MIDLAND REDEVELOPMENT AUTHORITY

HELENA EAST PRECINCT REMEDIATION AND REDEVELOPMENT: PUBLIC ENVIRONMENTAL REVIEW

VOLUME I

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MARCH 2006

REPORT NO: 2005/142

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Checked by: Signed:

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Approved by: Signed:

Name: Dr Greg Milner Date: 28 March 2006

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INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

The Midland Redevelopment Authority (MRA) proposes to remediate and rehabilitate 17ha of the former Midland Railway Workshops site to make it suitable for the development of a mix of Heritage, residential and commercial uses. In accordance with the Environmental Protection Act, a Public Environmental Review (PER) has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of 4 weeks from 10 April 2006 closing on 8 May 2006.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA’s report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the PER:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the PER;
- if you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering; and
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is:

Submissions should be addressed to:

The Environmental Protection Authority
Westralia Square
141 St George's Terrace
PERTH WA 6000
Attention: Ms I-Lyn Loo, Project Officer

EXECUTIVE SUMMARY

Introduction

The former West Australian Government Railways (WAGR) operated the Midland Railway Workshops from 1904 until its closure in 1994. The workshops were used for the manufacture and maintenance of locomotives and rolling stock and employed several thousand people at any one time in a heavy industrial setting. The workshops, as a consequence, provided significant momentum to the State's development and in particular the social and economic growth of the Midland area.

Following consultation between the community, City of Swan and West Australian Planning Commission the Midland Redevelopment Authority (MRA) was formed in January 2000. Recognised as the single biggest potential development opportunity in the area, a primary aim of the MRA is to redevelop the workshops site in a manner that revitalises the local economy and consequently attracts more capital investment into the broader Midland area.

As a result of past industrial and waste-disposal practices, the soil and groundwater at the workshops site has been contaminated. Since its inception in 2000 the MRA has overseen the progressive remediation and redevelopment of much of the former workshops site. In essence, the MRA is fulfilling the Government's responsibility to the community of Western Australia to return the site to a state suitable for productive use, as well as facilitating the revitalization of the district.

The Proposal and Approvals

The final major area to be remediated and redeveloped is the portion of the site known as the Helena East Precinct. The precinct is located centrally and is the oldest part of the workshops area where the majority of the maintenance and manufacturing activities were undertaken.

Approximately 100 years of industrial use have created large volumes of contaminated material which has been disposed of across the site and down the embankment (Southern Embankment) at the southern end of the site adjacent to the Helena River floodplain. The MRA proposes to undertake remedial works at Helena East and the Southern Embankment (the site) so soil and groundwater contamination issues are ameliorated to allow site redevelopment in accordance with the preferred uses described under the Midland Redevelopment Scheme (residential, commercial, and community uses) and *Midlandmetro Concept Plan 2010*.

As part of the remedial works it is planned that lightly contaminated soils be moved to a proposed Containment Cell located on contaminated land at the western edge of the Midland Saleyards site which is currently operated by the Meat Industry Association (MIA). A Cabinet decision has indicated that the land will be made available to the MRA as soon as practicable; it is anticipated that this will be by late 2006.

The proposed redevelopment of the Helena East land was referred to the Environmental Protection Authority (EPA) in April 2004. In May 2004 the EPA determined that the project was sufficiently complex to warrant formal assessment under the provisions of the Environmental Protection Act, 1986 and subsequently set the level of assessment for the project as a Public Environmental Review (PER). This level of assessment is typically applied to proposals of significance that raise environmental factors which are considered complex and require in depth examination to assess whether approval should be granted, and if approved how potential environmental impacts will be managed.

An environmental scoping document was submitted by the MRA in early May 2005. The EPA accepted the document in late May 2005.

Geology and Hydrogeology

On the basis of on-site investigations, the strata underlying the site in the upper approximately 30m are described as the following units: Inert Fill, Waste Fill, Upper Clays and Lower Sands. The Inert Fill and Waste Fill units comprise manmade fill overlying with increasing depth the clays and uppermost portion of the Lower Sands of the Guildford Formation and the sand-rich Henley Sandstone Member of the Osborne Formation (lower portion of the Lower Sands). Black shale of the Pinjar Member of the Leederville Formation underlies the Lower Sands which are located as being approximately 40m below ground level (BGL).

The Inert Fill includes all bitumen hardstand and underlying gravel and crushed limestone sub-base. The Waste Fill comprises large amounts of cinder, ash, foundry sand, building rubble, scrap metal and other general waste that varies in thickness from approximately 0.5m to 1m across Helena East Precinct to up to 9m thickness in the Southern Embankment. The Upper Clays comprise irregular clay-rich horizons intercalated with discontinuous sandy clay and clayey sand horizons. The Lower Sands comprise unconsolidated quartz sands with varying amounts of silt.

Groundwater at Helena East has been subject to detailed hydrogeological investigations and review. These investigations indicate that there are two main groundwater systems at the site, comprising a complex, low-permeability shallow flow system perched in the Upper Clays (Shallow Superficial Aquifer, SSA) and a deeper aquifer in the Lower Sands (Lower Superficial Aquifer, LSA), which is in direct hydraulic continuity with the Henley Sandstone and essentially forms a single hydrogeological unit. The Henley Sandstone is underlain at depth by shale of the Pinjar Member of the Leederville formation, which forms an aquiclude capping the extensive regional aquifer system in the Leederville Formation. The Leederville Aquifer is understood to be confined under pressure by the Pinjar Shale.

In the Shallow Superficial Aquifer groundwater migrates slowly through the clay-rich intervals, with occasional coarser sandy horizons providing preferential flow pathways. The sandier horizons do not form a continual unit within the Upper Clays, but are a weakly interconnected system across the majority of the site with flows moving generally to the southwest. The extensive hardstand across much of Helena East, combined with the low permeability of the Upper Clays has reduced the infiltration of rainwater for recharge. The depth to groundwater in the SSA ranges between approximately 1.5–6.5mBGL, being deeper towards the Southern Embankment.

The Lower Superficial Aquifer forms a relatively extensive aquifer beneath the site and is apparently partially confined by the Upper Clays. Groundwater flows towards the west-northwest, parallel to the Helena River. The depth to groundwater in the LSA ranges between approximately 9–10.5mBGL, deeper towards the western edge of the site.

Site Contamination

Investigations at the site indicate that contamination can be assigned to one of the following three categories:

- Waste Fill deposits from historical dumping at the site (generally comprising bulk soil, metal fragments, ash and clinker, slag, asbestos, and other debris) which is contaminated and/or geotechnically unsuitable;
- Natural soil affected by contamination migrating from overlying sources (e.g. hydrocarbons); and
- Groundwater impacted via migration of contaminants through overlying fill and/or natural soil.

Soil

The Waste Fill material encompasses the Southern Embankment with shallow deposits found across extensive areas of Helena East. It is often contaminated by a variety of heavy metals (mostly copper and zinc with lesser amounts of antimony, chromium, lead and tin) and contains some areas of asbestos contamination. The Waste Fill in the Southern Embankment is thicker and tends to have a greater proportion of concrete and other rubble. Overall, contamination associated with the Waste Fill comprises the bulk of soil contamination, with an estimated *in situ* volume of possibly up to 100,000m^3 in the Helena East and Southern Embankment areas.

Data show that natural soil beneath the Waste Fill is not contaminated with heavy metals, indicating negligible impact by the overlying material. Cyanide has been detected in soil at three locations near a former waste-water treatment facility. At some locations Waste Fill and underlying natural soil have been impacted by hydrocarbon-based compounds [primarily total petroleum hydrocarbons (TPHs); lesser polycyclic aromatic hydrocarbons (PAHs); rarely solvents including toluene, ethylbenzene, and xylenes, and volatile organic compounds (VOCs) such as trichloroethene and tetrachloroethene] which have migrated downward through soil from spills or leaks of stored hydrocarbon material. Soil affected by TPHs (including minor amounts of PAHs and solvents) is relatively extensive at Helena East and the Southern Embankment, with an estimated *in situ* volume of 30,000m^3 (including approximately 5,000m^3 which overlaps with Waste Fill in the Southern Embankment).

Groundwater

Four broad types of groundwater impact have been identified in the Shallow Superficial Aquifer (SSA) and Lower Superficial Aquifer (LSA):

- slight elevations of metals (particularly zinc and copper) in the SSA across much of the site that may be a regional phenomenon;
- localised acute nickel impacts on the SSA associated with the former Plating Shop;
- localised acute hydrocarbon impacts in the SSA associated with diesel and solvent spills, mainly in the vicinity of the Power House and south of the Tarpaulin Shop.
- localized solvent impacts in the LSA by dense non-aqueous phase liquids (DNAPLs, including trichloroethene and tetrachloroethene) which have migrated into the LSA through overlying soil as a result of their higher density and chemical characteristics.

Although groundwater entering the site contains slightly elevated concentrations of copper and zinc, it is considered that Waste Fill distributed across the site may also be contributing to metal concentrations in groundwater, particularly in the SSA system. These impacts are negligible relative to drinking water standards, but exceed guidelines for fresh waters. Despite this, the risk to the Helena River is considered minimal as the SSA is in poor connection with the LSA, and neither aquifer is considered to be in connection with the river system.

Only nickel concentrations locally exceed drinking water levels. The highest concentrations are associated with the Plating Shop, which is considered to have been the source of the nickel contamination.

Hydrocarbon impacts on groundwater are associated with the two areas with extensive soil hydrocarbon contamination: in the vicinity of the Power House and south of the Tarpaulin Shop. In the area south of the Power House, acute TPH, PAH, xylene and DNAPL impacts are very localized; low-level DNAPL solvent impacts have been detected in both the SSA and LSA in this area. South of the Tarpaulin Shop, TPH and PAH are the primary contaminants detected, with only very local solvent impacts.

Heritage

The Midland Redevelopment Act 1999 specifically commits the MRA to the conservation of the workshops, particularly its heritage and labour history. The site of the former Midland Railway Workshops is included on the Heritage Council of Western Australia's Register of Heritage Places, the Australian Heritage Commission's Register of the National Estate and the City of Swan's Municipal Heritage Inventory. It is also classified by the National Trust of Australia (WA). As a consequence the site has statutory protection through the provisions of the *Heritage of Western Australia Act 1990* which requires that all development be referred to the

Heritage Council of WA for comment. To this end a Heritage Strategy has been developed and adopted by the MRA.

The Helena East Precinct encompasses many of the oldest and most significant buildings of the former workshops which have essentially remained unchanged since their construction. As a result the remediation and redevelopment works must be sensitive to heritage requirements and therefore associated engineering constraints. The proposed remediation strategy has been developed to ensure there is no damage any Heritage-listed structures.

Remediation Strategy

The remediation strategy adopted by the MRA has the following objectives:

- Ensure that the environmental values of the site and the surrounding environment are protected and enhanced during and after the remediation process;
- Achieve a remediated site where those areas that will be subject to intensive use are relatively unconstrained by the presence of residual contamination so that future land occupiers can enjoy the use of the land without being subject to restrictive memorials;
- Maintain and enhance the heritage values of the site as far as is possible; and
- Based on an assessment of environmental and human risks associated with contamination on the site, develop a remediation strategy that does not impose undue costs on the community of Western Australia while achieving the Authority's remediation objectives.

To achieve this, the site will be remediated by excavating the majority of contaminated soil known to be present. The excavated soil will either be:

- directed to an on-site containment facility to be constructed on land to be vested with the MRA;
- subject to treatment and re-use; or
- directed for off-site disposal or treatment.

Limited areas of contamination will be left on-site beneath and immediately adjacent to Heritage buildings and in the area of the Southern Embankment and an ongoing ground and surface water monitoring program will be undertaken for several years following completion of the remediation to verify its success.

Benefits of the Proposal

Implementation of this proposal will provide the MRA with the necessary foundation upon which the vision of the Midland metro Concept Plan 2010 can be built. One hundred years of heavy industrial use has resulted in the site containing considerable volumes of contaminated soil and caused impacts to groundwater. The contamination has the potential to affect the environment and impose considerable restrictions on the MRA in its development of options to revitalise the land for productive and sustainable reuse in the community.

At the conclusion of the remediation works the site will be largely unconstrained by the contamination that is currently present as a result of its historical use and the risk of contamination migrating from the site into the surrounding environment will be largely eliminated.

Project Timing

MRA anticipates that remedial works will commence remediation of the site in the second quarter of 2006. The works will take approximately six to eight months to complete. Staging of the works may be required in order to minimize potential negative effects caused by seasonal weather conditions.

Management Commitments

MRA is committed to ensuring that the site remediation works and subsequent redevelopment will be undertaken in a manner that minimises impacts on the surrounding environmental and social receptors. Accordingly, MRA has proposed a number of management commitments. These management commitments are summarised in Table ES1.

TABLE ES1
HELENA EAST REMEDIATION AND REDEVELOPMENT ENVIRONMENTAL MANAGEMENT COMMITMENTS

ITEM NO.	PER SECTION NO.	TOPIC	ACTIONS	OBJECTIVE/S	TIMING	ADVICE
1	3.4.6	Groundwater	Implement a DNAPL investigation program to assess the extent of contamination impacts on the Lower Superficial Aquifer.	To assess the extent of contamination impact by solvents on the Lower Superficial Aquifer and based on the results of the investigation prepare a management plan for any impacts to the satisfaction of the DoE.	The DNAPL Investigation Program, including any reporting, will be completed prior to the issuing of titles.	DoE
2	6.4.5	DNAPL management	Develop and implement a DNAPL management strategy (if required, depending on the outcome of DNAPL investigation)	To monitor and manage DNAPL that is present in the Lower Superficial Aquifer.	Following the completion of the DNAPL investigation (if required). Prior to the issuing of titles on affected lots..	DoE
3	7.1	Air Emissions	Implement an approved Dust and Air Quality Management Plan, addressing dust management practices.	To ensure that there is no health risk or loss of amenity due air emission, to the environment.	Draft Plan is included in PER. Implementation to be during remediation	DoE, MRA
4	7.2	Noise & Vibration	Implement an approved Noise and Vibration Management Plan addressing the prevention of excessive and nuisance noise and prevention of damage to buildings due to vibration (require contractor to perform dilapidation survey).	To prevent noise and vibration during remediation activities exceeding regulatory standards.	Draft Plan is included in PER. Implementation to be prior and during remediation.	DoE, MRA
5	7.3	Surface and Groundwater (during remediation)	Implement an approved Surface and Groundwater Management Plan.	To prevent any potentially contaminated surface water from remedial activities from impacting on the beneficial use of groundwater beneath the site.	Plan is included in PER. Implementation to be during remediation	DoE

ITEM NO.	PER SECTION NO.	TOPIC	ACTIONS	OBJECTIVE/S	TIMING	ADVICE
6	10.1.3	Groundwater and Helena River Management and Contingency Plan (post - remediation)	Prepare a Groundwater and Helena River Management and Contingency Plan (post-remediation).	To assess the impact of the remediation on groundwater and River quality over time.	Concurrent with PER process and remediation. Implementation post-remediation	DoE
7	7.4	Waste Management	Implement an approved Waste Management Plan that addresses the appropriate management measures for the excavation and removal of waste from the site.	To ensure that waste material removed/excavated from the site is appropriately managed.	Plan is included in PER. Implementation to be during remediation.	DoE
8	Appendix 12	Remediation and Validation	Prepare Remediation and Validation Plan.	Document methods of remediation. Document that remediation is undertaken such that the site is suitable for the proposed uses.	Preparation prior to remediation commencement. Implementation during and post remediation.	DoE
9	2.5.5 and Appendix 12	Stormwater/ Drainage (post-remediation)	Implement the approved Stormwater/ Drainage Management (Egis, 2002)	To control the water onsite and prevent water being discharged directly to the Helena River	Post-remediation. Stormwater Management Strategy prepared by Egis (2002) has previously been approved by DoE	n/a
10	8.3 and Appendix 12	Traffic Management	Selected Contractor to prepare a Traffic Management Plan to provide appropriate management measures for the transport of bulk soils or contaminated materials off-site, or clean fill on-site to control any potentially associated traffic operation and road safety problems.	Minimise the effects of remediation related road traffic in adjoining areas.	Prepare Plan prior to remediation. Implementation during remediation	MRA, City of Swan.

ITEM NO.	PER SECTION NO.	TOPIC	ACTIONS	OBJECTIVE/S	TIMING	ADVICE
11	7.5 and Appendix 12	Community Consultation	Continue to consult with stakeholders and keep the community informed on the progress of the remediation project as outlined in the Community Consultation Plan.	To inform, seek feedback and address community and stakeholder concerns about the project.	Draft Plan is included in PER. Implementation prior to, during and post-remediation.	Environ-mental Reference Group
12	6.3.4	On-site soil treatment	Develop and implement a Management Plan for on-site treatment processes (if appropriate, depending on management strategy feasibility).	To ensure that there is no health risk or loss of amenity due to the use of any on-site treatment process	Prior to the commencement of remedial works (if appropriate)	DoE
13	10.1	Long Term Management for remaining contaminated soil and groundwater	Prepare a procedure for annotation of titles where contaminated soil and groundwater remain, and to place a ban on abstracting groundwater from the Superficial Aquifer.	To inform future landowner of the historical landuse and contamination status, and to prevent contaminated groundwater from abstracted and utilised.	Post Remediation	DoE
14	6.2.1	Long Term Management Southern Embankment	Prepare Irrigation Management Plan (if required, depending on subdivision plan final use).	To prevent excessive leaching of water and thereby potentially contaminants through remaining waste fill.	Prepare Plan during remediation. Implementation post remediation (if required)	DoE
15	6.2.1	Long Term Management of Waste Material remaining onsite	Prepare a Subsurface Management Plan.	To ensure the waste material remains intact and does not inadvertently come in contact with members of the public	Post Remediation	DoE

<u>Abbreviations</u>
MRA: Midland Redevelopment Authority
DoE: Department of Environment
DIA: Department of Indigenous Affairs

1. INTRODUCTION

1.1 Background

South of Midland town centre, adjacent to the rail lines, is an area where numerous buildings and workshops associated with the railway are located. Many buildings have been demolished, although some have been preserved. The area where railway workshops have been located over time, generally known as the Midland Railway Workshops area, is approximately 70ha.

The West Australian Government Railways (WAGR) operated the Midland Railway Workshops from 1904 until its closure in 1994. During this period large numbers of personnel were employed onsite and as a consequence the workshops were a significant social hub and economic driver for the Midland area. After the closure of the Workshops the Midland town centre and its surrounds began to decline due to limited capital investment in the area.

In 1997, the City of Swan and the West Australian Planning Commission (WAPC) worked with a design team and local residents to consider the issues facing Midland and the opportunities for the redevelopment of the area. In the resulting redevelopment plan, the Midland Railway Workshops area was identified as the largest single potential development opportunity for the area, and a key site because of its close proximity to the Midland town centre and train station.

In January 2000, the Midland Redevelopment Authority (MRA) was formed according to the Midland Redevelopment Act (1999) to undertake and manage the redevelopment of land south and northwest of the city centre (Figure 1), including the former Midland Railway Workshops area. The former Workshops area was divided into several precincts, comprising Helena East, Helena West, Areas B, C, & D, Area E, and MIA. The MRA area and relative locations of the precincts are shown on Figure 2.

Since its formation, the MRA has overseen the remediation, restoration and redevelopment of approximately 75% of the former Workshops area. Work commenced in 2001 with the eastern and north eastern portions of the Workshop area (Area A, Area B, C and D and Area E). These areas have been remediated in consultation with the Environmental Protection Authority (EPA) and redeveloped to provide commercial land. The remediated areas also encompass the site of a major communications facility (CADCOM) used by the WA Police Services (WAPS).

More recently (2003–2005), land at the western end of the Workshops area (Helena West Precinct) was remediated to a standard which made it suitable for residential purposes. Subdivisional works have now largely been completed in the Helena West Precinct and land is progressively being sold for residential development.

These projects have contributed to a progressive revitalisation of the Midland area and its surrounds, attracting additional capital investment in the form of commercial and residential development and are creating employment opportunities for Midland.

1.2 Proposal Overview

The last major precinct to be remediated and restored is Helena East and the Southern Embankment, which is located centrally in the Midland Railway Workshops area (see Figure 2). Helena East is the oldest area of the Workshops and historically where the majority of maintenance and manufacturing activities were undertaken. This area also has a large number of Heritage-listed buildings, which the MRA will restore to provide a strong link to the historical use of the site.

Approximately 100 years of intensive industrial activity at Helena East and the Southern Embankment has resulted in soil and groundwater contamination. The MRA is committed to remediating this contamination to a level which will not only be consistent with the proposed land use but will also prevent unacceptable impacts on the surrounding environment. Helena East and the Southern Embankment are the last major projects within the Midland Railway Workshops area and its redevelopment is considered to be a cornerstone to the success of the overall redevelopment project.

This PER describes the contamination status of Helena East and Southern Embankment and the proposed remediation strategy to allow development of the site in accordance with the *Midlandmetro Concept Plan 2010* (MRA, 2005). It is proposed to use post-remediation management measures including an ongoing monitoring program as well as caveats or memorials on titles to prevent the use of shallow groundwater in the future.

The remediation of Helena East and the Southern Embankment also includes a small parcel of land that is part of the Midland Saleyards which is currently owned and operated by the WA Meat Industry Authority (MIA) (see Figure 2). This land was part of the Workshops until the early 1990s and it is proposed that this land is used as a repository for contaminated material removed from Helena East and the Southern Embankment. The MRA has a Cabinet Decision (Appendix 1) indicating that the MIA land will be made available to the MRA as soon as it is practicable. It is anticipated that the saleyards site will be vacant by late 2006 (see Section 2.1.2 for more detail).

This project is part of a larger MRA program to remediate the impacts of historic activities on the former Midland Railway Workshops and reflects the government's commitment to fulfilling its corporate responsibilities and to making the Workshops suitable for future use.

Key characteristics of the proposal are presented in Table 1 below.

TABLE 1
KEY CHARACTERISTICS OF THE HELENA EAST PROPOSAL

Characteristic	Description
Site area	17ha
Location	The development site is identified as Lot 9006, DP 44198 (as at 15/12/05). The site occupies an area of approximately 17ha and is located in the central Helena Precinct of the former Midland Railway Workshops. The Southern Embankment area covers approximately 0.8ha. The proposal includes approximately 2ha of the saleyards site on the eastern boundary with the Workshops (MIA saleyards) defined as Lot 14241 on Plan

Characteristic	Description
	27672, Reserve 42712 (as at 15/12/05).
Current zoning	Commercial/Residential
Proposed end land use	The Midland Redevelopment Scheme designates the preferred uses for this precinct as residential, commercial and community uses.
Duration of the project	6 to 8 months from approval depending on site conditions
Projected Project Cost	Estimated maximum over $10 Million
Workforce Involved	Up to approximately 50 people, but will vary at any one time.
Traffic	Estimated to be up to 30 vehicles per day. Contractor to develop a Traffic Management Plan to meet MRA, local government and safety requirements.
Operational hours	Generally, 7am to 6pm, 6 days per week
Nature of contaminants	Soil and groundwater contaminated with metals and hydrocarbons (including chlorinated solvents) with lesser amounts of polycyclic aromatic hydrocarbons (PAHs), asbestos and cyanide
Protection of Fauna and Flora	Majority of site has been cleared with vegetation onsite restricted to occasional exotic trees and weeds. Southern embankment area and adjacent Helena River floodplain contains heavily disturbed and weed infested native vegetation.
Soil Remediation Strategy	Excavate the majority of contaminated soil and either: • relocate to onsite (MIA) containment bund; • subject to treatment and reuse; or • direct off-site for disposal or treatment. The presence of Heritage buildings onsite dictates that some contaminated soil will remain *in situ* beneath these buildings. The areas of relatively high level contamination will be removed from the Southern Embankment leaving behind the low level contaminated fill.
Environment and Health Criteria in Soil	As per DoE (2003): EILs: screening criteria; HILs: various as per proposed land uses (i.e. HIL-A, HIL-E, HIL-F); Other: USEPA SSLs for VOCs without EIL or HIL.
Groundwater Remediation Strategy	Following source (contaminated soil) removal, monitor groundwater to assess groundwater quality in the onsite discontinuous Shallow Superficial Aquifer (SSA) and Lower Superficial Aquifer (LSA), which have no beneficial uses.
Environment and Health Criteria in Groundwater	For screening purpose as per DoE (2003) assessment levels for: • Fresh Water; • Drinking Water; and • associated guidelines (e.g. ANZECC, 2000). Due to the discontinuous nature of the SSA, there is no beneficial use for the groundwater. Due to the poor quality of groundwater in the LSA, there is also no beneficial use. Groundwater quality will be monitored following source removal.
Dust Management	Preventative measures to be undertaken in

Characteristic	Description
	accordance with an approved Dust and Air Quality Management Plan
Remaining risk after remediation	Negligible for the receiving environment and for compatible future land uses at the site

1.3 Proposal Location

The Helena East Precinct is situated south of the Midland town centre bounded by rail lines to the north and Helena River floodplain to the south. The site is also bordered by the Helena West and Helena Street Extension Precincts to the west and Centennial Place and the Western Australian Police Service to the east. Figure 3 is a site layout plan showing the location of the main buildings and other infrastructure within the Helena East Precinct, as well as site topography.

In addition to the principal area of the Helena East Precinct ("Helena East"), two additional areas are included within this proposal. These two additional areas are described below:

- "Southern Embankment" - A parcel of land that abuts the southern edge of the Helena East Precinct and the northern edge of the Helena River Floodplain. It was an area historically where large volumes of waste materials produced by the workshops were buried as landfill. This area was originally identified in the environmental approval for the Helena West Precinct (Ministerial Statement No. 640; EPA, 2003) redevelopment as containing contaminated materials requiring remediation. It is intended however, that implementation of these works is undertaken in compliance with Ministerial Statement 640 as part of this project. The southern boundary of this area approximately follows the 7mAHD topographic contour. This area of land is referred to in this PER as the "Southern Embankment".

- "MIA Containment Area" - Although not part of the site for the purposes of this PER, a small parcel of land located on the western boundary of the Midland Saleyards will also be discussed. The site is owned by the WA Meat Industry Association (MIA). This area of land will be referred to in this PER as the "MIA Containment Area". It is discussed in the context of its suitability to accept waste generated during the remediation of Helena East and the Southern Embankment.

Together these areas comprise the subject of this PER. Helena East and the Southern Embankment form the area of investigation for the purposes of this PER. The MIA area is considered in terms of its suitability to accept waste material from Helena East and Southern Embankment. These parcels of land are shown on Figure 2.

1.4 Timeframe

MRA anticipates that remediation of the site will commence in the second quarter of 2006 following the relevant approvals being obtained and will take approximately six to eight months to complete.

Staging of the remediation/disposal may be required due to seasonal weather limitations (dust, wet, muddy conditions).

1.5 The Proponent

The proponent is:

Midland Redevelopment Authority (ABN 63 790 110 828)
Cnr Helena Street & Yelverton Drive
Midland WA 6056
PO Box 1335, Midland WA 6936
Ph: (08)9374 5500
Fax: (08) 9250 2437

1.6 Purpose and Scope of this Document

In order to achieve its redevelopment goals, as set out in the Concept Plan Report 2010 (MRA 2005), the MRA has prepared this PER document with the purpose of presenting information to the community about the proposed remediation and redevelopment of Helena East and the Southern Embankment.

The primary goals of the PER are to present the following information:

- The environmental and social aspects of the site at present and after its redevelopment.
- A summary of identified soil and groundwater contamination.
- The preferred remedial approach for the management of soil and groundwater contamination at the site and its rationale.
- The management of the environmental aspects associated with the implementation of the preferred remedial approach.
- The community consultation process in relation to the proposal.

1.6.1 PER Structure

This document aims to identify and assess the environmental effects of the proposal and to describe the management strategies the proponent (MRA) will adopt to manage and minimise any adverse environmental impacts. It outlines and discusses the following information:

- Section 1: Introduction to the proposal, overview of environmental approval process and purpose of the PER;
- Section 2: Background, including land tenure, historical site uses and the current environmental and social setting of the project;

- Section 3: Review of previous site investigations and the current extent of contamination;
- Section 4: Rationale for site remediation and the risk(s) associated with proposed remaining contamination;
- Section 5: Discussion of proposed options for remediation;
- Section 6: Discussion of preferred remediation approach;
- Section 7: Proposed management of potential environmental impacts associated with remediation;
- Section 8: Proposed management of potential social impacts associated with remediation;
- Section 9: Outline of communication plan for proposal;
- Section 10: Outline of post-remediation management measures; and
- Section 11: Summary of proponent's environmental management commitments.

1.7 Legislative Framework and Environmental Approvals Process

In April 2004, the MRA referred the proposal to remediate and redevelop a 17ha portion of the former Midland Railway Workshops area, identified as the Helena East Precinct, to the Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986* (as amended).

In May 2004, the EPA determined that the proposal was sufficiently complex to warrant formal assessment under the provisions of the *Environmental Protection Act 1986* and subsequently set the level of assessment for the proposal at PER. This level of assessment is typically applied to proposals of local or regional significance that raise a number of environmental factors, some of which are considered complex and require detailed assessment to determine whether approval should be granted, and furthermore how potential environmental impacts would be managed.

For proposals where the level of assessment has been set as a PER, the proponent is required to prepare an Environmental Referral and Scoping document. This document is required to include a summary description of the proposal, a preliminary impact assessment and a scope of works setting out the proposed environmental and other surveys/investigations to be carried out as part of the environmental impact assessment for the preparation of the PER. MRA submitted the Environmental Referral and Scoping document in early May 2005 (ENV, 2005), and on 25 May 2005 the EPA accepted the document and specifically, the proposed scope of works.

A PER is a public document and this proposal is subject to a four-week public review period. During that time the public, stakeholders and other interested groups are invited to make submissions to the EPA. These submissions are examined by the EPA, which identifies the key issues that are to be responded to by the proponent. Following this process the EPA will then submit its report and recommendation to the Minister for the Environment on the environmental acceptability of the proposal along with any environmental conditions, which should apply if the proposal is to proceed.

The EPA report for this project will be published in the form of an EPA bulletin. The public may appeal to the Minister against the recommendations or content of the bulletin. The Minister for the Environment will assess any appeals received and ultimately determine whether or not the proposal can proceed. If the Minister determines that the proposal can proceed, legally binding conditions, dictating the environmental requirements within which the proponent will have to comply, will be set pursuant to Section 45 of the *Environmental Protection Act 1986.*

In addition to gaining environmental approval from the Minister for the Environment, the proponent is required to comply with other legislation. A summary of the key relevant legislation, regulations or local laws are listed in Table 2 (all of which are Western Australian state laws, except where otherwise noted).

TABLE 2
KEY LEGISLATION AND LAWS

Aboriginal Heritage Act 1980
Australian Heritage Commission Act 1975
City of Swan various local laws (Local Government)
City of Swan Town Planning Scheme No. 9
Conservation and Land Management Act 1984
Environmental Protection Act 1986 (as amended) and Regulations
Environmental Protection (Noise) Regulations 1997
Environmental Protection (Controlled Waste) Regulations 2004
Explosives and Dangerous Goods Act 1961 (this act will soon be repealed and replaced by the *Dangerous Goods Safety Act 2004 (*and Regulations) which is due to be proclaimed in mid 2006;
Health Act 1911
Midland Redevelopment Act 1999
Occupational, Safety and Health Act 1984
Occupational Safety and Health Regulations 1996
Rights in Water and Irrigation Act 1914
Town Planning and Development Act 1959
Western Australian Planning Commission Act 1985

1.8 Management Commitments

MRA is committed to ensuring that the remediation of the site will be undertaken in a manner to minimise impacts on the surrounding biophysical and social environments. Accordingly, MRA has proposed numerous management commitments. These management commitments are carried out to meet EPA objectives for the identified Environmental Factors, which were initially outlined in the Environmental Scoping Document and summarised in Section 11.

2. THE SITE

The site in the context of this proposal can be defined as the Helena East Precinct and the Southern Embankment area. The tenure, historical, physical, ecological and social aspects of these land parcels are described in this section.

Tenure information about the MIA Containment Area is also presented in Section 2.1, as it is proposed to use this area to dispose of material excavated from Helena East and the Southern Embankment. Additional background and historical information about the MIA containment area is presented in Appendix 2.

2.1 Land Tenure and Proposed Land Use

2.1.1 Helena East and the Southern Embankment

Helena East and the Southern Embankment are situated within the Helena Precinct under the Midland Redevelopment Scheme (gazetted 8 Feb 2005).

The MRA proposes that the Helena East and Southern Embankment areas be developed for a number of land uses including:

- Residential (low to medium density)
- Commercial;
- Education;
- Mixed Use (Commercial/Residential);
- Community Uses (e.g. Public Open Space, Museum).

The Heritage status of buildings and areas within Helena East is an integral part of land use planning. The proposed site layout and associated land use following redevelopment are shown on Figure 4.

2.1.2 MIA Containment Area

The WA Meat Industry Authority (MIA) saleyards site is located east of Lloyd Street and south of Clayton Street as shown on Figure 2. The westernmost portion of the MIA site has been used in the past as a waste (including asbestos) disposal area. It is accordingly proposed that waste material from Helena East and the Southern Embankment is disposed in the MIA Containment Area as an alternative to disposing of large quantities of low-level contaminated soil to landfill.

It is anticipated that the MIA will continue to use the sale yards until the end of 2006. After this time, MIA will allow MRA access to the western portion of the MIA site for the purpose of constructing a containment area and depositing soil prior to the relocation of MIA (pers. comm. Neil Parry, MRA 7/12/05). The MRA is in the process of developing a Memorandum of Understanding (MOU) with the WA MIA to secure the site when it becomes available, and to provide for early access prior to it being sold to the MRA so that Helena East remediation works are not held up. Mr Neil Parry of MRA has indicated (pers. comm. Neil Parry, MRA 22/2/06; Appendix 1) that MRA is hoping to finalise the MOU by the end of April 2006.

As per the MRA–MIA Cabinet Decision issued by the Minister for Agriculture, Forestry and Fisheries on 23 September 2004 (Appendix 1), replacement facilities will be developed for the Midland Saleyard currently used by the MIA, and the MIA land will be sold to the MRA.

Remediation work will be staged in a manner that ensures that the containment cell is prepared prior to the excavation of soils in the Helen-East Precinct. As a result, it is not envisaged that any interim storage of excavated material will be required beyond the establishment of short-term stockpiles to allow verification testing of the excavated soils to demonstrate compliance with the agreed criteria for placement of waste into the cell.

2.2 Historical Site Uses

Helena East comprises the central portion of the former Midland Railway Workshops, which operated from 1904 until its closure in 1994. The site was used for the fabrication, maintenance and repair of locomotives and other rolling stock during this time. Associated buildings and their activities include the service conduit, foundry, boiler shop, blacksmith shop, machine shop, fitting shop, diesel shop, electrical shop, plating shop, power house, element shop, pattern shop and other various smaller buildings (see Figure 3). Many of these buildings are Heritage-listed (see Figure 4) and subject to preservation orders.

The Southern Embankment comprises a portion of land immediately abutting the southern boundary of Helena East (Figure 3). It is an area in which waste produced during the Workshops operations was deposited as landfill that progressively formed an embankment extending south towards the Helena River Floodplain.

The landfilling occurred along the southern boundary of both the Helena East and Helena West Precincts, but the portion directly south of the Helena East Precinct is yet to be remediated.

2.3 Current Site Condition

2.3.1 Helena East

Helena East is a generally flat site with buildings and infrastructure associated with the former Midland Railway Workshops covering much of the site. Approximately 35% or 6ha of the total Helena East area (17ha) is covered by buildings, with the three main blocks alone covering an area of approximately 4ha (see Figure 3). Bitumen hardstand or sub-base materials such as gravel and crushed blue metal cover almost all of the remainder of the site. Areas not currently covered by hardstand comprise an area located in the south western corner of the site abutting the Helena West Precinct, a relatively thin strip of land located on the southern edge of the Yelverton Drive road reserve near the intersection of Centennial Place and a grassed and landscaped area abutting the north western corner of the Helena Street/Yelverton Drive intersection.

Many of the buildings are of brick and concrete construction, with roofs generally clad with galvanised corrugated steel sheets and/or asbestos cement sheeting. As part of a separate State Government initiative the asbestos cement sheeting is planned to be progressively removed during Heritage restoration works to be undertaken on the buildings.

Numerous investigations (see Section 3.1) at the site have shown that extensive deposits of shallow fill typically 0.5m to 1m in depth are present across the surface and are overlying the natural clay. The volume of fill material is estimated at 10,000m^3 to 15,000m^3 and generally consists of layers of ash/cinder, gravel, rock ballast, sand and clays.

Security fencing bounds the entirety of Helena East south of Yelverton Drive, and access is via a 24hr manned security gate located on Yelverton Drive.

2.3.2 Southern Embankment

The Southern Embankment is characterised by a very narrow flat area abutting the southern boundary of Helena East leading to a steep embankment of some 6-7m height that slopes down to the Helena River floodplain. Originally the natural embankment was closer to the Helena East boundary, but progressive filling extended the embankment southwards over time. The southern boundary of the Southern Embankment approximates the toe of the slope at around 7mAHD.

The area of the Southern Embankment covered by this proposal is approximately 0.8ha and due to historic landfilling of waste is estimated to contain approximately 70,000m^3 of building rubble, coal cinders, ash/clinker, foundry slag, occasional asbestos products and hydrocarbon contaminated soils (ENV, 2002b). Additional investigations by ATA Environmental in support of this PER have indicated that the volumes of hydrocarbon contaminated materials in the fill south of the tarpaulin shop and above ground fuel storage tank are approximately three to four times greater than predicted by previous investigations.

Due to the use of the Southern Embankment area for waste disposal no buildings and few infrastructure items were built in this area. The only infrastructure item present is the former wastewater treatment system, which is located on the embankment just south of the former plating shop (shown on Figure 3).

The surface is formed by fill materials and sand, and is overgrown with weeds. Access is difficult and can only be made via locked gates along the southern boundary of Helena East or via four-wheel drive tracks accessed from the southern side of the Helena River.

Photos of Helena East and the Southern Embankment area in its current state are presented in Appendix 3. A further discussion of the existing environment of these areas is presented in Section 2.6.

2.4 Surrounding and Onsite Land Use

Helena East and the Southern Embankment areas are surrounded by the following land uses:

- North: Railway Reserve and Midland town centre.
- South: Helena River floodplain and Helena River.
- East: Western Australian Police Service (WAPS) and CADCOM complex are on part of Area B, C, D, and Area E; the remainder of Areas B, C, D is to be used for WAPS activities and commercial activities; the majority of Area E is proposed to be developed as a hospital.
- West: Helena West Precinct, comprising former rail yards remediated and subject to future residential redevelopment. The far western section of the Helena West Precinct, adjacent to Amherst Road, currently has housing being built as part of the Woodbridge Lakes residential development.

The nearest established residential area is approximately 200m to the north across Railway Parade in Midland. Semi-rural residences exist approximately 150m-200m south of the southern site boundary. The closest primary schools are Midland and Woodbridge Primary Schools located approximately 800m both north and west of Helena East, respectively.

Various parties hold lease agreements with the MRA and are currently using several buildings within Helena East on a daily basis. Several of these leases are due to expire in the next 12 months. A list of buildings being occupied by lessees, their activities and expected period of occupation is presented in Table 3.

TABLE 3
ON-SITE LAND USE

Location	Tenant	Use	Lease End
Former Chief Mechanical Engineers Building	Midland TAFE	Education Purposes	end December 2005
Former Chief Mechanical Engineers Building	ECU	Education Purposes	(begin Jan 2006) ongoing
Former Works Managers/Tool Office	WA Police Services South Spur Rail Services	Communication Infrastructure Project offices	December 2006 (demolition then construction of Education Bldg)
Block 1	South Spur Rail Services	Storage of Tourist Train & maintenance purposes of locomotives & rolling stocks	June 2006
Block 1	Australian Railway Historical Society	Restoration & storage of Heritage locomotives &* rolling stock	Ongoing
Block 1	EDI Rail	Final commissioning of Public Transport Authority Suburban rail cars	to 30 June 2006 minimum
Pattern Shop	Circa Furniture	Fine wood industry incubation program	Ongoing
Copper Shop	Machinery Preservation Club	Restoration & storage of Heritage machinery items	Ongoing
Element Shop	Machinery Preservation Club	Restoration & storage of Heritage machinery items	Ongoing
Portion of Block 3	Machinery Preservation Club	Restoration & storage of Heritage machinery items	Ongoing
Former Railway Institute Building	Midland Redevelopment Authority (MRA)	MRA Offices	Until completion of MRA project (ongoing)
Former Timekeepers Office	MRA / Rail Heritage WA	Railway Workshops Interpretive Centre. Starting point for Workshops tours.	Ongoing

2.5 Physical Environment

2.5.1 Climate

The site experiences a Mediterranean climate with hot dry summers and cool wet winters. Climatic data recorded for Perth Airport (approximately 4km southwest of the site) shows the area receives an average annual rainfall of 790mm, the majority of which is received between May and August (Bureau of Meteorology, 2005).

The predominant wind direction recorded at the Perth Airport is easterly in the morning and southwest to westerly in the afternoon. During the winter months the prevailing wind direction changes to a north-easterly direction in the morning with the afternoon wind losing its south-westerly predominance with winds coming from all directions. During summer afternoons the south-westerly is the strongest, reaching speeds in excess of 20km/hr.

2.5.2 Topography

The topography of the land in and around the Workshops and saleyards sites has been heavily altered over time to facilitate development. The topography of Helena East and the proposed MIA Containment Area is generally flat with an elevation of approximately 13m–14m AHD. The narrow portion of the Southern Embankment area that abuts the southern edge of Helena East is also similar in height.

The Southern Embankment also comprises a steep embankment of some 6-7m that slopes down to the Helena River floodplain that has a general elevation of approximately 6m to 7m AHD.

2.5.3 Geology

A stratigraphic sequence of the geology underlying Helena East and the proposed MIA Containment Area has been interpreted from observations made during onsite investigations undertaken to date. Broadly, the stratigraphy of the site comprises four main units in the upper 30m below ground level (BGL), which are described in this document as Inert Fill, Waste Fill, Upper Clays, and Lower Sands. The relationships between these units are described below. The locations of interpreted geological cross sections for the site are shown on Figure 5. Three east–west cross sections are presented in Figures 6a to 6c, and a north–south cross section is presented in Figure 6d.

Uppermost in the sequence is a thin horizon of fill (generally less than 1m total thickness), comprising both inert material such as gravel and limestone road base ("Inert Fill"), and waste from activities at the railway site such as ash, slag, clinker, metal fragments, asbestos material, and other rubble ("Waste Fill"). Fill overlies material comprising clay units with variable sand content ("Upper Clays"), which generally extend to approximately 10mBGL. The Upper Clays are characterised by clay-rich strata with some sand and silt, complexly interbedded with discontinuous coarser-grained lenses of sand to sandy clay. The Upper Clays are underlain at depth by unconsolidated sands ("Lower Sands"), which are understood to extend to approximately 40mBGL. Shale has been intersected at varying depths beneath the Lower Sands in holes drilled to the east and west of the site.

Waste Fill is most extensive along the southern boundary of Helena East and in the Southern Embankment, where it was deposited along a natural break in slope. Over time the build-up of Waste Fill extended the 13m–14m AHD portion of the site southwards. In this area, Waste Fill overlies a limited interval of Upper Clay at depth, which is in turn underlain by the Lower Sands.

Based on published geological mapping (Gozzard, 1986), published stratigraphic sequences (Davidson, 1995, and Playford et. al., 1976), and previous reports on investigations at the site (ENV, 2003b), the Upper Clays are considered to form part of the Guildford Formation, which is alluvial in origin. The upper part of the Lower Sands is also considered to form part of the alluvial Guildford Formation (ENV, 2003b), and this grades into glauconitic Henley Sandstone, which is the basal unit of the Osborne Formation, and is of shallow marine origin. There does not appear to be an obvious or distinct boundary between the sands of the Guildford Formation and the Henley Sandstone (which itself is a sand that is grey-green in colour lower in the profile). The Lower Sands would seem to act as a single aquifer unit hydrogeologically, as discussed in Section 2.5.4.

Underlying the Osborne Formation is the Leederville Formation, which forms an aquifer system in the Perth metropolitan area. The Pinjar Member is a shale unit which caps and locally confines an aquifer system in the Leederville Formation. This information is summarised in Table 4.

TABLE 4
STRATIGRAPHIC SUMMARY

Unit	Description	Geological Formation	Approx. Depth mBGL
Inert Fill	Gravel, limestone roadbase	-	0m – 0.3m
Waste Fill	Ash, cinder, metal fragments, rubble	-	0.3m – 0.5m
Upper Clays	Silty and sandy clays, clayey sands.	Guildford Formation	0.5m – 10m
Lower Sands	Unconsolidated sands with some silt, slightly indurated sandstone.	Guildford Formation, Osborne Formation - Henley Sandstone Member.	10m – ?25m ?25m – ?40m
Shale	Grey to black shale.	Leederville Formation, - Pinjar Member	?40m – ??

Although there is no information on the geology underlying the Guildford Formation at the proposed MIA Containment Area it is anticipated, due to the close proximity to Helena East, that whilst the thicknesses of individual formations may vary the overall geology is similar.

2.5.4 Hydrogeology

Groundwater at Helena East has been subject to detailed hydrogeological investigations. Hydrogeological data from an earlier investigation (ENV 2003b), together with additional investigations undertaken as part of this PER have been reviewed by an independent consulting hydrogeologist, Dr. Chris Barber of Crisalis International Pty. Ltd. (Crisalis, 2005 and 2006; see Appendix 4).

Site-specific investigations demonstrate that the groundwater gradients and flow direction across the site are strongly affected by the relatively complex geology within the Upper Clays unit, as well as by the ability of rainfall to infiltrate the ground (correlating to the presence or absence of extensive hardstand areas). The Coal Dam, approximately 250m to the west of Helena East, has been demonstrated to have a significant impact on groundwater levels in the Upper Clays at the Helena West Precinct (ENV, 2003b). The effect of the Coal Dam is likely also to have some impact on groundwater levels in the Upper Clays at Helena East.

Broadly, two groundwater systems have been identified and investigated: a complex shallow flow system perched within the Upper Clays, referred to as the Shallow Superficial Aquifer (SSA), and a deeper aquifer in the Lower Sands called the Lower Superficial Aquifer (LSA), which is in direct hydraulic continuity with the Henley Sandstone (ENV, 2003b) and essentially forms a single hydrogeological unit. The Henley Sandstone is underlain at depth by shale (interpreted as the Pinjar Member of the Leederville formation), which forms an aquiclude capping the extensive regional aquifer system in the Leederville Formation. The Leederville Aquifer is understood to be confined under pressure by the Pinjar Shale. Earlier reviews by ENV (2003) on the hydrogeology of the site concluded that there was little hydraulic connection between the SSA and LSA on the basis of a limited pumping test.

Monitoring bore elevation and construction information is summarised in Table 5. Bore logs for additional bores installed in support of this PER are provided in Appendix 5.

TABLE 5
BORE ELEVATION AND CONSTRUCTION DATA

Bore ID	Ground	Standing Water Level	Screened Interval	Base of Hole	Aquifer
	AHD	AHD	mBGL	mAHD	
ATA-1	13.65	9.91	3 - 9	4.65	SSA
ATA-2	13.59	9.73	2 - 8	5.59	SSA
ATA-3	13.7	12.33	2 -5	8.70	SSA
ATA-4	13.79	12.44	1 - 6	7.79	SSA
ATA-5	13.8	9.62	5 - 9	4.80	SSA
ATA-6	13.4	11.61	2 - 5	8.40	SSA
ATA-7	13.29	8.14	2 - 6	7.29	SSA
ATA-8	13.43	8.85	1.5 - 7	6.43	SSA
ATA-9	13.52	11.99	1.5 - 8	5.52	SSA
ATA-10	13.73	11.21	1.5 - 8	5.73	SSA
ATA-11	13.46	11.21	1.5 - 7	6.46	SSA
ATA-12	13.25	6.15	3.5 - 8.5	4.75	SSA
ATA-13	13.42	(Dry)	2 - 7	6.42	SSA
ATA-14	13.44	(Dry)	1 - 7	6.44	SSA
ATA-15	13.72	3.12	12 - 15	-1.28	LSA
ATA-16	13.66	4.35	10.5 - 13.5	0.16	LSA
ATA-72	5.97	2.52	2.5 - 5.5	0.47	LSA
ATA-73	6.14	2.54	2.5 - 5.5	0.64	LSA
ATA-75	6.29	2.58	2.5 - 5.5	0.79	LSA
ATA-76	5.82	2.52	3 - 5	-0.18	LSA
ATA-77	5.73	2.59	2 - 5	0.73	LSA
B3	5.37	4.44	2.5 - 7	-1.63	LSA
H5B	13.25	6.94	? - 11	2.25	SSA
H5H	13.40	11.45	? - 7	6.40	SSA
HE-1	13.63	12.27	1.5 - 10.5	3.13	SSA
HE-2	*13.72*	*4.45*	*9 - 15*	*-1.28*	*LSA*
HE-3	*13.72*	*4.30*	*9 - 15*	*-1.28*	*LSA*
HE-5	14.08	4.59	9 - 16	-1.92	LSA
HE-6	13.93	6.74	8 - 14	-0.07	Intermediate*
HE-7	*13.65*	*4.56*	*5.5 - 11.5*	*2.15*	*LSA*
HE-8	13.77	3.83	8 - 14	-0.23	LSA
HE-9	13.82	6.12	8 - 14	-0.18	Intermediate*
HE-11	13.24	4.43	7 - 13.5	-0.26	LSA
HE-14	13.91	5.68	? - 13	0.71	Intermediate*
HE-15	13.47	4.37	? - 12	1.47	LSA
HE-17	13.59	9.34	? - 12	1.59	SSA
HP-13	12.15	6.22	4 - 9	3.15	SSA
HP-15	12.55	7.79	4 - 9	3.55	SSA
HWMW1	13.10	4.48	7 - 13	0.10	LSA

Notes: Italicised bores were decommissioned and filled with a bentonite-cement grout mixture on 25/1/2006.
Shaded bores are considered to represent the LSA system.
Intermediate* indicates bores which have water levels intermediate between the SSA and LSA.

The perched SSA system has formed in the Upper Clays due to their generally low permeability. Groundwater migrates slowly through the clay-rich intervals, with occasional coarser sandy horizons providing preferential pathways for groundwater within the unit. The sandier horizons do not form a continual unit within the Upper Clays, but are considered to form a weakly interconnected system across the majority of the site. Groundwater contours within the SSA indicate a consistent gradient towards the southwest in the southern portion of the site. The extensive hardstand across much of the northern and eastern portions of Helena East, combined with the low permeability of the Upper Clays reduces the infiltration of rainwater and alters the groundwater gradients, particularly in the vicinity of the Foundry and Blocks 1 – 3. ENV (2003) suggest that there is no uniform water table within the SSA and groundwater in these sediments slowly discharges vertically downwards into the LSA; this is considered logical given the hydraulic gradient between the two aquifers. Any discharge from the SSA towards the Helena River floodplain is likely to be very small. ENV (2003) report no seepage of groundwater on the edge of the floodplain closest to the site, and it is concluded that most leakage from the SSA is into the LSA, rather than laterally into the sediments of low permeability immediately below the river floodplain.

Twenty groundwater monitoring bores (including two dry bores) are screened within the SSA, with groundwater in these bores found at between approximately 7–12mAHD (1.5–6.5mBGL) at Helena East (deeper towards the Southern Embankment.)

The LSA is confined or semi-confined by the Upper Clays. One pumping test has shown very limited hydraulic connection between the complex SSA system and the LSA (ENV, 2003b). The fine-grained sand and silt of the Lower Sands is understood to form part of a relatively extensive aquifer beneath the site. LSA Groundwater level contours within Helena East indicate a gradient towards the west-northwest at the site, parallel to the Helena River. Sixteen groundwater monitoring bores are screened within the Lower Superficial Aquifer. Groundwater in LSA bores within Helena East found at between approximately 3m AHD and 4.5mAHD, deeper towards the western edge of the site; levels along the Southern Embankment are approximately 2.5mAHD. The riverbed is scoured into clay-rich soils which overlie the LSA, precluding a hydraulic connection between the LSA and the Helena River.

Three other bores are screened near the base of the Upper Clays, and have groundwater at depths intermediate between those typical of the Shallow and Lower Superficial Aquifers (5.7mAHD to 6.7mAHD).

Although bores HE-7 and HE-17 are close together and have similar total depths, the water level in HE-7 indicates that it is accessing the LSA system, whereas the water level in HE-17 indicates that it is in the SSA. Excavations for the Hot and Cold Wells adjacent these bores may have disrupted the natural stratigraphy at these locations.

The bores in the SSA system were constructed using standard monitoring bore construction techniques, by placing gravel pack across the screened interval, a 0.5m bentonite plug above this, and backfilling the remainder with cuttings or clean fill. The available information indicates that all bores were installed using the same standard construction techniques. The two deep bores in the LSA system were constructed using an outer casing of 10mm thick blank PVC installed to the base of the Upper Clays and set with a cement grout; a day later, the screened interval of the bore was installed into the Lower Sands by drilling through the grout plug at the base of the outer PVC casing. This was done in order to isolate the Lower Sands from possible contamination by soil or water from the Upper Clays.

The main hydrogeological features of the SSA and LSA are summarised in Table 6, based on the data from extensive Helena East and Southern Embankment investigations.

TABLE 6
HELENA EAST & SOUTHERN EMBANKMENT
HYDROGEOLOGICAL DATA SUMMARY

	Shallow Superficial Aquifer	**Lower Superficial Aquifer**
Groundwater Elevation	7 – 12 mAHD	3 – 4.5mAHD
	1.5 – 6.5 mBGL	9 – 10.5 mBGL
Groundwater Flow Direction	SW (generally)	WNW
Horizontal Hydraulic Gradient	(variable)	0.0035 (locally)

Limited drilling information indicates that the LSA is approximately 30m in vertical extent, extending through unconsolidated sands comprising the Guildford Formation and Henley Sandstone Member. The Shale unit at approximately 40mBGL forms a basal aquiclude to the LSA. No site-specific investigations have been undertaken in the underlying Leederville Aquifer, although a sample from a nearby bore in the Leederville has been collected and analysed.

2.5.5 Site Drainage and Surface Water

Helena East and Southern Embankment

Storm water run-off from roofs and paved surfaces is currently collected by an existing drainage network and directed to outfalls into the Helena River floodplain. The drainage network is old and will require progressive replacement as part of the redevelopment project. Existing outlets discharge storm water direct without trapping of pollutants.

Stormwater drainage management for redevelopment of the workshops site will be governed by the Stormwater Drainage Strategy prepared by EGIS Consulting (2002) and subsequently approved by the DoE. This strategy divides the site into a series of drainage catchments that capture stormwater and direct flows to a designated and controlled outlet to the river flood plain. Outlets will be designed to contain flows to certain specified rates and discharge into natural swales within the flood plain to maximise detention and infiltration of stormwater flows. The outlet structures will be designed to include gross pollutant traps to collect gross and suspended pollutants before being discharged into the flood plain.

Within each catchment, run-off will be collected at source by gutters and gully pits being transferred via downpipes and piped connections to the drainage network. Hydraulically designed pipe networks will then route flows via pollutant traps to the outfall structures. The preliminary drainage network can be seen on the servicing concept plan of Egis (2002).

Helena River Floodplain and Regional Drainage

The Helena River floodplain is situated near the southern boundary of Helena East and Southern Embankment areas. The Helena River is a major tributary of the Swan River, with its confluence located at South Guildford. Its proximity to Perth's earliest settlements and agricultural region has resulted in significant anthropogenic changes to the river system. The most significant changes to the regional hydrology were the construction of the Mundaring Weir and the lower Helena River Pipehead Dam, both of which are upstream of Midland. Consequently, the Helena River flow in summer is highly restricted. Mosquito control is required by the local council in the seasonally stagnant pools.

In order to establish a baseline for the quality of Helena River water and sediments at the present time, sampling was undertaken as part of this PER. Water samples were collected at 4 locations (labelled HR-W, followed by a number), and sediment cores were collected from 5 locations (labelled HR-S, followed by a number), as indicated in Figure 2. Water samples were initially analysed for a suite of potability parameters, and subsequently for a suite of heavy metals, plus total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs). Sediment samples were analysed for a suite of heavy metals, TPHs, PAHs, and VOCs. The water and sediment results are presented in Appendix 6. Water results are compared to the Fresh Waters criteria (DoE, 2003), and the sediment results are compared to the Interim Sediment Quality Guideline (ISGQ) Low and High criteria.

In summary, TPHs, PAHs, and VOCs were not detected in any river sediment sample. With the exception of lead concentrations, results for heavy metals indicate that all sediment concentrations are below the ISGQ-Low and ISGQ-High criteria. The lead concentration exceeds the ISGQ-Low criterion of 50mg/kg in two samples, HR-S-3 (63mg/kg) and HR-S-4 (54mg/kg), but is well below the ISGQ-High criterion of 200mg/kg. The ISGQ-Low value represents a level at which biological effects would rarely occur and it is recommended that the results be compared against background concentrations when a result exceeds the Low value. If the most upgradient sample location (HR-S-2, with 8mg/kg lead) relative to Helena East is selected to represent the background concentrations, then it may be inferred that lead levels are somewhat elevated in the vicinity of Helena East. Sediment metal concentrations generally show an increasing trend from the upgradient (HR-S-2, adjacent Areas B, C, & D) sample to the downgradient sample (HR-S-4, at the western edge of Helena West), although none appear to be at levels indicating potential ecological harm.

No TPHs or PAHs were detected in any river water sample. A trace amount of the VOC dibromomethane was detected in sample HR-W-4. It is considered that this result may be due to laboratory error or bottle contamination, as chemical data for dibromomethane indicates that it has a half-life of 5.2 hours in a modeled river setting (Spectrum Laboratories, 2006). No metals were detected at concentrations exceeding the Fresh Waters guidelines.

2.6 Ecological Characteristics

2.6.1 Vegetation, Flora and Wetlands

This section summarises the vegetation characteristics and values of the vegetation closely associated with the site. An assessment of the site shows that any vegetation that is present is in a highly degraded condition.

A more detailed description of the work undertaken and the methodology is presented in Appendix 7.

Vegetation Complex

The vegetation at the site is mapped by Heddle *et al.*, (1980) as the Swan Complex. The Swan Vegetation Complex is representative of Fringing Woodlands of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* with localised occurrence of Low Open Forest of *Casuarina obesa* and *Melaleuca cuticularis*.

A target of 10% reservation of each vegetation complex may be used as a basis for determining appropriate recommendations for conservation of selected areas of bushland in the Perth Metropolitan Region, which form part of a constrained environment.

At a regional scale (ie as mapped by Heddle *et al*., 1980), the Fringing Woodlands of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* with localised occurrence of Low Open Forest of *Casuarina obesa* and *Melaleuca cuticularis* meets the 10% criterion for protection within conservation reserves with 11% of its original extent currently reserved in the conservation estate.

A site visit conducted by ATA Environmental on the 1 December 2005 confirmed that the remaining vegetation in the Helena East, Southern Embankment and MIA Containment areas is representative of the Swan Complex. However, although it is representative of the Swan Complex it is a highly degraded representation of that complex. It is essentially absent from Helena East and confined to the Southern Embankment.

Vegetation Types

Three vegetation types associated with the study area were identified and described during the site visit on the 1 December 2005 (See Figure 1 of Appendix 7). These are described as 1. *Eucalyptus rudis* Woodland (ErW). 2. Closed Grassland (Cg) and 3. Planted Species (Ps).

The vegetation condition in the study area was ranked according to Bush Forever (Government of Western Australia, 2000). The three vegetation types were found to be in a Degraded or Completely Degraded condition (Appendix 7).

Wetlands

According to the *Geomorphic Wetlands Swan Coastal Plain Dataset* provided by the DoE, the Southern Embankment abuts a Conservation Category Wetland (Floodplain) (UFI 13628). A Floodplain is a seasonally inundated flat.

The Bush Forever (2000) maps Bush Forever Sites and also shows Conservation Category Wetlands (CCWs) and ‘other native vegetation’. The vegetation on the Southern Embankment (Figure 1 of Appendix 7) is not listed as regionally significant in Bush Forever (2000). Floodplain, river, creek and estuarine CCWs were not considered for addition to the draft Environmental Protection (Swan Coastal Plain Wetlands) Policy 2004.

2.6.2 Fauna

As indicated in Appendix 7, due to the highly degraded nature of the vegetation and the potentially high number of feral mammals present, the site is considered to have very limited faunal conservation values. Eleven species of conservation significant fauna are possibly found within the vicinity of the site. Although remnant vegetation may provide a habitat for some bird species, none of these species are likely to rely on the project area for survival. There is likely to be a paucity of native mammals and reptiles present at the site.

2.7 Social Environment

2.7.1 Indigenous Heritage

The Midland Redevelopment Authority has consulted with Aboriginal community group representatives and made two separate applications under Section 18 of the Aboriginal Heritage Act 1972 to develop the land within its scheme area as follows:

- For stage 1 works within the area known as Helena West on 25 February 2004; and
- For stage 2 remediation and decontamination works along the banks and floodplain of the Helena River on 23 April 2004.

In both instances the Hon. Minister for Indigenous Affairs has given consent to use the land for the purposes noted in those applications. The remediation works proposed in Helena East pose no management issues with respect to Section 18 of the Aboriginal Heritage Act 1972.

2.7.2 Non-Indigenous Heritage

Introduction

The former Midland Railway Workshops area represents the most substantial industrial complex established by the State Government in the period around the turn of the 20th century and contains a large number of heritage buildings. Many of the oldest and most significant buildings onsite are located within Helena East and essentially remain unchanged since their construction. On this basis the preservation of these buildings is a primary focus of the redevelopment of Helena East.

The sections below describe the non-indigenous heritage issues associated with Helena East, the Southern Embankment, and the MIA Containment Area. The heritage aspects of the site were assessed by Heritage and Conservation Professionals (2004) with a Heritage Strategy prepared and adopted by MRA.

Helena East represents the original and oldest part of the workshops where the majority of industrial processes took place. The proposed remediation strategy is not expected to damage any Heritage listed structures.

Helena East and Southern Embankment

The site of the former Midland Railway Workshops is included on the Heritage Council of Western Australia's Register of Heritage Places, the Australian Heritage Commission's Register of the National Estate and the City of Swan's Municipal Heritage Inventory. The Workshops are also classified by the National Trust of Australia (WA). The place has statutory protection through the provisions of the *Heritage of Western Australia Act 1990* which requires that all development be referred to the Heritage Council of WA for comment.

The MRA is committed to the conservation of the significance of the former Workshops and adopted the *Heritage Strategy for the Midland Central Redevelopment Area* in March 2003. The Strategy outlines ways in which the historical and Heritage values of the former Workshops will be integrated into the redevelopment. Subsequent to the adoption of the Heritage Strategy the MRA has made a commitment to the development of a Rail Heritage Centre in the core group of historic Workshops buildings.

The Midland Railway Workshops opened in 1904. Helena East encompasses the core group of significant brick buildings and associated structures that date from that time. These represent the main workshops for the maintenance and manufacture of locomotives and rolling stock for the West Australian Government Railways (WAGR) from 1904 until its closure in 1994. Figure 4 illustrates the main Heritage-listed structures located within Helena East that will be retained as part of the redevelopment plan.

The 1904 Power House was literally the engine room for the Workshops. Together with the adjacent Boiler House and the Hot and Cold Wells, it provided the infrastructure that generated electricity for the Workshops.

The Power House is architecturally the most significant industrial building on the Workshops site. It is highly intact and features fine timber detailing and original tuck-pointed brickwork to the interior walls. A series of metal grilles are set into the floor, and inside the building is the entrance to the 'conduit', a tunnel that runs across the Workshops site and originally supplied power to the other buildings. The Power House contains a number of air compressors dating from 1904 to the 1940s which are considered one of Australia's most outstanding and visually appealing collections of such equipment.

The MRA's Heritage Strategy identifies the Power House to be of exceptional significance. It is proposed to be a central component of the Rail Heritage Centre and is essential to the story of power generation at the Workshops.

The Hot and Cold Wells were also constructed in 1904 as part of the original power generation system. These concrete lined wells were originally circulating tanks providing a cooling source for the condensers in the Power House. They were later used for cooling for the air compressors. They are identified as being of considerable significance in the MRA's Heritage Strategy and their retention is essential for telling the story of power generation at the Workshops as part of the proposed Rail Heritage Centre.

Immediately to the west of the Hot and Cold Wells is a timber-framed building identified in the Heritage Strategy as the Element Shop. This building dates from around 1910 and has been used for a variety of purposes over the years. Uses have included Copper Shop, Track Equipment Shop and Element Shop where electrical devices were manufactured. The building is identified as significant in the MRA's Heritage Strategy.

The Workshops formerly included a number of timber-framed weatherboard and corrugated iron clad buildings to supplement the original brick structures. While the majority of these will not be retained, the MRA proposes retaining the Element Shop as a representative example of the early framed Workshops buildings. Its location near the Power House is ideal for inclusion as part of the proposed Rail Heritage Centre where it will provide a window onto the working conditions of the former workers. The building is one of the last remaining examples of a workshop with the distinctive lantern roof that marked many of the early buildings on the site. The Element Shop will be restored and will remain as the only timber-framed Workshops structure to be kept on the site. Its retention is essential to the heritage of the site as it tells a part of the Workshops story that is not represented by any of the other Heritage buildings being retained.

2.7.3 Public Safety

Existing Site Access and Traffic

Helena East is surrounded on all sides by cyclone fencing: along Yelverton Drive to the north, Centennial Place to the east, on top of the Southern Embankment (approximately 6-7m embankment) to the south and between the site and the Woodbridge Lakes development to the west (pers. comm. K.Hutchinson, MRA. 11/11/05).

Other than for train access, the site entrance is located at the north end of the site where security staff control vehicle and pedestrian traffic 24 hours per day.

Currently most traffic onsite is pedestrian traffic, and vehicle traffic is limited to service vehicles, security vehicles and parking for use of buildings occupied by lessees. Trains enter and exit the site from the west for service and restoration. This includes the "Dinner Train" 2-3 times per week, Public Transit Authority passenger rolling stock several times per week as is required, and occasional rolling stock that are being refurbished by the Australian Railway Historical Society (ARHS).

Services and Associated Infrastructure

Following closure in 1994 many of the services present across the Workshops area were decommissioned. At Helena East all of the major services have been severed, with the exception of some minor electrical, water, and sewer lines. At the MIA Containment and the Southern Embankment Areas there are no services that present a danger to the workers onsite or to the public.

3. SITE CONTAMINATION

This section describes soil and groundwater contamination at Helena East, the Southern Embankment and the proposed MIA Containment Area which is known at the time of preparing this PER. Following an introduction to previous investigations (Section 3.1), the nature and extent of identified contamination is described (Section 3.2). The location and extent of soil contamination by different materials is discussed (Section 3.3), followed by a discussion of groundwater contamination and known impacts on aquifer systems (Section 3.4).

3.1 Previous Site Investigations

A number of environmental investigations have been completed for Helena East and the Southern Embankment, either specifically for the site or as part of investigations of larger areas such as the Midland Railway Workshops. Two assessments have been undertaken at the MIA Containment Area. Reports on relevant previous investigations that were reviewed in order to assess areas of contamination and consider their management comprise the following:

- Midland Railway Workshops Site Environmental Audit (BBG, 1994);
- Midland Railway Workshops Assessment of Contamination and its Implications (CMPS&F, 1995);
- Midland Railway Workshops Site Contaminant Migration Study (BBG, 1995);
- Environmental Investigations, Midland Railway Workshops (CMPS&F, 1996);
- Detailed Site Investigation, Helena Precinct Waste Fill, Midland Railway Workshops (ENV, 2002b);
- Hydrogeological Investigation, Helena West, Midland Railway Workshops (ENV, 2003b); and
- Environmental Investigations in Support of Referral, Helena East, Midland Railway Workshops Site (ENV, 2004).

3.2 Nature and Extent of Contamination

Helena East has been most intensively investigated, due to the long history of industrial use of that portion of the site, as well as the variety of potentially contaminating activities that took place there. A total of some 250 locations were tested across Helena East, and approximately 10 locations across the Southern Embankment (see Figure 7).

A review of contamination identified in previous investigations and additional investigations by ATA for this PER indicates that contamination can broadly be assigned to one of three categories as follows:

- Waste Fill deposits from historical dumping at the site (generally comprising bulk soil, metal fragments, ash, slag, asbestos, and other debris), which is contaminated and/or geotechnically unsuitable.

- Natural soil affected by contamination migrating from overlying sources (e.g. hydrocarbons).

- Groundwater impacted via migration of contaminants through overlying fill and/or natural soil.

Previous investigations differentiated between the extensive Waste Fill that comprises the Southern Embankment and shallow deposits of Waste Fill that are found across extensive areas of Helena East. Despite this differentiation, Waste Fill in the Southern Embankment is not fundamentally different in nature to Waste Fill found elsewhere on the site. The only significant distinctions are that the thickness and lateral continuity of Waste Fill increases along the southern margin of Helena East and into the Southern Embankment area, and the Southern Embankment area contains a greater proportion of bricks, concrete and other rubble. The shallow distribution of fill across Helena East is related to the original topography of the site, as material was spread across the site to slightly raise site levels and improve drainage; in contrast, the Southern Embankment Waste Fill deposits are continuous and commonly at least several meters in thickness due to the material being dumped along a significant break in slope adjacent the Helena River floodplain.

3.3 Soil Contamination

3.3.1 Introduction and Overview

Laboratory results of soil samples have been compared to values in Table 1 of *Assessment Levels for Soil, Sediment and Groundwater* (DoE, 2003). Soil results have been compared to the Ecological Investigation Levels (EILs), which are designed to protect the environmental receptors. The EILs are the most stringent assessment levels, and are therefore also protective of human health. Soil which exceeds one or more EIL criterion is considered contaminated for the purposes of this document. However, depending on the presence of environmental receptors and the proposed future land use, it is possible to use less stringent criteria which are still protective of human health (the Health Investigation Levels or HILs of DoE, 2003).

There are no EIL guidelines for asbestos or volatile organic compounds (VOCs) such as halogenated hydrocarbons. For asbestos, detection is considered to indicate contamination. For VOCs, Soil Screening Levels (SSLs) presented in the United States Environmental Protection Agency (US EPA) document, *Soil Screening Guidance: Technical Background Document* (US EPA, 1996) have been adopted in order to identify areas of impact. As groundwater is considered to be the primary receptor for contaminants in soil, the 20DAF values have been adopted. These values arrive at an acceptable soil concentration by assuming reduction by a dilution–attenuation factor (DAF) of 20 due to natural subsurface processes between the soil source and the receptor well. As the soils at the site have low hydraulic conductivity and the source area is less than 30 acres (12ha), the 20DAF values are considered appropriate.

A summary of the soil analytical results from previous investigations by ENV are presented in Appendix 8. A summary of the soil analytical results from investigations in support of this PER are presented in Appendix 9, together with quality control data. Soil samples were collected using a hollow-stem auger drill rig. Sample collection was undertaken in consultation with Standards Australia (1999).

The Waste Fill material is characterised by concentrations of a variety of heavy metals that exceed the EIL guidelines, and some asbestos contamination. Soil underlying contaminated fill does not exhibit concentrations of heavy metals that exceed EIL guidelines, indicating negligible impact by the overlying fill. However, some natural soil has been impacted by the migration of one of more of the following through the soil profile:

- cyanide;
- total petroleum hydrocarbons (TPHs);
- polycyclic aromatic hydrocarbons (PAHs); and/or
- solvents, comprising volatile organic compounds (VOCs) including benzene, toluene, ethylbenzene, and xylenes (BTEX), and halogenated aliphatic and aromatic hydrocarbons.

Overall, contamination associated with Waste Fill deposits comprises the bulk of soil contamination identified at the site, with an estimated *in situ* volume of possibly up to 100,000m^3 in total in the Helena East and Southern Embankment areas.

Restriction of heavy metal contamination to the Waste Fill unit supports the view that the contaminants in the waste fill are not mobile and therefore not contributing to contamination of either adjacent or deeper soil through leaching of heavy metals (as presented in ENV, 2002b). It can similarly be argued that the asbestos associated with the Waste Fill is not mobile within the soil profile. In addition to asbestos materials associated with the Waste Fill, limited asbestos has been identified in surface soil along the southern portion of Helena East. This material is considered to mainly derive from asbestos cement sheeting which clad the former Plating Shop.

Soil affected by hydrocarbons and/or solvents (i.e. TPHs, PAHs, BTEX and/or minor amounts of VOCs) is also relatively extensive at Helena East and the Southern Embankment, with an estimated *in situ* volume of 30,000m^3 (including approximately 5,000m^3 which overlaps with Waste Fill in the Southern Embankment.)

Cyanide contamination is very localised and minor. It is only identified at 3 sample locations adjacent to a former cyanide treatment plant area.

At the MIA Containment Area investigations by ENV (2003a) revealed that the western end of the saleyards site contains fill similar in nature to the Waste Fill unit at Helena East and Southern Embankment. The fill varies between approximately 0.5m and 1.5m thickness and is contaminated with heavy metals (arsenic, barium, copper, lead, manganese, mercury, nickel and zinc) and/or asbestos. A dedicated asbestos dump containing buried asbestos-containing materials is located in the central part of the site.

As indicated above, soil exceeding one or more Ecological Investigation Level (EIL) criteria is considered contaminated for the purposes of this document. For asbestos, detection is considered to constitute contamination. As groundwater is considered to be the primary receptor for contaminants in soil, the 20DAF values of the US EPA's Soil Screening Levels (SSLs) values have been adopted in order to identify areas of impact (US EPA, 1996).

The following sections describes in greater detail the soil contamination that has been identified at Helena East and the Southern Embankment during environmental assessments to date (see report list in Section 3.1), including investigations undertaken as part of this PER. Soil sampling locations are shown on Figure 7. The distribution of soil impacted by asbestos is described in Section 3.3.2, and the distribution of soil impacted by cyanide is presented in Section 3.3.3. Heavy metal impacts are described in Section 3.3.4, hydrocarbon impacts are described in Section 3.3.5, and an overall discussion is presented in Section 3.3.6.

3.3.2 Asbestos

Asbestos fibres have been identified in soil in the southern half of Helena East as well as in the Southern Embankment (Figure 8a). Fibres are primarily found in buried Waste Fill. Some asbestos was identified in surface soil in the vicinity of the Plating Shop (since demolished), which was constructed of asbestos fibre cement sheeting. Fragments of this sheeting were visually identified in the area of the shop. ENV reports indicate that within Waste Fill, asbestos is present almost exclusively in the form of chrysotile, detected in one out of five samples analysed.

Investigations by ATA revealed the presence of asbestos fibres in soil at two locations (F2 and F7) in the Foundry building (Figure 8a). The contamination was found in samples taken immediately beneath a concrete pad and indicates activity that is apparently more recent than the activity that caused the contamination originally. Investigations as part of this PER identified mainly chrysotile, with some amosite and crocidolite asbestos as well.

3.3.3 Cyanide

Cyanide at concentrations above the EIL criterion of 10mg/kg has been detected at 3 locations adjacent to the Tarpaulin Shop (Figure 8a), between 0.4mBGL and 1.5mBGL. It is understood that cyanide was formerly treated in the Waste Water Treatment Plant, which is located in the vicinity of the Tarpaulin Shop.

3.3.4 Heavy Metals

Soil samples were generally assessed for a suite of eight common heavy metals (arsenic, cadmium, chromium, copper, copper, lead, mercury, nickel, and zinc) and in some cases for additional metals which may have formerly been used at localised areas in significant concentrations (antimony, barium, cobalt, manganese, and tin). Figure 8b identifies the locations where samples exceed the EIL guidelines for one or more heavy metals.

Field observations indicate that the heavy metal contamination is almost exclusively associated with Waste Fill, which comprises a mixture of cinder, ash, clinker, metal fragments, foundry slag, casting sand, and rubble. Waste Fill forms visually distinct horizons of fine black ash with varying amounts of sand and other rubble. The lateral extent and maximum depth of heavy metal impact vary with distribution of Waste Fill, which generally is found to the south of the Foundry and increases rapidly in thickness at the southern edge of Helena East and along the Southern Embankment. Heavy metals associated with Waste Fill which exceed EIL guidelines principally comprise copper, lead and zinc, as well as lesser amounts of total chromium and tin. Relative to the less-stringent Health Investigation Levels (HILs) for heavy metals, lead most often exceeds either the HIL-A residential guidelines and/or the HIL-F industrial guidelines.

Figure 8c presents an indication of the approximate vertical and lateral extent of metal contamination. Based on the drawn contours, the estimated *in situ* volume of Waste Fill material at Helena East and the Southern Embankment is approximately 80,000m^3. As heavy metal contamination is almost exclusively associated with Waste Fill, it is considered that the Waste Fill volume is approximately equal to the volume of metal-impacted soil.

The Foundry building extends across the northwest area of Helena East. Waste Fill has been identified at up to 1m deep within and adjacent to the Foundry, but more commonly extends to 0.5m depth and is underlain by clean yellow sand and clays.

Heavy metal impacts associated with Waste Fill are also found at a few locations adjacent to Yelverton Drive, in soil beneath the Block 2 and Block 3 buildings, and in soil beneath and adjacent to industrial buildings to the south of the Foundry. Generally the Waste Fill (and hence metal contamination) extends to less than 0.5mBGL and is underlain by clean sand or clay.

Within the Southern Embankment, Waste Fill covers approximately 0.8ha with a thickness varying between approximately 0.5m and up to 9mBGL locally. A previous investigation (ENV, 2002b) indicates that waste material from a former electroplating shop may have been disposed of in a portion of the Southern Embankment where higher metal concentrations were identified in select samples of Waste Fill (sample location A3-16). However, this material does not appear to be visually distinct from the remainder of the Waste Fill in the Southern Embankment and the distribution of elevated results is not well defined, so it is considered part of the Waste Fill for the purposes of this report.

3.3.5 Hydrocarbons

Significant quantities of hydrocarbon material are known to have been stored or used at a number of areas including the Foundry, Diesel Shed and Refuelling area, Power House, Tarpaulin Shop, and the elevated Water Tank (which was used to store diesel in the latter years of operation at the site). Diesel was distributed around the site via underground and above-ground pipes.

Hydrocarbon material can leak or spill from storage areas, distribution points, or pipework linking storage and usage areas. Investigations to date have identified multiple locations where soil is impacted by hydrocarbons, as shown on Figure 8d. The areas of impact include the Foundry, Blocks 1 and 2, various locations between the Panel Shop and the Diesel Shed, and south of the Tarpaulin Shop. Where TPHs were identified, analytical results indicate the material is principally in the form of long chain-length, low-volatility hydrocarbons associated with degraded diesel fuel, which was the primary fuel used at the site. Limited amounts of PAH contamination have been identified in association with elevated TPH concentrations.

Although anecdotal evidence of the storage and use of solvents at the site indicates that solvents such as trichloroethylene and tetrachloroethylene were used at the workshops to clean grease and oil from metal, solvents were only identified in samples from three locations during this investigation. These three locations also have TPH contamination.

When areas of soil impact with similar hydrocarbon components are grouped together, a number of affected areas are identified, as shown on Figure 8e. The extent of the areas is inferred: where contamination has not been found in an adjacent hole at a similar depth, the impact is interpreted to truncate between the two holes. Based on the results, it is considered that there are may be multiple overlapping areas of impact of different compositions in the area between the Panel Shop and Diesel Shed, and two separate areas of impact south of the Tarpaulin Shop.

Foundry Area

PAHs have been identified at individual locations at the east and west end of the Foundry. At the east end, PAH contamination coincides with heavy metal contamination in Waste Fill at 0.3mBGL (location HE6). At the west end of the Foundry (location H4A-12), xylene, TPH, and PAH contamination is identified within Waste Fill at 1mBGL.

TPHs are present in samples from two locations within the Foundry at 1 to 1.5mBGL (locations F4 and F8). Conservatively assuming that all the TPHs at these locations is aromatic in nature, this material may be contaminated. One of these locations (F4) is adjacent to identified TPH contamination south of the Foundry (locations H4A-3 and HE9), where TPH contamination is found between approximately 0.5m and 2.0mBGL.

Main Blocks

PAH contamination has been identified in Waste Fill at one location within Block 1 (location H6W1-6). TPH contamination is located at three locations within Block 2; due to the distance between these points, the areas of impact are interpreted to be discontinuous. At two locations (H6W2-5 and H6W2-6) TPH contamination is present at between 1.5mBGL and 2.0mBGL. At location H6W2-7, hydrocarbon contamination is present between 0.4mBGL and 2.0mBGL. Finally, south of Block 3 one location with PAH contamination is identified in Waste Fill at 0.4mBGL (H6S-3).

Power House Area

An area of TPH contamination extends approximately 100m between the Panel Shop and the southeast corner of the Power House, with approximately 3m vertical thickness. The linear form of the contamination is thought to be due to leaks in pipework (presence unconfirmed) buried beneath surface asphalt. The contamination may extend beneath the Power House, Copper Shop, and Element Shop, but does not appear to extend beneath the full width of any of these buildings. No PAHs or VOCs were detected in analysed samples.

South of the Element Shop, a small area impacted by TPHs, PAHs, xylenes, and VOCs has been identified. Trichloroethene and tetrachloroethene were detected in concentrations above the 20DAF guidelines for these VOCs in this area. Contaminant concentrations are detected in soil between 1mBGL and 2mBGL, although field notes indicate hydrocarbons present to 6.5mBGL. The presence of residual hydrocarbon material in soil in this area suggests that it is the source zone for hydrocarbons, which are detected in groundwater bores to the north of this plume. The hydrocarbons may have migrated to the north of the source zone by following relatively more permeable horizons in the Upper Clays.

Two small areas of TPH and/or PAH contamination are located near the Diesel Shed and Refuelling Area. As elsewhere, the results suggest degraded diesel is the source material.

Tarpaulin Shop Area

The two areas of contamination south of the Tarpaulin Shop have the greatest vertical extent (up to 9m) and contain the greatest volume of hydrocarbon contaminated soil. The hydrocarbon impact affects both Waste Fill and natural soil, and extends from Helena East into the Southern Embankment area. The hydrocarbon contamination is principally in the form of long chain-length, low-volatility hydrocarbons associated with degraded diesel fuel, along with some PAHs. Trichloroethene and tetrachloroethene were detected in concentrations above the 20DAF guidelines for these VOCs in the plume at the southwest corner of the Tarpaulin Shop. Only one sample analysed from the plume near the Water Tank contained detectable concentrations of VOCs (benzene-based compounds such as isopropylbenzene and n-butylbenzene) for which there are no 20DAF guidelines. The southern extent of hydrocarbon impacts has been delineated.

3.3.6 Discussion

Metal contamination is extensive across the southern portion of Helena East and in the Southern Embankment area. Metal contamination is virtually exclusively associated with Waste Fill material, and as such forms a visually distinct soil horizon. The metal concentrations in Waste Fill commonly exceed EIL guidelines for copper, lead, and zinc. Lead concentrations in some samples exceed the HIL-F criterion. At one particular area in the Southern Embankment, consistently elevated concentrations have been identified, possibly comprising waste material from a former electroplating shop (ENV, 2004). Soil from within the Foundry locally has significant concentrations of metals as well. Hydrocarbon and solvent contamination has been identified in several areas, but is much more localised in comparison to metal contamination.

3.4 Groundwater Impacts

3.4.1 Introduction and Overview

Groundwater laboratory results have been compared to assessment levels for Fresh Waters as well as Drinking Water. The majority of the assessment levels are presented in Table 3 of *Assessment Levels for Soil, Sediment and Groundwater* (DoE, 2003), with a more extensive suite presented in the source documents ANZECC (2000), and NHMRC/ARMCANZ (1996). Some values were also taken from the Dutch Intervention Levels (Ministry of Housing, Spatial Planning and the Environment, 1994).

Based on the proposed future residential land use of some portions of the site, the Drinking Water criteria are considered reasonable assessment criteria to adopt, despite the fact that the development will be serviced by scheme water and groundwater use is likely to be restricted. As the Helena River is in close proximity to the southern boundary of the site, the sample data have also been compared against the Fresh Water criteria for additional information. The Fresh Waters assessment levels are more stringent than Drinking Water levels for pesticides and for heavy metals, with the exception of arsenic and manganese. The Drinking Water assessment levels are generally more stringent for VOCs and uniformly more stringent for BTEX. There are no assessment levels for TPHs in groundwater.

A summary of the groundwater analytical results from investigations in support of this PER are presented in Appendix 10, together with quality control data. Groundwater samples were collected using low-flow sampling techniques to reduce the possibility of cross-contamination between bores and to minimise potential effects from water-column disturbance and sediment entrainment. Sampling was undertaken in consultation with Puls and Barcelona (1996).

Extensive low-level metal impacts (i.e., above Fresh Waters levels) have been identified at Helena East and the Southern Embankment, although Drinking Water levels are only exceeded for manganese, nickel, and zinc. Metals which exceed either the Fresh or Drinking Water assessment levels in the most recent rounds of sampling (August/September 2005 and March 2006) comprise cadmium (8 bores above Fresh Waters), copper (18 bores above Fresh Waters), manganese (1 bore above Drinking Water), mercury (4 bores above detection limits, and consequently above Fresh Waters), nickel (18 bores above Fresh Waters, 9 bores above Drinking Water), and zinc (all but 2 bores above Fresh Waters).

It is considered that elevated zinc may be a regional phenomenon, not necessarily related to the presence of Waste Fill at the site. One bore near Yelverton Drive, considered to be representative of water entering the MRA site, contains zinc and copper at concentrations exceeding the stringent Fresh Waters assessment levels. A Leederville Aquifer abstraction bore downgradient of the site also contains zinc at levels equal to the Fresh Waters criterion. The former Plating Shop is considered to be the source for high nickel concentrations in at least two bores.

Hydrocarbon and solvent contamination in groundwater is localised within areas of the site where extensive hydrocarbons and/or solvents were identified in soil, particularly south of the Power House/Element Shop and south of the Tarpaulin Shop. Based on soil and groundwater results for hydrocarbons, it is considered that there may be multiple overlapping plumes of different composition in the vicinity of the Power House/Element Shop, and two separate plumes south of the Tarpaulin Shop.

A layer of light non-aqueous phase liquid (LNAPL) comprising hydrocarbon fractions similar to mineral turpentine and degraded diesel was identified in one bore south of the Element Shop. PAHs which exceed the Fresh Waters assessment levels are naphthalene (3 bores) and total PAHs (2 bores). Solvents which exceed the Drinking Water assessment levels are benzene (2 bores), toluene (1 bore), ethylbenzene (2 bores), and xylenes (1 bore); one other bore is likely to exceed the criteria for BTEX, based on detectable concentrations of C_{6-9} chain-length hydrocarbon material. A variety of VOCs were identified in six bores adjacent to the Power House/Element Shop, predominantly comprising halogenated aliphatic hydrocarbons (including tetrachlorethene, trichlorethene, dichloroethane, dichloroethene, and vinyl chloride). At three bores, one or more VOCs exceed both Fresh Waters and Drinking Water assessment levels.

Organochlorine pesticides are present at concentrations exceeding the Fresh Waters assessment levels in the same bore where free-phase LNAPL was identified.

The data indicate that the lateral extent of the hydrocarbon and solvent plume south of the Power House/Element Shop has a limited extent within the Shallow Superficial Aquifer. To assist with the PER, two bores (ATA-15 and ATA-16) were initially installed to assess impacts in the Lower Superficial Aquifer. Low concentrations of VOCs, derived from common solvents known as DNAPLs (dense non-aqueous phase liquids, which are denser than water and can move vertically in aquifers irrespective of whether the aquifer is saturated with water) were identified in one of these bores.

Despite investigations into the potential activities at the Workshops site that may have caused/contributed to the DNAPL contamination, no strong evidence was uncovered that provided any indication of the volume of DNAPL chemicals used. Much of the evidence gathered was purely anecdotal from past employees, and indicated that DNAPL compounds such as trichloroethylene and tetrachloroethylene were used at the Workshops to clean grease and oil from metal.

As a result of the VOC detection in ATA-16 and discussions with the DoE, additional investigations of the vertical extent of hydrocarbon and solvent impact on the Lower Superficial Aquifer are being undertaken concurrent with the PER process. Additional bores have been installed and sampled to better delineate DNAPL impacts, and the investigation is ongoing at present.

Two hydrocarbon plumes are located south of the Tarpaulin Shop: one to the southeast, by the Water Tank (which was used for diesel storage), and one adjacent the southwest corner of the Tarpaulin Shop. Both plumes extend from the southern portion of Helena East into the Southern Embankment. TPH in groundwater, derived from an LNAPL source (light non-aqueous phase liquids, which are less dense than water) appears to have migrated through the permeable Waste Fill to the Lower Sands; consequently, contamination is migrating through this material along the upper surface of the Lower Superficial Aquifer. No free-phase NAPL was identified in the affected bores, and additional work has confirmed that the plumes do not reach the Helena River, truncating near the Southern Embankment southern boundary.

As indicated above, groundwater results have been compared to assessment levels for Fresh Waters as well as Drinking Water in order to identify contamination. The Fresh Waters assessment levels are significantly more stringent for heavy metals (with the exception of arsenic and manganese) and pesticides. The Drinking Waters assessment levels are generally more stringent for VOCs and uniformly more stringent for BTEX. There are no assessment levels for TPHs in groundwater.

Groundwater bore locations are shown in Figure 9. All bores were assessed for a suite of heavy metals and TPHs. Field information and previous results from existing bores were used to determine other parameters required for analysis. Figure 10a shows the interpreted extent of heavy-metal impacts on groundwater, relative to both the Fresh Waters and Drinking Waters assessment levels. The interpreted extent of impacts by hydrocarbons, solvents, and pesticides are indicated on Figure 10b. (Where dichloromethane was the only VOC detected in a sample, it has been excluded from the discussion, as dicholormethane was identified in a trip blank, and is therefore considered to be residual from laboratory solvent-washing of bottles.)

The results of recent (September/October 2005, and March 2006) rounds of sampling are described below in two sections, representing impacts identified in bores representing the Shallow Superficial Aquifer (Section 3.4.2) and impacts in bores representing the Lower Superficial Aquifer (Section 3.4.3). Bores with their base in the Upper Clays are considered to represent the SSA, including three bores that have water levels suggesting some influence by the LSA (discussed in Section 2.5.4).

3.4.2 Shallow Superficial Aquifer (SSA)

Impacts have been identified in a number of bores screened in the SSA. No results are available for bores ATA-13 or ATA-14, which did not have sufficient water to allow sample collection following purging. Low level metal impacts (i.e. above Fresh Water Guidelines) are the most widespread form of contamination, present in samples from all bores in the SSA as summarised in Table 7. Three bores also exceed Drinking Water assessment levels for nickel or manganese. The Drinking Water level for manganese is more stringent than the Fresh Waters assessment level.

TABLE 7
METAL RESULTS EXCEEDING GUIDELINES, SHALLOW SUPERFICIAL AQUIFER (SSA)

	Cadmium	Copper	Manganese	Mercury	Nickel	Zinc
Drinking Water	**0.002**	**2**	**0.5**	**0.001**	**0.02**	**3**
Fresh Waters	**0.0002**	**0.0014**	**1.9**	**0.00006**	**0.011**	**0.008**
Sample ID	**2005-2006 Water Analytical Results (mg/L)**					
ATA-1	<0.0002	**0.002**	-	<0.0002	<0.001	0.003
ATA-2	<0.0002	**0.013**	-	**0.0003**	**0.017**	**0.62**
ATA-3	<0.0002	0.001	0.002	<0.0001	0.004	**0.049**
ATA-4	<0.0002	<0.001	**0.92**	<0.0001	0.006	**0.10**
ATA-5	<0.002	**0.004**	-	<0.0001	**0.013**	**0.29**
ATA-6	**0.0003**	0.001	-	<0.0001	**0.18**	**0.21**
ATA-7	**0.0005**	**0.006**	-	<0.0001	**10.0**	**0.21**
ATA-8	<0.0002	**0.009**	-	**0.0003**	**0.013**	**0.30**
ATA-9	<0.0002	**0.003**	-	<0.0001	0.007	**0.10**

ATA-10	<0.0002	0.001	-	<0.0001	0.002	**0.016**
ATA-11	**0.0003**	**0.003**	-	<0.0001	**0.014**	**0.14**
ATA-12	<0.0002	0.001	-	<0.0001	0.010	**0.096**
H5B	<0.001	<0.001	0.04	<0.0001	**0.017**	**0.032**
H5H	<0.0002	**0.003**	-	<0.0001	0.006	**0.14**
HE-1	<0.001	**0.002**	0.03	<0.0001	0.004	**0.067**
HE-6	<0.0002	**0.010**	-	<0.0001	**0.019**	**0.65**
HE-9	<0.0002	<0.001	-	<0.0002	0.003	0.003
HE-14	<0.0001	**0.006**	<0.01	<0.0001	**0.016**	**0.078**
HE-17	<0.0002	<0.001	0.039	**0.0004**	**0.013**	**0.39**
HP-13	<0.0002	<0.001	-	<0.0001	0.003	**0.095**
HP-15	<0.0001	<0.001	0.07	<0.0001	0.006	**0.043**

Relative to the Fresh Waters assessment levels, the data in Table 7 indicate that zinc contamination is present nearly uniformly across the site, and that nickel and copper impacts are also widespread. Relative to the Drinking Water assessment levels, manganese contamination is present in one bore, and nickel contamination is present in two bores. The highest nickel concentration (in bore ATA-7) is likely associated with historical activities at the adjacent Plating Shop.

The data in Table 8 indicate that PAH and OC pesticide impacts are confined to a total of three bores at Helena East. The most significant contamination is associated with Bore HE-17, which exceeds Fresh Waters assessment levels for PAHs and several OC pesticides. Bore HE-17 is also the location where free-phase LNAPL was identified. Although there are no guidelines for TPHs, detectable concentrations are in found all of these bores as well.

TABLE 8
PAH AND PESTICIDE RESULTS EXCEEDING GUIDELINES, SHALLOW SUPERFICIAL AQUIFER (SSA)

	PAHs		**OC/OP Pesticides**		
	Naphthalene	**Total PAH**	**Aldrin**	**DDT**	**Total Chlordane**
Drinking Water	**NV**	**NV**	**0.3**	**20**	**1**
Fresh Water	**16**	**3**	**0.01**	**0.006**	**0.03**
Sample ID	**2005-2006 Analytical Results (µg/L)**				
H5B	**97**	-	-	-	-
HE-17	**120**	**182.6**	**0.14**	**2.9**	**0.131**
HP-13	**71**	**250.3**	-	-	-

The PAHs in bores H5B and HP-13 are related to the plume of hydrocarbon contamination at the southwest corner of the Tarpaulin Shop. The data indicate that the large hydrocarbon plumes south of the Power House/Element Shop have a limited extent within the Shallow Superficial Aquifer, only impacting two bores (H5H and HE-17). As indicated in Table 9, HE-17 is also affected by solvents.

TABLE 9
SOLVENT RESULTS EXCEEDING GUIDELINES, SHALLOW SUPERFICIAL AQUIFER (SSA)

	Benzene	m & p-Xylenes	o-Xylene	Vinyl chloride	Carbon tetrachloride	Dichloromethane	1,2-Dichloroethane	Trichloroethene	Tetrachloroethene
Drinking Water	1	600		0.3	3	4	3	70	50
Fresh Waters*	950	200	350	0.7*	NV	NV	NV	500*	40*
Sample ID	**2005-2006 Analytical Results (µg/L)**								
H5H	4	<2.0	8.3	470	<1.0	4.4	29	1400	190
HE-17	9	670	580	320	590	98	85	4100	31000

* Indicates some values taken from Dutch Intervention Levels.

Solvent concentrations are above both Fresh Waters and Drinking Water assessment levels in bore HE-17 and in bore H5H. Trace concentrations of benzene-based solvents are detected in bore HP-13, although there are no guidelines for these compounds. In addition, low concentrations of multiple VOCs derived from DNAPL solvents were also detected in bores ATA-8, ATA-9, and ATA-11, although at concentrations below the assessment levels. The distribution of VOC impact (Figure 10b) may be a function of a relatively large source zone, or the migration of DNAPL material via permeable horizons in the Upper Clays.

3.4.3 Lower Superficial Aquifer (LSA)

As in the SSA, extensive impacts have been identified in bores screened in the LSA. Low level metal impacts (i.e. above Fresh Water Guidelines) are the most widespread form of contamination, present in samples from all bores in the LSA as summarised in Table 10. Seven bores also exceed the Drinking Water assessment level for nickel.

TABLE 10
METAL RESULTS EXCEEDING GUIDELINES, LOWER SUPERFICIAL AQUIFER (LSA)

	Cadmium	Copper	Mercury	Nickel	Lead	Zinc
Drinking Water	0.002	2	0.001	0.02	0.01	3
Fresh Waters	0.0002	0.0014	0.00006	0.011	0.0034	0.008
Sample ID	**2005-2006 Water Analytical Results (mg/L)**					
ATA-15	<0.0002	0.002	<0.0001	0.003	<0.001	0.093
ATA-16	<0.0002	<0.001	<0.0001	0.009	0.004	0.18
ATA-72	<0.0001	<0.001	<0.0001	0.005	<0.001	0.008
ATA-73	<0.0001	<0.001	<0.0001	0.007	0.002	0.011
ATA-75	<0.0001	0.001	<0.0001	0.028	0.001	0.36
ATA-76	<0.0001	<0.001	<0.0001	0.210	0.002	3.2
ATA-77	0.0005	0.001	<0.0001	0.032	0.004	0.23
B3	0.0003	0.003	<0.0001	0.17	<0.001	0.092
HE-2	0.0002	0.007	<0.0001	0.008	0.003	0.076

HE-3	<0.0002	0.001	<0.0001	0.003	<0.001	**0.28**
HE-5	<0.0002	**0.027**	<0.0001	**0.092**	0.002	**1.20**
HE-7	**0.0004**	**0.003**	<0.0001	0.002	<0.001	**0.22**
HE-8	<0.0002	**0.007**	**0.0004**	0.003	<0.001	**0.71**
HE-11	<0.0002	<0.001	<0.0001	**0.031**	<0.001	**0.19**
HE-15	**0.0002**	**0.004**	<0.0001	**0.063**	<0.001	**0.39**
HWMW1	<0.0002	<0.001	<0.0001	**0.011**	<0.001	**0.11**

Relative to the Fresh Waters assessment levels, the data in Table 10 indicate that elevated zinc levels are present in all bores, and that copper and nickel impacts are also extensive. Although cadmium impacts are identified in five bores, the Fresh Water assessment levels are equal to the laboratory limit of detection and thus the results have some uncertainty. The same caveat applies for mercury, where the Fresh Waters assessment level is less than the available laboratory limit of detection.

Relative to the Drinking Water assessment levels, nickel contamination is present in four bores. The nickel concentration in bores B3 and ATA-76 are similar to that in the Shallow Superficial Aquifer bore, ATA-6, which is considered to be associated with former activities at the adjacent Plating Shop. The next highest nickel concentration is in bore HE-5, which is upgradient of industrial activities at Helena East and considered representative of water entering from offsite.

No PAHs or OC pesticides were detected in bores representing the LSA. Solvents, in the form of VOCs derived from DNAPLs, were detected in two bores, as indicated in Table 11; no BTEX components were detected. (The VOC results for bores ATA-72 to ATA-77 have yet to be received.) TPHs were detected in bore HWMW1; however, there are no guidelines for TPH concentrations. The TPHs in groundwater, presumably derived from LNAPLs, have migrated through the Upper Clays, and consequently contamination is migrating in groundwater within the upper part of the Lower Sands. No free-phase LNAPL was identified in LSA bores.

TABLE 11
SOLVENT RESULTS EXCEEDING GUIDELINES, LOWER SUPERFICIAL AQUIFER (LSA)

	Vinyl chloride	**Trichloroethene**	**Tetrachloroethene**
Drinking Water	**0.3**	**70**	**50**
Fresh Waters*	**0.7***	**500***	**40***
Sample ID	**2005 Results (µg/L)**		
ATA-16	**5.4**	**120**	**180**
HE-7	**36**	**550**	**700**

* Indicates values taken from Dutch Intervention Levels.

Samples from bores ATA-16 and HE-7 (which are located approximately 2m apart) contain VOCs exceeding both Drinking Water and Fresh Waters assessment levels. Multiple VOCs were detected in only one other LSA bore, HE-3, whose location marks the northwest extent of known DNAPL impact. Based on the northwesterly flow direction of groundwater in the LSA, it is anticipated that VOCs may appear in bores HE-2 and ATA-15 in the future.

3.4.4 Leederville Aquifer

Site-specific groundwater investigations have not been performed in the Leederville Formation for several reasons, including its significant depth and due to the understanding that it is capped by a shale unit which should prevent downward migration of contamination, particularly DNAPL material.

The depth to the Leederville Formation is estimated at –20mAHD, approximately 35m to 40m BGL, at Helena East based on data obtained during the installation of abstraction (irrigation) bores into the Leederville Formation to the east and west of the site. An abstraction bore into the Leederville Formation, known as Irrigation Bore 2, was installed to 118mBGL at the northern edge of the Coal Dam in Helena West in July 2005. Based on a review of the drilling and geophysical logs, the strata intersected by Irrigation Bore 2 are interpreted as comprising Waste Fill material overlying Guildford Formation to a depth of 22mBGL, underlain by sands of the Henley Sandstone to a depth of 45mBGL, followed by intercalated sands and clays of the Leederville Formation. A water sample from this bore was analysed for physio-chemical parameters after bore installation in June 2005 (as reported in a letter by RBM Drilling, 2005), indicating that the water had a pH of 6.9 and total dissolved solids of 517mg/L.

Another sample from this bore was collected (sample label IB-1) during February 2006 and analysed for a suite of heavy metals, TPHs, PAHs, and VOCs. The results, included in Appendix 10, indicate that no TPHs, PAHs, nor VOCs were detected in the water sample, and all metal concentrations are below the Drinking Water guidelines. Zinc is present at 0.008mg/L, which equals the Fresh Waters criteria for this parameter. As Irrigation Bore 1 is located downgradient of the Helena East site, this result suggests that water in the Leederville Formation is unaffected by the contamination detected in the SSA and LSA at Helena East.

Another abstraction bore, known as Irrigation Bore 1, was installed at Area B, C, and D, just east of Helena East in May 2001. A sample of water from this bore was analysed for physio-chemical parameters, major and minor ions, nutrients, and silica in May 2001, as reported in the Bore Completion Report included in Appendix A of ENV (2003b). It is proposed to collect another sample from this bore in order to analyse the water for a suite of heavy metals, TPHs, and PAHs as was done for Irrigation Bore 2. However, Irrigation Bore 1 is not currently connected to a power supply, and ATA are awaiting confirmation that the bore and pump are operational in order to collect a sample.

3.4.5 Discussion

The bores installed by ATA in support of this PER provide additional data about groundwater quality beneath Helena East. Overall, recent rounds of sampling confirm what was anticipated based on previous rounds: widespread and elevated concentrations of zinc and some copper relative to the Fresh Waters assessment levels; some nickel at concentrations exceeding the Drinking Water assessment levels; and some BTEX, PAH, and VOC impacts in bores south of the Power House and south of the Tarpaulin Shop.

The additional bores better delineate the extent of various contaminants, particularly VOCs. Furthermore, a review of bore construction and groundwater elevation data as part of this PER has allowed a discussion of groundwater results in terms of those belonging to the Shallow Superficial Aquifer, and those representing the Lower Superficial Aquifer. Seven bores into the LSA have been installed and sampled by ATA, and data from ENV indicate seven previously installed bores also represent this system. On the basis of the bore log data, it is considered possible that several of the previously installed bores have been constructed in a manner that crosses the Upper Clay – Lower Sands boundary; three of these bores (HE-2, HE-3, and HE-7) were filled with grout and decommissioned in January 2006.

The earliest available results from bore HE-7 in September 2003 (ENV, 2004) indicate that this bore contains significant levels of VOCs. Between the last round of sampling by ENV (December 2004) and the most recent round of sampling by ATA (September/October 2005), the maximum concentrations of VOCs have moved westwards to bore HE-17, which remains significantly impacted by xylenes and the PAH naphthalene.

3.4.6 Additional Work

Although metal impacts are widespread, DNAPL contamination and its migration are considered to be the most significant groundwater issues at Helena East. Some of the metal contamination may be regional; the portion relating to leaching of metals out of Waste Fill will be substantially reduced by the removal of laterally extensive deposits of Waste Fill at Helena East as part of remedial works and redevelopment. TPH impacts can be significantly mitigated by removal of the source material in soil that is confined to the interval above the seasonal groundwater table elevation. On the other hand, DNAPL contamination is likely to be much more difficult to deal with as it is unlikely to be possible to remove sufficient source material to reduce the groundwater concentrations below assessment levels. Residual DNAPL can be excavated from the inferred source zone, but DNAPL that has reached the LSA is unlikely to be removable even by the most sophisticated current technology.

The full extent of the DNAPL impact on the LSA is not currently clear. Additional investigations to define the vertical and lateral extent of this contamination are currently in progress, and will continue concurrent with the PER process.

Based on the information that the LSA is underlain by a shale unit that caps the Leederville Formation, it is considered that DNAPL contamination from the site does not have access to the Leederville Formation. A water sample from an abstraction bore drawing from the Leederville Formation, downgradient of the site, did not contain detectable concentrations of VOCs. It is therefore considered unnecessary at this stage to conduct investigations into the Leederville Aquifer.

4. RATIONALE FOR SITE REMEDIATION

The Western Australian DoE has published a series of guidelines that provide advice on the preferred approaches to the assessment and remediation of contaminated sites. The approach is broadly based on the national site contamination assessment approach outlined in the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPC, 1999).

The methodology involves a staged approach to decision making commencing with an assessment of the site to determine the nature, extent and seriousness of any contamination that may be present and then proceeding to the development of a remediation strategy.

The purpose of a site assessment is to assess whether a site is contaminated to the extent that it poses an actual or potential risk to human health and the environment, either on or off the site, of sufficient magnitude to warrant remediation and to identify the extent of remediation required, appropriate to the final land use.

The site contamination assessment is undertaken as a risk assessment with the following basic components:

- identification of potential exposure pathways of contaminants;
- identification of the potential receptors that these pathways lead to;
- definition of assessment criteria and action trigger levels for health and environmental values that need to be protected;
- assessment of appropriate health investigation levels;
- assessment of the toxicity of contaminants on ecological and human health; and
- completion of ecological and health risk assessment.

The risk assessment is often undertaken in stages, with a decision to proceed to a greater level of complexity being made after evaluation of the completed stages.

The initial stage of assessment comprises the comparison of contaminant concentrations against the most appropriate trigger levels. Where appropriate, subsequent stages may involve numerical modeling to quantify the level of risk associated with contaminants. The final remediation strategy adopted is informed by the risk assessment in conjunction with consideration of a number of other site-specific factors.

The remainder of this section assesses the available data for the Helena East and Southern Embankment areas within this assessment framework.

4.1 Contaminant Pathways

4.1.1 Groundwater

Groundwater is present in the clays and sands that underlay the site. As discussed in Section 2.5.4, the minor SSA exists within the Upper Clays at the site, and the LSA is present as within the Lower Sands unit, typically located at approximately 10mBGL. The LSA appears to be continuous and to extend off-site. The regionally significant Leederville Aquifer is present at a depth of approximately 40mBGL, beneath a capping layer of shale

The low permeability of the Upper Clays unit limits the rate of vertical and horizontal groundwater movement in the SSA (Crisalis, 2005). The general direction of flow in the SSA is inferred as being to the south-west toward the Helena River, but flow velocities are low and the gradients large as a result of the low permeability of the sediments (Crisalis, 2005). As a consequence, there is little evidence that contaminants that are present in the SSA as a result of historical land uses are migrating into the LSA. (The downslope migration of hydrocarbon contamination at the Southern Embankment results from the presence of the permeable, sloping Waste Fill horizon rather than the Upper Clay unit at this break in slope.) The SSA is considered to be in only limited connection with the underlying LSA, which is in turn is considered not to be in hydraulic connection with the underlying Leederville Aquifer. The SSA is therefore not regarded as a significant pathway for contaminant migration.

Groundwater monitoring in the SSA indicates that water entering the site from the north is contaminated with detectable levels of metal contamination (particularly zinc) and water exiting the site to the south and west generally shows similar levels of contamination. There is little evidence that contamination is migrating laterally from the site in groundwater, aside from the downslope migration of hydrocarbon contamination from the southern edge of Helena East across at the Southern Embankment via Waste Fill, which has been delineated as truncating close to the southern boundary of the Southern Embankment.

Groundwater in the LSA flows to the north-west (ENV, 2003b; Crisalis, 2005). The sediments of the LSA are more permeable than those of the SSA and this aquifer appears to extend off-site; the LSA is therefore a potential pathway for contaminants to migrate off-site from Helena East and the Southern Embankment. The ultimate fate of water in the LSA is uncertain; it is possible that the groundwater in the LSA eventually discharges into the Swan River.

There is some evidence that VOC contamination in the SSA has migrated vertically to impact on the LSA, and as a result there is a need for further investigation to determine the extent and severity of this contamination. Investigations into this issue have commenced and are currently ongoing.

The Helena River runs along the southern boundary of the site at a distance of approximately 50m at its closest point. The Helena River has been dammed upstream and now only flows during the winter months or following major rainfall events in the drier months of the year. The Helena River eventually discharges into the Swan River approximately 4km to the west of Helena East. The channel of the Helena River is incised into impermeable clays; as a result there is no significant groundwater recharge to the river from the LSA in the vicinity of Helena East (ENV, 2002b). The LSA is located at sufficient depth that there appears to be limited or no connection between it and the Helena River (Crisalis, 2006). The LSA is therefore not regarded as a significant pathway for contaminant migration.

4.1.2 Surface Water

Much of the site is covered by buildings and hardstand. Surface water from these areas is collected and piped to the Helena River floodplain before it eventually discharges to the Helena River channel in periods of high rainfall.

There is no evidence of significant surface flows in the limited areas of the site that are not covered by buildings or hardstand. This suggests that incident rainfall tends to infiltrate through the shallow surface fill and then either migrate laterally along the clays at the top of the SSA or recharge the more permeable sediments where these are present at shallow depths.

Where the surface water contacts contaminated material it would act as a pathway for the migration of contaminants but given the fact the majority of the site is covered by buildings or hardstand there is limited risk of this occurring.

The risk of contamination of surface water will increase during the remediation process, and as a result there a Surface Water Management Plan has been developed (see Section 7.3). The purpose of the plan is to ensure that contaminated surface water does not contaminate the Helena River (and potentially the Swan River) during remediation operations.

4.1.3 Air Emissions

Hydrocarbon (i.e. TPH, PAH, BTEX, and VOC) contamination in soils can, under some circumstances, emit vapours to atmosphere that can expose those living or working in the area to airborne contamination. This is generally only a concern with volatile materials (particularly BTEX and VOCs) located near the soil surface and in porous sandy soils. This is not the case at Helena East where the hydrocarbon contamination is generally confined at some depth in the Upper Clays unit. In some cases, contaminated areas are covered by buildings or hardstand. In addition, the contamination was generally caused by activities that occurred at least a decade ago, allowing time for materials to volatalise and disperse where geology and site cover allowed. As a result, the airborne release of materials is not regarded as a significant pathway unless hydrocarbon or solvent contaminated soil is disturbed.

There is a risk of airborne emissions during the remediation and redevelopment of the site which could result in the release of contaminated dust and hydrocarbon vapours. As a result there is a need for management plans to be developed to control these impacts

4.1.4 Summary

The following contaminant pathways are considered **complete** to varying extents and are therefore a potential risk to receptors:

- The SSA:
  - Due to its low permeability and the limited recharge from rainfall, this is regarded as a minor pathway.

- The LSA:
  - This is potentially a significant pathway for off-site migration of contaminants if contaminants migrate into it from the SSA.

- Surface drainage flows:
  - Under current site conditions and following remediation redevelopment these are regarded as a minor pathway (i.e. only where they contact contaminants).
  - During the remediation process when contaminated soils will be exposed to incident rainfall these are regarded as potentially a significant pathway.

- Air emissions:
  - At present or following remediation these are not regarded as a complete pathway.
  - During the remediation process when contaminated soils will be disturbed air emissions are regarded as a potentially significant pathway.

The following potential exposure pathways were considered to be **incomplete** and therefore do not represent a risk to receptors:

- Exposure of aquatic ecosystems due to migration of groundwater in the Leederville Aquifer:
  - There is evidence of local metal and hydrocarbon contamination in the SSA.
  - There is limited evidence of minor solvent (DNAPL) contamination in the LSA.
  - The Leederville Aquifer is present at significant depth and is overlain by a shale unit which would act to prevent vertical migration of DNAPL contamination from the deeper superficial aquifer.

- Extraction of groundwater as a primary potable water source:
  - The limited capacity of the SSA and the vulnerability of both the SSA and the underlying LSA due to adjacent urban areas that surround them means that groundwater in the vicinity of the site would not be suitable for extractive use as a primary potable water source.
  - The LSA is not a proclaimed drinking water resource, nor is it likely to be in the future.
  - The Department of Health strongly recommends against the human consumption of untreated shallow groundwater underlying Perth's urban areas.
  - Accordingly, the aquifer has not been recognised as a source of drinking water within this PER.

- Exposure of the Swan River aquatic ecosystems due to the discharge of potentially contaminated water from the Helena River into the Swan River.
  - There is little evidence to suggest contamination is occurring in the Helena River due to discharges from Helena East and the Southern Embankment.

- Investigations suggest there is minimal hydraulic connection between the aquifers under Helena East and the Southern Embankment and the Helena River (ENV, 2002a).
- The discharge point for the Helena River into the Swan River is located some 4km down-gradient of the site, providing for lengthy travel times for contaminants to mix with the overall flow and be attenuated by a range of natural processes.
- The minor nature of the flows from the Helena River when compared to the flows in the Swan River suggest that the water quality in the Helena River would have a minimal impact on the overall water quality in Swan River.

4.2 Potential Receptors

This section of the report discusses the potential receptors of contamination impacts from Helena East and the Southern Embankment at present, prior to remediation.

4.2.1 Groundwater Pathway Receptors

The presence of contamination in the groundwater system is not necessarily a significant risk unless the groundwater pathway links to a sensitive receptor. Possible receptors for the groundwater system include:

- Human receptors, should the groundwater be brought to the surface due to discharge in a river, wetland or spring or as a result of pumping from a well or bore. This includes the possibility that groundwater under the site may discharge into another aquifer that is used for human consumption.

- Vegetation where the root systems intersect contaminated groundwater, or where water is extracted for irrigation purposes.

- Ecosystem receptors such as rivers and wetlands, where the contaminated groundwater discharges into these systems.

There is currently negligible threat to human receptors at the site resulting from contaminated groundwater at the site as:

- There is no onsite extraction of groundwater from the SSA where soil and groundwater contamination is known to be present.

- Only a limited connection exists between the SSA and underlying LSA, so the potential for the LSA to become significantly contaminated (i.e. by DNAPL) is low. In any case, there is no onsite extraction from the LSA, so the only threat to a human receptor from the LSA would be in the case that contamination migrates offsite in this aquifer into a surface water body or to an area where this aquifer is used for extraction.

- The Leederville Aquifer underlying the LSA is used as a source for both irrigation water and water used for human consumption. The top of this major regional aquifer lies at a depth of at least 40mBGL and is protected by a shale aquiclude. Given the limited connection between the SSA and LSA, the lack of evidence of widespread contamination in the LSA, the depth to the shale unit and its low permeability, the Leederville Aquifer is not identified as potential receptor for contamination originating from the site.

- Only a limited connection exists between the SSA and LSA, and a similarly limited connection is thought to exist between the LSA and the Helena River. As a result, contaminants are not considered likely to migrate from Helena East at a rate or in concentrations that will result in significant human exposures in the waters of either the Helena River or the Swan River, which is the final discharge point for the Helena River.

The vegetation on the Helena River floodplain is considered in Section 2.6.1. The vegetation is degraded, consists largely of wetland species, and is reliant on the presence of shallow ground- and surface water in winter. As a result, this vegetation is a potential receptor for contaminants that migrate from Helena East and the Southern Embankment. Evidence from groundwater monitoring suggests that extensive low-level metal contamination exists in the SSA and LSA, but that no TPH contamination extends off-site. The regional groundwater metal contamination may potentially impact on the floodplain vegetation, suggesting that the vegetation is a potential receptor to groundwater impacts.

4.2.2 Surface Water Receptors

The only significant surface water features in the immediate vicinity of Helena East and the Southern Embankment are the Helena River and the Coal Dam. The Coal Dam, located in the Helena West Precinct, is not considered further as a receptor due to the low hydraulic conductivity of the SSA, and as the groundwater flow direction within the SSA is away from the Coal Dam at Helena West, and towards the southeast at Helena East.

The Helena River is natural watercourse that drains water from the Darling Scarp and foothills area to the east of Midland into the Swan River at Guildford. Flows in the Helena River have greatly decreased since the construction of the Mundaring Weir and Lower Helena Pipehead Dam, which capture and retain much of the flow of the Helena River.

The Helena River has been assigned a ‘slightly to moderately disturbed’ level of aquatic ecosystem protection in recognition of the fact that the site is located quite high in relation to the catchment area and much of the upstream catchment area is in a natural or rural state. The fact that the Helena River discharges into the Swan River which has high ecological and societal importance also influenced this decision.

No studies could be located that described the types of potential ecological receptors present in the Helena River near the site. However, given the transient nature of flows in this section of the river and the narrowness of the channel, it is considered that the river supports a limited range of aquatic fauna in the vicinity of Helena East and the Southern Embankment.

The watercourse of the Helena River is largely incised in impermeable clay and therefore there is little contribution to the river flow from groundwater compared with the lower reaches of the Swan River. A previous investigation (ENV, 2003b) indicates that there is no hydraulic connection between the SSA and the Helena River. This view is supported by an independent hydrogeology review completed by Dr. Chris Barber at the request of ATA Environmental (see Appendix 4, Crisalis 2005 and 2006). The review supports the view that there is limited connection between either the SSA or the LSA and the Helena River and as a result contaminant migration will be limited (Crisalis, 2005 and 2006). As a result, the Helena River is not considered to be a significant receptor of contamination from Helena East and the Southern Embankment except in the case of contaminated surface water flows.

4.2.3 Airborne Pathway - Human Receptors

Workers, visitors, and residents living on the site (under future residential or industrial/commercial land use) could potentially be exposed to contamination through emissions of dust, direct contact with contaminated soils on the ground surface, or through aerosols released from irrigation with contaminated waters. The latter contact has been discounted in the discussion in Section 4.2.1.

Under current site conditions, there are no residents on site and a limited workforce that is confined largely to the relatively lightly contaminated northern area of Helena East. As the majority of the site is covered by hardstand or buildings, the threat of airborne emissions affecting human receptors is considered is assessed as non-significant.

During remediation, direct contact with contaminated material will be minimised and management measures implemented to suppress the emission of dust and volatile organics. These are detailed in the Environmental Management Plans prepared for the remediation.

With regard to the risk to human health post-development, a number of preventative measures will be put in place to ensure human risk is minimised, these are discussed in later sections.

4.3 Contamination Assessment Criteria

The results of the soil investigation program were assessed in accordance with the DoE document *Assessment Levels for Soil, Sediment and Water* (DoE, 2003). The soil assessment levels used to identify contamination were discussed in Section 3.3.1. Less-stringent criteria may also be used to assess a site, depending on its land use and if there are potential receptors for the contaminants identified.

Based on available information about contamination at the site, proposed future land uses, and minimal potential impacts on receptors, it is considered that less-stringent remediation criteria may be adopted. The various assessment criteria are reviewed below.

4.3.1 Soil

Ecological Investigation Levels (EILs)

The contaminant levels in soil were initially screened against Ecological Investigation Levels (EIL) to assess the potential risk to environmental receptors and groundwater resources (as presented in Appendix 9). EIL guidelines represent protection of ecological values and are the first tier of assessment criteria. EIL guidelines are almost uniformly more stringent than Health Investigation Levels. EIL values (from DoE, 2003) are presented in Table 12 below.

Health Investigation Levels (HILs)

Contaminant concentrations present in the soils have also been compared against the Health Investigation Levels (HILs) to assess the potential risk to human health (Appendix 9). Due to the variability in proposed land uses the exposure settings selected for assessment purposes are HIL-A, HIL-E and HIL-F, which correspond to the following:

- HIL-A: standard residential with garden/accessible soil and includes children's day care centres, kindergarten, pre-schools and primary schools.
- HIL-E: parks, recreational open space and playing fields, including secondary schools.
- HIL-F: commercial/industrial land uses including premises such as shops and offices.

These levels are based on very conservative exposure scenarios for particular land uses such as long term occupation of the site. HIL values (from DoE, 2003) are presented in Table 12 below.

Other

There are no EIL or HIL guidelines for asbestos or volatile organic compounds (VOCs) such as halogenated hydrocarbons. For asbestos, detection is considered to indicate contamination. For VOCs, Soil Screening Levels (SSLs) presented in the United States Environmental Protection Agency (US EPA) document, *Soil Screening Guidance: Technical Background Document* (US EPA, 1996) have been adopted in order to identify areas of soil impact at the site. As groundwater is considered to be the primary receptor for contaminants in soil, the 20DAF values have been adopted. These values arrive at an acceptable soil concentration by assuming reduction by a dilution–attenuation factor (DAF) of 20 due to natural subsurface processes between the soil source and the receptor well. As the soils at the site have low hydraulic conductivity and the source area is less than 30 acres (12ha), the 20DAF values are considered appropriate. The 20DAF levels do not consider residential or industrial scenarios. It may therefore be appropriate to use the US EPA's Preliminary Remediation Guidelines (PRGs) as assessment criteria for remediation (www.epa.gov/region09/waste/sfund/prg/intro.htm).

TABLE 12
ASSESSMENT LEVELS FOR SOIL (DoE, 2003)

Parameter	Ecological Investigation Levels[1] (mg/kg)	Health Investigation Levels (mg/kg)					
		A	B[2]	C[3]	D	E	F
Total Petroleum Hydrocarbons (TPH)							
C_6-C_9	100[4]	-	-	-	-	-	**deleted**
C_{10}-C_{14}	500[4]	-	-	-	-	-	**deleted**
C_{15}-C_{28}	1000[4]	-	-	-	-	-	**deleted**
>C_{16}-C_{35} (Aromatics)	-	90[5]	-	-	360[5]	180[5]	450[5]
>C_{16}-C_{35} (Aliphatics)	-	5600[5]	-	-	22400[5]	11200[5]	28000[5]
>C_{35} (Aliphatics)	-	56000[5]	-	-	224000[5]	112000[5]	280000[5]
Monocyclic Aromatic Hydrocarbons (MAHs)							
Benzene	1[7]	**1[8]**	-	-	-	-	**1.5[8]**
Toluene	3[6]	**520[8]**	-	-	-	-	**520[8]**
Ethylbenzene	5[6]	**230[8]**	-	-	-	-	**230[8]**
Xylenes	5[6]	**210[8]**	-	-	-	-	**210[8]**
Metals/Metalloids							
Antimony, Sb	20[7]	**30[8]**	-	-	-	-	**820[8]**
Arsenic, As	20[7]	100[5]	-	-	400[5]	200[5]	500[5]
Barium, Ba	400[6]	**5370[8]**	-	-	-	-	**100000[8]**
Beryllium, Be	-	20[5]	-	-	80[5]	40[5]	100[5]
Cadmium, Cd	3[7]	20[5]	-	-	80[5]	40[5]	100[5]
Chromium (III)	-	12%[5]	-	-	48%[5]	24%[5]	60%[5]
Chromium (VI)	-	100[5]	-	-	400[5]	200[5]	500[5]
Chromium (Total), Cr	50[7]	**210[8]**	-	-	-	-	-
Cobalt, Co	50[8]	100[5]	-	-	400[5]	200[5]	500[5]
Copper, Cu	60[7]	1000[5]	-	-	4000[5]	2000[5]	5000[5]
Lead, Pb	300[7]	300[5]	-	-	1200[5]	600[5]	1500[5]
Manganese, Mn	500[7]	1500[5]	-	-	6000[5]	3000[5]	7500[5]
Methyl mercury	-	10[5]	-	-	40[5]	20[5]	50[5]
Mercury, Hg	1[7]	15[5]	-	-	60[5]	30[5]	75[5]
Molybdenum, Mo	40[6]	**390[8]**	-	-	-	-	**10220[8]**
Nickel, Ni	60[7]	600[5]	-	-	2400[5]	600[5]	3000[5]
Tin, Sn	50[7]	**46900[8]**	-	-	-	-	**100000[8]**
Zinc, Zn	200[7]	7000[5]	-	-	28000[5]	14000[5]	35000[5]
Phenols							
Phenol	-	8500[5]	-	-	34000[5]	17000[5]	42500[5]
Total Phenols	1[6]	-	-	-	-	-	10[8]
Pesticides							
Individual Organochlorine Pesticides eg. Aldrin	0.5[6]	-	-	-	-	-	-
Total Organochlorine Pesticides	1[6]	-	-	-	-	-	-
Individual Non-Chlorinated Pesticides	1[6]	-	-	-	-	-	-
Total Non-Chlorinated Pesticides	2[6]	-	-	-	-	-	-
Dieldrin	0.2[7]	-	-	-	-	-	-
Aldrin + Dieldrin	-	10[5]	-	-	40[5]	20[5]	50[5]
Chlordane	0.5[6]	50[5]	-	-	200[5]	100[5]	250[5]
DDT + DDD + DDE	1[6]	200[5]	-	-	800[5]	400[5]	1000[5]
Heptachlor	0.5[6]	10[5]	-	-	40[5]	20[5]	50[5]

(continued over)

Parameter	Ecological Investigation Levels[1] (mg/kg)	Health Investigation Levels (mg/kg)					
		A	B[2]	C[3]	D	E	F
Polychlorinated Biphenyls (PCBs)							
Total PCBs	1[7]	10[5]	-	-	40[5]	20[5]	50[5]
Polycyclic Aromatic Hydrocarbons (PAHs)							
Total PAHs	20[6]	20[5]	-	-	80[5]	40[5]	100[5]
Anthracene	10[6]	**21900[8]**	-	-	-	-	**100000[8]**
Benzo[a]pyrene	1[6]	1[5]	-	-	4[5]	2[5]	5[5]
Fluoranthene	10[6]	**2290[8]**	-	-	-	-	**30100[8]**
Naphthalene	5[6]	**60[8]**	-	-	-	-	**190[8]**
Phenanthrene	10[6]	-	-	-	-	-	100[8]
Pyrene	10[6]	**2310[8]**	-	-	-	-	**54220[8]**
Other							
Boron, B	-	3000[5]	-	-	12000[5]	6000[5]	15000[5]
Cyanides (Complexed)	50[6]	500[5]	-	-	2000[5]	1000[5]	2500[5]
Cyanides (Free)	10[6]	250[5]	-	-	1000[5]	500[5]	1250[5]
Sulphate[9]	2000[7]	-	-	-	-	-	-

Notes:

Where changes have been made to this table since the release of the first draft of this guideline (formerly Contaminated Sites Assessment Criteria (DEP, 2000)), these are identified in bold print.

A. Standard residential with garden/accessible soil (home grown produce contributing less than 10% of vegetable and fruit intake; no poultry); this category includes children's daycare centres, kindergartens, pre-schools and primary schools.

B. Residential with substantial vegetable garden (contributing 10% or more of vegetable and fruit intake) and/or poultry providing any egg or poultry meat dietary intake.

C. Residential with substantial vegetable garden (contributing 10% or more of vegetable and fruit intake); poultry excluded.

D. Residential with minimal opportunities for soil access: includes dwellings with fully or permanently paved yard space such as high-rise apartments and flats.

E. Parks, recreational open space and playing fields, includes secondary schools.

F. Commercial/Industrial, includes premises such as shops and offices as well as factories and industrial sites

Adopted from the *National Environment Protection (Assessment of Site Contamination) Measure (NEPC 1999)*

– No level available.

1. The EILs presented in this table vary slightly to the EILs presented in NEPM (NEPC, 1999). These variations relate to chromium (total), copper, lead, barium, phosphorus and sulphur. In the NEPM, these values are based on considerations of phytotoxicity and background soil survey data from four Australian cities (all outside Western Australia). For chromium (total), copper, and lead, the DEP has retained the values as presented in the ANZECC/NHMRC 1992 document. For barium, the DEP has retained the value as presented in Moen et. al. (1986) (Dutch B). There is currently insufficient information to establish values for sulphur, phosphorus and vanadium for soils in WA. For these parameters, site-specific criteria should be developed.
2. Site and contaminant specific: on-site sampling is the preferred approach for estimating poultry and plant uptake. Exposure estimates may then be compared to relevant Acceptable Daily Intakes (ADIs), Provisional Tolerable Weekly Intake (PTWIs) and Guideline Doses (GDs).
3. Site and contaminant specific: on-site sampling is the preferred approach for estimating plant uptake. Exposure estimates may then be compared to relevant ADIs, PTWIs and GDs.
4. Victorian EPA (1990) Acceptance Criteria in the Clean-up Notice for the Bayside Site, Port Melbourne.
5. Health Investigation Levels, *National Environment Protection (Assessment of Site Contamination) Measure* (NEPC, 1999).
6. Dutch B (Indicative value for further investigation) from Moen, J.E.T., Comet, J.P and Evers, C.W.A (1986) Soil protection and remedial actions: criteria for decision making and standardisation of requirements, in Assink, J.W and van den Brink, W.M (1986) *Contaminated Soils, First International TNO Conference on Contaminated Soil 11-15 November 1985.*
7. ANZECC B (Environmental Investigation Levels) from ANZECC/NHMRC (1992) *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*.
8. US EPA 2000 Region 9 Preliminary Remediation Goals (PRGs) EPA National Center for Environmental Assessment (NCEA) Superfund Technical Support Center (Internet link: http://www.epa.gov/region09/waste/sfund/prg/intro.htm). **The use of PRG levels for HILs is an interim approach until these substances have been scrutinised through the enHealth Council process for determining health-based soil investigation levels.**
9. For protection of built structures (as presented in the NEPM, NEPC 1999).

4.3.2 Groundwater

As discussed in Section 3.4.1, groundwater laboratory results have been compared to assessment levels for Fresh Water as well as Drinking Water. The majority of the assessment levels are presented in Table 3 of *Assessment Levels for Soil, Sediment and Groundwater* (DoE, 2003), with a more extensive suite presented in the source documents ANZECC (2000), and NHMRC/ARMCANZ (1996). Some values were also taken from the Dutch Intervention Levels (Ministry of Housing, Spatial Planning and the Environment, 1994), to provide additional criteria for VOCs.

As the Helena River is in close proximity to the southern boundary of the site, the sample data have also been compared against the Fresh Waters criteria (DoE, 2003) for protection of aquatic ecosystems. The Helena River is considered to be a slightly to moderately disturbed system with upgradient sources capable of degrading water quality. Based on the proposed future residential land use of some portions of the site, the Drinking Water criteria are also considered to be an appropriate assessment criteria to adopt, despite the fact that the development will be serviced by scheme water and groundwater use is likely to be restricted. Comparison against the Drinking Water criteria will determine the potential risk to the underlying confined Leederville aquifer as this represents a public water supply resource, which maybe expanded in the future.

The Fresh Waters assessment levels are more stringent than Drinking Water levels for pesticides and for heavy metals, with the exception of arsenic and manganese. The Drinking Waters assessment levels are generally more stringent for VOCs and uniformly more stringent for BTEX. There are no assessment levels for TPHs in groundwater.

4.4 Hazard Assessment

This section broadly describes the hazards associated with the major contaminants that have been identified on the site.

4.4.1 Metals

Metals are found naturally in the environment in soil, water and the atmosphere in various forms but usually in small quantities. Many metals are essential for the healthy function of organisms; however in larger quantities heavy metals can be toxic to both humans and other organisms.

Some metals (generally the heavy metals) are unable to be metabolised and thus accumulate in organisms during their lifetime; aquatic fauna inhabiting polluted environments are particularly vulnerable. Whilst the contaminant may not be toxic in small quantities, organisms at the higher end of the food chain such as fish may accumulate sufficient levels for metal toxicity to develop. This magnification of toxicity is termed bioaccumulation.

The effect of heavy metals on humans varies depending on the form or compound the metal is in. Skin contact with particular heavy metal compounds can lead to absorption into the body and skin conditions such as dermatitis. Various diseases including brain damage, cancer and organ damage may result from ingestion of large amounts of certain heavy metals (Goyer, 1996).

The main metals detected at concentrations exceeding the stringent EIL guidelines in soils at the site comprise chromium, copper, lead, tin and zinc. The metal contamination is almost exclusively associated with Waste Fill.

Relative to the stringent Fresh Waters assessment levels, groundwater contamination comprises predominantly copper, nickel, and zinc. Metal contamination is found in both the Shallow Superficial Aquifer and the Lower Superficial Aquifer. There is some evidence that elevated metal concentrations, particularly zinc, are a regional phenomenon.

A study by (ENV, 2001) assessed the potential for metals to leach out of Waste Fill at Area B, C, and D and affect soil and groundwater quality. As site investigations have shown the Waste Fill at Helena East is of a similar nature to waste fill at Area B, C, and D, the ENV (2001) study is considered to be relevant to the Helena East site. The results indicate that copper, nickel, lead, and zinc are most leachable. Actual leaching of material is affected by the infiltration rate (which is minimal beneath hardstand or buildings) as well as the pH of the water. Furthermore, the impact of leachate may be reduced due to low groundwater flow velocities and/or attenuation in underlying soil.

4.4.2 Asbestos

Inhalation of respirable-size asbestos fibres (defined as less than 3µm, or 3/1,000ths of a millimetre) can result in fibrosis of the lungs, bronchial carcinoma, mesothelioma and lung cancers (NOHSC, 2004).

Asbestos does not present a risk to human health and the environment when it is undisturbed and covered with a barrier such as clean fill or hardstand. Risk arises when the ground is disturbed and there is the potential release of respirable fibres into the atmosphere.

Asbestos fibres were detected in surface soil and in Waste Fill at Helena East, the Southern Embankment, and the MIA Containment Area. Asbestos does not pose a risk to groundwater at the site.

4.4.3 Hydrocarbons

The term ‘hydrocarbon’ encompasses many natural and manufactured organic substances, including liquid and gaseous substances such as oils, volatile spirits and natural gas. Hydrocarbons can cause environmental harm through the chemical and physical nature of the various compounds. Hydrocarbons may be accumulated through the food chain and are often found to be persistent in the environment. Inhalation of some forms of volatile hydrocarbons by humans can cause respiratory irritation or affect the nervous system. Some hydrocarbon compounds are carcinogenic and mutagenic (ATSDR, 2005).

Compounds detected at the site include PAHs such as naphthalene, long chain-length, low-volatility hydrocarbons associated with degraded diesel fuel, and solvents such as BTEX compounds and VOCs, particularly the DNAPL compounds trichloroethene and tetrachloroethene and their degradation products. The contamination has resulted from spills or leaks of hydrocarbon material, which was stored and used across the site at areas including the Foundry, Refuelling Area, Diesel Shed, Power House, Tarpaulin Shop, and the elevated Water Tank.

4.4.4 Cyanide

Cyanide is a compound of carbon and nitrogen and exists in a wide range for forms. Many cyanide compounds are exhibit human and ecotoxicity. Fortunately most cyanide compounds are highly reactive and are short-lived in the environment, but cyanide does for stable complexes with some metals and these may persist in the environment.

Cyanides were used in metal plating processes on the Workshops site and were processed in the Waste Water Treatment Plant at the toe of the Southern Embankment. Cyanide contamination of soil appears very limited in extent, and no cyanide was detected in groundwater in the most recent round of monitoring.

4.5 Ecological and Health Risk Assessment

Risk assessment is commonly used to assess the health and ecological impacts associated with contaminated soil and groundwater. This process allows for the development of site-specific risk-based criteria, which can be applied as response levels for remedial works (i.e. clean-up criteria for remediation or levels requiring management action).

Risk assessment is a well-recognised process outlined in the *National Environmental Protection (Assessment of Site Contamination) Measure 1999 Schedule B (4) Guideline on Health Risk Assessment Methodology* (NEPM, 1999) and the *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites* (ANZECC & NHMRC, 1992). The primary objective in an overall risk-based approach to decision making is to manage risk to human health and facilitate the redevelopment of contaminated land.

4.5.1 Soil Risk Characterisation

Section 3 of this PER describes the nature, extent and characteristics of soil contamination on the site.

When assessing the level risk it poses, the soil contamination at Helena East and the Southern Embankment can be divided into three main categories or classes:

1. Waste Fill material, located in the Southern Embankment and in the upper 0.5–1m of the soil profile across much of Helena East which comprises lightly contaminated soil, ash, and slag which tend to be highly permeable. As indicated in Section 3, contaminants in Waste Fill are present in concentrations in the range of EIL to HIL-F. The contaminants in the Waste Fill material have been shown to have low leachability (as described in Section 4.4.1) and as a result, these soils are assessed as a low environmental and health risk. One area of particularly high concentrations has been identified in the Southern Embankment area, and will be removed. The heterogeneous nature of the Waste Fill material

means that it is geotechnically unsuitable and will need to be excavated and be treated or disposed over the majority of Helena East.

2. Localised hydrocarbon contamination south of the Power House, at levels in the range of EIL to in excess of HIL-F, is associated with previous diesel and solvent (including DNAPL) use at the site. The contaminants present are potentially mobile in the environment, but as described in Section 3.4, the extent of any horizontal or vertical migration has been minimised due to the low permeability of the soils in the SSA. The concentrations of the contaminants in these areas and their potential to migrate offsite (via a permeable strata) and potentially impact the Helena River and its vegetation suggests that they are an unacceptable risk and should be remediated where feasible within the constraints imposed by Heritage structures.

3. Localised hydrocarbon contamination, at levels in the range EIL to in excess of HIL-F, associated with diesel and solvent spills south of the Tarpaulin Shop and adjacent to the Southern Embankment. Investigations described in Section 3.3.5 indicate that a substantial quantity of hydrocarbon contamination is present in the Waste Fill of the Southern Embankment. This contamination has been delineated as truncating near the southern boundary of the site. However, given sufficient time, this material might eventually extend offsite towards the Helena River if not remediated. The concentrations of the contaminants, together with their mobility, suggests that they present a relatively significant ecological risk and should be remediated.

4.5.2 Water Quality Risk Characterisation

The extent and nature of groundwater contamination is described in Section 3.4.

Five main areas of potential risk to the groundwater system have been identified:

- Widespread low level metal contamination in the Waste Fill.
- Hydrocarbon contamination associated with the soil contamination areas south of the Tarpaulin Shop and Water Tank near the Southern Embankment.
- Nickel contamination associated with the former Plating Shop.
- Laterally extensive hydrocarbon contamination between the Panel Shop and former Diesel Shed & Refuelling Area.
- Contamination associated with DNAPLs south of the Element Shop, which affects both the SSA and the LSA.

It would appear that the Upper Clays underlying Helena East have tended to minimise the movement of contamination in the groundwater. The most significant movement comprises hydrocarbon-impacted groundwater migrating downslope through Waste Fill along the Southern Embankment. There is little evidence that significant levels of groundwater contamination are present outside the areas of soil contamination. As a result, if the source of the groundwater contamination is removed by remediating the bulk of the contaminated soils, it is likely that the major part of the groundwater contamination will also be removed.

5. ASSESSMENT OF REMEDIATION OPTIONS

The Ecological and Health Risk Assessment in Section 4.5 identified a number of areas of the site where soil requires remediation and treatment to ensure that contaminant levels do not represent an unacceptable risk to the environment or health. This section of the PER describes the options available to the Midland Redevelopment Authority for remediating both soil and groundwater to a condition suitable for its intended purpose.

For the purpose of assessing the various remediation options, the contaminated soils in Helena East and the Southern Embankment have been grouped into two distinct classes that lend themselves to different remediation approaches:

1. *Waste Fill*: This material is found in large volumes in shallow deposits across Helena East, and in vertically extensive deposits at the Southern Embankment. This material is generally a heterogeneous mix of sand, ash, clinker and rubble and is characterised by low levels of a range of contaminants that are not leachable or bio-available. The large volumes of this material, coupled with its generally benign nature means that it is difficult to justify an expensive remediation option. Across the majority of Helena East, shallow Waste Fill will be removed due to its geotechnical unsuitability. In addition, it is proposed to remove material in areas where concentrations exceed the HIL assessment levels for the proposed land use of the area. An example of this is soil sample location HA3-16 on the Southern Embankment which has particularly high concentrations of metals, possibly representing electroplating waste (see Section 3.3.4).

   Similar material is located in the embankments on the southern boundary of the Helena West Precinct and Area B, C, and D Precinct of the workshops area. In both cases, the EPA approved a remediation strategy based on retaining the material in its current location and covering it with a visual warning barrier and at least 1m of clean fill (EPA, 2003).

   With the exception of a portion of the Southern Embankment Waste Fill that is significantly contaminated with hydrocarbons, the MRA proposes that the Waste Fill material present at Helena East and the Southern Embankment is managed in a similar manner to that approved for the Helena West and Area B, C, and D Precincts.

2. *Hydrocarbon Contaminated Soil:* An extensive soil drilling program has identified several areas in Helena East and the Southern Embankment where elevated concentrations of hydrocarbons (including TPHs, BTEX, PAH, and VOCs) are present in the soil. The most extensive areas of impact are located near the Power House, and south of the Tarpaulin Shop extending into the Southern Embankment. It is envisaged that these areas will be excavated to the extent permitted by the presence of Heritage structures that must be retained. The excavated soil will be handled using one of the methods described below.

Figure 11a identifies the extent of soil exceeding the stringent EIL guidelines at Helena East and the Southern Embankment; Figure 11b indicates the proposed post-remediation extent of contamination, based on the approach outlined above. The following sections discuss the available remediation options and justify the approaches adopted by the MRA.

5.1 Soil Remediation Criteria

Soil remediation criteria for this site have been established based on the concentration of contaminants (i.e. metals and hydrocarbons) in the soil.

The site will be redeveloped for a mixture of residential and commercial land uses post-remediation, as discussed in Section 4.3.1, and hence it is proposed to adopt the Health Investigation Levels (HILs) appropriate for these uses (HIL-A to HIL-F) as the trigger level for identifying soils requiring remediation depending on the particular use proposed in an area. Figure 4 shows the range of land uses proposed by MRA, and the proposed remediation levels are shown in Table 13. The land use allocation depicted in Figure 4 represents the currently-approved planning for Helena East. There may be some changes in land use prior to remediation commencing, and the associated remediation targets may therefore change accordingly.

TABLE 13
SOIL REMEDIATION TARGETS

Guideline	**EIL** (Ecological Receptors)	**HIL-A** (Standard Residential)	**HIL- D** (High-density Residential)	**HIL-E** (Parks, Schools)	**HIL-F** (Industrial)
Metals (mg/kg)					
Arsenic	20	30	400	200	500
Cadmium	3	20	80	40	100
Copper	60	100	4,400	200	500
Chromium (total)	50	210	NV	NV	NV
Chromium (III)	NV	12%	48%	24%	60%
Chromium (VI)	NV	100	400	200	500
Lead	300	1,000	4,000	2,000	5,000
Tin	50	46,900	NV	NV	100,000
Zinc	200	7,000	28,000	14,000	35,000
Total Petroleum Hydrocarbons (mg/kg)					
C_{6-9}	100	NV	NV	NV	NV
C_{10-14}	500	NV	NV	NV	NV
C_{15-28}	1000	NV	NV	NV	NV
$>C_{16}$-C_{35} (aromatic)	NV	90	360	180	450
$>C_{16}$-C_{35} (aliphatic)	NV	5,600	22,400	11,200	28,000
Solvents (mg/kg)					
Benzene	1	1	NV	NV	1.5
Toluene	3	520	NV	NV	520
Eythlbenzene	5	230	NV	NV	230
Xylenes	5	210	NV	NV	210
Polycyclic Aromatic Hydrocarbons					
Naphthalene	5	60	NV	NV	190

Source: DoE (2003)
NV indicates no value provided.

Where soils require excavation to remove contamination, the walls and bases of the excavations will be validated against the remediation targets specified in Table 13, as appropriate for the proposed land use of the area.

5.2 Soil Remediation Options

The *Guidance for the Assessment of Environmental Factors: Guidance for Remediation Hierarchy for Contaminated Land No 17* (EPA, 2000) recommends the following preferred hierarchy of remedial approaches for managing contaminated soils:

1. On-site treatment of the soil so that the contaminant is either destroyed or the associated risk is reduced to an acceptable level;

2. Off-site treatment of excavated soil which, depending on the residual levels of contamination in the treated material, is then returned to the site.

3. Disposal of contaminated material to an approved waste disposal facility or landfill or

4. 'Cap and contain' on site.

The Guidance documents suggest that options 3 or 4 should only be considered where:

- treatment of the contaminated material is shown or demonstrated not to be practicable;

- these options can be undertaken in an environmentally acceptable manner; and

- the risk of disturbance of the contaminant exceeds the risk of leaving it undisturbed and contained on site.

5.2.1 Treatment

Several alternative treatment processes, or a combination of processes can be used to achieve to treat the contaminated soils. These are described below.

Soil Washing to Separate Metals

Well established processes exist for separating metal contaminants from soils through physical and chemical washing which preferentially removes fine soil particles that contain the majority of metal contamination. The application of such processes would typically result in three distinct streams of material:

1. cleaned soil meeting the HIL-A (residential) to HIL-F (commercial) levels as required according to the land use;

2. a residual stream of soil that is much smaller in volume and enriched in metals and would require disposal to a Class 3 or 4 landfill; and, possibly,

3. wastewater stream that will require treatment on or off-site.

Soil washing is technically feasible for some of the metal-contaminated material at Helena East and the Southern Embankment. However, drawbacks to soil washing include the following:

- it is generally only applied to sandy soils where the coarser sandy material is readily separated from finer clays that preferentially contain the metals;
- it requires significant quantities of process water, which must be recycled;
- it may require the addition of treatment chemicals; and
- it is generally only feasible where there a very large volumes of soil with similar properties requiring treatment in view of the high cost of establishing and operating a treatment system.

In view of the moderate volumes of soil and the heterogeneous nature of the soil contamination, soil washing and related process were not considered feasible for this project.

Screening

Screening or sieving is a simple physical process that can be used to separate particles of different sizes from a soil. The process can be conducted using simple techniques such as winnowing the soils through a rake bucket on an excavator or a fixed 'grizzly' through to the application of mobile or stationary screening plants.

The screening process produces two or more streams depending on the size fractions to be separated. The process has the potential to produce dust unless dust control measures are used.

Depending on the characteristics of the material being screened it is possible that either the undersize or oversized material may suitable for re-use of suitable for disposal in a lower class of landfill.

The MRA considers that large volumes of Waste Fill material will be suitable for screening.

Bioremediation

Bioremediation is a well-established and widely used process where natural soil microbes are used to decompose and degrade organic contaminants (i.e., hydrocarbons) in waste or contaminated soil to produce either a clean product or one that is less heavily contaminated and can be re-used as fill.

Bioremediation can be conducted either on-site or off-site, and the process can vary greatly in complexity from small stockpiles of material that are occasionally turned through to sophisticated covered windrow systems with forced aeration.

MRA envisages that significant amounts of the hydrocarbon and solvent contaminated material from Helena East and the Southern Embankment may be suitable for treatment using bioremediation techniques. A final decision on whether the bioremediation will be undertaken off-site or on-site will depend on the scheduling for the project and the prices submitted by contractors.

Where on-site composting is used, it is envisaged that mechanically turned windrows will be constructed adjacent to the southern boundary of the site, on either existing concrete hardstand areas or on constructed liners. Windrows would be formed with soil and controlled additions of nutrients, and other organic materials and water to maintain optimum moisture nutrient balance. It is envisaged that the material will be turned fortnightly using earth moving equipment to aerate the windrow and maintain aerobic conditions.

Thermal Desorption

Thermal desorption systems operate by subjecting hydrocarbon-impacted soils to elevated temperatures to desorb the hydrocarbons into a gas stream, which is then treated to either capture the hydrocarbons in a condenser/carbon filter combination or destroy them in a 'thermal oxidation' unit or incinerator. A number of different types of thermal desorption units are available, including:

- low, medium and high temperature units;
- direct and indirect units; and
- mobile or stationary plants.

Thermal desorption units tend to be expensive to mobilise and operate as there are none permanently available in Western Australia. As a result, typically, the cost of treatment is not competitive with conventional 'dig and dump' approaches in this State. In this case, however, it is considered thermal desorption may be feasible and therefore approval will be sought for application of this technique.

Preliminary cost estimates suggests that the treatment costs for thermal desorption would be in the range of $150-$200/tonne allowing for mobilisation of plant. There prices exceed the budget available to the MRA for remediation but is likely more competitive pricing will be achieved through a tender process.

Two significant issues arise when evaluating thermal desorption processes:

1. The quality of the treated soil can vary greatly depending on the technology selected. Should MRA elect to use a thermal desorption process, it is proposed that the treated soil complies with the stringent HIL-A criteria for hydrocarbons and solvents to allow re-use of the soil.

   It must be noted that thermal desorption will not remove metal contamination and may in fact mobilise metal contaminants. It will therefore only be applied to soils that are contaminated with hydrocarbons and that have relatively low metal concentrations. Any soils treated by thermal desorption will be tested in accordance with relevant DoE guidelines before a final decision is made on reuse or final disposal.

2. The desorption/treatment process has the potential to result in the emission of hydrocarbons and particulates to the atmospheric if not correctly controlled.

If the MRA is to utilise thermal desorption as a treatment methodology, it is essential that the treatment unit incorporates appropriate scrubbing and filtration equipment to meet the emission requirements set by the DoE.

The final decision on whether to use the technique will be dependant on the cost of treatment when tendered and whether the treated soil will be suitable for re-use as fill. Should thermal desorption be adopted as a remediation option, the Dust and Air Quality Management Plan will be amended accordingly.

Products Produced from Treatment Processes

Given the heterogeneity of the soils and the different nature of the treatment process that are under consideration, it is not possible to confidently predict the quality of products that will be produced. The aim of the treatment process is to either reduce the volume of soil that must be directed for containment or disposal, or to reduce the concentrations of contaminants in soils to the extent that they can be utilised as fill on site.

Table 14 presents the assessment criteria that will be used to assess the products of treatment and make decisions on whether they are re-used on-site as fill subjected to further treatment or directed for disposal (either off-site or in the on-site Containment Cell).

TABLE 14
SOIL RE-USE TARGETS

Proposed Use	Basis for Acceptance
Re-use as Clean Fill	The average plus standard deviation of concentration results is less than the EIL or 95% Upper Confidence Limit (UCL) of the mean is less than EIL.
Re-use as Fill in Residential Areas	The average plus standard deviation of concentration results is less than the HIL-A criteria or 95% UCL of the mean is less than HIL-A.
Re-use as Fill in Commercial/Industrial Areas	The average plus standard deviation of concentration results is less than the HIL-F or 95% UCL of the mean is less than HIL-F.
Placement in the Proposed MIA Containment Cell	The average plus standard deviation of concentration results is less than two (2) times the Concentration Limit (CL1) Criteria for a Class 1 Landfill or 95% Upper Confidence Limit (UCL) of the mean is less than two (2) times the concentration Limits for a Class 1 Landfill; and The average plus standard deviation of ASLP results is less than the ASLP criteria for a Class 1 Landfill (ASLP1) or 95% Upper Confidence Limit (UCL) of the mean is less than the ASLP criteria for a Class 1 Landfill (ASLP1).
Off-site Disposal	Compliance with relevant criteria for the appropriate landfill.

5.2.2 Off-Site Disposal/Containment

In the hierarchy of treatment options, off-site disposal is listed as the third preference after on-site and off-site treatment. In Western Australia, off-site disposal to landfill has tended to be the preferred option for managing the majority of contaminated soils for one or more of the following reasons:

- Land developers and owners have a preference for producing land that is unconstrained by the presence of partially remediated material.

- Relatively small volumes of soil are produced from most sites, which make the economics of treatment unattractive.

- The lack of established centralised treatment facilities for contaminated soils within Western Australia which increases treatment costs.

- The high mobilisation and start-up costs for most on-site treatment facilities, which renders them financially uncompetitive with off-site disposal to landfill.

- The level of concern expressed by landowners/residents around sites where remediation operations are proposed, which makes developers reluctant to use techniques such bioremediation or thermal desorption because of high levels of regulatory oversight and monitoring, and community interest. This tends to add expense and also may result in delays to project completion.

- The relatively low cost of landfill disposal in Western Australia.

All of the factors listed above are relevant to the redevelopment of Helena East and the Southern Embankment. Although the volumes of some types of contaminated soil are sufficient to warrant consideration of different treatment options, there will certainly be some materials where the preferred option will be off-site disposal. In particular, any metal-contaminated soil which exceeds the criteria for re-use or containment on site will be directed off-site for disposal at an appropriate class of landfill. Where contaminated soil is to be directed for offsite disposal, testing will be conducted to ensure that the soil to be removed meets the requirements for disposal as Class I, III or Class IV landfill. Selective excavation will be used to remove the material to stockpiles for assessment prior to it being directed to the appropriate class of landfill.

There are a number of facilities in the Perth Metropolitan region licensed by DoE to receive Class I waste. The final decision on which facility is to be used will be at the discretion of the contractor appointed to the complete the remediation. However, the MRA would require documentary evidence from the contractor the facility selected holds the appropriate license, and require and proof of delivery for the purposes of validation.

There are currently only two facilities within the Perth area that are licensed by the DoE to receive Class III waste (Millar Road Landfill, Rockingham and Red Hill, Shire of Swan). The Red Hill facility is also able to accept Class IV waste. The Red Hill landfill facility, operated by the Eastern Metropolitan Regional Council, is able to receive the types of soil described above and given its proximity to the site is likely to be the disposal site used.

5.2.3 On-site Containment

On-site or *in situ* containment generally refers to engineering and constructing a cell into which contaminated soil is transferred. Barrier systems can be established to prevent the movement of contaminants or contaminated water from the containment cell to the environment or provide a visual or physical barrier to disturbance of the contamination.

The design of the barrier is determined by the nature of the material to be contained. Highly toxic or hazardous materials would require a sophisticated low permeability lining/capping system. In contrast lightly contaminated material or materials with a low leachability can be contained in a cell using a relatively simple lining/capping system.

5.2.4 Replacement Fill

Where clean fill is to be imported as part of any remediation it needs to be verified as clean either through be documented as being from a source such as a sand pit or quarry or alternatively, if derived from other sources by virtue of sampling and analysis, which demonstrates it to be free of contamination.

5.3 Groundwater Remediation Options

Section 3.4 describes the extent of groundwater contamination at Helena East and the Southern Embankment. Overall, there is little evidence to suggest that contamination on the site is contributing to off-site contamination of local or regional aquifers or the waters of the Helena River. The findings allow the identification of four broad types of groundwater impact:

1. There is evidence of slight elevations of metals in the SSA across much of the site that may be a regional phenomenon. The principal metals concerned are zinc and copper.

2. There is evidence of localised acute nickel impacts on the SSA which appear to be associated with particular historical land uses (i.e. the Plating Shop).

3. There is evidence of localised acute hydrocarbon and solvent impacts in the SSA, which appear to be associated with solvent and diesel spills, mainly in the vicinity of the Power House and south of the Tarpaulin Shop.

4. There is limited evidence which indicates chlorinated solvents (particularly DNAPLs) have migrated into the LSA as a result of their higher density and chemical characteristics. As indicated in Section 3.4.6, it is recommended that additional investigations are conducted to better establish the extent of solvent contamination in the LSA. This will in turn determine if there is a need for active management to limit the impact of this contamination down-gradient of the affected area.

The remediation of groundwater is generally complex because of the difficulty in either accessing the groundwater for in-situ techniques or extracting it for 'pump and treat' options. Recently, there has been a trend towards the use of techniques such as permeable reactive barriers, which are constructed down-gradient of known areas of contamination and interact chemically and physically with a migrating plume to remove contaminants while allowing the normal groundwater flow regime to be maintained.

Typically groundwater remediation is a costly and inefficient exercise that is only justified where there is a clear likelihood of adverse off-site impacts or where the presence of the contamination constrains on-site land-uses to an unacceptable extent.

A brief discussion of each of the main approaches is included in the following sections together with a comment on their application at Helena East and the Southern Embankment.

5.3.1 *In situ* Groundwater Containment

A range of techniques exist for *in situ* treatment of groundwater contamination. These include techniques such as sparging where air is injected to an aquifer to either drive off volatiles or increase oxygenation and promote natural microbial breakdown through to injection of biological or chemical agents to promote biodegradation of contaminants.

These techniques are generally only effective where there is a well defined plume of contaminants and a reasonably permeable aquifer. The Upper Clays at the site hosting the SSA lack continuous permeable strata, meaning that these *in situ* techniques will likely not be effective.

Impermeable Barriers

Impermeable barriers are used to either intercept or divert rainfall/storm water from interacting with soil contaminants or to block or divert a known groundwater plume where it is likely to impact on a sensitive environmental receptor. The feasibility of installing such barriers is very much dependant on site characteristics and the nature of the plume.

MRA proposes the use of impermeable membranes to block the infiltration of storm water through residual contaminants left unexcavated adjacent to Heritage buildings and structures.

At this stage, there is no evidence of significant plume migration off-site that warrants the use of impermeable barriers in relation to movement of the identified areas of groundwater contamination.

Permeable Reactive Barriers

Permeable reactive barriers are a relatively recent development in groundwater treatment. The barriers are installed as curtains of chemically reactive materials down gradient of known contaminant plumes. The curtains can be constructed by a range of methods, from simple surface trenching into a shallow watertable, to the use of sophisticated excavation techniques such as those used to construct bentonite membrane walls.

The medium for the curtain is selected to be permeable and allow groundwater to pass through it. The medium is also selected to have chemical characteristics that will adsorb or react with and degrade the contaminants in the groundwater as it migrates through the barrier.

The cost of installation of such barriers and their effectiveness is dependant on aquifer and plume characteristics. Typically they will be most effective for a well-defined plume in relatively shallow groundwater.

The nature and extent of the contamination in the SSA is such that it is doubtful that the use of a permeable reactive barrier is warranted. However, if subsequent investigations indicate that significant solvent contamination is present in the LSA, and that it is migrating at a sufficient rate, the use of a permeable reactive barrier may be considered.

5.3.2 'Pump and Treat' Options

One of the most commonly used techniques for remediating groundwater is to extract it using a network of wells sited to intercept the plume of contamination and then to treat the extracted water before re-injecting it back into the aquifer. There are a range of possible treatment options, from simple physical process such as gravity or plate separators through to sophisticated chemical treatments or the use of technologies such as membrane filtration.

As with *in situ* remediation techniques, this approach is best suited to uniform, transmissive aquifers and well defined plumes. In view of the variable and low permeability nature of the SSA, it is unlikely that the MRA could effectively utilise 'pump and treat' options.

6. REMEDIATION APPROACH

6.1 Remediation Objectives

This section describes the MRA's preferred and proposed approach for remediating the site. The preferred approach has been developed on the basis of a range of considerations including:

- the land uses proposed following redevelopment of the site *(Sections 1 and 2)*;
- the nature of surrounding land uses *(Section 2)*;
- the nature and extent of soil contamination that has been identified as a result of the extensive investigations that have been completed on the site *(Section 3)*;
- the contaminant pathways that exist and the level of risk that unacceptable impacts may occur environmental and human receptors *(Section 4)*;
- the available remediation and disposal options *(Section 5)*; and
- the cost of remediation, in economic, environmental and social terms *(Section 5)*.

In developing the proposed remediation strategy, the objectives of the MRA were:

1. to ensure that the environmental values of the site and the surrounding environment are protected and enhanced during and after the remediation process;
2. to achieve a remediated site where areas that will be subject to intensive use are relatively unconstrained by the presence of residual contamination, so that future land occupiers can enjoy the use of the land without being subject to restrictive memorials;
3. to maintain and enhance the heritage values of the site as far as is possible; and
4. based on an assessment of environmental and human risks associated with contamination on the site, develop a remediation strategy that does not impose undue costs on the community of Western Australia while achieving the Authority's remediation objectives.

A fundamental requirement for achieving Objective 1 is to reduce or remove the contaminated soil which is the primary source of groundwater contamination and hence any attendant ecological or human health risks associated with it. The off-site risks, although not high prior to remediation, will be relatively considerably diminished once the majority of the source material has been removed.

The remediation approach is based on the NEPC (1999) ecological risk assessment guidelines. The guidelines indicate that where the EIL is lower than the background concentration for a chemical, then the background concentration becomes the EIL (NEPC, 1999). Therefore, the background Helena River and groundwater concentrations not impacted by the site serve as target remediation endpoints for the project.

6.2 Preferred Soil Remediation Strategy

6.2.1 Overview

The MRA's preferred remediation strategy has been developed to achieve the following outcomes:

1. Structures and buildings identified as having significant heritage values as indicated on the Figure 4 will be preserved wherever feasible.

2. Following remediation the site must be suitable for a mixture of both commercial and residential uses as shown on Figure 4.

3. As far as is possible, the MRA wishes to sell residential land without the encumbrance of memorials stating that soil contamination is present on the purchased land, although it is recognised that it may be difficult to avoid the need for a memorial identifying the potential for groundwater contamination and preventing the use of on-site bores. Accordingly, the MRA intends that for residential land:

   - All contaminated material present above HIL-A levels will be excavated for subsequent treatment or disposal, unless engineering or Heritage constraints prevent the removal of materials adjacent to structures or at depth.

   - Where, due to the presence of heritage constraints, contaminated soil with contaminant concentrations less than HIL-F cannot be excavated adjacent to Heritage structures, it will be covered by a visual warning barrier of coloured geotextile material. Where feasible 0.5m of clean fill will be placed above the warning barrier.

   - Where, due to the presence of heritage constraints, material above HIL-F levels is to be left at depth on land zoned for residential use, it will be covered by an appropriate visual warning barrier. Where feasible, at least 1m of clean fill will be placed above the warning barrier and the ground surface will be treated in a manner that minimises the risk of erosion using hardstand or an equivalent treatment approved by the DoE.

   - Where material is present under or adjacent to a Heritage structure and remediation is not possible, the land title will be annotated to identify the presence of the contamination and refer to an EPA approved management plan for any activity that is likely to disturb the contaminated material.

   - Where contaminated groundwater is present beneath, or may potentially migrate under residential land, the land title will be annotated to reflect this constraint and manage or prevent groundwater extraction.

   - Where contaminated groundwater is present in excavations, it will be treated to remove the contamination to the maximum extent possible. Treatment methods may include chemical dosing and flocculation for metals and the use of absorbent mats and carbon filters for recovering hydrocarbon-based materials.

4. In the case of commercially-zoned land, the MRA wishes to remove to contaminated material above HIL-F to the extent possible given the constraints imposed by heritage buildings and engineering constraints for deep excavations. MRA emphasizes that much of the commercial land at Helena East is constrained by Heritage structures. The strategy for commercially-zoned land will be as follows:

   - All contaminated material present above HIL-F levels will be excavated for subsequent treatment or disposal unless engineering or Heritage constraints prevent the removal of materials adjacent to structures or at depth.

   - Where material above HIL-F levels is to be left at depth on land zoned for commercial use, it will be covered by an appropriate visual warning barrier. Where feasible at least 0.5m of clean fill will be placed above the warning barrier and the ground surface will be treated in a manner that minimizes the risk of erosion using hardstand or an equivalent treatment approved by the DoE.

   - Where contaminated material is left under or adjacent to a heritage structure and remediation is not possible, the land title will be annotated to reflect the presence of the material and management plan will be developed for any activity that is likely to disturb the contaminated material.

   - Where contaminated groundwater is present in excavations, it will be treated to remove the contamination to comply with DoE guidelines. Treatment methods may include chemical dosing and flocculation for metals and the use of absorbent mats and carbon filters for recovering hydrocarbon-based materials.

5. The MRA proposes that the Waste Fill material that forms shallow deposits at Helena East be excavated to the extent possible given Heritage constraints, and that it is treated to remove geotechnically suitable components. Treated material that is suitable for re-use will be replaced.

6. The MRA proposes that Waste Fill material in the Southern Embankment that has not been identified as heavily contaminated with metals and/or hydrocarbons and that is not located beneath land to be developed will treated in the same manner to that approved by the EPA for the Helena West and Area B, C and D Precincts. That is:

   - the embankment slope will be contoured to achieve a stable form;

   - a coloured warning barrier be placed to provide a visual warning that the fill is present;

   - at least 1m of clean fill on top soil be placed over the warning barrier; and

   - the land title will be annotated to reflect the presence of the fill.

- A subsurface management plan has been developed to address long term management of waste fill that remains on-site (Appendix 12).

6.2.2 Excavation Methodology

The major areas of soil contamination at Helena East and the Southern Embankment are described in Section 3.3. Figure 11a shows the extent of soil contamination prior to the commencement remedial works.

This section presents the MRA's proposed strategy for excavation of soils that have been identified as:

- constraining the development of land for its intended purpose due to contaminant levels or geotechnical unsuitability;
- contributing to unacceptable contamination of groundwater; or
- potentially contributing to unacceptable contamination of groundwater.

Figure 11b shows the proposed post-remedial extent of contamination.

The portion of the Southern Embankment identified as having significantly elevated levels of heavy metals (location HA3-16, 'Electroplating Dump' of ENV, 2005) will be delineated to segregate this material from the remainder of the Waste Fill, which is relatively lightly contaminated. The purpose of this is to limit the volumes of soil requiring treatment or disposal.

Heritage Constraints

In areas unconstrained by heritage buildings or infrastructure, significant areas of contamination will be excavated with the aim of removing all contamination above the relevant Health Investigation Level for the land use at that location. The walls and floor of the excavation will be validated against the criteria listed in Table 13. The results of soil contamination investigations suggest that due to the clay geology there has been limited migration of contamination from the overlying Waste Fill and therefore, in many cases, it will likely be possible to remove sufficient contaminated soil to allow validation to EIL levels. Where this is achieved, the land will be identified as contamination free and suitable for unrestricted land use subject to the presence of contaminated groundwater.

Contamination beneath and immediately adjacent to heritage buildings and structures cannot be excavated due to engineering constraints. The insets in Figure 12 illustrate the extent of the required buffer zones around heritage buildings. The areas immediately adjacent to the heritage structure will be remediated to the extent possible without damaging the stability of the structures. This will involve a maximum excavation depth of approximately 300mm within 2m of Heritage structures. Beyond the 2m buffer zone around the structure, the wall of the excavation will be excavated on a 1:1 slope to either the maximum depth of contamination or the maximum depth possible given the presence of other heritage structures. The effect of this excavation strategy on remediation of contamination in the vicinity of heritage structures is shown in Figure 12.

Where constraints imposed by the presence of heritage structures results in residual contamination levels in the base and walls of the excavation that exceed the assigned remediation targets, a visual warning barrier will be placed on the excavated surface and clean fill placed over the membrane to achieve design levels.

Shallow Waste Fill

Where not constrained by heritage structures, geotechnically unsuitable Waste Fill material in the upper soil profile at Helena East will be progressively excavated until natural ground is intersected. The excavated material will treated as described in Section 6.2. The base of the excavation will be validated against the relevant remediation assessment criteria for the land use, as listed in Table 13. As with other areas of the site, it is anticipated that in most circumstances validation testing will meet the EIL criteria as excavation will likely proceed until the undisturbed clay surface is exposed due to geotechnical imperatives.

Where heritage structures are present, excavation of the Waste Fill will only proceed to within 2m of the building. Outside the 2m buffer around heritage structures, the depth of excavation will be limited by a 1:1 slope to the maximum required depth of excavation. Where residual Waste Fill is left adjacent to heritage structures, the title will be annotated and a visual warning layer placed over the Waste Fill if possible. In some circumstances it will not be possible to achieve sufficient depth of excavation near buildings to allow placement of warning layer. The title of any property where residual fill remains will be annotated to reflect the presence and extent of the Waste Fill.

Southern Embankment

Areas of the Southern Embankment that have been identified as heavily contaminated with hydrocarbons (south of the Tarpaulin Shop) or metals (location HA3-16) will be delineated, excavated and stockpiled separately from other Waste Fill for specific treatment or off-site disposal. The remainder of the Southern Embankment will be managed in accordance with the following actions:

- the southern face of the embankment will be re-contoured to produce a stable landform (this may include some retaining works);
- the areas of Waste Fill at the top of the embankment that underlie land intended for redevelopment, will be excavated to the underlying natural soil and managed, as for other Waste Fill;
- the Waste Fill remaining after excavation of unsuitable materials will be covered with a warning barrier;
- the warning barrier will in turn be covered with at least 1m of clean fill;
- the clean fill will be stabilized initially using mulch and then planted with grasses and shrubs to produce a table and attractive landscape feature; and

- the design of the embankment will address surface and sub-surface drainage flows to prevent erosion of the clean fill and exposure of the barrier layer.

On completion of excavation activities, all excavations will be re-instated to design levels using either clean fill or fill that has been tested in accordance with the Department of Environment document *Landfill Waste Classification and Waste Definitions* (DoE, 2005). The assessment criteria to be used are discussed in Section 6.3.1.

6.2.3 Quantity of Soil Requiring Remediation

Figure 11a illustrates the extent of soil contamination identified at Helena East and the Southern Embankment, relative to the EIL guidelines. The estimated volumes of soils identified for excavation and treatment are summarised in Table 15.

TABLE 15
ESTIMATE OF SOIL VOLUMES DESIGNATED FOR REMEDIATION

Area	Material	Contaminants	Total Volume (m^3)	Volume to be Remediated (m^3)*
Helena East	Waste Fill	Metals, Asbestos	15,000	15,000
	Upper Clays	Hydrocarbons	25,000	25,000
	Foundry	Metals, Asbestos, Hydrocarbons	9,000	9,000
Southern Embankment	Waste Fill	Metals	70,000	10,000
		Hydrocarbons	(5,000)[1]	(5,000)[1]
		TOTALS	119,000	59,000

*Remedial volumes are approximations based on currently available data. Actual volumes will be subject to validation sampling.
[1] Indicates hydrocarbon contamination in Waste Fill which overlaps with Waste Fill to be excavated due to elevated metal concentrations.

6.2.4 Predicted Reduction in Contamination via Soil Extraction

Table 16 contains estimates of the volumes of primary contaminants that are predicted to be currently present at the site, the volumes that will be removed, and by subtraction the volumes that will remain following remediation.

The final volumes removed will be updated and reported to the DoE in a detailed validation report on the remediation.

TABLE 16
VOLUME ESTIMATES OF KEY CONTAMINANTS TO BE REMOVED FROM SITE TO COMPLY WITH HIL-F CRITERIA

Material and Area	Approximate Total Volume (m^3)	Estimated Excavation Volume (m^3)*	Primary Contaminants	Maximum Remaining Concentration (mg/kg)
Waste Fill:			Arsenic	500
			Cadmium	100
Helena East & Foundry	15,000	14,000	Copper	500
			Chromium (total)	NV
			Chromium (III)	60%
Southern Embankment	70,000	10,000	Chromium (VI)	500
			Lead	5,000
			Mercury	75
			Nickel	3000
			Tin	100,000
			Zinc	35,000
Hydrocarbons:			C_{16}-C_{35} (aromatic)	450
Helena East	25,000	24,000	C_{16}-C_{35} (aliphatic)	28,000
Southern Embankment	5,000	5,000	Benzene	1.5
			Toluene	520
			Eythlbenzene	230
			Xylenes	210
			Napthalene	190

*Excavation volumes are approximations based on currently available data. Actual volumes will be subject to validation sampling.
[1] Hydrocarbon contamination in the Southern Embankment overlaps with Waste Fill to be excavated due to elevated metal concentrations.

6.2.5 Post-Remediation Soil Risk Assessment

Concentrations of residual contaminants in soils exceeding EIL assessment levels may continue to pose a risk to both on-site and off-site ecological receptors. Although, as demonstrated in Table 16 above, remediation of the site will result in a significant reduction in the volume of contaminants of concern, the associated reduction of risk of adverse impact upon ecological receptors following the remediation needs to be confirmed.

This demonstration of reduced impact could be achieved by the development of a detailed hydrogeological model of the site, which makes predictions of the overall reduction in groundwater impacts over time. Alternatively, given the current low-level of groundwater impact at the site boundaries and the limited contamination pathway between the SSA and the surrounding receptors, demonstration of risk reduction can be achieved by a structured monitoring program to ensure that the trend in water quality both on and off-site improves as a result of the remediation.

Given the complexity of the geology and the consequent difficulty in producing an accurate hydrogeological model, the MRA proposes to implement a monitoring program to allow completion of the post-remediation risk assessment.

6.3 Management Strategy for Excavated Soils

The options identified by MRA as potentially applicable to the treatment of soils are discussed in Section 5.2. This section identifies the MRA's preferred management approach to the main classes of contamination that will be excavated on the site as a result of the excavation strategy outlined in Section 6.1.

Excavated soils will be stockpiled for sampling and assessment in accordance with DoE (2005). Based on the results from these assessments a decision will be made on a stockpile by stockpile basis as to the appropriate option for management of the soil.

Where soils are heavily contaminated, they will either be stockpiled on an impermeable liner or the area of hardstand to limit the potential for contamination of underlying soils. Where it is not possible to use a liner or hardstand, the soil beneath the stockpile will be subjected to validation sampling.

The following sections detail the management approach proposed by MRA for excavated soil.

6.3.1 Re-use and Disposal Criteria for Soils

It is proposed that remediation of soils at the site be conducted to standards appropriate for the proposed land use (HIL-A to HIL-F). This will remove the bulk of the contaminated source material that is contributing to groundwater contamination. The proposed zoning at the time of remedial works would be used to determine the appropriate remediation target.

Where feasible the MRA will treat soil to allow re-use or to reduce the level of hazard associated with a soil so that it can be disposed of at a lower class of landfill or directed to the MIA Containment Area.

Given the heterogeneity of the soils and the different nature of the treatment processes that are under consideration, it is not possible to confidently predict the quality of products that will be produced. The aim of the treatment process is to either reduce the volume of soil that must be directed for containment or disposal, or to reduce the concentrations of contaminants in soils to the extent that they can be utilised as fill on site.

Depending on the treatment strategy adopted, the entire soil volume may be suitable for re-use or the contaminated material may be segregated into a 'clean' or 'suitable fill' stream and a 'contaminated' or 'unsuitable' stream that requires disposal.

Table 17 presents the assessment criteria that will be used to assess the products of treatment and make decisions on whether they are re-used on-site as fill subjected to further treatment or directed for disposal (either off-site or to the MIA Containment Area).

TABLE 17
PROPOSED SOIL RE-USE/DISPOSAL CRITERIA

Proposed Use	Basis for Acceptance
Re-use as Clean Fill	The average plus standard deviation of concentration results is less than the EIL or 95% Upper Confidence Limit (UCL) is less than EIL.
Re-use as Fill in Residential Areas	The average plus standard deviation of concentration results is less than the HIL-A criteria or 95% UCL is less than HIL-A.
Re-use as Fill in Commercial/Industrial Areas	The average plus standard deviation of concentration results is less than the HIL-F or 95% UCL is less than HIL-F.
Placement in the Proposed MIA Containment Cell	The average plus standard deviation of concentration results is less than two (2) times the Concentration Limit (CL1) Criteria for a Class 1 Landfill or 95% Upper Confidence Limit (UCL) is less than two (2) times the concentration Limits for a Class 1 Landfill; and The average plus standard deviation of ASLP results is less than the ASLP criteria for a Class 1 Landfill (ASLP1) or 95% Upper Confidence Limit (UCL) is less than the ASLP criteria for a Class 1 Landfill (ASLP1).
Off-site Disposal	Compliance with relevant criteria for the appropriate landfill.

6.3.2 Proposed MIA Containment Cell

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During the assessment of the Helena West Precinct, MRA received environmental approval for the construction of an unlined containment cell to contain up to 50,000m^3 of lightly contaminated soil on the eastern boundary of the Area B, C and D Precinct. The unlined containment cell was considered suitable because of the low environmental threat posed by the lightly contaminated Waste Fill, material that had been subject to weathering processes for decades at the site without any evidence of significant adverse environmental impacts. The MRA presented evidence that the clay soils to the site down-gradient of the containment cell had the capacity to attenuate the low levels of metals that leach from the contained waste into the local groundwater.

The scoping document of the Helena East PER (ENV, 2005) identified an area of land on the Meat Industry Authority (MIA) Site that lies within the MRA boundary on its eastern margin (refer Figure 2), which was prospective for establishing a similar unlined containment cell to contain the large volumes of Waste Fill material that will be generated during the remediation of Helena East and the Southern Embankment. The location proposed for the Containment Cell is shown on Figure 2, and its broad characteristics are illustrated on Figure 13. A description of the physical and environmental characteristics of the proposed MIA Containment Area is provided in Appendix 2.

The MRA considers that the use of on-site containment on the MIA land for lightly contaminated soils is justified on the following grounds:

- Large volumes of the lightly contaminated Waste Fill material have been deposited at Helena East and the Southern Embankment since the Workshops were originally established in 1904. This Waste Fill material is relatively inert and has been exposed to weathering and leaching processes over decades.

- MRA has completed extensive investigations on similar material at Helena West Precinct and Area B, C and D which demonstrate that the material is not a significant environmental threat. Investigations conducted at Helena East demonstrate that the Waste Fill there is similarly benign.
- It is the MRA's view that no viable treatment option exists for the lightly contaminated waste fill other than screening to remove geotechnically unsuitable material and that the negative overall environmental associated with off-site disposal (utilizing scarce landfill space, energy use in transport and associated greenhouse emissions) cannot be justified on a sustainability basis given the low environmental threat associated with the material.

The MIA Containment Area site was selected for the following reasons:

- The area is located within the MRA boundaries, and an interagency agreement exists to transfer the MIA site to the control of the MRA once a new saleyard site is established in Muchea. The site will therefore be vested with MRA and under its planning control. A copy of relevant correspondence on the agreement for MRA to acquire the land is included as Appendix 2.

- The MIA Containment Area was selected because it is underlain by approximately 12,000m^3 of Waste Fill material and an asbestos dump, which significantly constrains the future use of the land. The Health Department of WA and the DoE have expressed a preference for on-site containment of asbestos to avoid the potential for airborne asbestos emissions that may occur during the excavation of large quantities of asbestos products. It is therefore considered preferable to consolidate the Waste Fill from Helena East in a Containment Cell constructed on this area which is already heavily constrained by the presence of the asbestos.

In the scoping document, the MRA argued that no liner or cap was needed on the containment cell due to the low concentration and leachability of contaminants in the soils to be stored and the fact the clay soil in and adjacent to the contaminant cell had the capacity to attenuate any contaminants that may leach from the cell. In view of comments from staff in the DoE's Land and Water Quality Branch of a preference for a higher level of containment instead of reliance solely on the ability of soils to attenuate contaminants, the MRA is now proposing that the contaminant cell should be capped with an impermeable clay liner constructed to achieve a permeability of 10^{-7}m/s. This decision has been made to limit the inflow of rainwater through the fill and therefore prevent migration of contaminants and the likelihood of ongoing management of leachate.

Figure 13 identifies the MIA Containment Area and the notional footprint for the Containment Cell within the area. It is anticipated that up to 80,000m^3 of Waste Fill material will be placed in the Containment Cell. The Cell will have the following broad characteristics:

- Prior to depositing Waste Fill in the Cell, the base will be prepared with clean clay to a depth of approximately 300mm. The clay will be compacted and leveled to provide a stable non-eroding surface over the existing asbestos dump.

- Selected waste, conforming to the acceptance criteria specified in Table 17, will be placed and compacted into a stable landform that will drain readily following capping. The maximum height of the cell will be 12m; a typical section through the Cell is illustrated in the inset in Figure 13.

- On achievement of the final landform, a compacted clay cap of 300–500mm thickness will be placed over the Cell. The cap will be placed under engineering supervision to achieve a nominal permeability less than 10^{-6}m/s.

- At least 500mm of clean free-draining soil will be deposited on the cap and drainage structures incorporated into the cell to prevent erosion.

- Shallow-rooted shrubs and grasses will be planted over the Cell to achieve a stable landform consistent with the amenity of the area.

The MRA considers that the proposal to use a Containment Cell is the most environmentally sustainable option for management of this low-level contaminated soil.

The inclusion of a low-permeability clay cap over what is essentially an inert landfill cell means that there is now no need to rely on the ability of the surrounding soils to attenuate metal contamination that may have leached from the Cell.

6.3.3 Management of Excavated Metal-Contaminated Soil

Electroplating Waste

As indicated in Section 5.2.1, the MRA has not identified any feasible treatment techniques for treating Waste Fill material that is contaminated with significant levels of metal contamination.

Contaminated soil excavated from areas identified as containing significant concentrations of metals, will be assessed against the relevant landfill disposal criteria and directed for off-site disposal at an appropriate class of landfill.

Waste Fill

Large volumes of lightly contaminated waste fill material will be excavated from the shallow surface fill deposits and the southern embankment area. This lightly contaminated material is known to be geotechnically unsuitable due to the presence of rubble and cemented lumps of clinker or ash. It is proposed that it is screened to remove segregate oversize material and render the fill geotechnically suitable for re-use or placement in the MIA Containment Cell.

Where screening is to be used, the material to be remediated would be excavated to the extent possible while preserving Heritage structures. The excavated material would then be screened in a mobile mechanical screening plant of appropriate design.

The undersized material from the screening process will be stockpiled for chemical testing. Depending on the results, the material would be disposed of in one of the following three ways:

1. re-used as fill provided it meets the relevant re-use criteria specified in Tables 14 and 17;

2. directed to the proposed MIA Containment Cell subject to compliance with the acceptance criteria proposed for that cell; or

3. directed for off-site disposal at a suitable landfill.

The oversize material will be stockpiled for testing before being directed off-site to an appropriate class of landfill.

Where areas are known to be more highly contaminated (e.g. hydrocarbon- or solvent-contaminated areas near the Power House), these materials would be excavated and handled separately to avoid contamination of the lightly contaminated areas of Waste Fill.

Screening has the potential to cause dust emissions. As a result MRA will ensure that any screening equipment is fitted with dust control equipment and operated in manner which minimizes dust emissions. Monitoring of dust will be performed in accordance with the air quality management plan detailed in Section 7.1 to ensure that atmospheric particulate levels are within agreed criteria.

6.3.4 Management of Excavated Hydrocarbon-Contaminated Soil

Section 5.2.1 indicates that four options exist for management of excavated soils that are impacted by hydrocarbons or solvents. These are:

1. on-site Bioremediation;
2. off-site Bioremediation;
3. thermal desorption; and
4. off-site landfill disposal.

At this stage MRA considers it probable that Options 1 and 4 will be utilized to manage the majority of the hydrocarbon impacted soil excavated on the site. Much of the hydrocarbon and solvent contaminated soil is capable of being treated by bioremediation to reduce concentrations of hydrocarbons significantly. However, experience with on-site bio-remediation in previously remediated areas indicates that the high clay content of the soil makes the bioremediation process management intensive and time consuming.

The redevelopment program for the Helena-East Precinct is such that MRA may not consider it has sufficient time for on-site bioremediation of hydrocarbon impacted soils and therefore it has costed the feasibility for the remediation process on the basis of all hydrocarbon impacted soils being directed off-site either for treatment by bioremediation or landfill disposal.

In addition, those soils that are contaminated with chlorinated solvents are not well suited to bioremediation and will therefore be directed for disposal in an appropriately licensed landfill. It is envisaged that soils impacted with chlorinate solvents will be directed to the Class III or IV cells at Red Hill but a final decision on this will be made after assessing stockpile concentrations.

If the successful tenderer for the remedial works puts forward a competitive tender based on the use of on-site bioremediation or thermal desorption processes, the MRA will require the successful tenderer, to prepare and obtain approval for a management plan for the additional on-site treatment process.

If either a thermal treatment process or on-site bioremediation is to be used, the MRA envisages it being undertaken on a hardstand or lined area adjacent to the Southern Embankment in the vicinity of Block 3 (See Figure 3). This location has been selected as there is large concrete pads already in existence and this area of the site is the most isolated from surrounding residential and commercial areas.

As indicated in Section 5.2.1, on-site treatment processes need to be carefully managed to limit air emissions and also to ensue that the treatment process produces treated soils that are suitable for either re-use or on-site containment.

6.4 Groundwater Remediation Strategy

6.4.1 General Approach

The nature and extent of groundwater contamination is described in Section 3.4. The available remediation options are presented and discussed in Section 5.3.

As indicated in Sections 3.5 groundwater contamination is largely confined to the soils that form the upper part of the soil profile. The fact that these soils are clay rich, together with the lack of continuity of any permeable soils, has limited the mobility of contaminants in the groundwater. As a result there is little evidence that contamination is migrating off-site

Section 5.3 suggests that in such circumstances none of the conventional approaches to groundwater remediation are viable. As a result, MRA proposes that the localised groundwater contamination in the Shallow Surface Aquifer is managed using the following approach:

- removal of as much of the contaminated soil as feasible;
- simultaneous removal and treatment of contaminated groundwater that accumulates within soil excavations during remediation activities.
- installation of impermeable barriers over any areas of high concentration residual contamination that cannot be removed because of the presence Heritage structures adjacent to areas requiring remediation;

- monitoring the groundwater for a sufficient period following remediation to demonstrate the effectiveness of the remediation via source removal and/or natural attenuation.

The MRA considers that in view of the relatively low level of impact identified, this strategy will ensure that off-site ground and surface water receptors are not adversely impacted.

6.4.2 Regional Metal Contamination of the Shallow Superficial Aquifer

Given the extensive nature of the low level metal contamination and the fact that it appears to be a regional phenomenon, there is no feasible method for remediating this impact.

The concentrations being reported are at or above the Fresh Waters assessment levels. Given the lack of a sensitive environmental receptor for this groundwater, there is little likelihood of environmental impact resulting from this low level regional contamination.

Accordingly, MRA propose that it continues to monitor concentrations for 1–3 years following redevelopment to assess whether any obvious trends are apparent. The need for monitoring beyond this period will be determined following a review of the monitoring data.

6.4.3 Localised Nickel Contamination of the Shallow Superficial Aquifer

As described in Section 3.4, very high concentrations of nickel in groundwater in the Shallow Superficial Aquifer are associated with the former Plating Shop (Figure 10a). The approach to remediating the groundwater in this area will be to excavate metal-contaminated soils in this area which may be contributing to this contamination. Where contaminated groundwater is encountered during the dewatering process of the excavation, it will be treated to remove the metals; or, if this is not feasible, the affected water will be disposed of off-site to a licensed disposal site.

The clay-rich nature of the soils hosting the SSA has limited the migration of groundwater contamination. As a result, it is anticipated that the removal of the contaminated soils and the associated interstitial groundwater, combined with treatment of dewatering effluent, will result in the removal of much of the contaminated groundwater.

On completion of the soil remediation program it is proposed that the MRA monitor groundwater to assess the quality. If the concentration of nickel in groundwater at the identified area remains of concern after 3 years of monitoring, the MRA will develop further management measures in conjunction the DoE.

6.4.4 Localised Hydrocarbon Contamination of the Shallow Superficial Aquifer

As described in Section 3.4.1 and illustrated in Figure 10b, areas of hydrocarbon and/or solvent groundwater contamination have been identified in the SSA south of the Power House and south of the Tarpaulin Shop adjacent to the Southern Embankment. The approach to remediating the groundwater in these areas will be to excavate any contaminated soils that are the source of this contamination. Where contaminated groundwater is encountered during the dewatering process of the excavation, it will be treated to ensure that any dewatering effluent meets appropriate criteria for discharge into the environment. Treatment options may include but would not be limited to:

- gravity or plate separators in conjunction with carbon filters;
- membrane filtration; or
- treatment in a thermal desorption unit, if one is available.

The clay-rich nature of the soils hosting the SSA has limited the migration of groundwater contamination. As a result, it is anticipated that the removal of the contaminated soils and the associated interstitial groundwater combined with treatment of dewatering effluent will result in the removal of much of the contaminated groundwater.

On completion of the soil remediation program it is proposed that the MRA monitor groundwater to assess the quality. If the concentration of contaminants in groundwater associated with the identified hotspots remains of concern after 3 years of monitoring, the MRA will develop further management measures in conjunction the DoE.

6.4.5 Solvent Contamination of the Lower Superficial Aquifer

As described in Section 3.4.2, there is some initial evidence that solvents capable of forming a Dense Non Aqueous Liquid (DNAPL) plume have migrated vertically through the Shallow Superficial Aquifer and are causing impacts in the underlying LSA. This conclusion has been reached on the basis of limited sampling data.

As indicated in Section 3.4.6, there is a need for additional investigations to determine the nature and extent of impacts in the LSA. The need for remediation action will be determined on completion of these additional investigations, which are currently underway.

The MRA commits to the development and implementation of a DNAPL Investigation Program to the satisfaction of the Department of Environment to establish the nature and extent of any solvent contamination that may have entered the LSA.

6.5 Groundwater Remediation Targets

The targets for remediation should be either the background surface and groundwater quality or the relevant assessment criteria described in Sections 3.3.and 3.4.1.

MRA has identified the following as the target receptors for monitoring the success of the remediation program:

- Water quality in the Helena River to be used as a measure of the remediation success for the contaminants in the groundwater at the site. Water quality will be measured regularly in the Helena River upstream and downstream of Helena East to assess the extent of any impacts that may occur.

- Groundwater will also be monitored on a regular basis to establish the background quality and monitor trends, with the ultimate aim being that the quality of groundwater exiting at the site is similar to the regional groundwater quality.

The groundwater monitoring programs that are proposed are discussed further in Section 10.1.3.

7. MANAGEMENT OF ENVIRONMENTAL FACTORS

During the remediation of the site a number of environmental impacts could potentially arise which require management. The source of these issues and their management are discussed in the following subsections and cover:

- Air quality
- Noise and vibration management
- Surface and groundwater management
- Waste management
- Reporting and communication
- Community consultation
- Long term management of contaminated material

Detailed management measures for the following issues will be documented closer to the date of the remediation process in the form of Management Plans. These will have to be reviewed and approved by the DoE prior to remediation commencing and will be made available to the public via the MRA website, at www.mra.wa.gov.au.

7.1 Air Quality

Apart from dust emissions, which are discussed in Section 7.1.1, there will be negligible air emissions generated during remedial works.

7.1.1 Dust and Particulates

Dust and particulates may potentially be generated at the site during remediation works through activities such as excavation and relocation of material, movement of trucks and earthmoving equipment, and placement of clean fill in excavated pits.

The proposed remediation of Helena East represents a significant earthworks event that requires a strong commitment to management and dust control. The MRA has demonstrated through its management team that it can undertake these large scale earthworks whilst ensuring air quality is maintained at the strict standards set by the DoE and Health Department.

In order to demonstrate how the MRA's management of dust issues during previous earthworks programs, a review of how MRA has managed and monitored air quality during the remediation of various parts of the former Workshops area including Area E, Helena West, Area B, C, D, and Helena Street Extension has been undertaken and is provided in Appendix A of the Dust and Air Quality Management Plan, which is included as Appendix 11.

Experience has shown that air monitoring alone will not ensure maintenance of air quality and that an understanding of effective dust management along with real time air monitoring ensures the best outcome. MRA is committed to effective dust management measures in addition to undertaking air monitoring to demonstrate and document that acceptable air quality will be maintained during the remediation program.

A Dust and Air Quality Management Plan (DAQMP) has been prepared to manage the issue of nuisance dust and adverse air quality during the remediation phase at the Helena East site within the former Midland Workshops area. The DAQMP is included as Appendix 11.

The objective of the plan is to ensure that nuisance and contaminated dust including asbestos fibres are not generated during the remedial works and are minimised as best as practical in accordance with ALARA (as low as reasonably achievable) principles. Air quality is to comply with regulatory guidelines set for the protection of human health.

This DAQMP specifically addresses the following:

- measures and practices to minimise the generation of dust;
- location of air quality monitoring sites;
- monitoring for fine particulates
- monitoring for airborne asbestos fibres;
- monitoring for nuisance dust;
- confirmatory monitoring for heavy metal particulates contained within the dust;
- monitoring for volatile compounds associated with the removal and remediation of hydrocarbon impacted soils;
- identify regulatory guidelines and compliance criteria; and
- nominate action levels and contingency measures in the event that air quality approaches or is likely to exceed the relevant compliance criteria.

7.2 Noise and Vibration Management Plan

Noise and vibration may potentially be generated at the site during remediation works from vehicles (such as trucks and earthmoving equipment) and during compaction activities.

Noise is not considered to be a significant issue given the commercial nature of the site and the regular noise from adjacent railroad tracks and from the active railroad workshop on-site at Helena East.

A Noise and Vibration Management Plan has been prepared to ensure that noise emissions from activities at Helena East and the Southern Embankment do not elevate noise levels to an environmentally unacceptable level. The Plan is included in Appendix 12.

Due to the Heritage status of buildings at the former Midland Workshops, it is considered prudent for dilapidation surveys to be undertaken prior to remedial works. It is envisioned that dilapidation survey will be required as part of contractual specifications for the remedial works.

7.3 Surface and Groundwater Management Plan

The occurrence of rainfall or the excessive use of water sprays for dust suppression during the remediation program has the potential to generate contaminated surface runoff as a result of contact with contaminated soil.

The remediation program also has the potential for contributing to groundwater pollution as a result of poor surface water management. Groundwater monitoring has indicated that groundwater underneath the site is contaminated as a result of historical land use.

A Surface and Groundwater Water Management Plan has been prepared to ensure that activities at Helena East and the Southern Embankment do not impact on the beneficial use of surface and groundwater by detrimentally affecting the water quality of these resources. The Plan is included in Appendix 12.

7.4 Waste Management Plan

The remediation approach is to remove contaminated soil/fill and to replace with clean soil, except where Heritage Buildings will be retained. The remediation approach will allow the development of the site in accordance with the proposed concept plan.

In order to manage the environmental and social issues applicable to the removal of contaminated material across the site, a Waste Management Plan (WMP) has been prepared (Appendix 12). The purpose of the WMP is to detail how contaminated soil will be removed, and the environmental protocols for managing the remediation.

The plan includes and addresses the following items.

- A Waste Tracking System (WTS) to ensure all the excavated contaminated material is accounted for and removed off-site.

- Management requirements for excavating, transporting and stockpiling of contaminated material.

- Identifying transport routes for shifting material off-site.

The Waste Management Plan includes objectives, controls, actions, key performance indicators, monitoring / reporting and corrective actions for each of the specific items listed above.

7.5 Community Consultation

Given the location of the proposed remediation works at Helena East and the Southern Embankment, and the nature of remedial activities, there is potential for disruption to both the local and broader community as a result of the works. The works will be subject to scrutiny from regulatory authorities, stakeholders and the public. Accordingly, a communications strategy has been formulated (Appendix 12) and will be implemented in consultation with the community consultation group to ensure that the following key objectives are met:

- works will be implemented in a manner that minimises disruption to the community;
- adequate information of a sufficient quality will be made available in a timely manner to interested parties about the purpose, nature, and size of the project, and management measures that will be implemented to ensure that environmental objectives are met; and
- issues of concern associated with potential disruptions to the community will be considered and appropriately addressed.

Management practices to meet the above objectives including community consultation group, other distribution of information to the public and interested parties are discussed in Appendix 12.

The MRA is committed to keeping the community informed about the on-going remediation and redevelopment activities at the site. The MRA has been proactive and has formed a community-based consultation group referred to as the Midland Central Environmental Reference Group. This group is regularly informed on all environmental issues, including land contamination and is able to provide comment back to the MRA.

8. MANAGEMENT OF SOCIAL FACTORS

During the remediation of the site a number of social issues could potentially arise which require management. These issues and their management are discussed in the following sub-sections and cover:

- occupational health and safety;
- non-indigenous heritage; and
- traffic management.

8.1 Occupational Health and Safety

The remedial works proposed for Helena East and Southern Embankment pose a number of potential issues as a result of the varied types of contaminants present and the remedial methodologies likely to be used.

In this regard, the contractor appointed to undertake the remedial works will be required as part of specifications in a civil works contract to prepare an occupational health and safety plan. The plan will be required to acknowledge the risks associated with the implementation of the civil works design and present strategies to minimise and manage those risks.

The plan will be required to be approved by an occupational health and safety consultant appointed by the MRA and the relevant Stage and Local Government authorities.

8.2 Non-Indigenous Heritage

As outlined in Section 2.7.2 numerous buildings on the site have been assessed and determined to be of significant heritage value. This has been acknowledged by the MRA in its endorsement of the Heritage Strategy prepared by Heritage and Conservation Professionals (2004).

Investigations on the site however, have revealed that in several instances soil contamination is in close proximity to or extends beneath buildings requiring preservation. In light of this information and on this basis the preservation of these buildings is a primary focus of the redevelopment considerable effort will given to the development of civil engineering solutions that fulfil both environmental and heritage goals.

In instances where contaminated soils are in close proximity to preserved buildings, Heritage imperatives will take precedence. As a result, engineering solutions to remove contaminated soil from close proximity to Heritage-listed buildings will likely result in relatively thin ring of residual material being left abutting the buildings (see Figure 12). Any residual contamination will be recorded and managed in a manner appropriate for the building's intended use.

8.3 Traffic Management

Remediation will require the heavy haulage of bulk soils or contaminated materials to either landfill or for placement at the MIA Containment Area. This in turn is likely to increase heavy vehicle usage within the area posing a potential risk to other road users.

Depending on the type of works being undertaken it is estimated that up to 40 to 50 vehicles movements per day will be required to and from the site. At present it is expected that all vehicles entering and leaving the site will do so via Centennial Place and will travel to the east via Clayton Street then as follows:

- to the North via Lloyd Street, Great Eastern Highway, and Tonkin Highway; and
- to the south via Military Road, Bushmead Road, Stirling Crescent, and then Great Eastern Highway Bypass or Roe Highway.

It is not intended that haulage traffic be allowed to travel west along Yelverton Drive and Amherst Drive.

To ensure that no impact occurs on surrounding land users and road users adjacent to the site, a Traffic Management Plan (TMP) will be prepared. The Plan will include:

- measures to manage traffic movements and potential road safety conflicts; and
- the plan will be discussed and agreed with Main Roads Western Australia and the City of Swan before being implemented.

9. CONSULTATION

Since its inception in 2000, the MRA has actively involved the community in the evolution of the conceptual design for the redevelopment of its vested landholdings. MRA considers community consultation an important issue and is committed to open communication.

MRA's key stakeholders include State and Local Government, the local community and nearby businesses, its employees and future landowners.

9.1 Target Groups

The following groups have been identified as having an interest or potential interest in the remediation and redevelopment of Helena East and the Southern Embankment:

- lease holders, residents and businesses potentially affected by remedial works;
- individuals potentially affected by remedial works;
- Midland community;
- Local and State Government; and
- State Regulators.

9.2 Processes for Communication

As part of an ongoing community consultation program MRA has convened the Midland Environmental Reference Group for several years. The reference group has been a primary mechanism for the dissemination of information to the public and key stakeholders.

Meetings are held on a bi-monthly basis and information on all aspects of the MRA redevelopment process is tabled for discussion.

These meetings are attended by representatives from:

- City of Swan;
- Local resident representatives;
- Local Member of Parliament representative;
- Technical and further Education representative;

These meetings have included discussions on the proposed remedial works at Helena East and Southern Embankment and the development of this PER.

In addition to the regular reference group meetings information relating to various aspects of ongoing projects within the redevelopment area are posed on the MRA website. When remedial works have been ongoing monitoring data and/or other relevant environmental aspects have been made available on the website. The MRA website address is www.mra.wa.gov.au.

10. POST-REMEDIATION MANAGEMENT

10.1 Helena East and Southern Embankment

As discussed in Section 6.2.1, MRA wishes to sell land without the encumbrance of memorials stating that soil contamination is present on the land, although it is recognised that this outcome may be difficult to achieve and the need for memorials identifying the potential for groundwater contamination and/or residual soil contamination may be required. The following two sections discuss the required annotation for land titles.

10.1.1 Single Residential Lots

Following remediation, it is envisaged that the soil on all lots developed for single residential housing will have been remediated to EILs and therefore there will be no need for memorials or covenenants to be included in relation to soils contamination. There is however, widespread low level groundwater contamination on the site with localised areas where more severe contamination is present. Overall it is considered that there is little risk that householders will install groundwater extraction bores in view of the limited availability of water in the Superficial Formations and the unlikely possibility of receiving a license to assess the Leederville Formation Aquifer. Notwithstanding, in the interests of transparency, the MRA proposes that all single residential titles be annotated with the following notation:

"The land that is the subject of this title has been established on land that was formerly part of the Midland Railway Workshops. The Workshops were used for a wide range of industrial activities over the period 1904-1994.

On the basis of extensive environmental and engineering investigations, the soils on this lot have been verified as being free of contamination. However, there is a low risk that groundwater in some areas of the former Workshops site may still contain metal or hydrocarbon contamination at levels that, whilst low, are above environmental or health guidelines. The presence of this low level contamination does not represent a threat to health or the environment provided the groundwater is not extracted for use. Accordingly, the installation of bores utilising the groundwater in the Superficial Formations is prohibited. Any proposal to install bores on this property is required to be referred to the Department of Environment."

10.1.2 Commercial or Mixed Residential/Commercial

In other areas of the site where land will be developed for commercial purposes or for mixed residential (medium density) and commercial purposes, remediation may be constrained by the presence of heritage structures, resulting in minor amounts of residual soil contamination. As a consequence, the title will be annotated to read as follows:

"The land that is the subject of this title has been established on land that was formerly part of the Midland Railway Workshops. The Workshops were used for a wide range of industrial activities over the period 1904-1994.

On the basis of extensive environmental and engineering investigations, the surface soils on this lot have been remediated to a level that is compatible with the land uses permitted by the zoning of the land. Some contaminated soil may be present at depth in the immediate vicinity of heritage buildings. Where this is the case, a coloured visual warning barrier has been installed above the contaminated soil to warn of its presence. Attached with this title is a plan showing the extent and depth of the visual warning barrier.

Should works be required that may disturb the warning barrier, a management plan has been developed and can be obtained from the Midland Redevelopment Authority/City of Swan (as appropriate).

Further information on the remediation that has been completed on your land can be obtained from the Midland Redevelopment Authority /City of Swan (as appropriate).

There is also a low risk that groundwater in some areas of the former Workshops site may still contain metal or hydrocarbon contamination at levels that, whist low, are still above environmental or health guidelines. The presence of this low level contamination does not represent a threat to health or the environment provided the groundwater is not extracted for use. Accordingly, the installation of bores utilising the groundwater in the Superficial Formations is prohibited.

Further information on the remediation that has been completed on your land can be obtained from the Midland Redevelopment Authority /City of Swan (as appropriate)".

To ensure the necessary information is readily available, on completion of the remedial works, the MRA will develop maps showing the pre- and post-remediation status of the land. The maps will include overlays of the historical and new cadastre. The plans, together with copies of all investigation and validation reports will initially be held by the MRA but will be transferred to the City of Swan when the MRA has completed development.

A commitment to this effect is included in Table 18 (item number 14).

10.1.3 Management and Monitoring of Groundwater Contamination

With the exception of some localised hotspots, the current level of groundwater contamination, while extensive, is quite low.

The remediation of the site will be completed in a manner that removes a large proportion of the mass of contamination on the site. Residual waste will only be left on the site in the following circumstances:

- Some low-level contaminated 'Waste Fill' material will be left on the Southern Embankment. This material is being left *in situ* because of its relatively inert status and low leachability (refer to PER Section 4.4.1).

- Contamination will be left in and immediately adjacent to Heritage structures in situations where it cannot be removed. This contamination will either be under the building or covered with a warning barrier.

As a result of the extensive nature of the remediation and the fact that any residual contamination will be covered by a building or hardstand that will limit the potential for leaching of contaminants, it is considered that the risk of ongoing groundwater contamination is considerably lower than in the current situation, where much of the contaminated soils are infiltrated by rainfall.

In order to establish the success of the remediation strategy, and to identify any significant remaining contamination, the MRA proposes to develop a Groundwater and Helena River Management and Contingency Plan, within 6 months after completion of remediation, along with a Helena River Surface Water Management Plan. This plan will focus on the remediation targets identified in Section 3.4.1, and will involve the following:

- Six-monthly groundwater monitoring of selected bores within and around the boundary of the Helena-East Precinct for a period of not less than three (3) years.

- Quarterly monitoring of the Helena River at three (3) locations for a period of three (3) years. Baseline monitoring is currently being undertaken to assess the water condition prior to remediation. The monitoring sites have been selected to be representative of:

    1. Conditions up-gradient of Helena-East;
    2. Conditions adjacent to Helena-East; and
    3. Conditions down-gradient of Helena-East.

The Groundwater and Helena River Management and Contingency Plan will include a description of the following:

- monitoring locations;
- monitoring methodology;
- analytes and analytical methods;
- quality assurance; and
- reporting of results.

A review of the monitoring program and sampling frequency will be conducted after three years.

In the event that ground or surface water monitoring results subsequent to remediation indicate that significant impacts are occurring, the following contingency measures will be implemented:

- A more detailed analysis of the results will be completed to identify the source that is contributing to the contamination. If necessary, additional samples will be taken or additional monitoring bores installed to delineate the source or cause of the contamination.

- If appropriate, a risk assessment will be completed to establish the significance of the contamination and the potential need for remediation.

- Where monitoring data identifies a clear source of contamination that can feasibly be remediated, then the MRA will undertake the additional soil remediation and implement a specific monitoring regime to demonstrate that groundwater impacts have been addressed.

- Where monitoring data identifies a clear source of contamination that **cannot** feasibly be remediated, then the MRA will either install an impermeable barrier to prevent the migration of contaminants or use a technique such a Permeable Reactive Barrier that is capable of intercepting and treating the contamination *in situ*.

A commitment to the development of a Groundwater Management and Contingency Plan is presented in Table 18 (Item 6).

10.1.4 DNAPL Monitoring

The soil in the source region of the DNAPL contamination will be removed during remedial works; however, it is unlikely that active remediation of impacted groundwater will be feasible. The extent of groundwater affected by DNAPL is the subject of additional, ongoing, groundwater investigations. The results of the field investigations will be used to provide data for a model of potential plume behaviour. Once this information is available, it will be submitted to DoE for approval, together with a proposed monitoring regime to provide ongoing information about contaminant levels. A commitment to this effect has been included in the PER (Table 18).

10.2 MIA Containment Cell

The MIA containment cell will be designed to be a stable non polluting structure, which will require minimal management into the future. This design, when coupled with the stringent controls proposed over the material placed in the cell, will ensure that there will be minimal potential for contaminants to migrate from the cell.

The features of the containment cell design that limit the need for on-going management are:

1. Nature of Materials placed in the Cell

The assessment criteria set for material placed in the cell are similar to those for a Class 1 Landfill. Class 1 landfills are unlined facilities, and the waste acceptance criteria for these facilities have been set with the objective that they do not require capping or extensive post-closure management. Due to the non-polluting nature of the materials they accept, Class 1 landfills can generally be sited on porous or permeable soils with little capacity to attenuate pollutants.

In consideration of the above, even in the absence of any containment structure or management controls, the MIA containment cell would not be expected to pose any significant threat to the surrounding environment.

2. Nature of Surrounding Environment

There are few controls placed over the siting of Class 1 landfills other than that they should not be sited in Priority 1 or 2 Water Protection Areas. The entire MRA are is not located within a Priority 1 or 2 Water Protection Area.

The MIA Containment Cell will be located in an area of clay rich soils. These soils will act to limit the rate of migration of contaminants as the clays will attenuate contaminants that may be present. Investigations at Helena East have clearly indicates that the clays in the SSA have impeded the spread of contaminants despite the long time frame (over 100 years) over which contamination has occurred.

The lack of a well developed, continuous superficial aquifer within these sediments indicates that there is limited ability for the groundwater to transport contaminants towards the Helena River, which is located to the south of the cell.

3. Design of Containment Cell

The containment cell has been designed with the following features that will act to limit the likelihood of impacts:

- its surface contours are stable and capable of shedding any incident stormwater without erosion;
- the cell design incorporates a low permeability clay cap and base (<10^{-6} m/s permeability), which will minimise infiltration of stormwater through the soils contained in the cell;
- the cell cap will be designed to facilitate drainage of stormwater and direct it away from the cell; and
- the surface of the clay cap will covered with a topsoil/growing medium and planted with shallow rooted species that will act to provide a stable non-eroding surface.

4. Management

The following management framework is proposed to ensure that the responsibility for the future management of the cell is clear, the integrity of the structure is maintained, and contained soils are not inadvertently disturbed:

- The land on which the Containment Cell is to be sited will be excised from the title covering the MIA site and a specific title will be created that will be retained by MRA for the specific purpose of the Containment Cell.
- The land title will have an annotation identifying the presence of the contaminated soils and the management plan.
- The surface of the containment cell will be assessed annually for at least the first 3 years following final capping. The assessment will check stability, subsidence, cap integrity and erosion, to ensure that the cell is maintaining its ability to minimise stormwater infiltration. Any problem areas will be rectified and the annual inspections will continue until any subsidence has ceased, the drainage

controls are working effectively, and the vegetation cover is sufficiently established to prevent erosion.

The subsurface management plan for the Helena-East Precinct site (Appendix 12) includes a section that describes the cell, its purpose, the soils it contains, the nature of management controls included in the design and contingency measures to be adopted in the event that there is evidence that the integrity of the cell is compromised.

11. MANAGEMENT COMMITMENTS

MRA is committed to ensuring that the remediation of Helena East and the Southern Embankment will be undertaken in a manner that minimises impacts to the surrounding environment. On this basis, MRA propose a number of management commitments to ensure that remedial goals are achieved. The management commitments will be carried out to meet EPA objectives for the identified environmental factors outlined in the Environmental Scoping Document. These objectives and commitments are summarised in Table 18.

TABLE 18
HELENA EAST REMEDIATION AND REDEVELOPMENT ENVIRONMENTAL MANAGEMENT COMMITMENTS

ITEM NO.	PER SECTION NO.	TOPIC	ACTIONS	OBJECTIVE/S	TIMING	ADVICE
1	3.4.6	Groundwater	Implement a DNAPL investigation program to assess the extent of contamination impacts on the Lower Superficial Aquifer.	To assess the extent of contamination impact by solvents on the Lower Superficial Aquifer and based on the results of the investigation prepare a management plan for any impacts to the satisfaction of the DoE.	The DNAPL Investigation Program, including any reporting, will be completed prior to the issuing of titles.	DoE
2	6.4.5	DNAPL management	Develop and implement a DNAPL management strategy (if required, depending o n the outcome of DNAPL investigation)	To monitor and manage DNAPL that is present in the Lower Superficial Aquifer.	Following the completion of the DNAPL investigation (if required). Prior to the issuing of titles on affected lots.	DoE
3	7.1	Air Emissions	Implement an approved Dust and Air Quality Management Plan, addresseing dust management practices.	To ensure that there is no health risk or loss of amenity due air emission, to the environment.	Draft Plan is included in PER. Implementation to be during remediation	DoE, MRA
4	7.2	Noise & Vibration	Implement an approved Noise and Vibration Management Plan addressing the prevention of excessive and nuisance noise and prevention of damage to buildings due to vibration (require contractor to perform dilapidation survey).	To prevent noise and vibration during remediation activities exceeding regulatory standards.	Draft Plan is included in PER. Implementation to be prior and during remediation.	DoE, MRA
5	7.3	Surface and Groundwater (during remediation)	Implement an approved Surface and Groundwater Management Plan.	To prevent any potentially contaminated surface water from remedial activities from impacting on the beneficial use of groundwater beneath the site.	Plan is included in PER. Implementation to be during remediation	DoE

ITEM NO.	PER SECTION NO.	TOPIC	ACTIONS	OBJECTIVE/S	TIMING	ADVICE
6	10.1.3	Groundwater and Helena River Management and Contingency Plan (post - remediation)	Prepare a Groundwater and Helena River Management and Contingency Plan (post-remediation).	To assess the impact of the remediation on groundwater and River quality over time.	Concurrent with PER process and remediation. Implementation post-remediation	DoE
7	7.4	Waste Management	Implement an approved Waste Management Plan that addresses the appropriate management measures for the excavation and removal of waste from the site.	To ensure that waste material removed/excavated from the site is appropriately managed.	Plan is included in PER. Implementation to be during remediation.	DoE
8	Appendix 12	Remediation and Validation	Prepare Remediation and Validation Plan.	Document methods of remediation. Document that remediation is undertaken such that the site is suitable for the proposed uses.	Preparation prior to remediation commencement. Implementation during and post remediation.	DoE
9	2.5.5 and Appendix 12	Stormwater/ Drainage (post-remediation)	Implement the approved Stormwater/ Drainage Management (Egis, 2002)	To control the water onsite and prevent water being discharged directly to the Helena River	Post-remediation. Stormwater Management Strategy prepared by Egis (2002) has previously been approved by DoE	n/a
10	8.3 and Appendix 12	Traffic Management	Selected Contractor to prepare a Traffic Management Plan to provide appropriate management measures for the transport of bulk soils or contaminated materials off-site, or clean fill on-site to control any potentially associated traffic operation and road safety problems.	Minimise the effects of remediation related road traffic in adjoining areas.	Prepare Plan prior to remediation. Implementation during remediation	MRA, City of Swan.

ITEM NO.	PER SECTION NO.	TOPIC	ACTIONS	OBJECTIVE/S	TIMING	ADVICE
11	7.5 and Appendix 12	Community Consultation	Continue to consult with stakeholders and keep the community informed on the progress of the remediation project as outlined in the Community Consultation Plan.	To inform, seek feedback and address community and stakeholder concerns about the project.	Draft Plan is included in PER. Implementation prior to, during and post-remediation.	Environ-mental Reference Group
12	6.3.4	On-site soil treatment	Develop and implement a Management Plan for on-site treatment processes (if appropriate, depending on management strategy feasibility).	To ensure that there is no health risk or loss of amenity due to the use of any on-site treatment process	Prior to the commencement of remedial works (if appropriate)	DoE
13	10.1	Long Term Management for remaining contaminated soil and groundwater	Prepare a procedure for annotation of titles where contaminated soil and groundwater remain, and to place a ban on abstracting groundwater from the Superficial Aquifer.	To inform future landowner of the historical landuse and contamination status, and to prevent contaminated groundwater from abstracted and utilised.	Post Remediation	DoE
14	6.2.1	Long Term Management Southern Embankment	Prepare Irrigation Management Plan (if required, depending on subdivision plan final use).	To prevent excessive leaching of water and thereby potentially contaminants through remaining waste fill.	Prepare Plan during remediation. Implementation post remediation (if required)	DoE
15	6.2.1	Long Term Management of Waste Material remaining onsite	Prepare a Subsurface Management Plan.	To ensure the waste material remains intact and does not inadvertently come in contact with members of the public	Post Remediation	DoE

REFERENCES

ATSDR (2005). http://www.atsdr.cdc.gov/. Agency for Toxic Substances and Disease Registry. Department of Health and Human Services. Last accessed 19/12/2005.

ANZECC (2000). *Australian Water Quality Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council.

Bureau of Meteorology (2005). *Climatological Data for Perth Airport Using Data from 1944 to (November) 2005*. Climate and Consultancy Section in the WA Regional Office of the Bureau of Meteorology, Australian Government. December, 2005.

Bowman Bishaw Gorham (1994). *Midland Railway Workshops Site Environmental Audi*t. August, 2004. Report R13181.

Bowman Bishaw Gorham (1995). *Midland Railway Workshops Site Contaminant Migration Study.* Report R14185.

CMPS&F (1995). *Midland Railway Workshops. Assessment of Contamination and its Implications*. July, 1995.

CMPS&F (1996). *Environmental Investigations: Midland Railway Workshops*. December, 1996.

Crisalis International (2005). *Midland Railway Workshops site, Helena East Precinct: Review of Reports Relating to Hydrogeology of the Site and Potential Impacts of Groundwater Contaminants on The Helena River*. Report to ATA Environmental for Midland Redevelopment Authority. June, 2005.

Crisalis International (2006). *Review and Recommendation on Groundwater Monitoring at Helena East Precinct, Midland Railway Workshop.* Report to ATA Environmental for Midland Redevelopment Authority. March, 2006.

Davidson, W.A. (1995). *Hydrogeology and Groundwater Resources of the Perth Region, Western Australia.* Western Australian Geological Survey, Bulletin 142.

DoE (2003). *Assessment Levels for Soil, Sediment and Water (Draft).* Contaminated Sites Management Series. Department of Environment (DoE), Perth.

DoE (2005). *Landfill Waste Classification and Waste Definitions 1996 (as amended).* Department of Environment (DoE), Perth.

EGIS Consulting (2002). *Stormwater Discharge Strategy from the Midland Redevelopment Authority into the Helena River Flood Plain*. March 2002.

ENV Australia (2001). *Environmental Investigations, Midland Railway Workshops Area B, C & D, Police Operations Facility Site*. Report for Midland Redevelopment Authority, 2001.

ENV Australia (2002a). *Meat Industry Authority: Preliminary Site Investigation*. Report for Midland Redevelopment Authority, May 2002.

ENV Australia (2002b). *Detailed Site Investigations/Helena Precinct Waste Fill, Midland Railway Workshops*. Report for Midland Redevelopment Authority, October 2002.

ENV Australia (2003a). *Meat Industry Authority Site: Detailed Site Investigation*. Report for Midland Redevelopment Authority, March 2003.

ENV Australia (2003b). *Hydrogeological Investigation Helena West, Midland Railway Workshops*. Report for Midland Redevelopment Authority, May 2003.

ENV Australia (2004). *Environmental Investigations in Support of Referral Helena East, Midland Railway Workshops Site*. Report for Midland Redevelopment Authority, October 2004.

ENV Australia (2005). *Midland Railway Workshops Site Helena East Precinct Referral and Scoping Document*. Report for Midland Redevelopment Authority, May 2005.

EPA (2000). Guidance Statement for Remediation Hierarchy for Contaminated Land. Bulletin July, 2000. Environmental Protection Authority (EPA), Perth.

EPA (2003). *Remediation of Midland Railway Workshop Site, Helena West, Midland*. Bulletin 1111. September, 2003. Environmental Protection Authority, Perth.

Government of Western Australia (2000a). *Bush Forever - Keeping the Bush in the City*. *Volume 1: Policies Principles and Processes*. Perth, WA.

Government of Western Australia (2000b). *Bush Forever - Keeping the Bush in the City*. *Volume 2: Directory of Bush Forever Sites*. Perth, WA.

Goyer, R.A. (1996). *Toxic Effects of Metals*. In Klaassen, C.D., Amdur, M.O. and Doull, J. (eds). Casarett and Doull's Toxicology: The Basic Science of Poisons. McGraw-Hill, USA.

Heddle E.M., Loneragan, O.W. & Havel, J.J. (1980). *Atlas of Natural Resources Darling System Western Australia*. Department of Conservation and Environment, Western Australia.

Heritage and Conservation Professionals (2004). *Heritage Strategy Midland Central Redevelopment Area*. Report for Midland Redevelopment Authority, November 2001, updated August 2004.

Midland Redevelopment Authority (2005). Midlandmetro Concept Plan 2010 Midland Central Redevelopment Area.

Ministry of Housing, Spatial Planning and the Environment (1994). *Environmental Quality Objectives in the Netherlands.* Risk Assessment and Environmental

Quality Division, Directorate for Chemicals, External Safety and Radiation Protection. The Hague, Netherlands.

National Environment Protection Council (1999) *National Environment Protection (NEPM) Assessment for Site Contamination Measure*.

NHMRC/ARMCANZ (1996). *Australian Drinking Water Guidelines.* National Health and Medical Research Council/Agriculture and Resource Management Council of Australia and New Zealand.

NOHSC (2004). *Code of Practice for the Managements and Control of Asbestos in Workplaces (NOHSC:2018)*. National Occupational Health and Safety Commission.

Playford, P.E., Cockbain, A.E., and Low, G.H. (1976) Geology of the Perth Basin Western Australia. Western Australian Geological Survey, Bulletin 124.

Puls R.W., and Barcelona M.J. (1996). *Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures.* United States Environmental Protection Agency, Ground Water Issue, EPA/540/S-95/504.

US EPA (1996). *Soil Sampling Guidance: Technical Background Document.* Publication EPA/540/R95/128. United States Environmental Protection Agency (US EPA).

RBM Drilling (2005). Bore construction & water analysis report, dated 15 July 2005.

Spectrum Laboratories (2006). *Chemical Fact Sheet – CAS #74953*. Webpage: http://www.speclab.com/compound/c74953.htm.

Standards Australia (1997). *Wastes, Sediments and Contaminated Soils Part 3: Preparation of Leachates - Bottle Leaching Procedure. AS 4439.3-1997*. Standards Australia, Homebush.

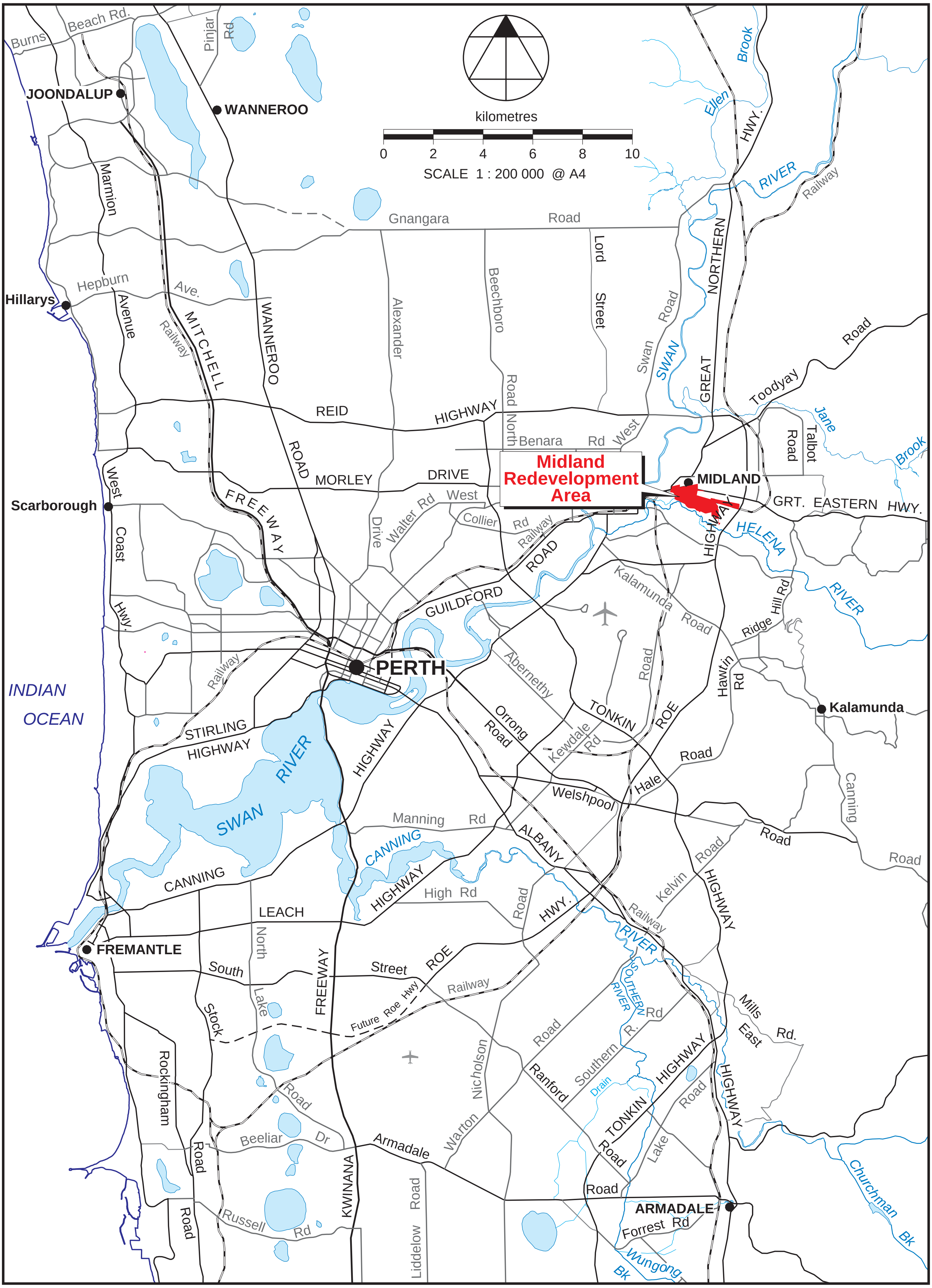
Standards Australia (1999). *Guide to the Sampling and Investigation of Potentially Contaminated Soil: Part 1 Non-volatile and Semi-volatile Compounds AS4482.1*. Standards Australia, Homebush.

ACRONYMS

ALARA	As Low As Reasonably Achievable
ATA	ATA Environmental
ARHS	Australian Railway Historical Society
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CADCOM	Computer Aided Dispatch and Communications
CCW	Conservation Category Wetland
DAF	Dilution – Attenuation Factor
DAQMP	Dust and Air Quality Management Plan
DNAPL	Dense Non-Aqueous Phase Liquids
DoE	Department of Environment
EIL	Ecological Investigation Level
EPA	Environmental Protection Authority
Ha	Hectare
HDPE	High Density Polyethylene
HIL	Health Investigation Level
LNAPL	Light Non-Aqueous Phase Liquids
LSA	Lower Superficial Aquifer
m	Metre
mAHD	metres Australian Height Datum
mBGL	metres Below Ground Level
MIA	Meat Industry Association
MRA	Midland Redevelopment Authority
NAPL	Non-Aqueous Phase Liquid
OC	Organochlorine (Pesticide)

OP	Organophosphorous (Pesticide)
PAHs	Polycyclic Aromatic Hydrocarbons
PER	Public Environmental Review
PRG	Preliminary Remediation Guideline
PVC	Polyvinyl Chloride
SSA	Shallow Superficial Aquifer
SSL	Soil Screening Level
TMP	Traffic Management Plan
TPH	Total Petroleum Hydrocarbons
UCL	Upper Confidence Limit
US EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
WA	Western Australian
WAGR	West Australian Government Railways
WAPC	Western Australian Planning Commission
WAPS	West Australian Police Service
WMP	Waste Management Plan
WTS	Waste Tracking System

FIGURES



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HELENA EAST - REMEDIATION & REDEVELOPMENT
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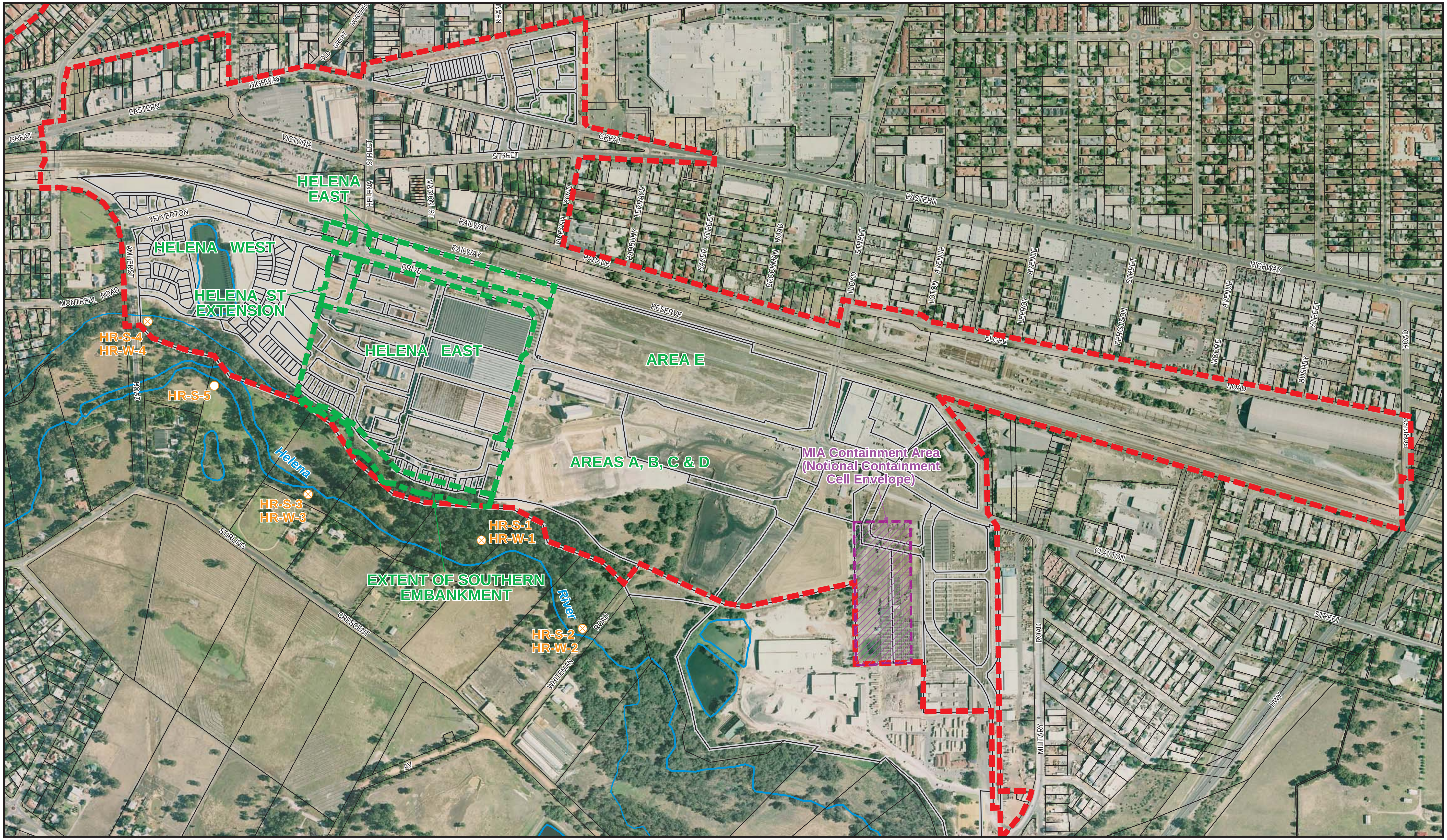
REGIONAL LOCATION

FIGURE 1



LEGEND

- Midland Redevelopment Authority Boundary
- Helena East Area Boundary
- Cadastral / Proposed Cadastral Boundary
- River / Stream
- HR-W-1 × River Sample Location
- HR-S-1 ○ Sediment Sample Location

metres

0 100 200 300 400 500

SCALE 1 : 7 500 @ A3

SOURCE: McMullen Nolan & Partners, PHOTO 2005; CAD 2004

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MIDLAND REDEVELOPMENT AUTHORITY AREA

FIGURE 2

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DATUM: MGA

MRA5-4/PER/25_142f02.dgn

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DRAWN BY: TE/EDS 20-12-05

DATUM: MGA

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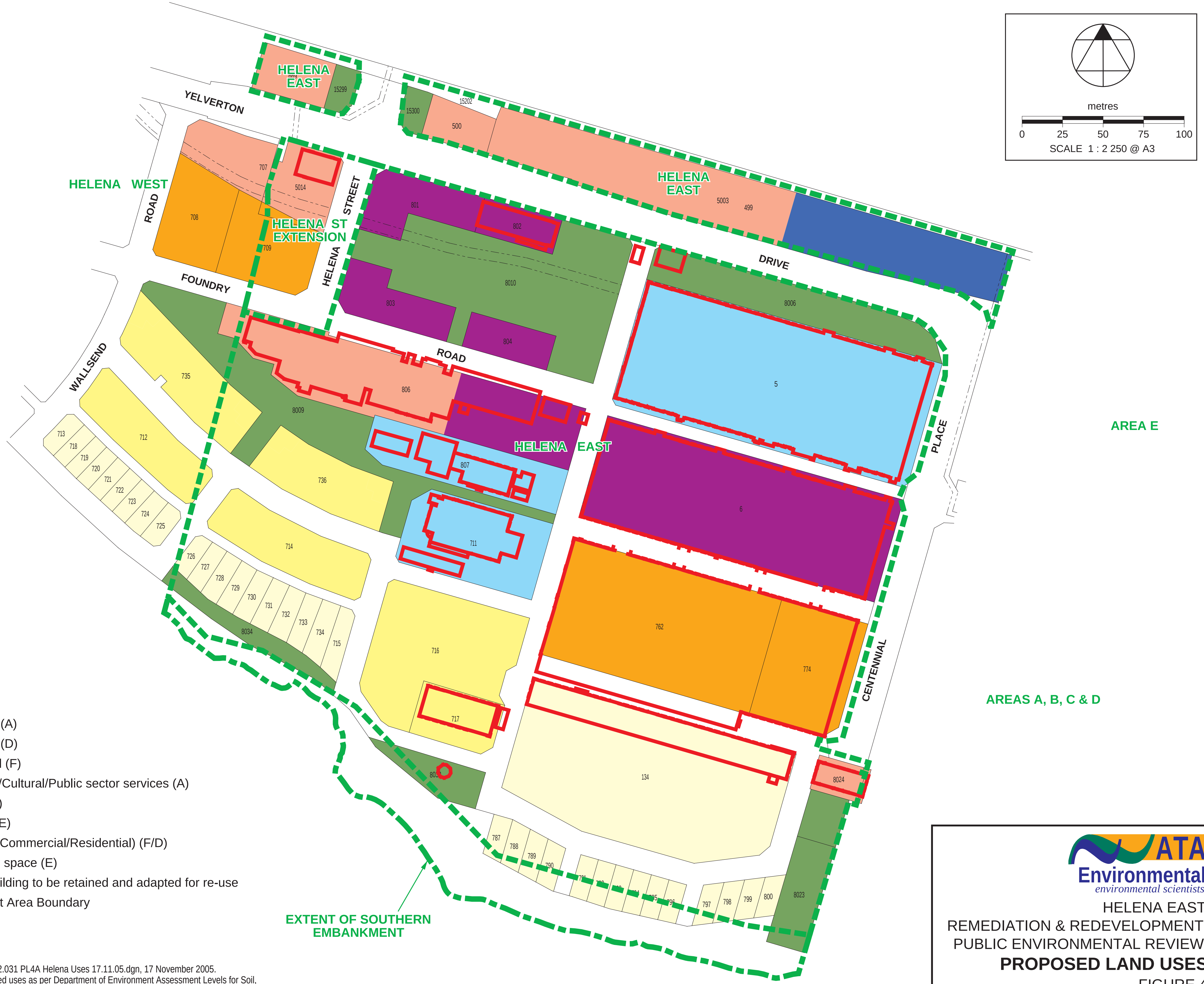

LEGEND

- Residential (A)
- Residential (D)
- Commercial (F)
- Community/Cultural/Public sector services (A)
- Museum (F)
- Education (E)
- Mixed use (Commercial/Residential) (F/D)
- Public open space (E)
- Heritage building to be retained and adapted for re-use
- Helena East Area Boundary

SOURCES
BASE: The Planning Group, Dwg No. 702.031 PL4A Helena Uses 17.11.05.dgn, 17 November 2005.
PROPOSED USES: MRA Concept Plan 2010. Proposed uses as per Department of Environment Assessment Levels for Soil, Sediment and Water (2003). Health Investigation Levels (HIL) A, B, D, E and F.

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REMEDIATION & REDEVELOPMENT
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PROPOSED LAND USES

FIGURE 4

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DATUM: MGA

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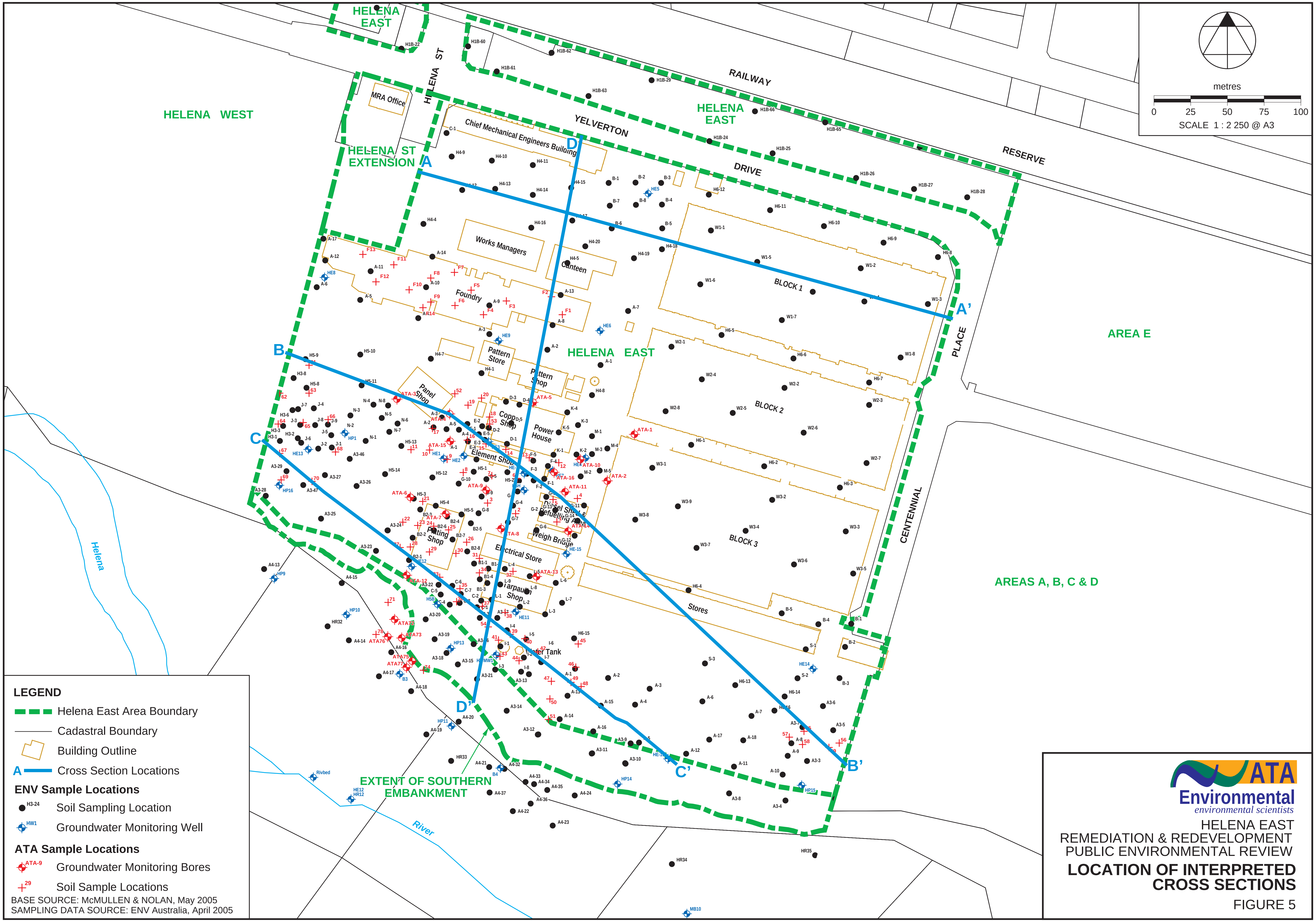

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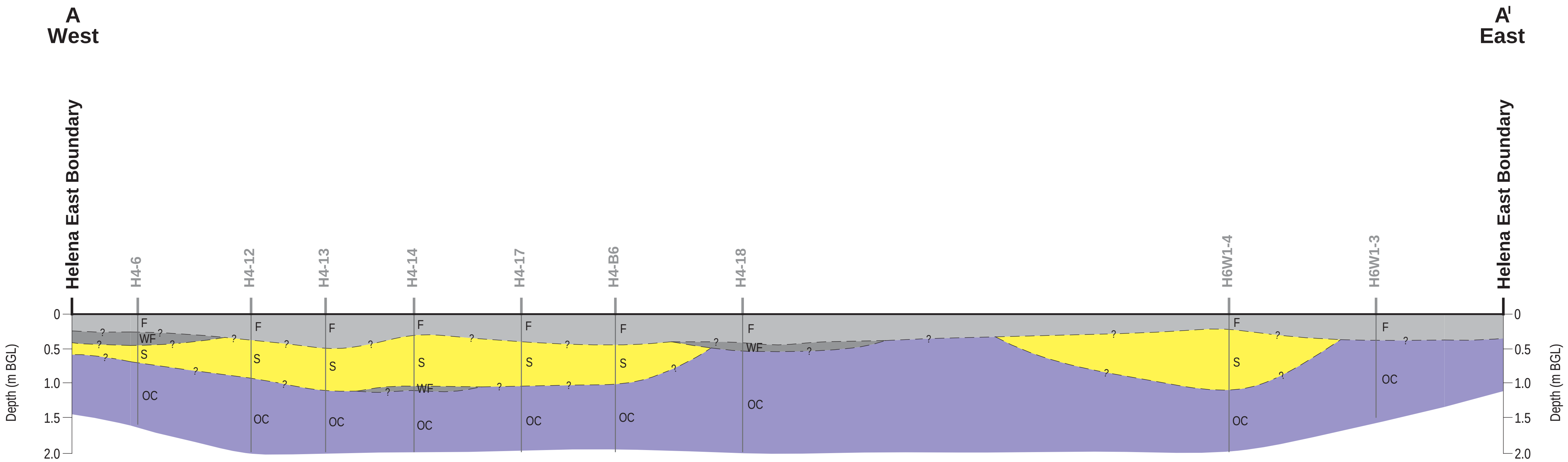

LEGEND

- Hole trace.
- F — INERT FILL compromising roadbase, gravel, concrete, etc. (grey to brown).
- WF — WASTE FILL compromising ash, slag, coal, metal, asbestos, etc. (dark grey to black).
- S — Medium grained quartz SAND (grey to brown).
- Variably coloured (grey, red, yellow-brown) SANDY CLAY/CLAYEY SAND with some silt and/or gravel, dominantly medium grained with some fine and coarse grained intervals.
  - OC — Yellow-brown, red and grey CLAY with some sand and/or gravel.
  - FS — Grey, white and red SILTY SAND with some clay, generally dry and friable.
  - SA — Yellow-brown, red and grey COARSE-GRAINED SAND with some clay.
  - L — LOAMY SILTY SANDS, medium to coarse grained.
  - CL — Grey, white and olive brown fine to medium grained SANDY CLAY/CLAYEY SAND.
  - Y — Yellow-brown SAND WITH SOME CLAY, transition to saturated sand below grey/red clays.
- SS — Grey to brown fine medium grained quartz SAND WITH SOME SILT, generally saturated.

FOOTNOTES:

1. Refer to Figure 5 for cross section locations.
2. The subsurface cross section has been inferred from logs of subsurface conditions encountered in boreholes. Actual subsurface conditions may vary from those indicated in the cross section.
3. Bore locations were surveyed.

HORIZONTAL SCALE 1 : 1 500
VERTICAL SCALE 1 : 150

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CROSS SECTION A-A' (EAST - WEST)

FIGURE 6a

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DATUM: N/A

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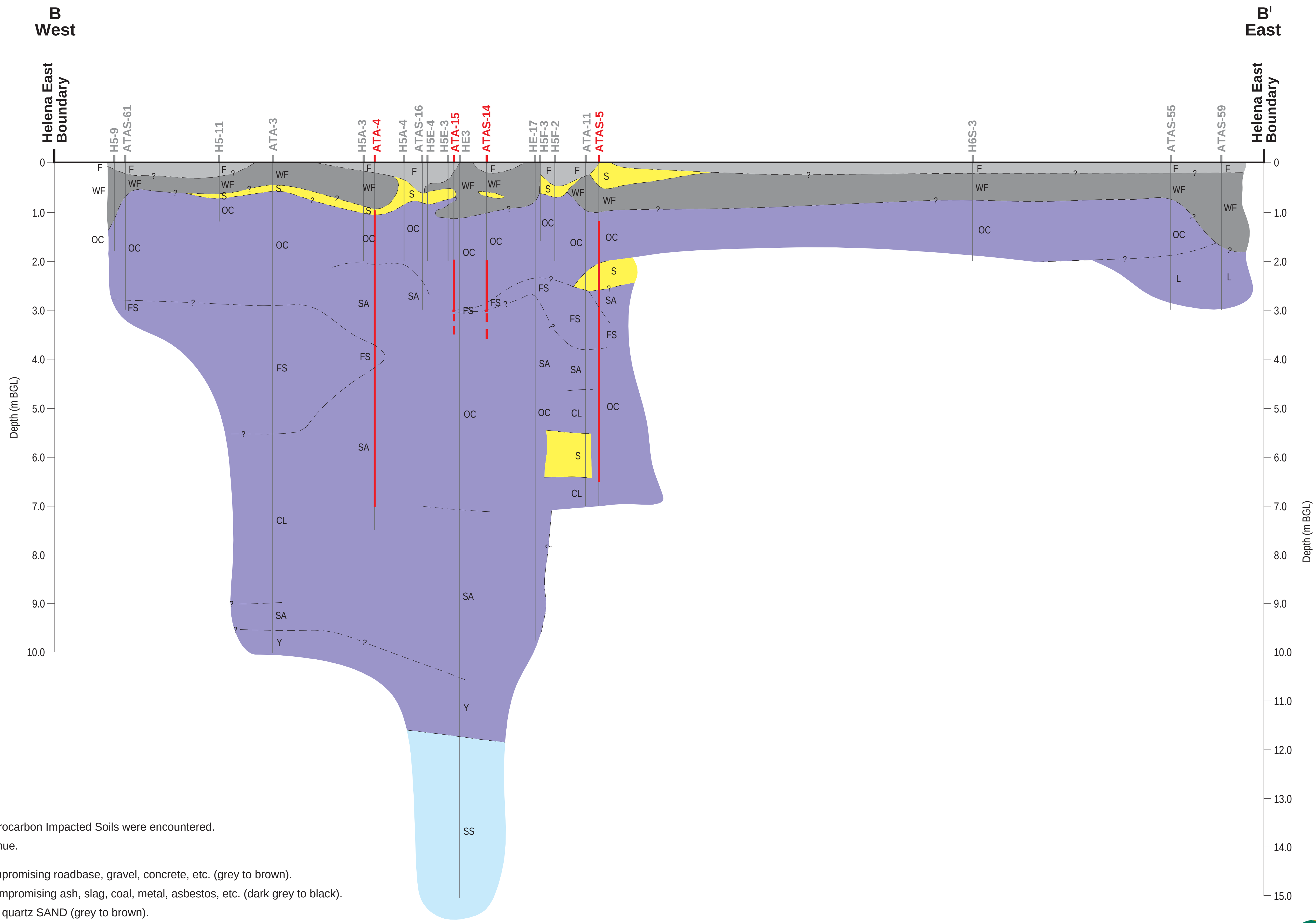

LEGEND

(grey line)	Hole trace.
(red line)	Hole where Hydrocarbon Impacted Soils were encountered.
(red dashed line)	Inferred to continue.
F	INERT FILL compromising roadbase, gravel, concrete, etc. (grey to brown).
WF	WASTE FILL compromising ash, slag, coal, metal, asbestos, etc. (dark grey to black).
S	Medium grained quartz SAND (grey to brown).
(purple)	Variably coloured (grey, red, yellow-brown) SANDY CLAY/CLAYEY SAND with some silt and/or gravel, dominantly medium grained with some fine and coarse grained intervals.
OC	Yellow-brown, red and grey CLAY with some sand and/or gravel.
FS	Grey, white and red SILTY SAND with some clay, generally dry and friable.
SA	Yellow-brown, red and grey COARSE-GRAINED SAND with some clay.
L	LOAMY SILTY SANDS, medium to coarse grained.
CL	Grey, white and olive brown fine to medium grained SANDY CLAY/CLAYEY SAND.
Y	Yellow-brown SAND WITH SOME CLAY, transition to saturated sand below grey/red clays.
SS	Grey to brown fine medium grained quartz SAND WITH SOME SILT, generally saturated.

FOOTNOTES:

1. Refer to Figure 5 for cross section locations.
2. The subsurface cross section has been inferred from logs of subsurface conditions encountered in boreholes. Actual subsurface conditions may vary from those indicated in the cross section.
3. Bore locations were surveyed.

HORIZONTAL SCALE 1 : 1 500
VERTICAL SCALE 1 : 150

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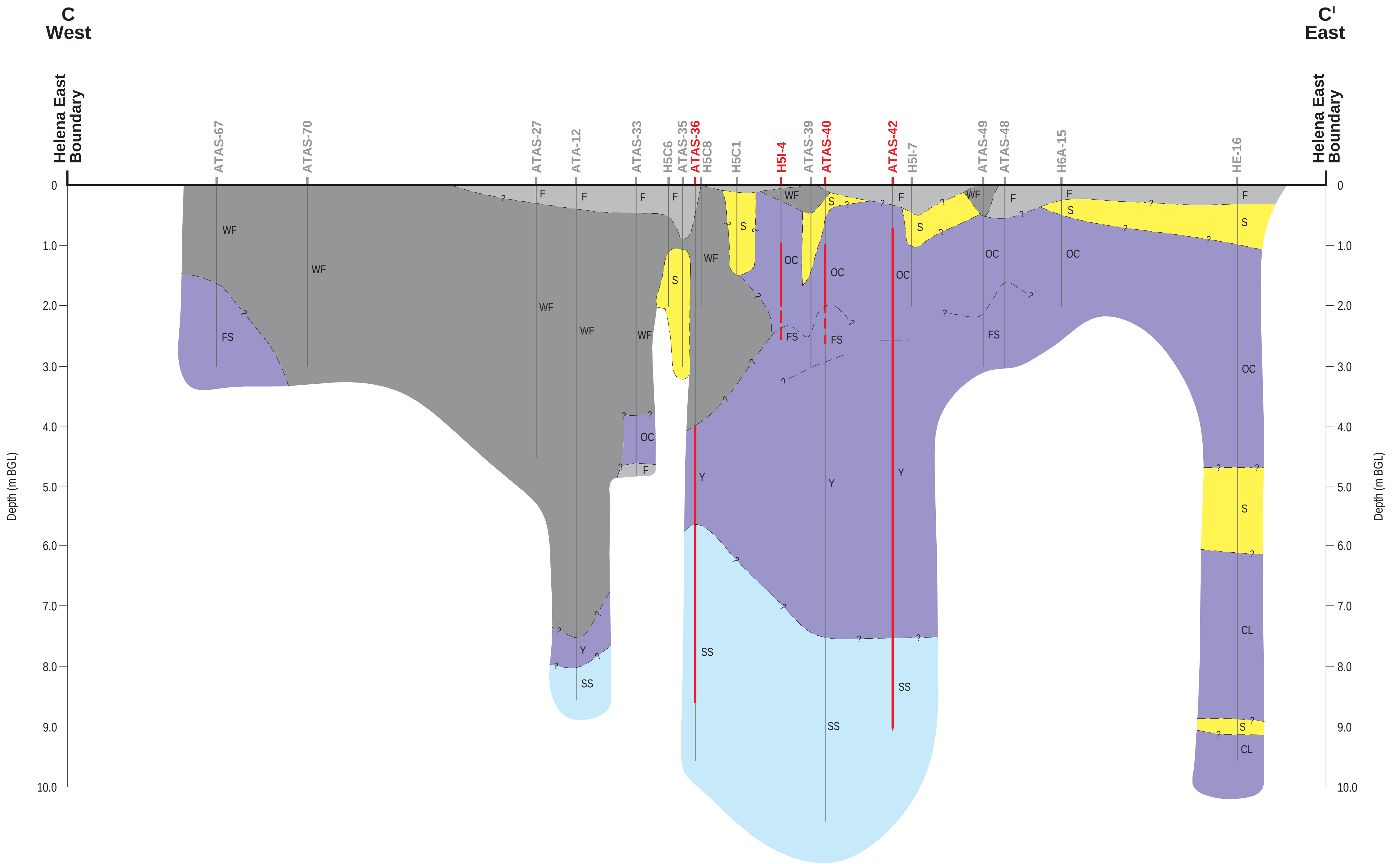
CROSS SECTION B-B' (EAST - WEST)

FIGURE 6b



LEGEND

Hole trace.

Hole where Hydrocarbon Impacted Soils were encountered.

Inferred to continue.

F — INERT FILL compromising roadbase, gravel, concrete, etc. (grey to brown).

WF — WASTE FILL compromising ash, slag, coal, metal, asbestos, etc. (dark grey to black).

S — Medium grained quartz SAND (grey to brown).

Variably coloured (grey, red, yellow-brown) SANDY CLAY/CLAYEY SAND with some silt and/or gravel, dominantly medium grained with some fine and coarse grained intervals.

- OC — Yellow-brown, red and grey CLAY with some sand and/or gravel.
- FS — Grey, white and red SILTY SAND with some clay, generally dry and friable.
- SA — Yellow-brown, red and grey COARSE-GRAINED SAND with some clay.
- L — LOAMY SILTY SANDS, medium to coarse grained.
- CL — Grey, white and olive brown fine to medium grained SANDY CLAY/CLAYEY SAND.
- Y — Yellow-brown SAND WITH SOME CLAY, transition to saturated sand below grey/red clays.

SS — Grey to brown fine medium grained quartz SAND WITH SOME SILT, generally saturated.

FOOTNOTES:

1. Refer to Figure 5 for cross section locations.
2. The subsurface cross section has been inferred from logs of subsurface conditions encountered in boreholes. Actual subsurface conditions may vary from those indicated in the cross section.
3. Bore locations were surveyed.

HORIZONTAL SCALE 1 : 1 500
VERTICAL SCALE 1 : 150

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CROSS SECTION C-C' (EAST - WEST)

FIGURE 6c

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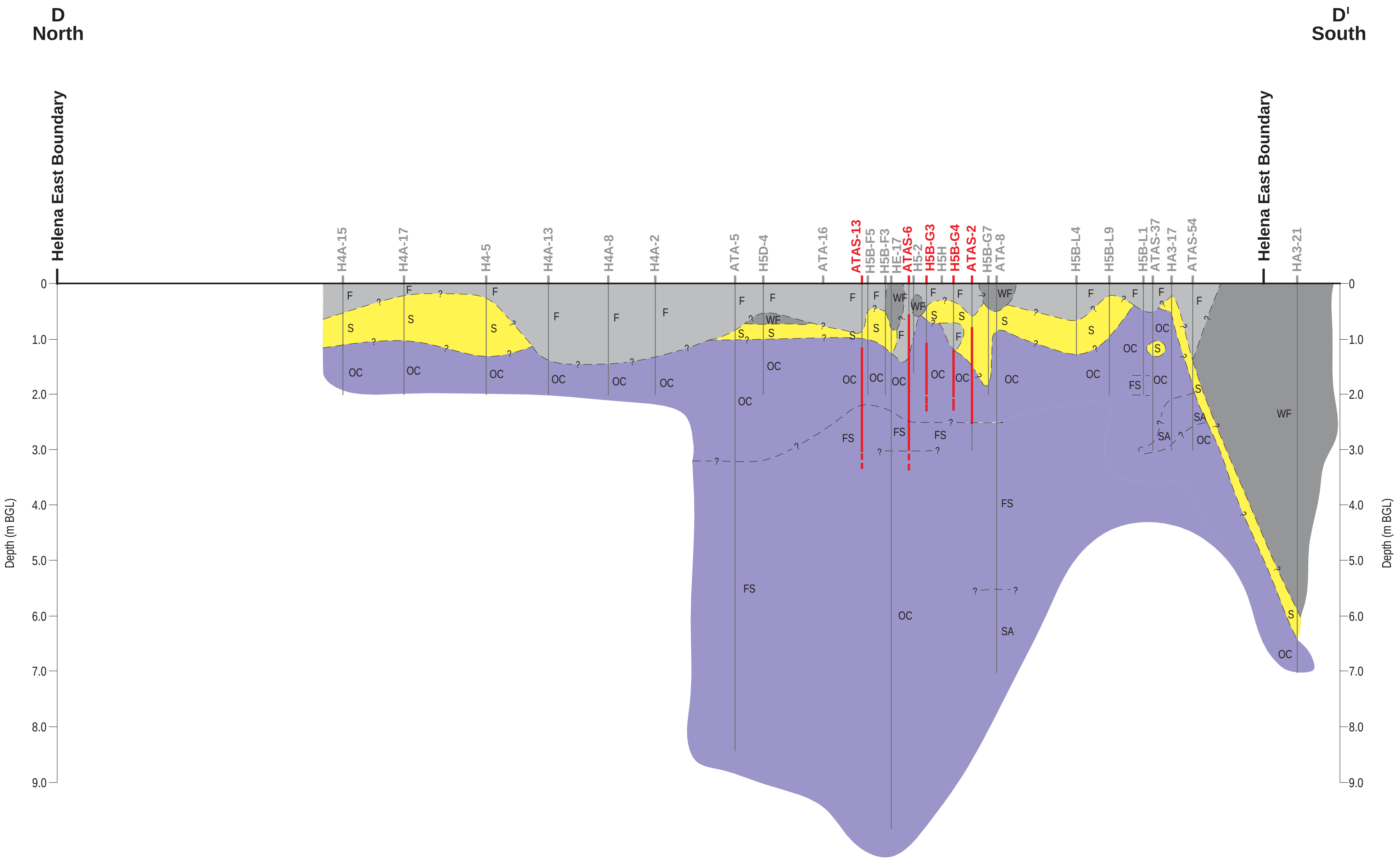
MRA-2005-004/PER/25_142f06d.dgn DATUM: N/A DRAWN BY: EDS 16-12-05 CHECKED BY: SB 16-12-05



LEGEND

Hole trace.

Hole where Hydrocarbon Impacted Soils were encountered.

Inferred to continue.

F — INERT FILL compromising roadbase, gravel, concrete, etc. (grey to brown).

WF — WASTE FILL compromising ash, slag, coal, metal, asbestos, etc. (dark grey to black).

S — Medium grained quartz SAND (grey to brown).

Variably coloured (grey, red, yellow-brown) SANDY CLAY/CLAYEY SAND with some silt and/or gravel, dominantly medium grained with some fine and coarse grained intervals.

- OC — Yellow-brown, red and grey CLAY with some sand and/or gravel.
- FS — Grey, white and red SILTY SAND with some clay, generally dry and friable.
- SA — Yellow-brown, red and grey COARSE-GRAINED SAND with some clay.
- L — LOAMY SILTY SANDS, medium to coarse grained.
- CL — Grey, white and olive brown fine to medium grained SANDY CLAY/CLAYEY SAND.
- Y — Yellow-brown SAND WITH SOME CLAY, transition to saturated sand below grey/red clays.

SS — Grey to brown fine medium grained quartz SAND WITH SOME SILT, generally saturated.

FOOTNOTES:

1. Refer to Figure 5 for cross section locations.
2. The subsurface cross section has been inferred from logs of subsurface conditions encountered in boreholes. Actual subsurface conditions may vary from those indicated in the cross section.
3. Bore locations were surveyed.

HORIZONTAL SCALE 1 : 1 500
VERTICAL SCALE 1 : 150

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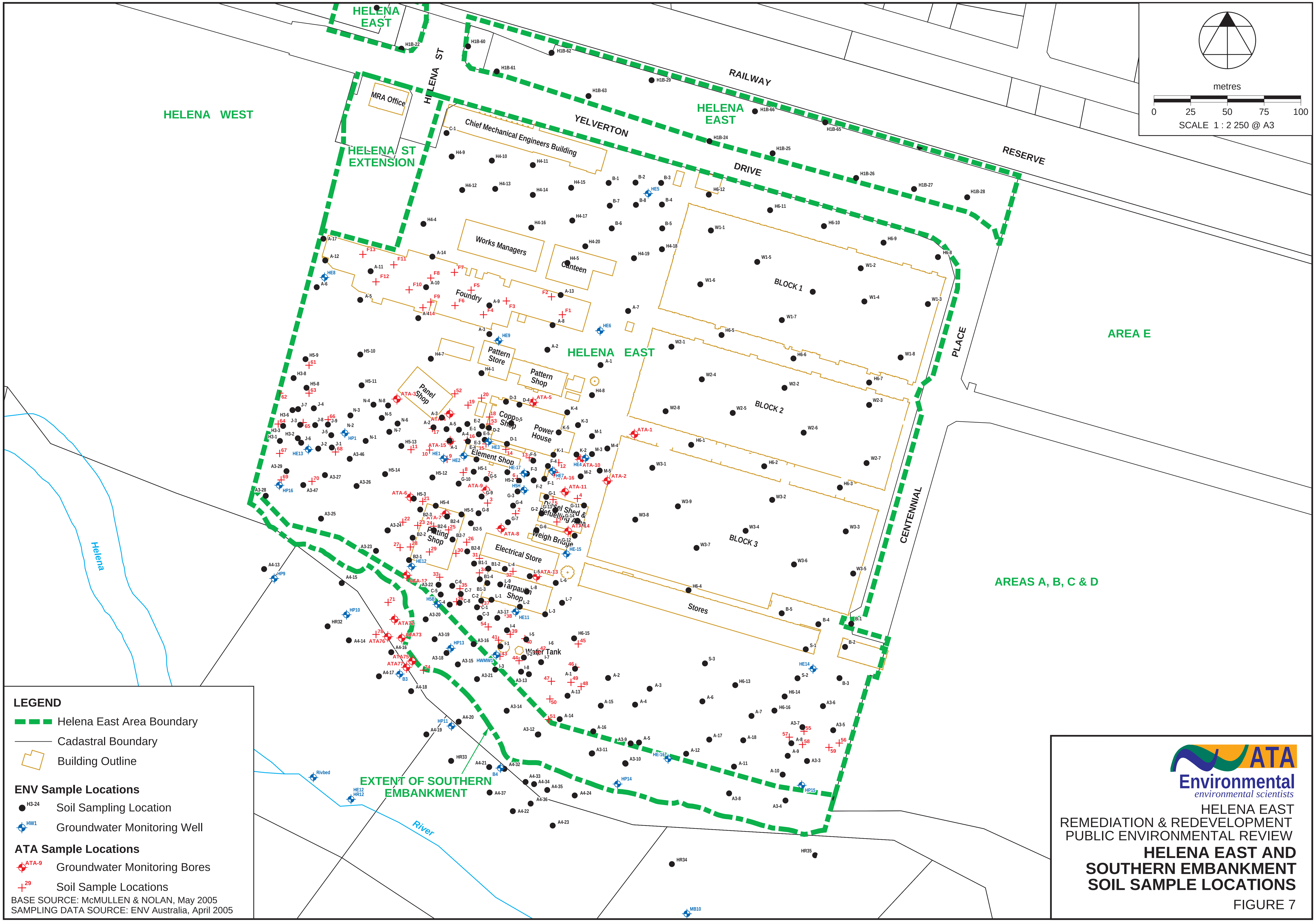
CROSS SECTION D-D' (NORTH - SOUTH)

FIGURE 6d



LEGEND

Helena East Area Boundary

Cadastral Boundary

Building Outline

ENV Sample Locations

H3-24 Soil Sampling Location

HW1 Groundwater Monitoring Well

ATA Sample Locations

ATA-9 Groundwater Monitoring Bores

29 Soil Sample Locations

BASE SOURCE: McMULLEN & NOLAN, May 2005
SAMPLING DATA SOURCE: ENV Australia, April 2005

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HELENA EAST AND SOUTHERN EMBANKMENT SOIL SAMPLE LOCATIONS

FIGURE 7

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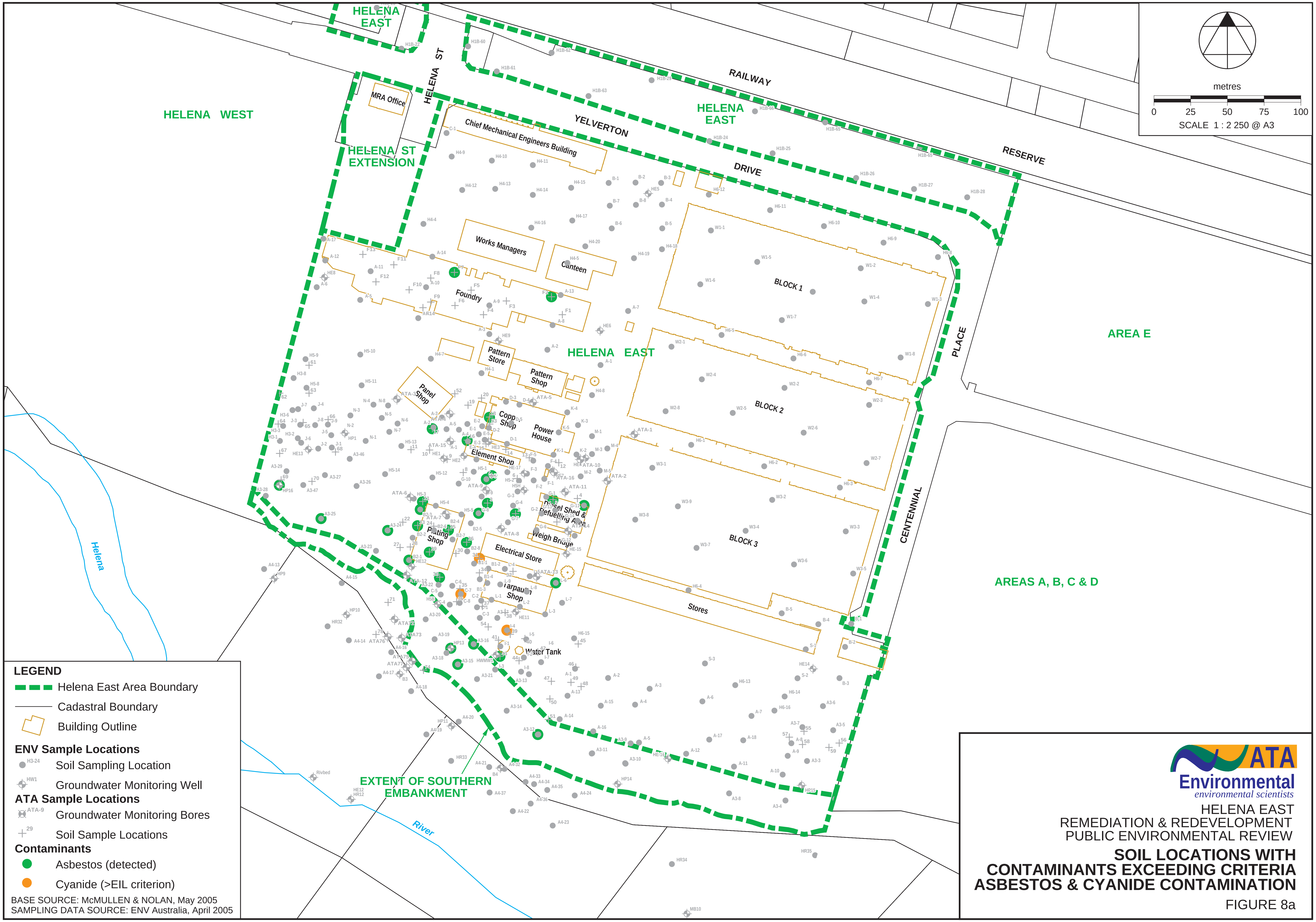
MRA-5-4/PER/25_142f07.dgn DATUM: MGA DRAWN BY: TE/EDS 23-03-06 CHECKED BY: SB/GJM 23-03-06



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SOIL LOCATIONS WITH CONTAMINANTS EXCEEDING CRITERIA ASBESTOS & CYANIDE CONTAMINATION

FIGURE 8a

PRINTED: Mon 03 Apr 06

MRA-5-4/PER/25_142f08a.dgn DATUM: MGA DRAWN BY: TE/EDS 23-03-06 CHECKED BY: SB/GJM 23-03-06

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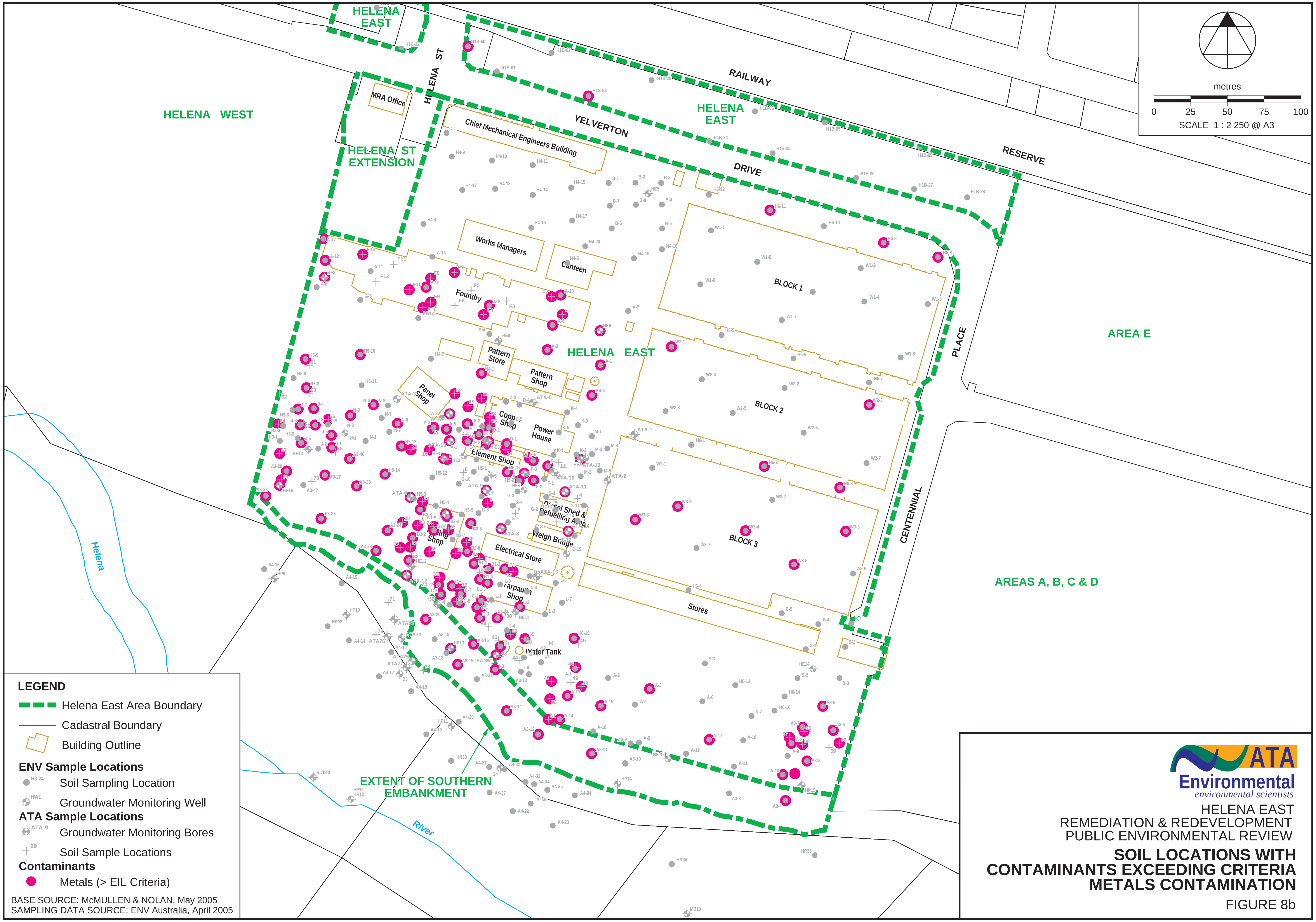
DATUM: MGA

MRA-5-4/PER/25_142f08b.dgn



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APPROXIMATE AREA OF METAL IMPACT, WITH DEPTH CONTOURS

FIGURE 8c

PRINTED: Mon 03 Apr 06
CHECKED BY: SB 23-03-06
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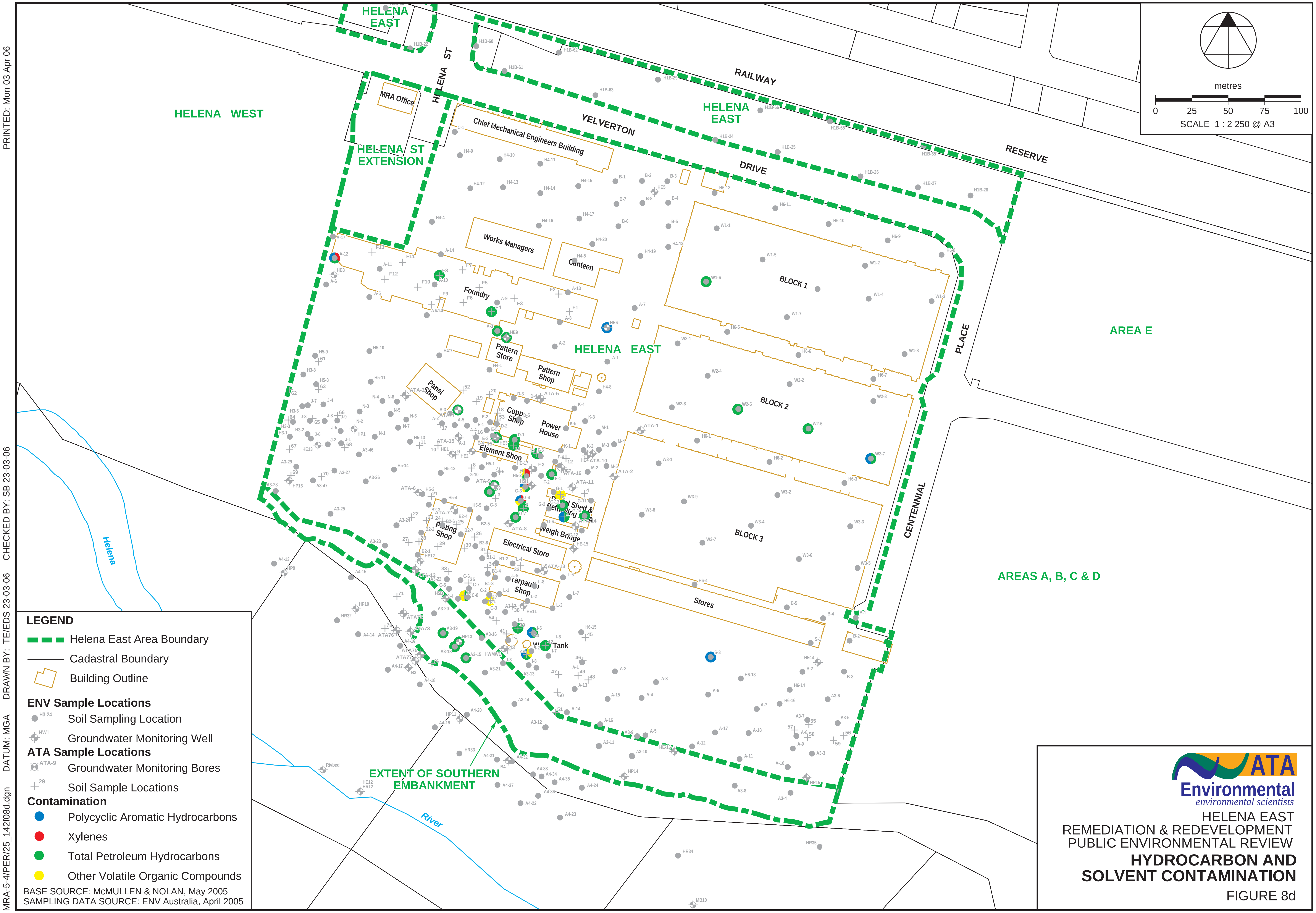
DATUM: MGA
MRA-5-4/PER/25_142f08c.dgn


HELENA WEST
HELENA EAST
HELENA ST
HELENA ST EXTENSION
MRA Office
Chief Mechanical Engineers Building
RAILWAY
YELVERTON
DRIVE
RESERVE
CENTENNIAL
PLACE
AREA E
AREAS A, B, C & D
EXTENT OF SOUTHERN EMBANKMENT
Helena
River
Works Managers
Canteen
Foundry
Pattern Store
Pattern Shop
Panel Shop
Copp Shop
Power House
Element Shop
Plating Shop
Electrical Store
Tarpaulin Shop
Weigh Bridge
Stores
BLOCK 1
BLOCK 2
BLOCK 3
Tank
metres
0 25 50 75 100
SCALE 1 : 2 250 @ A3
LEGEND
Helena East Area Boundary
Cadastral Boundary
Building Outline
ENV Sample Locations
Soil Sampling Location
Groundwater Monitoring Well
ATA Sample Locations
Groundwater Monitoring Bores
Soil Sample Locations
Contamination
Polycyclic Aromatic Hydrocarbons
Xylenes
Total Petroleum Hydrocarbons
Other Volatile Organic Compounds
BASE SOURCE: McMULLEN & NOLAN, May 2005
SAMPLING DATA SOURCE: ENV Australia, April 2005
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HYDROCARBON AND SOLVENT CONTAMINATION
FIGURE 8d
PRINTED: Mon 03 Apr 06
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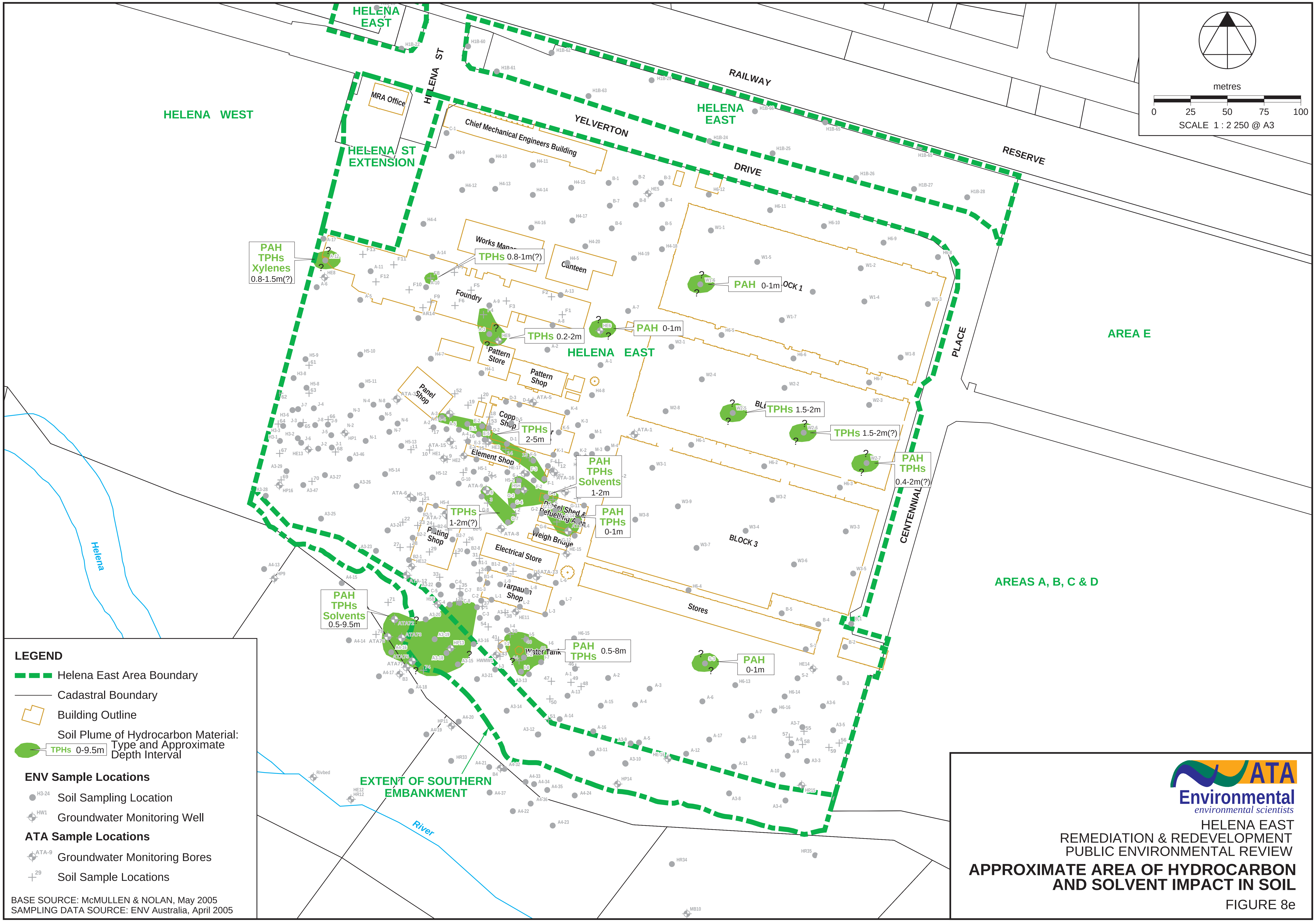
DRAWN BY: TE/EDS 23-03-06
DATUM: MGA
MRA-5-4/PER/25_142f08d.dgn



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DATUM: MGA
MRA-5-4/PER/25_142f08e.dgn

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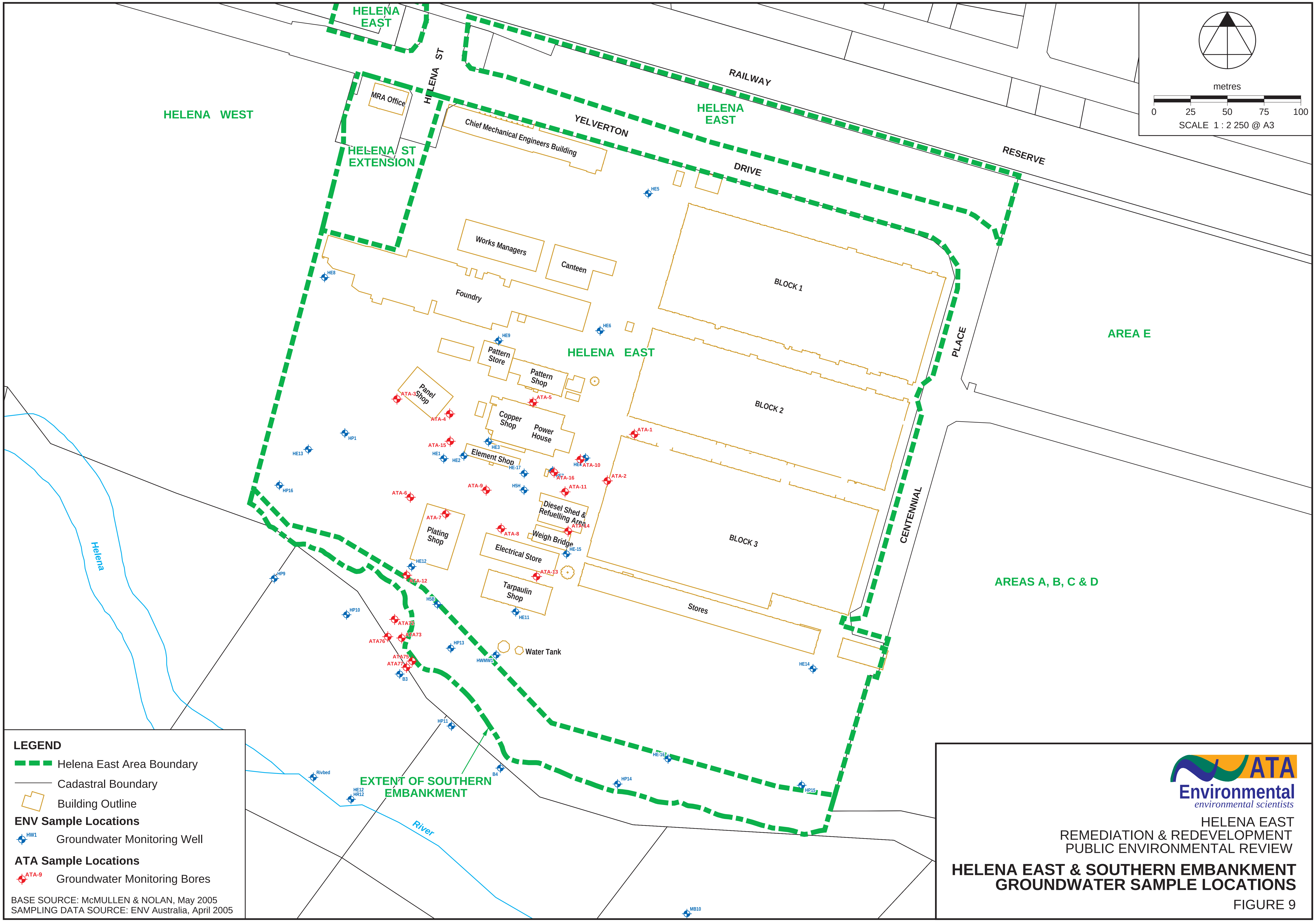
DRAWN BY: TE/EDS 23-03-06 CHECKED BY: SB 23-03-06
DATUM: MGA
MRA-5-4/PER/25_142f09.dgn



BASE SOURCE: McMULLEN & NOLAN, May 2005
SAMPLING DATA SOURCE: ENV Australia, April 2005

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HELENA EAST & SOUTHERN EMBANKMENT GROUNDWATER SAMPLE LOCATIONS

FIGURE 9

PRINTED: Mon 03 Apr 06

CHECKED BY: SB/GJM 23-03-06

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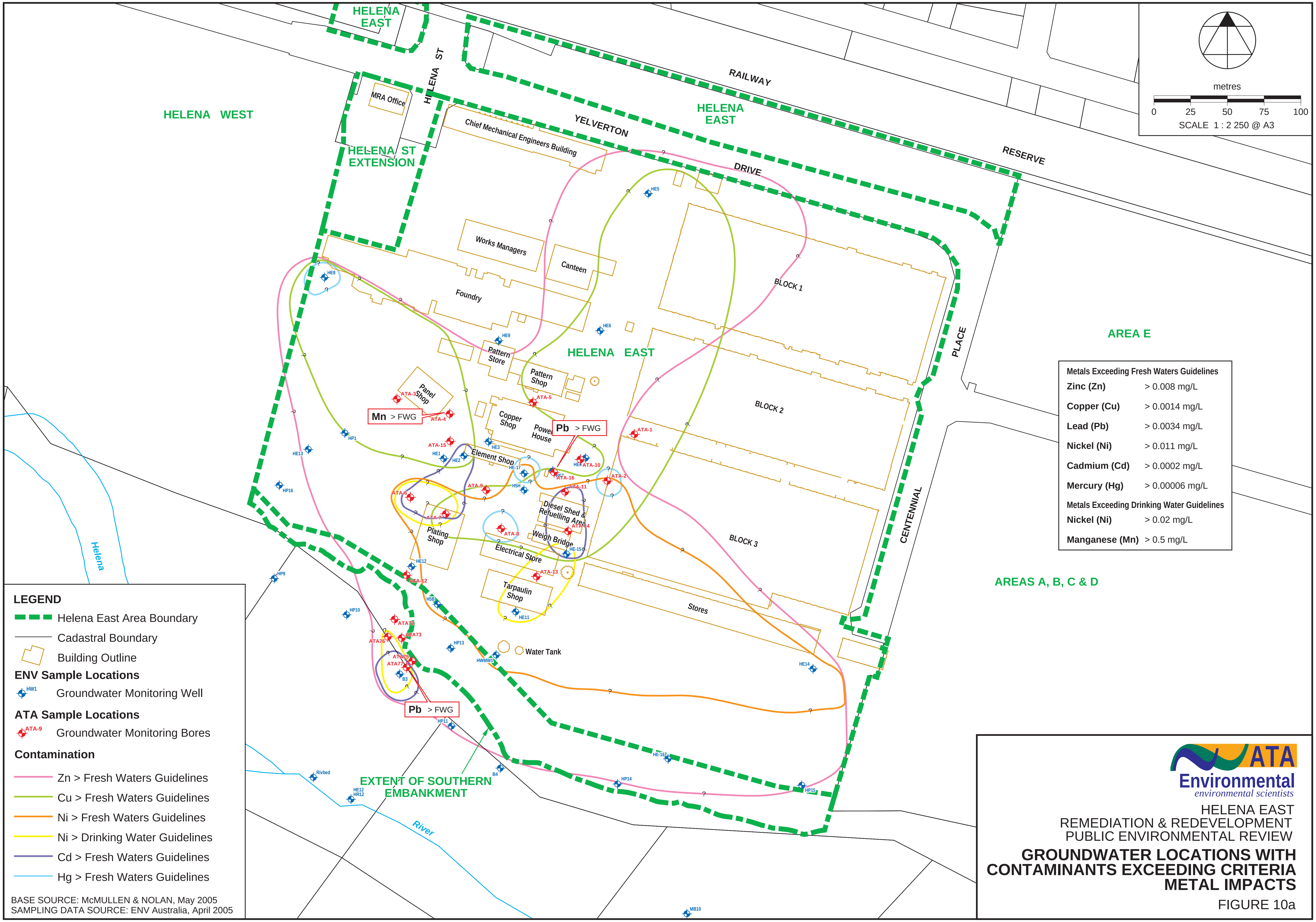
DATUM: MGA

MRA-5-4/PER/25_142f10a.dgn



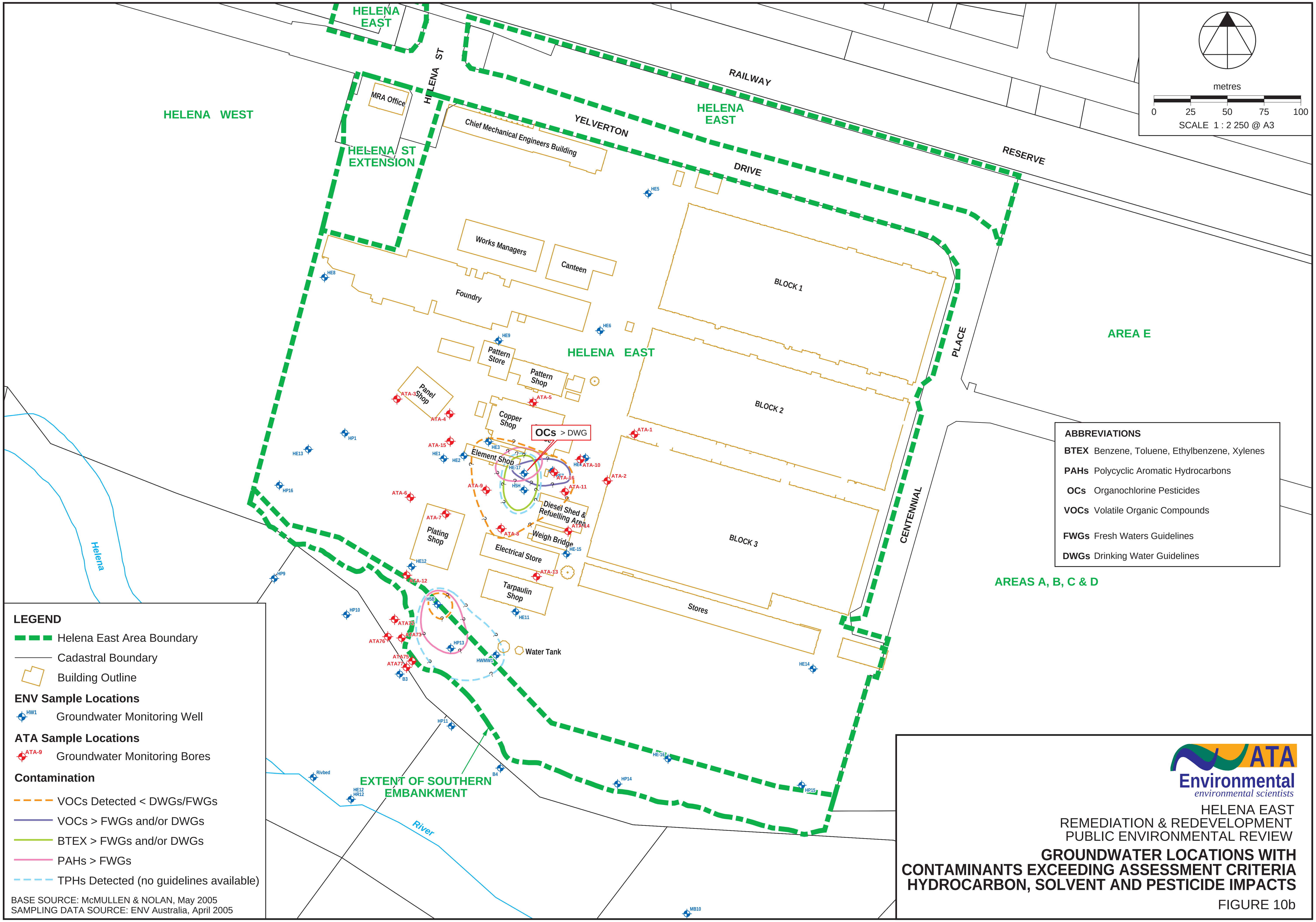
PRINTED: Mon 03 Apr 06

CHECKED BY: SB/GJM 23-03-06

DRAWN BY: TE/EDS 23-03-06

DATUM: MGA

MRA-5-4/PER/25_142f10b.dgn



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PRINTED: Mon 03 Apr 06
CHECKED BY: SB 23-03-06
DRAWN BY: TE/EDS 23-03-06
DATUM: MGA
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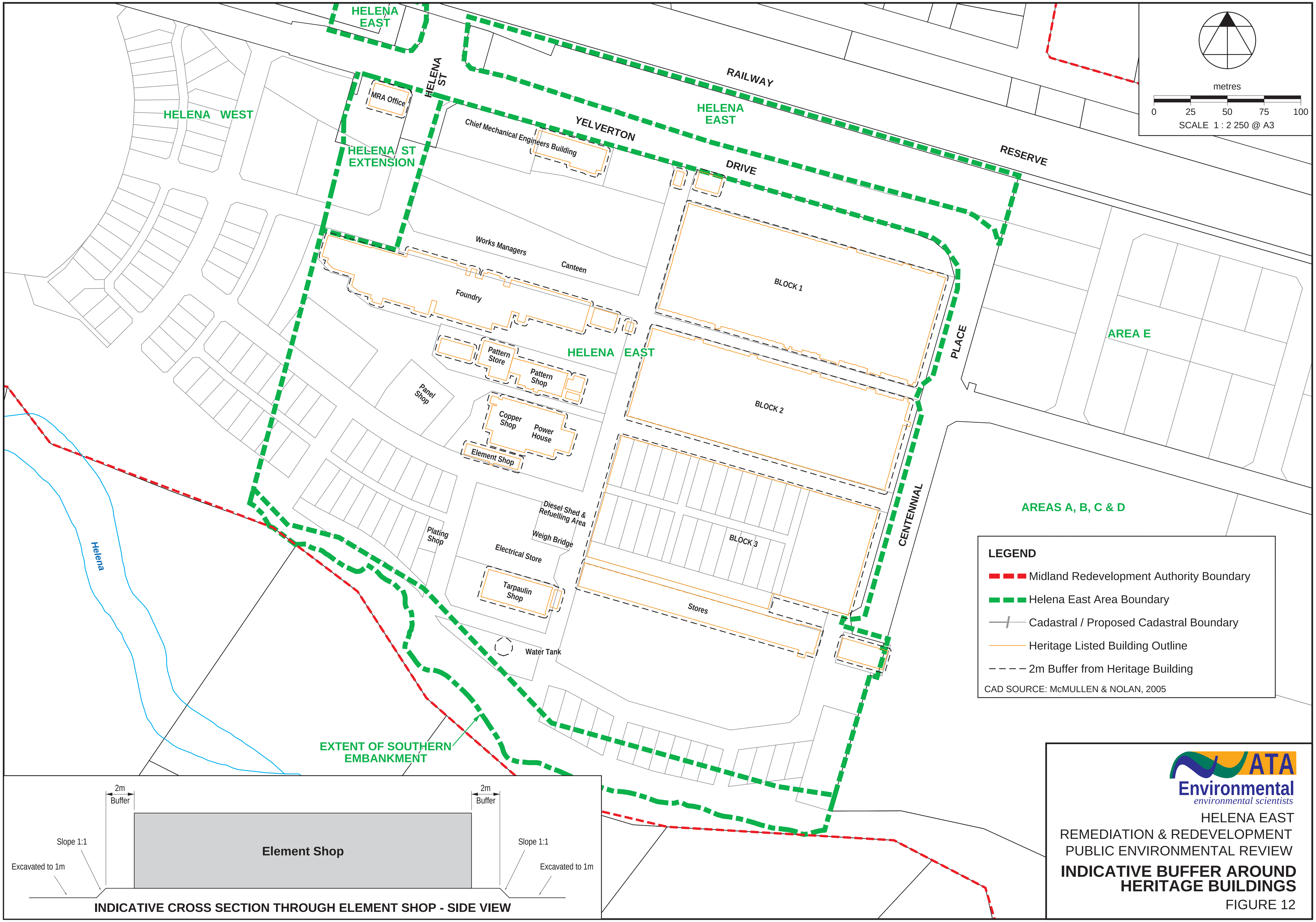

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INDICATIVE BUFFER AROUND HERITAGE BUILDINGS

FIGURE 12

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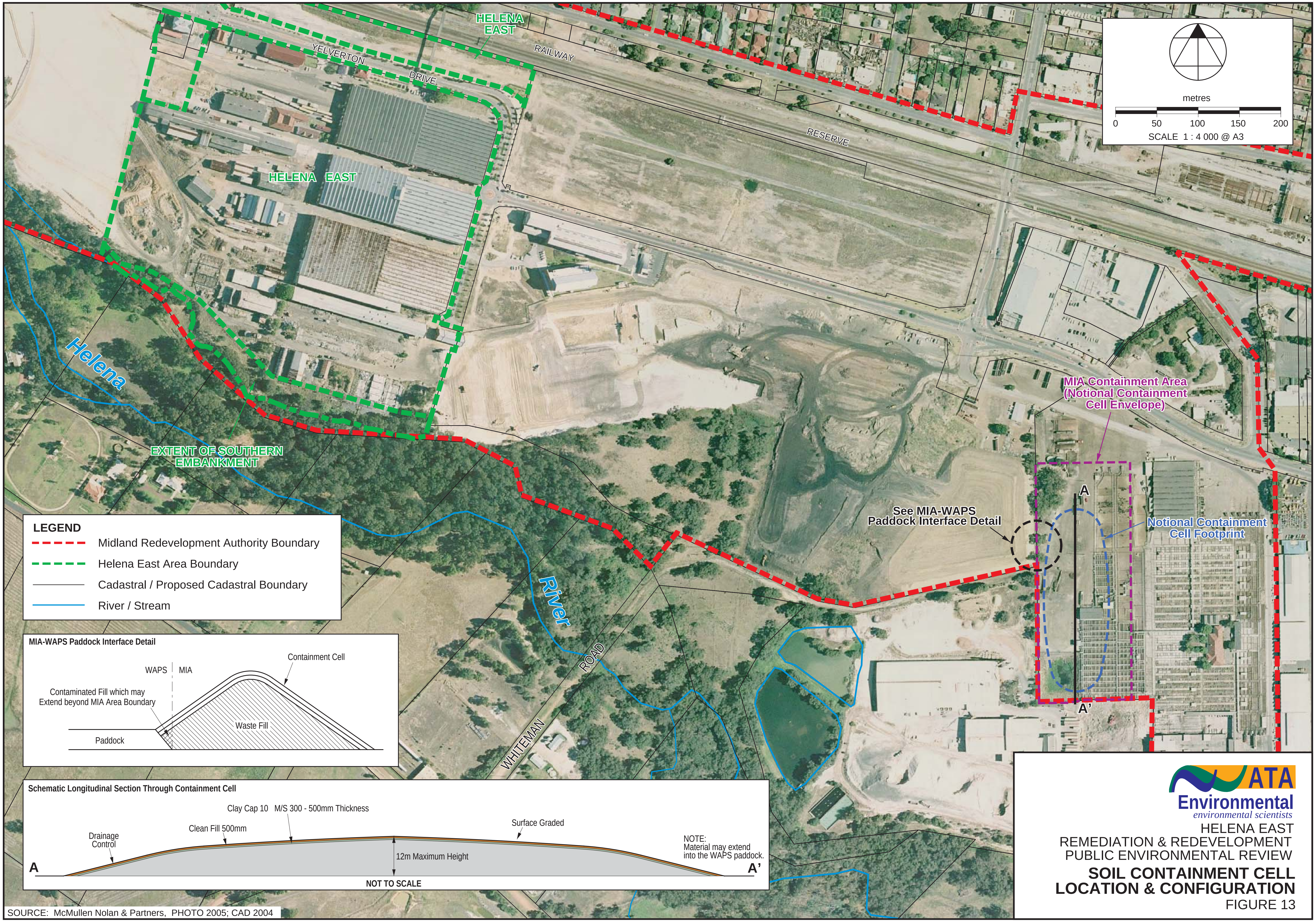
CHECKED BY: KS 20-12-05

DRAWN BY: EDS 20-12-05

DATUM: MGA

MRA-5-4/PER/25_142f12.dgn



PRINTED: Mon 03 Apr 06

CHECKED BY: ND 20-12-05

DRAWN BY: TE/EDS 20-12-05

DATUM: MGA

MRA5-4/PER/25_142f13.dgn