which will be developed to achieve the DQOs detailed in Steps 1 to 6. The SAQP will ensure that the data generated from the remedial works is from appropriate locations, that analytical testing is undertaken for the identified CoPC, in appropriate quantities and of acceptable quality to confirm that the objectives of the remedial works have been achieved.

20.0 Groundwater Monitoring Program

Based on the hydrogeological conditions at the Site, the contaminant characteristics and the findings of the groundwater modelling, the identified groundwater impacts at the Site and in off-site areas are likely to present for a long period of time. Consequently, a groundwater monitoring program will be undertaken at the Site and in off-site areas. The objectives of the monitoring program will be to:

- Monitor and confirm contaminant concentrations associated with the identified groundwater plumes in onsite and off-site locations;
- Assess possible changes to contaminant concentrations at the Site in areas downgradient of Remediation Areas following the proposed excavation works. This may occur following a high rainfall event at the completion of the excavation works; and
- Facilitate contingency planning in the event that the groundwater plumes are found to migrate faster than predicted.

The monitoring network is likely to include selected onsite wells within the identified groundwater plumes and adjacent to Remediation Areas and in off-site areas. URS has derived RBGC which will be used as trigger levels for the proposed groundwater monitoring program. The RBGC will be used to assess whether additional risk assessment or contingency remedial actions may be required in the situation that contaminant concentrations are identified to be increasing significantly.

The specific detail of the monitoring works will be confirmed with the preparation of a Groundwater Monitoring Plan to be developed in consultation with the Auditor and DECCW.

Based on the persistent nature of the identified contaminants present in groundwater at the Site, the monitoring program will need to be undertaken for a long-term duration (approximately 5-10 years depending on the findings of the monitoring).

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21.0 Environmental Management Plan

21.1 General

An EMP will be developed to provide a management strategy to effectively manage the environment and the remediation activities considered to potentially have an adverse impact on the environment.

This section outlines the environmental management measures proposed to minimise and mitigate the potential impacts of the remediation operations on the environment and surrounding Site areas. These measures address the following:

- Surface water management;
- Management of water in excavations;
- Air quality management including dust, gaseous emissions and odours;
- Noise management;
- Vibration;
- Equipment operation; and
- Traffic control.

The remediation works will comply with relevant legislative requirements, licences and approvals and notices. At all times work will be undertaken to minimise impact on the environment and the surrounding areas. Regular monitoring will be conducted to monitor environmental performance and to identify areas of improvement in both work methods and scope. The EMP will also provide details on incident reporting and investigation procedures.

21.2 Environmental Protection Measures

The installation, operation and regular maintenance of a wide range of environmental protection measures will be undertaken to minimise impacts on the environment and surrounding areas. These works will include the installation and operation of the following:

- Stormwater control measures including retention basins, bunding, silt fences, oil absorbent materials, dewatering systems, and water treatment systems for the management of site water;
- Works enclosures for waste excavation and handling as described in **Sections 12.0** and **14.0**;
- Vehicle emission controls, stockpile covering and treatment designed to control air and dust emissions from equipment, plant and stockpiles;
- Equipment decontamination control measures, comprising washing facilities, to manage the potential for cross-contamination during excavation and soil treatment; and
- Protective fencing and restricted site access, including delineation of Exclusion Zones to limit unauthorised access to designated areas.

21.3 Environmental Inspections

Regular inspections of all implemented environmental protection measures will be undertaken as follows:

- Adjacent to the active TWL excavation areas, within active Remediation Areas and in the vicinity of the STA area – prior to the commencement of work on each day;
- Along haul roads and in perimeter areas outside Exclusion Zones – prior to the commencement of work on the first working day of each week; and
- At the above Site locations – at hourly intervals throughout major storm events.

An inspection report will be recorded and maintained on file after each inspection.

21.4 Water Management

21.4.1 General

The work methodology has been developed to manage surface water at the Site and to minimise the impact of surface water on the remediation works. Drainage and sediment control measures will be constructed to prevent surface water originating in surrounding areas from entering works areas and becoming contaminated. These measures will be progressively installed and maintained as works proceed to the Remediation Areas across the Site.

This section of the RAP outlines the water management control measures proposed for use during the remediation works.

21.4.2 Controlling Surface Run-off from Outside Work Areas

Perimeter drainage control measures will be installed upgradient of all operational site areas prior to the commencement of works to prevent clean surface water from entering work areas and becoming potentially contaminated. Drainage control measures such as diversion drains, ditches, straw bales and silt fences will be constructed. The diverted water will be directed away from works areas, through a series of sediment and erosion control devices into existing on-site stormwater drains.

21.4.3 Controls on the Existing Stormwater System

Existing stormwater discharge points in and adjacent to the Remediation Areas and STA will be blocked-off to prevent any unauthorised discharge of site water. Clean water will be directed away from works areas, through a series of sediment and erosion control devices and into existing on-site stormwater drains.

21.4.4 Controlling Surface Run-off within Work Areas

Additional bunding and diversion drains will be constructed within finished excavations where necessary to minimise the impact of surface water on reinstatement activities.

21.4.5 Controlling Surface Run-off within Stockpile Areas

As shown in **Figure 25**, perimeter drainage control measures, bunding and erosion control measures will be installed around the perimeter of all stockpile areas. Additional drainage measures will be constructed upgradient of all stockpile areas prior to the commencement of stockpiling activities to minimise the volume of clean surface water entering stockpile areas.

21.4.6 Spill Response Plan

A Spill Response Plan will be developed and implemented as part of the Emergency Management Plan (refer to **Section 23.2**). The procedures outlined in the plan will be aimed at minimising the impact of any contaminant releases that may occur.

21.4.7 Groundwater Management Strategy

Based on the results of previous investigations, groundwater should not be encountered during excavation of the Remediation Areas. However, minor seepage water from the upper surface of the unweathered shales and infiltrated water from adjacent areas may be encountered during the excavation works. Should water accumulate in active excavations, it will be regarded as contaminated and transferred directly to the WTP for treatment.

21.5 Air Quality Management

21.5.1 General

The objective of the Air Quality Management Plan is to conduct site works in a manner that ensures that ambient air quality on-site and in adjacent areas complies with statutory requirements.

21.5.2 Odour Control for Site Works

Emissions from the STA will be addressed by the construction of the FSB and operation of an ECS for the structure.

The following odour control measures may also be implemented for the remedial excavations (as required):

- Use of appropriate excavation rates – where particularly odorous materials are encountered, the rate of excavation may be slowed to reduce odour generation, and assist in the management of emissions;
- The use of tarpaulins and odour suppressant sprays/foams on materials being stockpiled within the Central Stockpile Area; and
- Installation and operation of a boundary misting system – consisting of a polyethylene pipework system for the discharge of deodorising agents in water sprayed into the atmosphere around the perimeter of the Site.

21.5.3 Dust Suppression

Water carts will be used to assist in dust suppression across unsealed areas of the Site, such as roadways, excavated and validated areas, and during reinstatement works. The water cart will be on-site and available for use at all times. A misting system may also be installed for the active excavation area, and stockpiling areas within the Central Stockpile Area and the STA (as required). Trucks transporting materials around the Site will also be required to cover their loads at all times.

21.5.4 Ambient Air Quality Monitoring Program

An Air Quality Monitoring Plan will be developed prior to Site establishment. Air quality monitoring will be conducted by an appropriately qualified and experienced air monitoring consultant, in accordance with Licence requirements. The selection of appropriate sampling locations would be determined by the prevailing winds at the time of monitoring, and it is anticipated that the monitoring locations will generally be on the down-wind boundaries of the Site. Should concerns regarding air quality arise either through monitoring results or the receipt of complaints, additional targeted monitoring will be conducted, as required.

The Air Quality Monitoring Plan will detail specific information regarding the monitoring techniques and equipment, frequency of monitoring, monitoring locations, and outline the specific air quality standards applicable to conditions and emissions from the remediation works.

21.5.5 Personal Air Monitoring Program

A program of personal air monitoring will be undertaken during all stages of the works. This program will be aimed at monitoring worker exposure to airborne hazardous substances to determine the appropriateness of work methods and levels of personal protective equipment (respirators in particular) for specific site works. The personal air monitoring program will conducted by a qualified and experienced OH&S consultant, and will be documented in the OHSP.

21.5.6 Stack Emission Monitoring Program

A stack emission monitoring program will be undertaken to document the performance of the DTD Plant and FSB ECS. This program will be undertaken by a qualified and experienced stack emission consultant in accordance with Licence requirements. It should be noted that the Site is not located adjacent to residential areas but is surrounded by commercial/industrial operators.

21.6 Noise Management

21.6.1 General

The proposed works program and strategy have been developed to minimise the noise impact of the works on nearby receptors. This section of the RAP outlines the noise control strategies and measures proposed.

21.6.2 Control Measures

DTD and associated plant will be sourced/designed with the objective of complying with the NSW EPA, Noise Policy Section *NSW Industrial Noise Policy* (NSW EPA 2000). The following general mitigation measures will be considered in the detailed design of the plant in order to achieve the required noise reductions.

- Plant layout and orientation shall be designed to minimise noise impacts;
- ECS and DTD Plant fans to incorporate silencers and enclosures to achieve appropriate noise reductions;
- Solid barriers shall be incorporated, wherever reasonably practicable at noise sources at a height;
- Plant items shall be located at lower heights where reasonably practicable such that noise shielding from the FSB is maximised; and
- Ductwork, including the stacks shall be acoustically lagged if required.

Also, a Noise and Vibration Management Plan will be prepared which will include the following:

- Appropriate noise monitoring program for the project including details of periodic noise and vibration testing to be undertaken during activities deemed likely to generate high noise and vibration levels; and
- Provision of a 24 hour community hotline to allow the local community to register complaints regarding noise at the Site.

Orica will ensure that works on the Site are carried out in accordance with the following:

- All remedial excavations within the Remediation Area shall be undertaken between the hours of 7.00am and 5.00pm from Monday to Saturday;
- All operations undertaken within the enclosed FSB (screening, crushing, blending of stockpiled materials and feeding material to the DTD Plant) and the operation of the DTD Plant may be undertaken 24 hours per day, seven days per week;
- All other works including stockpile management, maintenance of drainage and environmental control measures, and the maintenance of haul roads will be undertaken between the hours of 7.00am and 7.00pm from Monday to Saturday;
- All equipment and plant used on-site will be maintained in good order in accordance with manufacturers recommendations; and
- All construction vehicles will enter and exit the Site in accordance with the Site entry controls specified in **Section 12.4.3**.

21.6.3 Noise Emission Standards

The noise levels arising from operations are to comply with the Bankstown City Council (BCC) requirements.

21.6.4 Noise Monitoring Program

An ambient Noise Monitoring Plan will be developed prior to Site establishment. It is anticipated that a noise monitoring program will be conducted for the duration of the remediation works. The objective of the monitoring program will be to measure performance of the Site works at the nearest sensitive receptors, and to monitor compliance with BCC requirements.

The monitoring program will be conducted by a qualified and experienced noise monitoring specialist. The program will commence prior to Site establishment in order to determine background noise levels.

Noise level monitoring will be conducted at off-site locations to monitor the impacts of Site works on the surrounding community. These locations will be determined prior to Site establishment and will be detailed in the Noise Monitoring Plan. Additional monitoring will be conducted for all plant and equipment to be used on-site.

Additional monitoring will be conducted as appropriate in response to noise complaints and during site works identified as a potential noise hazard.

21.6.5 Definition of Non-Compliance

Noise levels measured from the site works will be considered to be unacceptable if:

- The $L_{Aeq,max}$ noise level of any item of plant or equipment working on the Site exceeds its maximum recommended noise level; or
- The $L_{Aeq,15min}$ noise levels exceed the limit detailed by the BCC requirements.

Where unacceptable noise levels are identified at the Site boundary, measures will be instigated to reduce the noise levels to below the acceptable limits. Where a sustained exceedance of the NSW EPA (2000) requirements is recorded, either as a result of regular monitoring or monitoring in response to a complaint, the exceedance will be investigated and prompt action taken to identify the source of the noise, determine the appropriate mitigation measures, and to implement corrective measures. Additional monitoring of noise levels at these locations will be conducted following the implementation of these measures.

The adoption of corrective measures may include the following:

- Modification of the works program to minimise noise impacts on the surrounding areas;
- Modification of the works program to minimise or reduce the duration of the activities responsible for the noise impacts;
- Further reduction in the noise emissions from individual equipment items;
- Reduction in the number of equipment items on site, or changes to the works program to reduce noise impacts; and
- Other noise control measures as deemed appropriate for the works

21.7 Equipment Control Measures

21.7.1 General Operational Requirements

Plant and equipment used on the Site has the potential to create a hazard to workers, other items of plant and to the surrounding environment. The following measures will be implemented to minimise these risks:

- Each item of plant and equipment will be operated in a proper manner by a trained, licensed and competent person;
- All items of plant and equipment will be maintained in a clean and safe condition;
- All noise, odour and dust attenuation measures provided for each item of plant and equipment will be maintained in good working order; and
- Site works will be conducted by all site personnel in a safe and responsible manner; and
- HAZOP inspection and certification.

21.7.2 Controls on the Movement of Vehicles

Due to the presence of contaminated materials, the following controls will be placed on the movement of vehicles in and around work areas:

- All vehicles and equipment inside the FSB will be decontaminated within the air-lock before leaving these areas;
- All trucks and equipment will travel along designated haul roads;
- No vehicles or equipment carrying contaminated materials will travel across validated or clean areas except on designated haul roads;
- All designated haul roads will be regularly inspected for the presence of BACM to prevent the possible crushing and spreading of these materials to other site areas;
- All vehicles transporting materials on-site will be operated in a safe and responsible manner to prevent the loss of materials during loading, soil transport and unloading activities; and
- All vehicles leaving the Site will be cleaned to prevent the trafficking of soil to local roads.

21.7.3 Equipment Cleaning

Plant and equipment that come in contact with contaminated material will be washed and cleaned before they are removed from the Site. The primary locations of contamination will be within the Remediation Area compounds and the FSB. Cleaning will be conducted by high pressure water sprays in the truck wash facilities located in the exit air-locks of the FSB and within wheel washes (refer to **Figure 26**).

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22.0 Occupational Health and Safety

22.1 General

This section of the RAP describes the minimum standards to be adopted to protect the health and safety of all persons involved in the Site works. A suitable Health and Safety Management System will be developed and implemented in compliance with legislative and regulatory requirements. A Site-specific OHSP will also be developed prior to commencement of the works. The OHSP will detail the appropriate health and safety information necessary to conduct the remediation works in a safe manner.

22.1.1 Occupational Health & Safety Plan

The purpose of the site-specific OHSP is to present all relevant health and safety information for the works. The information presented in the OHSP will include:

- Assignment of responsibilities for all Site personnel;
- An outline of the existing Site conditions;
- Details of all work to be conducted;
- An evaluation of hazards and risks;
- Details of the proposed measures to be implemented to manage the identified hazards and risks;
- Establishment of personnel protection standards and mandatory safe work and hygiene procedures;
- Establishment of OH&S monitoring protocols;
- Training requirements for emergency team members;
- Communication protocols and training procedures;
- Evacuation procedures, emergency contacts and emergency drills to be implemented;
- Provision for contingencies and changes in work practices; and
- Incident reporting procedures and investigation

22.1.2 Responsibilities

The responsibilities and duties of the principal contractor in relation to OH&S will include:

- Ensuring all work undertaken is performed in accordance with relevant legislation and regulations, and directions issued by regulatory authorities;
- Developing and documenting safe working practices for all employees and subcontractors, as well as reviewing adequacy of safe working practices following an incident or near miss and implementing appropriate changes to safe working practices;
- Ensuring workers are adequately trained to undertake their work tasks using the adopted safe working practices;
- Ensuring that work is performed in strict adherence to the adopted safe work practices;
- Appointing a suitably qualified and experienced Site Safety Officer (SSO) to supervise and control safety matters;
- Supplying and maintaining first aid kits, first aid facilities and ensuring first aid attendants are present in accordance with statutory requirements;
- Ensuring that workers are inducted prior to their commencement of work. This will include site-specific training in regard to the Site conditions, works procedures, emergency and evacuation procedures, first aid procedures, decontamination procedures and other relevant matters detailed in the OHSP;
- Ensuring that copies of the OHSP are readily available;
- Establishment and maintenance of a record of all hazardous substances on the Site including provision of Material Safety Data Sheets (MSDSs);
- Ensuring that all personnel who work with contaminated materials undergo a medical examination prior to and at the completion of their work on-site;
- Reporting all site incidents and accidents to WorkCover;
- Ensuring that the SSO is on-site during all site works to monitor compliance with the OHSP;

- Ensuring that regular documented OH&S inspections are conducted, including the use of a documented follow-up system to monitor improvements and measures introduced to rectify any observations made;
- Supplying and maintaining the required PPE;
- Ensuring all workers are trained in the use of the PPE and correctly use PPE;
- Ensuring all OH&S incidents are appropriately reported and investigated: and
- Ensuring that all electrical equipment, plant and tools comply with appropriate statutory requirements and are maintained in a good, serviceable and safe condition.

22.1.3 OH&S Legislation, Regulations and Standards

The remediation works will be conducted in compliance with applicable OH&S legislation, regulations and standards. In addition, the remediation works will comply with relevant industry codes of practice, guidelines and other publications that have been developed by WorkCover. These may include:

- The Occupational Health and Safety Act 2000 and Regulation 2001;
- The Dangerous Good Act 1975 and General Regulation 1999;
- *Guide for Riggers* (November 1995);
- Electrical Practices for Construction Work (February 1992); and
- Exposure Standards for Atmospheric Contaminants in the Occupational Environment (National Occupational Health and Safety Commission (NOHSC), 1995).

A number of Australian Standards (AS) have been identified relating to OH&S issues for the works proposed at the Site. These standards include:

- AS 1319 -1994 Safety Signs for the Occupational Environment;
- AS 1336 -1997 Recommended Practices for Occupational Eye Protection;
- AS 1470 -1986 Health and Safety at Work - Principles and Practices;
- AS 1715 -1994 Selection, Use and Maintenance of Respiratory Protective Devices;
- AS 1716 -2003 Respiratory Protective Devices;
- AS 1801 -1997 Occupational Protective Helmets;
- AS 1885.1 -1990 Measurements of Occupational Health and Safety Performance - Describing and Reporting Occupational Injuries and Disease (known as the National Standard for Workplace Injury and Disease Recording);
- AS 2161 - 2000 Occupational Protective Gloves;
- AS 2210 - 2000 Occupational Protective Footwear;
- AS/NZS 2865-2001 Safe Working in a Confined Space;
- AS 2986 -1987 Workplace Atmospheres - Organic vapours - Sampling by Solid Adsorption Techniques;
- AS/NZS 3012 -1995 Electrical Installations – Construction and Demolition Sites;
- AS 3640 -1989 Workplace Atmospheres - Method for Sampling and Gravimetric Determination of Inspirable Dust;
- AS/NZS 4576 -1995 Guidelines for Scaffolding; and
- Any other recognised Standard applicable to works conducted at the Site.

22.2 Risk Assessment

A hazard analysis will be conducted prior to site establishment to identify the OH&S hazards expected during the course of the project. A Risk Management Plan will be developed to identify hazards associated with the proposed site works, evaluate the associated risks and determine the necessary measures to reduce or mitigate those risks. This section of the RAP outlines some of the hazards expected over the course of the project. Hazard identification and risk assessment will be conducted and documented on an ongoing basis as the project works proceed.

22.2.1 Chemical Hazards

Based on the information obtained from historic and AECOM site investigations at the Site, the presence of OCPs and VHCs has been confirmed at the Site. The hazard posed by these materials will be evaluated and the associated risks assessed in the Risk Management Plan.

22.2.2 Atmospheric Exposure Limits and Recognition Qualities

The exposure limits and recognition qualities of the chemicals likely to be encountered in the remediation works will be taken from the following guidelines (listed in order of precedence) and detailed in the OHSP:

- NOHSC, Exposure Standards For Atmospheric Contaminants in the Occupational Environment, 1995;
- American Conference of Governmental Industrial Hygienists – Threshold Limit Values and Biological Exposure Indices for 1991 – 1992; and
- National Institute for Occupational Safety and Health (NIOSH) 1994, *Pocket Guide to Chemical Hazards*.

22.2.3 Additional Hazards and Risks

The OHSP will identify and describe a range of other hazards anticipated during the remediation works. These hazards will include:

- Heat stress;
- Explosive atmospheres in areas dealing with contaminated materials;
- Oxygen deficient atmospheres and confined spaces (as defined under AS/NZS 2865 - 2001 *Safe Working in a Confined Space)*;
- Underground utilities;
- Underground pipelines, pits, and other obstructions;
- Above ground electrical and utility hazards;
- Traffic hazards;
- Instability of excavation batters and stockpiled material;
- Hazards associated with the construction and decontamination of the FSB;
- Hazards associated with operation of the DTD Plant;
- Hazards associated with the airlock and decontamination operations in the FSB; and
- Physical hazards such as trip hazards and mobile plant.

Specific minimum standards for these hazards will be outlined within the Risk Management Plan.

22.3 Work Practices

22.3.1 Levels of Personal Protective Equipment

For all works outside Exclusion Zones (FSB and DTD operation) standard PPE comprising long sleeve shirt, long pants, hard hat, eye protection, hearing protection, steel capped boots and high visibility vest will be required for site personnel. This level of protection will be referred to as the Base Level. When working within the Exclusion Zones, personnel will require additional protective equipment, with the amount of the protection dependent upon the type of hazards present in the specific work area.

The necessary levels of PPE will be detailed in the OHSP.

22.3.2 Personnel Decontamination

Site workers will be decontaminated to limit the transport of contaminants from one zone to another. All personnel leaving the Remediation Area and the STA will be decontaminated upon exit. The OHSP will detail the decontamination methods proposed.

Clean and dirty zones will be located adjacent to the decontamination stations and the STA. The decontamination stations will be located such that all workers will pass through these zones when entering and exiting these parts of the Site. All site workers will be decontaminated upon exiting the Site through these facilities, and all staff will be trained in the purpose and use of these zones during the site-specific induction.

22.3.3 Medical Checks

Site workers who will be engaged in activities involving potentially significant exposure to contaminated materials will undergo a health assessment prior to commencement of the project.

The assessment will be carried out by an Occupational Physician and comprise;

- An appropriate medical history and examination;
- Baseline full blood count, liver and renal function tests, micro urine and assessment of lung function; and
- Baseline measures of specific site chemicals.

"Fitness for Duty" reports will be prepared by the Occupational Physician and made available to the Remediation Contractor prior to each employee commencing work on the Site**.** At the conclusion of their involvement with the project, participants will be offered:

- Repeat measurements of baseline parameters; and
- A further health evaluation to be undertaken within six months of completion or work at the site.

22.3.4 Work Zones

The Site will be divided into a number of work zones, as follows:

- Exclusion Zones – the areas surrounding and the STA, comprising the FSB and the DTD Plant areas;
- Decontamination Zones – decontamination stations including the air-locks within the FSB and the personnel decontamination facilities; and
- Support Zones – the site office and site facilities areas located adjacent to the STA.

Movement of personnel and equipment between these zones will be minimised and restricted to specific access control points and decontamination stations to prevent cross contamination to clean areas.

Exclusion Zone

Exclusion Zones are areas of the Site that require the adoption of specific OH&S requirements and work practices. These zones will primarily correspond to areas of the Site where there is a potential for exposure to contaminated materials, potentially hazardous vapours or physical hazards. Exclusion Zones may also include other areas of the Site that are affected by emissions from the works being undertaken or are in close proximity to the works area, such as haul roads.

Access of personnel in and out of Exclusion Zones will be limited by the inclusion of designated Decontamination Stations. The Exclusion Zones will be defined by fencing, with safety signage placed at regular intervals around the perimeter warning on-site personnel of the boundary of the zone, the nature of the hazards associated with it and any access restrictions that apply.

Decontamination Stations

The Decontamination Stations will be the only entry and exit points to Exclusion Zones. The stations will be located to minimise the transportation of contaminants between the various areas of the Site, and to ensure that the Support Zone does not become contaminated or affected by other site hazards. Decontamination Stations will be constructed at the following locations:

- The exit air-lock of the FSB; and
- The Site entry and exit located adjacent to the site office.

As discussed in **Section 22.3.2**, clean and dirty zones will be established at all decontamination stations. All workers will be required to pass through the Decontamination Stations when entering and exiting the Exclusion Zones.

These stations will also house the PPE stock rooms and change rooms, so that when entering the Exclusion Zones workers are able to apply the necessary PPE.

Support Zone

The Support Zone refers to the site office and other support facilities involved in administering the remediation works. Site personnel may wear normal work clothes within this zone, leaving any potentially contaminated clothing, equipment and materials in the decontamination station until decontaminated or appropriately disposed of.

In the event of an emergency, support zone personnel are responsible for alerting the correct authorities. All emergency telephone numbers, evacuation route maps, vehicle keys and site safety information would be held within the Support Zone.

22.3.5 Buddy System

Work activities conducted in the Exclusion Zones should be conducted with a "buddy" who is able to:

- Provide their partner with assistance;
- Observe their partner for signs of chemical or heat exposure;
- Periodically check the integrity of their partner's protective clothing; and
- Notify others in the Support Zone if emergency help is needed.

22.3.6 Site Induction Procedure

The workplace safety induction will be undertaken prior to all workers starting on-site. The induction should provide each worker with the following information:

- Plan of the Site layout showing:
- Site Office locations;
  - First aid facilities;
  - Fire extinguisher;
  - Spill kit equipment;
  - Extent and location of the Work Zones;
  - Exclusion Zones and decontamination stations;
  - Site access; and
  - Amenities location.
- Description of the anticipated site contaminants;
- Procedure for reporting hazards identified on-site;
- Procedure for reporting incident/accidents occurring during site works;
- Emergency Evacuation Plan;
- First Aid Procedures;
- Health & Safety Committee Meetings and Tool Box Meetings;
- Applicable Specific Work Procedures;
- Personal Protective Equipment requirements;
- Hazardous Substances Handling Procedures;
- Plant Safety requirements;
- Drugs and Alcohol Policy and Procedures; and
- Site Safety Rules.

The induction program will be presented by the SSO at the beginning of the project and at any time when new workers are due to commence work on-site. Inductions may also be presented when conditions vary from those anticipated prior to commencement. All safety inductions will be documented and the names of all participants will be recorded.

22.4 Occupational Air Monitoring Program

The Occupational Air Monitoring Program will be undertaken to monitor gas and particulate levels within the breathing zone of site workers to indicate the need for respiratory protection. Over the course of the project, the air quality will be monitored periodically in all work areas by qualified and experienced personnel. These results will be recorded and compared with the exposure levels and limits detailed in the OHSP.

An Occupational Health Risk Assessment will be completed prior to site establishment. The assessment will detail all monitoring techniques, the frequency of monitoring and the appropriate exposure limits and action levels.

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23.0 Contingency and Emergency Response

23.1 Contingency Plan

23.1.1 Approach

The purpose of the contingency plan is to outline procedures for the identification and management of unexpected issues or events that may occur during the works. The contingency plan will detail the following information:

- The assignment of responsibilities to nominated key personnel;
- The assessment of hazards associated with such situations, and the potential off-site impacts;
- Contingency responses; and
- Procedures for reporting relevant issues to regulatory authorities.

The following events have been identified as having the potential to occur during the remediation works:

- Identification of greater amounts of contaminated material than presently anticipated;
- Variation of contaminant characteristics or identification of unanticipated contaminants and materials;
- BACM may be encountered during the excavation works;
- Generation of unacceptable levels of dust during excavation and reinstatement works;
- Release of unacceptable levels of volatile gases during remedial excavations, from the FSB or DTD processes;
- Generation of unacceptable odours from the remedial excavations, from the FSB or DTD processes;
- Generation of unacceptable noise levels during site works;
- Generation of unacceptable vibration levels during the remedial excavations and reinstatement works; and
- Spills and leaks of hazardous materials.

23.1.2 Increased Volumes of Contaminated Material

Excavated, treated and reused materials will be managed on-site using the Materials Tracking System outlined in **Section 14.3** of this RAP. The quantities of materials excavated, screened and treated will be regularly compared to the estimated quantities.

Increased volumes of foreign materials in the form of steel reinforcement, scrap steel and pipework may have the potential to adversely impact on the project. Depending on the magnitude of the changes of anticipated volumes of excavated materials, and the extent of contamination within the Remediation Areas, changes to the depth of excavation and to the final reinstatement levels may be made during the project.

23.1.3 Variation of Contaminant Characteristics

The range of contaminants analysed in previous site investigations is considered to be appropriate for the characterisation of the Remediation Areas, and for development of risk-based Remediation Goals.

Should any significant changes to the nature or types of contaminants be identified during the works, a variation to the RAP and Remediation Goals may be required. Variations will be issued to the Contaminated Land Auditor for review and approval.

23.1.4 Management of Bonded Asbestos Containing Materials

In the event that BACM is encountered during the excavation works, the material will be collected and disposed of by a licensed Asbestos Removal Contractor (ARC) in accordance with the requirements of the NSW WorkCover the NSW Occupational Health & Safety Regulation Act (2001) and the requirements of the NSW Occupational Health and Safety Commission (NOHSC) Asbestos Code of Practice and Guidance Notes.

The BACM removal works would be undertaken as follows:

- The remediation contractor would establish appropriate barriers and signage around the area where BACM has been identified;
- The BACM will be suitably removed from the Site by an ARC;
- Airborne asbestos fibre monitoring will be undertaken around the working area during the works to confirm that the BACM is being removed in an appropriately controlled manner; and

- Validation soil samples will be collected from the soils adjacent to and surrounding the BACM removal area and analysed for asbestos. Should the soils beneath the BACM be impacted with asbestos fibres, the impacted soils will be excavated for off-site disposal.

The remediated area must not contain asbestos (bonded or otherwise) as determined by the following:

- No detection of asbestos in samples submitted for analysis; and
- A visual inspection of the remediated area to confirm the removal of all visible BACM fragments.

23.1.5 Flooding of the Site and Waste Water Management

The EMP for the remediation works was developed to control the impact of site works in order to minimise and mitigate against any impacts to off-site waters. The implementation and maintenance of a variety of environmental control measures will be undertaken during the project to manage water encountered during the works. Measures such as the installation of drains to divert clean water from upgradient areas to on-site stormwater drains, recycling of water, and the use of an on-site WTP will be implemented to manage and control water.

In extreme situations such as flooding , heavy rainfall, or if surface water reuse/sewer discharge options are unavailable for treated or untreated water, the Site's first flush system will be used for storage. This system (total capacity of 360 kilolitres [KL]) comprises the following:

- 2 x 60 KL stormwater pits located in the northern part of the Site; and
- 2 x 120 KL stormwater pits located in the southern part of the Site.

The above system is designed to receive the first 10 minutes of a 100 year rainfall event and is considered to be appropriate for temporary storage purposes.

The discharge of untreated water may be permitted to the sewer system in accordance with the conditions of the Trade Waste Licence.

Records of all discharges will be kept describing the estimated volume of water discharged, the time period over which the discharge occurred, and the water quality results of water samples collected during discharge.

23.1.6 Control of Dust

Should unacceptable levels of dust be detected during the project, an investigation will be conducted to determine the source of the dust, and evaluate the appropriate measures to be implemented.

These measures may include the following:

- Increased use of a water cart to suppress dust in open areas;
- Installation of temporary sheeting to cover localised exposed areas and stockpiles;
- Alteration of the works program to minimise the extent of disturbed open areas;
- Consolidation of material stockpiles;
- Use of chemical dust-suppressants provided the chemicals do not pose a contamination or OH&S hazard;
- Use of alternative coverings such as PVA spray, odour suppressant sprays/foams or hydromulch to stabilise the surface of open disturbed areas;
- Use of additional dust suppression features on items of dust generating plant and equipment; and
- Use of alternate work practices such as modified equipment to minimise dust generation.

23.1.7 Volatile Gases and Odours

Should unacceptable levels of volatile gases be detected at the Site boundaries or in the surrounding area during the project, an investigation will be conducted to determine the source of the emissions, and to evaluate the appropriate measures to be implemented.

These measures may include the following:

- Alteration in the works program to minimise in the extent of disturbed open areas;
- Prompt removal and treatment of heavily contaminated materials that have been exposed and are identified to have caused the emissions;
- Conducting the work in more favourable weather conditions;
- Use of alternate work practices to minimise the period of impact of the emissions;
- Use of additional features to control emissions from plant and equipment;

- Use of alternate work practices such as using modified equipment;
- Relocation of offending plant and equipment to less sensitive on-site areas;
- Reducing the number of plant and equipment items on-site;
- Use of odour suppressing methods (i.e. application of PVA, hydromulch or sprays/foams) to cover the surface and mitigate volatile emissions; and
- Use of a deodorant within water sprays at locations on-site and at Site boundaries provided the chemicals do not pose a contamination or OH&S hazard.

23.1.8 Noise and Vibration

Should unacceptable noise levels be detected during the project the following measures may be implemented:

- Modify the works program to minimise the impact of noisy or vibratory operations, including:
  - Modify the timing of the works to appropriate times of the day; and
  - Accelerate the works program to complete the works quickly and minimise the period of disturbance;
- Install additional noise suppression features on plant and equipment;
- Construct additional noise attenuation measures such as stockpile barriers, works area enclosures; and
- Use of different items of plant and equipment that generate less noise or vibration.

23.1.9 Spills and Leaks

A spill response plan will be developed and implemented as part of the ERP detailing the procedures for responding to spills and leaks. The procedures outlined in the plan will be aimed at minimising the impact of any contaminant releases that may occur during the works.

The following actions will be taken in preparation for spills or leaks:

- Training of site personnel in appropriate spill response techniques;
- Allocation of spill response materials and equipment on-site (such as oil absorbent pads, booms and biodispersants);
- Containment of all storage tanks and drums inside bunded areas with a capacity of 110% of the largest container, or 25% of the total volume of all containers, whichever is greater.
- Initial assessment of the spill;
- Notification of the appropriate authorities if necessary;
- Following a spill or leak, an investigation to determine the root cause of the incident will be undertaken; and
- Corrective and preventative actions implemented to prevent future incidents.

23.2 Emergency Response Plan

An ERP will be prepared prior to the commencement of the Site remediation works. The plan will outline the process for identifying possible emergency situations and detailing the procedures necessary to ensure the safety of both on-site and off-site personnel in the event of an emergency.

The plan should include the following general information:

- Assignment of responsibilities to nominated key personnel;
- Assessment of the potential on-site and off-site impacts of hazards;
- Emergency reporting procedures including on-site reporting and reporting to the appropriate authorities;
- Emergency response procedures including, but not limited to, the following:
  - On-site fires or explosions;
  - Chemical spills;
  - Rupture of buried services;
  - Hazardous gas releases and emissions;
  - Confined spaces situations;
  - Traffic accidents both involving the transportation of "Dangerous Goods";
  - First aid for injured personnel;

  - Evacuation of on-site personnel;
  - Managing unknown/uncertain situations; and
- Incident investigation procedures to determine the root cause of the incident, and to identify the appropriate corrective and preventative actions to prevent future incidents.

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25.0 Glossary of Terms

Abiotic

Not involving biological activity. A term used to describe chemical degradation processes.

Absorption

Chemical assimilation or incorporation of liquids in solids or gases in liquids.

Accuracy

Degree of agreement between a measured value and a true or expected value.

Adsorption

The attraction and adhesion of a layer of ions from an aqueous solution to the solid surface with which it is in contact.

Advection

The process by which solutes are transported by the motion of flowing groundwater.

AECOM

AECOM Australia Pty Limited.

Aerobic

Environment where oxygen is present.

AHD

Australian Height Datum - a standard reference point for the elevation of a location.

Anaerobic

Reducing environment or without oxygen.

ANZECC

The Australian and New Zealand Environment Conservation Council was a Ministerial Council that operated between 1991 and 2001 and provided a forum for member governments to develop coordinated policies about national and international environment and conservation issues.

ARMCANZ

Agriculture and Resource Management Council of Australia and New Zealand.

AQMP

Air Quality Monitoring Plan

Aqueous Phase

Contaminants dissolved in water.

Aquifer

An underground geological formation that contains water and is capable of yielding water to a well or spring; a water bearing formation.

Aquitard

A low-permeability stratigraphic layer that can store groundwater and transmit it slowly from one aquifer to another.

AS

Australian Standards.

ASFSO

Automatic soil feed shut off.

Attenuation

The reduction in mass or concentration of a compound in groundwater over time or distance due to naturally occurring physical, chemical, and biological processes, such as biodegradation, dispersion, dilution, adsorption, and volatilization.

BCD

Base Catalysed Decomposition.

Biodegradation

The breaking down of compounds by biological processes including micro-organism activity.

Biotic

Involving biological activity.

Bioremediation

Removal of in situ organic contamination by utilising naturally occurring or specifically engineered or introduced bacteria.

Biotransformation

Structural alteration of a chemical by an organism. In regard to organic compounds, it refers primarily to their decomposition by micro-organisms.

Bore/Borehole

An uncased well drill hole.

Bore Log

See - Geological Log.

BP

See Bundle Piezometer.

BTEX

BTEX is an acronym for benzene, toluene, ethyl benzene, and xylene.

Bundle Piezometer

A cluster of narrow diameter piezometers with very short screens at different depths in the same hole.

CCO

Chemical Control Order.

CFM

Trichloromethane (Chloroform).

CO

Carbon Monoxide.

CO_2

Carbon dioxide.

CoC

Contaminant of Concern.

CoPC

Contaminant of Potential Concern.

COD

Chemical Oxygen Demand.

CEM

continuous monitoring equipment.

CPRC

Community Participation and Review Committee.

CH_4

Methane.

CHC

Chlorinated Hydrocarbon.

Chemical Reduction

Degradation of chemicals in an oxygen deficient environment.

CLM Act

Contaminated Land Management Act (1997).

CMJA

C.M. Jewell & Associates Pty Limited.

DDX

The sum of DDE, DDD and DDT.

Dehalogenation

Selective removal of halogen (fluorine, chlorine, bromine and iodine) molecules.

Density

The mass or quantity of a substance per unit volume.

DEC

NSW Department of Environment and Conservation.

DECC

NSW Department of Environment and Climate Change.

DECCW

NSW Department of Environment, Climate Change and Water.

DGI

Data Gap Investigation (Phase 3 DGI, HLA 2007)

Diffusion

The process by which both ionic and molecular species dissolved in water move from areas of higher concentration to areas of lower concentrations.

Desorption

Reverse of Adsorption, (ion movement from solid phase to aqueous).

Dispersion

The phenomenon by which a solute in flowing groundwater is mixed with uncontaminated water and becomes reduced in concentration. Dispersion is caused by both differences in the velocity that the water travels at the pore level and differences in the rate at which it travels through different strata in the flow path.

Dissolution

The process of dissolving DNAPL into the aqueous phase.

Dissolved Phase

See Aqueous Phase.

Distribution Coefficient

The slope of a linear isotherm (Freundlich Isotherm). A numerical parameter used to quantify the ability of compounds in solution to be adsorbed onto the surface of solid particles e.g. soils, organic matter etc.

DMR

NSW Department of Mineral Resources.

DNAPL

Dense Non-Aqueous Phase Liquid - an organic chemical or mixture of organic chemicals that does not readily mix with water and is heavier than water.

DNAPL Source Zones

Zones where residual or free phase DNAPL is present.

DNR

NSW Department of Natural Resources.

DO

Dissolved oxygen.

Drawdown

A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping from wells.

DQO

The Data Quality Objective process is used to develop performance and acceptance criteria that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.

DQI

Data Quality Indicators are signs of data’s performance against agreed indicators. DQIs helps to measure the Precision, Accuracy, Representativeness, Comparability and Completeness of the obtained data.

EC – Electrical Conductivity

Electrical Conductivity – A measure of the conductance of water which is general an indication of the salinity – see TDS.

ECS

Emission Control System.

EDC

1,2-Dichloroethane (Ethylene Dichloride).

Eh

Redox potential.

EPA

NSW Environment Protection Authority.

ETP

Effluent Treatment Plant.

Equipotential

A line in a two-dimensional groundwater flow field such that the total hydraulic heads are equal for all points along the line.

f_{oc}

Fraction of organic carbon.

FSB

Feed Soil Building.

Field Duplicates

These are a set of two discrete samples collected from the one sampling point. The sample is prepared in the field by splitting a field sample, then submitting both to either the same laboratory (inter-laboratory duplicates) or a different laboratory (inter laboratory duplicate) as two independent samples, which are labelled as two discrete locations, the duplicate sample having no reference to the primary sample.

Flow Lines

Direction of groundwater flow.

Flow Net

A set of intersecting equipotential lines and flowlines representing two-dimensional steady state flow through a porous media.

Flow Path

The direction in which groundwater is moving.

Free Phase DNAPL

DNAPL saturation exceeding the capillary pressure of the soil.

GC/MS

Gas Chromatograph/Mass Spectrometer - Instruments for the measurement of concentrations of organic compounds in soil and water.

Geological Log

A record of the lithology or stratigraphy of the rock or soil encountered in a borehole.

GIS

Geographical Information System.

Gradient

The rate of inclination of a slope. The degree of deviation from the horizontal.

Groundwater

Water beneath ground surface.

HCB

Hexachlorobenzene.

HEPA

High Efficiency Particulate Air

HHERA

Human-Health and Environmental Risk Assessment.

HLA

HLA-Envirosciences Pty Limited.

Hydraulic Conductivity

A coefficient of proportionality describing the rate at which water can move through a permeable medium.

Hydraulic Gradient

The change in total head in an aquifer with the change in distance in a given direction.

Hydrocarbon

Organic chemicals such as benzene or tetrachloroethene that contain atoms of carbon and hydrogen.

Hydrostratigraphic Unit

A formation, part of a formation, or a group of formations in which there are similar hydrologic characteristics.

IHPT

2-imino-3-(2-hydroxy-2-phenylethyl)thiazolidine plant – intermediate product in the manufacture of tetramisole

Inorganic

A chemical substance that does not contain carbon.

In Situ Pore Fluids

Water occupying the volume between mineral grains in a porous medium.

ISZ

Impacted Soil Zone.

KL

kilolitre

Laboratory Control Sample

Samples prepared by the laboratory by spiking an aliquot of appropriate clean matrix reagent with known concentrations of specific analytes. The control sample is then analysed and the results are used to assess the laboratory performance on sample preparation and analysis procedure.

Laboratory Duplicate

These are prepared within the laboratory by dividing a field sample into two samples and analysing separately.

Lithology

The geological (physical) character of a rock or soil.

Matrix Spike/Matrix Spike Duplicate

Samples prepared by the laboratory in duplicate by individually spiking two aliquots of a field sample with known concentrations of specific target analytes. The matrix spike and matrix spike duplicate samples were then analysed and subsequently, the results used to assess the effects of the sample matrix on the accuracy and precision of analyses.

MCB

Monochlorobenzene (chlorobenzene).

MPDoRE

Maximum, practicable depth of remedial excavations.

Microgram (µg)

One thousandth part of a milligram (mg) one millionth part of a gram (g); one billionth part of a kilogram (kg).

Migration

The movement of materials (e.g. water, gas or contaminants in soil) from one location to another.

MODFLOW

A modular three-dimensional finite difference ground-water flow model.

Monitoring Well

A well installed to routinely observe groundwater levels or to systematically collect water samples and analyse these for chemical pollution.

Multilevel Piezometer

See - Bundle Piezometer.

NAPL

Non-Aqueous Phase Liquid - An organic chemical or mixture of organic chemicals that does not readily mix with water.

Organic Compound

A carbon containing compound.

OCPs

Organochlorine Pesticides.

PCE

Tetrachloroethene (Perchloroethene).

Peristaltic Pump

A pump that can be used for purging and sampling of monitoring wells and bundle piezometers.

Permeability

The property or capacity of a porous material to transmit a fluid.

Petroleum Hydrocarbon

A chemical compound that originally come from crude oil.

PID

Photoionisation Detector.

Piezometer

A well with a short slotted screen for measuring a potentiometric surface or elevation of the water table.

Plume

A mass of contaminated water extending outward from the source of the contamination.

Plume Axis

Inferred centre line of a dissolved phase groundwater contamination.

Porosity

The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.

Potentiometric Surface

An imaginary surface representing the total head of groundwater and defined by the level to which water will rise in a well.

Precision

The degree to which a measurement is reproducible.

PRGs

USEPA Region IX Preliminary Remediation Goals.

PoP

Proof of Performance

Pure Phase Solubility

Aqueous solubility of a single organic compound.

PVA

Polyvinyl acetate

QA/QC

Quality Assurance/Quality Control.

Recharge

Replenishment of an aquifer by a natural process such as addition of water at the ground surface, or by an artificial system such as addition through a well.

Recovery Test/ Recovery Trial

Hydraulic test performed on a monitoring well which measures the rate at which the water level rises in the well after pumping has ceased.

Residual Saturation

The term given to DNAPL that is trapped in a pore space by hydrostatic forces. Once the residual saturation has been exceeded it is then termed free phase DNAPL.

Retardation

A term used for the adsorption of contaminants in the aquifer that results in the plume front travelling more slowly than the rate of the groundwater flow.

RI

Remedial Investigation.

Rinsate Blank

Type of field blank used to check specifically for cross-contamination from reuse of the sampling equipment.

RBSWC

Risk-Based Site Wide Criteria.

RBGC

Risk-Based Groundwater Concentrations.

RO

Remediation Order – declared by the EPA.

Saturated Zone

An underground geologic formation in which the pore spaces or interstitial spaces in the formation are filled with water under pressure equal to or greater than atmospheric pressure.

Screen

Perforation in a well casing and usually located near the bottom of the well or at selected depths to tap perched aquifers.

Semi-volatile Compound

An organic compound which has a low potential to form a vapour at room temperature.

SGS

Soil Gas Survey.

STA

Soil Treatment Area.

Solubility Limits

Maximum concentration at which an organic contaminant will dissolve in the aqueous phase.

Sorption

See Absorption and Adsorption.

SMP

Site Management Plan.

Stratigraphy

The study of rock and soil strata, especially their distribution, deposition and age.

Surrogate Compound

A compound that is introduced into a sample at a known concentration and is used as a system monitoring compound to assess the performance of individual organic analyses.

Surrogate Spike

System monitoring compounds used to assess the performance of the individual analyses. Compounds are spiked into all sample aliquots then undergo normal extraction and analysis procedures. Percent recoveries are calculated for each surrogate, providing an indication of the analytical accuracy.

TCE

Trichloroethene.

TDS

Total Dissolved Solids - A basic measure of water quality (salinity), which refers to the amount of solids that remain when a water sample is evaporated to dryness.

TMR

Telescopic mesh refinement.

TNT

Trinitrotoluene.

Trip Blank

Type of field blank used to check if samples have been cross-contaminated with volatile contaminants during handling and transit between the field and laboratory. A trip spike typically comprises a sample of deionised water supplied by the laboratory in a laboratory sample bottle.

TOC

Total Organic Carbon.

Topography

The relief and contour of the land surface.

TPH

Total Petroleum Hydrocarbons.

Transmissivity

The transmission rate of water (based on a unit width of an aquifer) relative to a hydraulic gradient.

TWL

Trade Waste Line.

Unconfined Aquifer

An aquifer whose upper level can extend to ground surface.

Unsaturated Zone

The area between ground surface and the underground water table. Interstitial spaces in this zone contain moisture (water) and air.

USEPA

United States Environmental Protection Agency.

VC

Vinyl Chloride (Chloroethene).

VHC

Volatile Halogenated Compound.

VOC Scan

Volatile Organic Compound analytical scan.

Volatile Compound

Chemical with sufficiently low vapour pressure to become a gas at room temperature.

Water Table

The top of the saturated zone where unconfined groundwater is under atmospheric pressure.

Well Log

A record of installation of a well. It includes construction specifications of the well, depth, owner, location and a description of the soil profile. It is prepared by the driller, geologist or other appropriately qualified personnel.