MOOREBANK INTERMODAL COMPANY

Moorebank Intermodal Terminal Project Environmental Impact Statement

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PARSONS BRINCKERHOFF

Technical Paper 5
Environmental Site Assessment (Phase 2)

Technical Paper 5 – Environmental Site Assessment (Phase 2)

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Moorebank Intermodal Company

Phase 2 Environmental Site Assessment

Moorebank Intermodal Terminal

28 May 2014

PARSONS BRINCKERHOFF
A BALFOUR BEATTY COMPANY

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Abbreviations

ABC	Ambient background concentration
ACL	Added contaminant limit
ACM	Asbestos containing materials
AFFF	Aqueous film forming foam
AHD	Australian height datum
ANZECC	Australian and New Zealand Environment and Conservation Council
AOPC	Area(s) of potential concern
As	Arsenic
ASS	Acid sulfate soils
ASSMAC	Acid Sulfate Soils Management Advisory Committee
AST	Above ground storage tank
BTEX	Benzene, toluene, ethyl Benzene, xylenes
C_6–C_9	Light hydrocarbon chain groups (for example, petrol)
C_{10}–C_{14}	Medium hydrocarbon chain groups (for example, kerosene)
C_{15}–C_{28}	Heavy hydrocarbon chain groups (for example, diesel)
C_{29}–C_{36}	Heavy hydrocarbon chain groups (for example, lube oil)
Cd	Cadmium
CE	Combat engineering
CEC	Cation exchange capacity
CEMP	Construction environment management plan
CLM	Contaminated land management
COC	Chain of custody
CoC	Contaminants of concern
CHC	Chlorinated hydrocarbons
COPC	Contaminants of potential concern
C-RAT	Contaminant risk assessment tool
Cr	Chromium
CSIRO	Commonwealth, Scientific and Industrial Research Organisation
Cu	Copper
DCE	Dichloroethene
DECCW	Department of Environment, Climate Change and Water NSW (now the NSW EPA)
DNSDC	Defence National Support and Distribution Centre
Defence	Department of Defence
DO	Dissolved oxygen
DQO	Data quality objective
EC	Electrical conductivity
EIL	Environmental investigation level
EOW	Explosive ordnance waste
EPA	Environment Protection Authority
ESA	Environmental site assessment
ESDAT	Environmental database system

ESL	Environmental screening level
FVS	Field validation survey
FTA	Fire training area
GIL	Groundwater investigation limit
G-Tek	G-Tek Pty Ltd
GPR	Ground penetrating radar
GPS	Geographical positioning system
GPT	Gross pollutant trap
GSW	General solid waste
GWS	Glenfield Waste Services
Ha	Hectare
HA	Hand auger
HESP	Health, environment and safety plan
Hg	Mercury
HIL	Health investigation level
HQ	Headquarters
HSL	Health screening level
IMT	Intermodal terminal
IMEX	Import export
ISQG	Interim sediment quality guideline
L	Litres
LC	Leachable concentration
LGA	Local government area
LOQ/LOR	Limit of quantitation/limit of reporting of chemical concentrations attainable from laboratory analysis. (also see PQL)
m BGL	Metres below ground level
mg/kg	Milligram per kilogram (or part per million)
mg/L	Milligram per litre (or part per million)
m btoc	Meters below top of casing
MW	Monitoring well
NA	Not applicable
NAPL	Non aqueous phase liquid
NATA	National Association of Testing Authorities
NBC	Nuclear, biological and chemical
NCP	No cathodic protection
ND (nd)	Not detected above the LOQ or PQL
NDD	Non-destructive drilling
NEPC	National Environmental Protection Council
NEPM	National Environmental Protection Measure
Ni	Nickel
NK	Not known
OCPs	Organochlorine pesticides
OPPs	Organophosphorus pesticides
OS	Oxidisable sulfur

PAHs	Polycyclic aromatic hydrocarbons
Pb	Lead
PCBs	Polychlorinated biphenyls
PID	Photo ionisation detector
PFOA	Perfluorooctanoate
PFOS	Perfluorooctanesulfonic acid
PQL	Practical quantitation limit (of chemical concentration)
PSD	Particle size distribution
QA	Quality assurance
QC	Quality control
RA	Risk assessment
RAE	Royal Australian Engineers
RAP	Remedial action plan
RSW	Restricted solid waste
SAA	Small arms ammunition
SAQP	Sampling, analysis and quality plan
SB	Soil bore
SCC	Specific contaminant concentration
SME	School of Military Engineering
SPOCAS	Suspension peroxide oxidation combined acidity and sulfate test
S_{POS}	Peroxide oxidisable sulfur
SRS	Seismic refraction survey
SS	Sediment sample
STP	Sewage treatment plant
SVOC	Semi volatile organic compounds
SW	Surface water
SWL	Standing water level
SWS	Single walled steel
TCE	Trichloroethene
TCLP	Toxicity characteristics leaching procedure
TDS	Total dissolved solids
TPA	Titratable peroxide acidity
TRH	Total recoverable hydrocarbon
TP	Test pit
TSA	Total sulfidic acidity
UCL	Upper confidence limit of data set
µg/L	Micrograms per litre
USEPA	United States Environmental Protection Agency
UST	Underground storage tank
UXO	Unexploded ordnance
VOC	Volatile organic compounds
WCG	Waste classification guidelines
Zn	Zinc

Executive summary

Moorebank Intermodal Company (MIC) commissioned Parsons Brinckerhoff Australia Pty Ltd (Parsons Brinckerhoff) to undertake a Phase 2 environmental site assessment (ESA) for the proposed Moorebank Intermodal Terminal (IMT) located adjacent to Moorebank Avenue in Moorebank, NSW ('the Moorebank IMT site').

The primary functions of the Moorebank IMT are as a transfer point in the logistics chain for shipping containers and to handle international import export (IMEX) cargo and domestic interstate and intrastate (regional) cargo. The aims of the project are to increase Sydney's rail freight mode share, including promoting the movement of container freight by rail between Port Botany and western and south-western Sydney, and to reduce road freight on Sydney's congested road network.

The objectives of the Phase 2 ESA (this report) were to assess and characterise the nature and likely extent of contamination at the Moorebank IMT site based on the areas of potential environmental concern and associated contaminants of concern identified in the Phase 1 ESA. The Phase 2 ESA assessed the suitability of the Moorebank IMT site for the proposed future land use and to provide sufficient information to enable provision of a remediation action plan (RAP) and construction environment management plan (CEMP) to be prepared.

Site description and setting

The site is located approximately 30 km south-west of Sydney, between Liverpool and Campbelltown along the Georges River, west of Moorebank Avenue and the Defence National Support and Distribution Centre (DNSDC) and south of the M5 South Western Motorway. The site location is presented in figures in section 18 of this report (Figure 1).

The Moorebank IMT site currently comprises two main areas, the northern portion of the site, known as Moorebank Barracks and the southern portion of the site known as Steele Barracks, which houses the School of Military Engineering (SME). Twenty eight potential areas of environmental concern were identified following a review of environmental information undertaken during the Phase 1 ESA.

Fieldwork

Fieldwork was undertaken by Parsons Brinckerhoff between 24 January and 10 February 2011 and was conducted in accordance with the approach outlined in the sampling analysis and quality plan (SAQP) (2011) and was endorsed by an accredited Site Auditor, Frank Mohen of AECOM, who was appointed by MIC to review the contaminated land assessment.

Parsons Brinckerhoff fieldwork comprised of the drilling of 22 bores (21 of which were drilled to a maximum depth of 16 metres (m) below ground level (BGL) and converted to groundwater monitoring wells and 1 which was drilled to 6 m BGL for soil testing only), 40 test pits excavated by a backhoe, 10 hand augured locations and the sampling of 7 sediment and 8 surface water samples. Groundwater gauging and sampling of newly installed monitoring wells and selected existing wells was undertaken from 25 January to 10 February 2011.

In addition to the intrusive works, an unexploded ordnance (UXO) specialist contractor, G-Tek Pty Ltd, was engaged to undertake an assessment of potential UXO in the subsurface environment. A seismic refraction survey (SRS) was also undertaken by geophysical survey specialists Earth Technology Solutions Pty Ltd with the objective of assessing the inferred extent of fill on a number of transects across the site.

The findings of the UXO assessment and SRS have been integrated into the findings of the intrusive investigation in order to augment the conceptualisation of environmental conditions on-site.

An extensive suite of chemical laboratory analysis for contaminants of potential concern (COPCs) was conducted for representative soil, groundwater, surface water and sediment samples collected from the Moorebank IMT site, including total recoverable hydrocarbons (TRH), BTEX compounds (benzene, toluene, ethylbenzene and xylene), polycyclic aromatic hydrocarbons (PAHs), heavy metals (including arsenic, cadmium, chromium, copper, lead, mercury nickel and zinc), polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), semi volatile organic compounds (SVOCs), asbestos, aqueous film forming foams (AFFF), compounds associated with explosives, organophosphate pesticides (OPPs) and organochlorine pesticides (OCPs). Laboratory tests were also carried out on selected soils for particle size distribution (PSD) and to determine whether there is the potential for acid sulfate soils (ASS) to be present.

Results summary

Revision A of this document was produced in 2011, at which time the results of analytical sampling from the Phase 2 investigation undertaken by Parsons Brinckerhoff and other available historical data were compared with consideration to then-current guideline criteria which have now been superseded by the *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1)* (NEPM; National Environment Protection Council, 2013). Under Revision B (this document), the screening assessment of analytical results has been undertaken using the NEPM (2013) guidelines. However, for total recoverable hydrocarbons (TRH) the NEPM (2013) specifies criteria for different hydrocarbon fractions than those previously used (in accordance with the former NEPM, 1999), making a direct comparison impossible. An indicative comparison has been undertaken, with conservative grouping of hydrocarbon fractions to encompass the revised fractions.

The Phase 2 ESA found that the surficial geology on-site consisted of localised fill with variable alluvial deposits consisting of clay, sandy silty clay, sandy clay, sand, clayey sand, silty sand, silty clay and gravelly sand. No bedrock was encountered during intrusive works. Saturated horizons were encountered between 7 and 15 m BGL within the natural alluvium.

Based on analytical soil results, shallow soil impacts were detected on-site, generally consisting of localised detections of TRH, PAHs, BTEX, DDD, DDE, chlordane, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). Soils that indicate acid generating potential (potential acid sulfate soils (ASS)) were also present in some locations at the Moorebank IMT site.

Fill was found to be present in localised areas, generally comprising sands, gravels, clays and building demolition materials such as fragments of concrete, bricks, metals and plastic. Asbestos cement fragments were also detected in surface soils at a limited number of locations. A number of stockpiles were observed on-site which, based on anecdotal evidence, consist of building and demolition type materials with the potential to contain asbestos containing materials (ACM).

Based on the results of the UXO survey undertaken by G-Tek, artefacts of military origin and exploded ordnance wastes (EOW) are present at the Moorebank IMT site. UXO/EOW items were generally found within active and former training areas such as the explosive ordnance disposal area, dog training area, practice mine detection area and demolitions training areas. All detected items were confirmed as inert training ordnance with the appearance of UXO/EOW. Based on specialist advice provided by G-Tek, the Moorebank IMT site has a very low potential to contain remnant UXO/EOW containing high explosive or other energetic material other than propellants/primers in unfired/misfired small arms ammunition (SAA) blank cartridge cases. Items of military origin which have the appearance of UXO/EOW may cause concern if encountered during redevelopment works; however the occupational health and safety risk of such items is considered to be perceptual rather than actual.

Groundwater levels were measured at depths of between 5.2 and 12.4 m BGL (1.7 and 9.1 m Australian Height Datum (AHD)). Based on the gauging data, groundwater flow is inferred to be west to the north-west towards the Georges River. Concentrations of dissolved metals, chlorinated hydrocarbons (trichlorethene (TCE) and cis-1, 2-dichloroethane (DCE)), TRH, formaldehyde, chloroform and perfluorinated chemicals were detected in groundwater sampled from beneath the site. Dissolved concentrations of cadmium, copper, lead, nickel and zinc, PFOA and PFOS and TCE were reported at concentrations exceeding the groundwater investigation limits (GILs) that were adopted for the study. Perfluorinated chemicals (PFOA and PFOS) were identified both in soil and groundwater. These chemicals are emerging environmental pollutants with relatively limited toxicity information.

Conclusions

Based on data collected by Parsons Brinckerhoff (2011) and anecdotal evidence for the site, the following conclusions are made.

Surficial geology encountered at the site generally comprised fill with variable alluvial deposits. Saturated horizons were encountered between 7 and 15 m BGL within the natural alluvium.

Based on analytical soil results, contaminant impacts were identified in shallow soils, generally consisting of localised detections of TRH, metals, PAHs, BTEX, DDD, DDE, chlordane, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, PFOA and PFOS.

Only one sample exceeded the adopted health investigation limit (HIL), for lead. Results were also assessed against the most conservative ecological investigation levels (EILs) provided within the NEPM (2013) and these limits were exceeded for copper, lead, nickel and zinc.

Soil results showed marginal and localised exceedances of the commercial land use health screening levels (HSLs) for TRH fractions C_{10} to C_{16}. Petroleum hydrocarbon management limits (PHML) were also exceeded for four samples collected from the vehicle storage and maintenance area (Area 2), the dust bowl (Area 11), the plant, road and airfield (PRA) yard (Area 13) and former fire training area (FTA) (Area 20). The PHMLs are to used consider the formation of light non-aqueous phase liquids (LNAPLs), fire and explosion risks and damage to buried infrastructure and represent the maximum values that should remain in a site following evaluation of human health and ecological risks and risks to groundwater resources and apply to all soil depths. During future excavations these areas will need to be appropriately remediated and/or managed to remove any ongoing risks that may be associated with the TRH impacts identified.

Soil contamination is limited to TRH and heavy metals impacts identified in near surface soils in localised areas of the site, associated with areas of operational plant and machinery (such as the bridging yard (Area 8) and PRA yard and wash bay (Areas 12 and 13)), the vehicle maintenance and storage area (Area 2), the former fire training areas (Area 20) and where underground storage tanks (USTs) are or were present.

Where elevated concentrations of contaminants have been detected, these have generally been vertically delineated to indicate that natural soils are not contaminated and the soil contamination does not intercept the saturated zone.

A potential human health risk from the soil contamination identified may exist to excavation workers during redevelopment. However, it is considered that this risk can be adequately managed through the use of a construction environmental management plan (CEMP) that outlines site management procedures, exposure mitigation controls and occupational hygiene practices to be implemented during excavation works to mitigate potential exposure pathways.

Asbestos cement fragments have been identified in localised surface soils and within waste fill at the Moorebank IMT site and may present a hazard if not appropriately managed.

The site is has been largely modified for use as a Defence site and is likely to be further modified based on the proposed IMT use. There is no evidence to suggest that the contamination identified in soils and groundwater on-site has affected the established riparian vegetation as no evidence of plant stress was noted. Although the adopted EILs were exceeded for TRH and metals, the screening values are considered conservative and the value of the site as a terrestrial ecosystem is considered to be limited based on the proposed design. On this basis, the chemical concentrations identified in soil on-site are not considered to pose significant risk to ecological receptors.

Based on available soil analytical results, it is considered likely that the majority of the soil excavated from the Moorebank IMT site during redevelopment would likely be classified as general solid waste. Where asbestos is present within excavated materials this would need to be managed as waste containing asbestos. A waste classification should be completed for all excavated soil destined for reuse or disposal off-site.

Based on limited analytical results, soils with acid generating potential (ASS) are present in some locations at the Moorebank IMT site. Subsurface material may pose an acid generation risk if exposed to oxygen during redevelopment. This potential issue merits further investigation and would need to be addressed within an appropriate management plan prior to site redevelopment (developed with reference to the Acid Sulfate Soils Management Advisory Committee (ASSMAC) Assessment Guidelines (1998)), with active on-going management through the construction phase as prescribed within the plan (as required).

Following a qualitative analysis, a potentially complete exposure pathway has been identified for the chlorinated hydrocarbon contamination (TCE) identified in groundwater in the north-west of the Moorebank IMT site (Area 1). It is considered that a potential risk may exist to downgradient environmental receptors should contamination migrate off-site to the Georges River. It is considered that, based on elevated dissolved lead and nickel, TRH, TCE and perfluorinated compounds identified, the groundwater beneath the site is not considered to be suitable for potable use. The potential health risk to humans may be mitigated by restricting groundwater abstraction and use on site.

Based on an indicative risk assessment, potential vapour risks associated with the TCE plume in groundwater (Area 1) are negligible based on theoretical input values. Should the eventual design of the IMT include construction activities within Area 1 (likely associated with construction of the northern rail access option), further assessment of potential vapour intrusion risks during and after construction may be required.

Based on the Community River Health Monitoring Program (2009 and 2010) the overall grades of freshwater areas in the mid-Georges River have been consistently reported as poor. The report detailed that macro invertebrate communities are dominated by pollution tolerant species. The waterways in this part of the catchment have been affected by degraded water quality, riparian vegetation and depleted macro invertebrates typically due to urbanisation. It is not considered that the soil and groundwater contamination identified at the Moorebank IMT site contributed significant additional impacts to the water quality within Georges River. Impacts due to potential migration of contaminated groundwater and surface water from the Moorebank IMT site to the Georges River are considered to be low.

Based on the SRS undertaken, no burial pits or any indication of their presence was discovered in areas surveyed or excavated during intrusive works. Areas of buried fill may exist in other areas of the Moorebank IMT site that have not yet been identified, however, based on the fact that no grossly contaminated fill was identified in areas of the Moorebank IMT site already assessed, it is considered likely that fill materials encountered during site redevelopment can be managed via appropriate handling of excavated waste which should be detailed in the CEMP.

Ordnance related wastes (UXO and EOW) exist at the Moorebank IMT site. Specialist advice received from G-Tek (2011) however, indicated that the site has a very low potential to contain remnant UXO/EOW containing high explosive or other energetic material. Items of military origin have the appearance of UXO/EOW and may cause concern if encountered during redevelopment works but the occupational health and safety risk of such items is considered to be perceptual rather than actual.

Based on the available data, the site is considered suitable for industrial commercial use subject to implementation of the RAP measures (refer to Appendix F) and management controls during site development and post-construction management where contamination issues may be ongoing to mitigate the potential risks that have been identified.

It is considered that the Phase 2 ESA undertaken by Parsons Brinckerhoff in 2011, incorporating anecdotal data from earlier investigations, provides sufficient information on which to base recommendations for remediation and management measures and to calculate broad scale cost estimates for the works to manage the contamination impacts.

A RAP has been developed and is provided in Appendix F, which addresses the following:

- requirements to decommission and remove of all on-site USTs
- clearance/clean-up of spent UXO/EOW items prior to site development
- management requirements for known waste fill and fill encountered during site development, including asbestos in soil
- requirements for additional groundwater monitoring of TCE groundwater impacts identified the north-west of the IMT site (Area 1).

In addition the following management plans should be developed prior to site works commencing:

- CEMP to manage surface soils, excavated materials and incorporating measures to be implemented during redevelopment of the Moorebank IMT site to mitigate any potential human health risks
- UXO/EOW management plan which documents a procedure to manage military related finds encountered during redevelopment works.

1. Introduction

1.1 Background

Moorebank Intermodal Company (MIC) commissioned Parsons Brinckerhoff Australia Pty Limited (Parsons Brinckerhoff) to undertake a Phase 2 environmental site assessment (ESA) for the proposed Moorebank Intermodal Terminal (IMT) located adjacent to Moorebank Avenue in Moorebank, NSW ('the Moorebank IMT site').

The primary function of the Moorebank IMT is to be a transfer point in the logistics chain for shipping containers and to handle both international IMEX cargo, and domestic interstate and intrastate (regional) cargo. The aims are to increase Sydney's rail freight mode share including: promoting the movement of container freight by rail between Port Botany and western and south-western Sydney; and to reduce road freight on Sydney's congested road network.

The Moorebank IMT project also includes a rail link connecting the Moorebank IMT site to the Southern Sydney Freight Line (SSFL) and road entry and exit points from Moorebank Avenue. Three separate rail access options are being considered, including northern, central and southern rail access options.

1.1.1 Phase 1 ESAs

Phase 1 ESAs were completed for the Moorebank IMT site and for each of the rail access options.

The Phase 1 ESAs were undertaken to assess environmental conditions and potential contamination issues at the site and each of the rail access option locations, with the purpose of evaluating the feasibility of the land for the future proposed use.

The scope of work for the Phase 1 ESAs comprised a review of aerial photographs, council records, public registers, geological and hydrological information and previous reports containing environmental information pertaining to the Moorebank IMT site provided by Defence, a site inspection (where site access was available) and the preparation of four Phase 1 ESA reports (refer to appendices B through E).

A Phase 1 ESA review of the three rail alignment options for the IMT concluded there is limited potential for contamination to exist in the northern and central rail access options. However, due to the landfill located to the south and the inferred north-easterly groundwater flow direction; there may be the potential for contamination from off-site to have migrated to these areas through groundwater flow.

In addition, for the northern rail access option, there is the potential for buried waste and tipped waste (potentially including asbestos containing materials (ACM)) and imported fill to be present and potential impacts from dispersed aerial deposition of contaminants from the roadway. Historical land use associated with former Casula Power Station and deposition of potential contaminant via stormwater drainage from the adjacent road, may be another potential source of contamination within the northern rail access option.

The historical and ongoing use of the southern rail access option as a waste disposal facility suggests that there is high potential for contamination to exist including contaminated fill, soils, groundwater, leachate and generation of landfill gases. The key exposure pathways would likely be via direct contact with soils, surface water, groundwater, leachate and landfill gases (via dermal contact, ingestion and inhalation) by construction/utility workers, site users and potentially future land users.

Parsons Brinckerhoff recommended that at subsequent project approval stages (under the NSW *Environmental Planning and Assessment Act 1979*) and depending on the rail access option selected, the following investigations are undertaken:

- Northern rail access option: an intrusive soil and groundwater investigation to be undertaken to gather site specific data on soil and groundwater quality within the design footprint of the proposed northern rail alignment so that remediation options can be evaluated (if required) prior to development of the Moorebank IMT site.
- Central rail access option: as a minimum, a site walkover to be completed to verify if fill mounds and/or depressions exist or if there are any visual indications of potential contamination at surface. If evidence of potential contamination is observed, targeted intrusive soil and groundwater investigation may be recommended in order to gather site specific data so that remediation options can be evaluated (if required) prior to any development of the Moorebank IMT site.
- Southern rail access option: a targeted intrusive investigation be undertaken in order to gather data on soil and groundwater quality so that construction design, management and/or remediation options can be evaluated prior to any development of the Moorebank IMT site.

1.1.2 Phase 2 ESA

Following the review of information pertaining to the Moorebank IMT site undertaken during the Phase 1 ESA (refer to Appendix B), potential areas of environmental concern were identified and recommendation was given for a detailed Phase 2 ESA to be undertaken.

The Phase 2 ESA works for the site includes the review of previous investigations, preparation of a sampling, analysis and quality plan (SAQP), an intrusive site investigation and preparation of this report.

1.1.3 Report structure

The report has been structured to present the supporting data for this Phase 2 ESA report, as well as providing the Phase 1 ESA reports, as outlined below.

- Phase 2 ESA – Moorebank IMT Site:
  - Appendix A – Phase 2 ESA – Moorebank IMT Site data:
    - appendices A1 through A17 containing Phase 2 ESA data
  - Appendix B – Phase 1 ESA – Moorebank IMT Site
  - Appendix C – Phase 1 ESA – Northern Rail Access Option
  - Appendix D – Phase 1 ESA – Central Rail Access Option
  - Appendix E – Phase 1 ESA – Southern Rail Access Option
  - Appendix F – Preliminary Remediation Action Plan.

1.2 Objectives

The objectives of the Phase 2 ESA were to:

- assess and characterise the nature and likely extent of contamination at the Moorebank IMT site based on the areas of potential environmental concern and associated contaminants of concern identified in the Phase 1 ESA
- assess the nature and likely extent of contamination at the Moorebank IMT site using the data generated from this investigation
- assess the suitability of the Moorebank IMT site for the proposed future commercial/ industrial land use as an IMT
- evaluate the remedial works that may be necessary to address the contamination impacts identified that would render the site suitable for the proposed future land use
- provide Parsons Brinckerhoff with sufficient information to calculate broad scale cost estimates at the concept stage for the remedial works in respect of contaminated land management prior to construction.

Further to the Phase 2 ESA, a preliminary RAP has been prepared to document the remedial works and management actions that are likely to be required to facilitate the redevelopment of the site whilst mitigating any potential human health and environmental risks identified (refer to Appendix F). The preliminary RAP will be updated and finalised before the start of the Early Works development phase.

1.3 Scope of work

The scope of work required for Phase 2 ESA included:

- preparation of a SAQP outlining the sampling and assessment strategy for the Phase 2 ESA
- preparation of a health, environment and safety plan (HESP) (refer to Appendix A17) for all site related activities, to identify the potential risk associated with the works and to document and implement control measures to manage and mitigate the risks
- review of data from the previous investigation undertaken by Earth Tech (2006), so that the previous data can be relied upon and used in conjunction with the data generated from this investigation to assess the nature and extent of contamination and assist in identifying management and/or remediation options to address the contamination impacts identified on-site
- a targeted field investigation, involving;
  - soil, sediment, surface water and groundwater sampling
  - geophysical surveys in areas of suspected fill
  - unexploded ordnance (UXO) and explosive ordnance waste (EOW) field validation survey (FVS) in areas of the Moorebank IMT site where munitions training activities occur or are likely to have occurred historically
  - some locations were also selected to fill spatial data gaps in areas of the site (such as the golf course) where no known investigations had occurred previously.
- preparation of this Phase 2 ESA report to include:
  - findings of the intrusive investigation including an account of fieldwork undertaken, site conditions encountered, field observations, environmental bore logs and analytical laboratory results
  - an assessment of the potential risk associated with contamination identified and the potential to impact human health or environmental receptors (indicative risk assessment)

- recommendations of the management options and/or remediation actions required to address the contamination impacts identified
- a general evaluation of the feasibility of the proposed Moorebank IMT development based on the potential environmental constraints identified.

UXO was identified as an issue of potential concern at the Moorebank IMT site in the Phase 1 ESA. UXO specialist contractor G-Tek Pty Ltd was engaged by Parsons Brinckerhoff to undertake an assessment of UXO. Relevant findings are incorporated into the Phase 2 ESA report discussion and in full in Appendix A12.

Earth Technology Solutions Pty Ltd was engaged by Parsons Brinckerhoff to undertake a geophysical seismic refraction survey (SRS). The objective was to provide an indication of likely fill in the sub surface at a various specific locations on-site, particularly where intrusive investigation has not been undertaken historically or, where it was not feasible due to access restrictions, to augment the findings of the intrusive works.

1.3.1 Guidelines

The Phase 2 ESA works were undertaken generally in accordance with the following guidelines:

- ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
- Australian Standard AS4482.1 (2005) Guide to the investigation and sampling of sites with potentially contaminated soil - Part 1: Non-volatile and semi-volatile compounds.
- NSW EPA (2000) Guidelines for Consultants Reporting on Contaminated Sites.
- NSW DECC (2006) Guidelines for the NSW Site Auditor Scheme (2nd Edition).
- NSW DECC (2007) Guidelines for the Assessment and Management of Groundwater Contamination.
- DUAP (1998) SEPP 55 – Managing Land Contamination.
- NEPC (2013) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1); NSW EPA (1995), Sampling Design Guidelines.
- NSW EPA (1994), Guidelines for Assessing Service Station Sites.

1.3.2 Phase 2 ESA audit

Frank Mohen, accredited Site Auditor, of AECOM (assisted by Paul McCabe) was engaged by MIC to review the investigation works conducted by Parsons Brinckerhoff. The NSW Auditor Scheme is administered by the NSW Environment Protection Agency (EPA) under Part 4 of *the Contaminated Land Management Act 1997*. The audit was undertaken to provide increased certainty in the non-statutory sign off of the Phase 2 ESA and conclusions relating to the feasibility of the proposed future use of the Moorebank IMT site. AECOM independently reviewed Parsons Brinckerhoff reports to ensure the methodology and interpretation of data is consistent with current regulations and guidelines.

2. Background information

2.1 Site description

The site is located approximately 30 km south-west of Sydney between Liverpool and Campbelltown along the Georges River, immediately west of Moorebank Avenue and the Defence National Support and Distribution Centre (DNSDC) and south of the M5 South Western Motorway. The site is Commonwealth land currently utilised by the Department of Defence (‘Defence’), covering an area of approximately 220 hectares (ha). The main access road to the Moorebank IMT site is from Moorebank Avenue which runs north to south on the eastern perimeter of the site. The site location is presented in Figure 1 section 18.

The site is legally identified as three lots, as presented in Table 2.1.

Table 2.1 Site legal identification

Lot	Deposited plan	Approximate area (ha)	Description
100	1049508	5.3	Northern area of the Moorebank IMT site, adjacent to the Georges River
101	1049508	4.0	Northern area of the Moorebank IMT site, adjacent to Moorebank Avenue
3001	1125930	185	Main IMT site including the SME

The geographical co-ordinates of the Moorebank IMT site boundaries are presented in Table 2.2.

Table 2.2 Site geographical co-ordinates

Corner boundary	Coordinates
north-east (top)	308194/6242544
south-east (right)	307900/6236769
south-west (bottom)	307194/6239769
north-west (left)	307687/6242233

2.2 Current site uses

The site is currently an Army base comprising two main areas, the northern portion of the site, known as Moorebank Barracks and the southern portion of the site, known as Steele Barracks.

Steele Barracks houses the Royal Australian Engineers (RAE) School of Military Engineering (SME) and is the regional headquarters of the NSW Brigade of the Australian Army Cadets and is also home the RAE Museum and RAE Golf Club. Within Steel Barracks it is understood the site is used for the purposes of accommodation, administration offices, engineering workshops, sports ovals and military training areas including a parade ground, bomb detection and disposal compounds, a small arms range, firefighting training areas, a large bulk earth movement training area (known as the ‘dust bowl’), dog kennels and a dog training compound and a bridging yard.

Moorebank Barracks predominantly comprises areas of open space interspersed with heavy vegetation. Land use within Moorebank Barracks appears to be limited to administration and older accommodation buildings, a warehouse structure believed to be utilised for the vehicle storage and maintenance of vehicles and a concrete lined surface water drainage culvert, which runs east to west towards the Georges River.

2.3 Surrounding land use

Areas surrounding the Moorebank IMT site is generally characterised by industrial land with residential land use beyond. Descriptions of the surrounding land uses in the immediate vicinity of the Moorebank IMT site are presented in Table 2.3 and shown in Figure 2 section 18.

Table 2.3 Surrounding land uses

Direction	Description
North	Factory and warehouse facilities (ABB Transmissions Pty Ltd) with the M5 South Western Motorway and industrial, commercial and residential land uses beyond
North-east	Moorebank Business Park on the corner of Moorebank Avenue and Anzac Road comprising commercial warehousing premises. A review of aerial photographs indicates that the land use generally comprised vacant land with sparse trees from 1930 to 1994
East	Moorebank Avenue, the DNSDC facility and Wattle Grove residential area beyond
South	The East Hills railway line with Cambridge Avenue beyond and Defence owned land including an explosives confidence range, practice mine fields and munitions training areas
South-west	Former quarry and current Glenfield Waste Services (GWS) landfill and waste transfer station across the Georges River, with residential development beyond
West	Georges River, Casula Powerhouse Arts Centre (formerly a diesel fuelled power station), Casula Railway Station and residential properties beyond

2.4 Site history

From the historical land use records reviewed as part of the Phase 1 ESA, it is understood that the majority of the Moorebank IMT site has been owned by the Commonwealth Government from 1913 to present day. The site has been utilised by Defence since the 1940s with various construction, demolition and excavation events occurring.

In the surrounding areas, residential and industrial development has gradually increased in the locality since the 1970s as well as the development of transport infrastructure including construction of the M5 Motorway to the north, the East Hills railway line to the south and the Liverpool to Holsworthy railway line to the west. The DNSDC facility located to the east of the site has been present since the early 1950s.

A summary of the Moorebank IMT site history based on a review of aerial photographs and land title information is provided in Table 2.4.

Table 2.4 Historical land use summary

Year	Moorebank Barracks site features	Steele Barracks site features	Land use
1930	Mostly undeveloped vacant bushland/grazing land. Moorebank Avenue is visible running north to south. A grid of buildings (possibly sheds) is present in the north-eastern corner. The pond feature (which is still present at the Moorebank IMT site) is also visible. One small road transects the north of the site from east to west. The rest of the area is characterised by small tracks/pathways.	Mostly undeveloped vacant bushland/grazing land with tracks and pathways. A square clearing is visible in the northern area but there are no buildings visible. Site disturbance appears to be limited, particularly in the 'dust bowl' area which appears vegetated.	North – Farmland with some small buildings. ABB land is vacant. South – Undeveloped vacant bushland (no railway infrastructure visible). East – Twelve large rectangular buildings are visible in the north of the current DNSDC with the rest of this area as native bushland. West – Georges River which appears to be more meandering than present day and vacant land/farmland with gullies/tributaries visible. The current Glenfield waste Services (GWS) landfill appears to be farmland. A clearing along the Liverpool to Holsworthy track is visible but not track appears to be present.
1956	Moorebank Barracks - No aerial available.	Significant clearing of land with the current access road layout is visible (Chatham Avenue, Litani, Ripon and Jordon roads) The Chatham Village appears to be under construction extending north of Litani Road with numerous rectangular buildings visible in the central to western area. The southernmost area appears to be relatively undeveloped with small tracks and clearings visible. The development of Jacquinot Court can be seen. The dustbowl area is clearly visible as is a cleared area in the vicinity of the current parade ground. The current playing field to the south of Chatham Avenue is also visible.	North – No aerial available. South – Some rectangular clearings immediately south of the Moorebank IMT site with vacant bushland and Cambridge Avenue beyond. East – DNSDC buildings reminiscent of present day layout. West – Vacant land with residential land use beyond, residential road networks developing. Liverpool to Holsworthy Rail line visible.
1961	The Pickles Auction Yard building is clearly visible with much of the north-eastern area populated with warehouse buildings and what appears to be residential barracks. Much of the vegetation in the west (south of the current ABB Facility) appears to have been cleared. The pond to the north of Bapaume Road is clearly visible.	Steele Barracks – No aerial available.	North – No ABB facility or motorway present although some industrial development and residential development is visible beyond towards the north-east. South – No aerial available. East – DNSDC buildings reminiscent of present day layout. West – Vacant land with Initial stages of residential land use with road networks developing beyond. Liverpool to Holsworthy Rail line visible. A number of surface water ponds/tributaries are also noted on the western bank of the Georges River.

Year	Moorebank Barracks site features	Steele Barracks site features	Land use
1965	NSC except the ground surface in the west appears to be more disturbed compared to the previous record.	Much of the central area is covered by buildings including Chatham Village with structures also visible to the west of the playing fields. The south-east of the Moorebank IMT site (current golf course area) remains as vacant bushland with the exception on Jacquinot Court buildings. Some land clearance is visible in the south-western area. The dustbowl is still clearly visible. A large excavated area is present in the central northern area of Steel Barracks (potentially waste fill area). The sewage treatment plant (STP) is visible including the settlement pond and two large circular structures.	North – NSC. South – Vacant bushland with some vegetation clearance/cutting visible immediately south of the Moorebank IMT site in the vicinity of the current East Hills Line. East – NSC. West – Some quarrying activity is visible in the GWS area vacant land with increased residential development beyond.
1970	NSC except the east to west drainage line which currently exists at the Moorebank IMT site is clearly visible.	The large excavated area identified in the central area in the 1965 aerial photography is now appears to be grass covered with sparse trees. The current parade ground is visible.	
1975/ 1978	Moorebank Barracks – NSC.	The vegetated area in the south-eastern area of the Moorebank IMT site has been cleared of vegetation to form the current golf course area. The CE Store appears to be under construction.	North – Large industrial building under construction visible on current ABB land with industrial buildings beyond. South – Vacant bushland with some vegetation clearance/cutting visible immediately south of the Moorebank IMT site in the vicinity of the current East Hills Line. East – DNSDC buildings reminiscent of present day layout. West – The previously quarried area appears to be filled with water. Vacant land with increased residential development beyond.
1986	NSC except some additional buildings and merging of buildings plus the current pond near the eastern boundary between Bapaume and Litani roads is visible.	Steele Barracks - No aerial available.	North – NSC except construction of M5 Motorway visible and more industrial units are present. South – No aerial available. East – NSC. West – increased residential development.

Year	Moorebank Barracks site features	Steele Barracks site features	Land use
1994	NSC except some additional buildings and merging of buildings.	The Chatham Village has been demolished and now exists as a grassed area with sparse trees. Additional barracks and administrative buildings are present the east and north of Ripon and Jordan roads, layout is much like the current site layout. Current surface water features present in the golf course area similar to present day are visible.	North – M5 Motorway construction appears to be complete, increased industrial development beyond. South – East Hills Railway line construction visible. East –Some refurbished and additional buildings visible in the DNSDC. A clearing is visible in the south-east thought to be the initial development stage of the current Wattle Grove Residential area.
Current (2011)	NSC except, the buildings in the far north-east of the Moorebank IMT site have been removed and exist as grassed area with sparse trees. Vegetated areas have become denser.	Steele Barracks – NSC.	North – NSC except increased industrial buildings. South – NSC. East – NSC except the residential properties of Wattle Grove are visible. West – NSC except extensive excavated areas visible on GWS landfill area.

2.5 Proposed development

The proposed future land use of the Moorebank IMT site is the development of a strategic IMT which is intended to provide an integrated transport solution for the movement of freight to and from Port Botany.

The Commonwealth Government has committed $300 million through the Nation Building Program, towards the development of an IMT at Moorebank, on land owned by the Commonwealth and currently occupied by the Department of Defence (Defence).

In 2010, funding was allocated to complete the detailed planning and approval of the Moorebank IMT and the relocation of the SME and other Defence units to Holsworthy Barracks.

The Moorebank IMT development is proposed to address the shortage of intermodal terminal capacity in Sydney and complement other Commonwealth investments in rail connections on the main Melbourne-Sydney-Brisbane interstate rail line as well as to Port Botany.

2.6 Previous investigations

As part of the Phase 1 ESA undertaken by Parsons Brinckerhoff, the reports listed in Table 2.5 were provided to Parsons Brinckerhoff by Defence.

Table 2.5 Previous investigations reviewed by Parsons Brinkerhoff

Author (year)	Report title
Dames and Moore (1996)	Environmental Management Plan
Egis Consulting Australia (ECA) (2000)	Stage 1 Preliminary Site Investigation
HLA (2002)	Soil and Groundwater Investigation Precinct H (DNSDC) Moorebank Defence Land
HLA Envirosciences (2003)	Preliminary Groundwater Study, Moorebank Defence Land
URS (2003)	Investigation of Potential Sources of TCE, North West Precinct of Moorebank Defence Lands
GHD (2004)	Groundwater Investigation of the North Western Portion of the Moorebank Defence Land
GHD (2005)	Proposed Intermodal Freight Hub, Moorebank, Summary of Environmental Planning Reports
HLA Envirosciences (2005)	Above ground storage tank (AST) and UST Management Plan, Volume 10, Sydney West Defence Region
Earth Tech (2006)	Stage 2 Environmental Investigation
Parsons Brinckerhoff (2011)	Phase 1 Environmental Site Assessment

A summary of the reports is provided in the Phase 1 ESA for the Moorebank IMT site. From this review, Parsons Brinckerhoff became aware that the following additional reports exist that contain information pertaining to environmental conditions at the Moorebank IMT site, as listed in Table 2.6. These additional documents were requested via MIC in a formal request for information (RFI). At the time of finalising the SAQP and Phase 2 ESA, these reports were not available for Parsons Brinckerhoff to review.

Table 2.6 Previous investigations not reviewed by Parsons Brinkerhoff

Author (year)	Report title
Groundwater Technology (1994)	Environmental Site Assessment
Dames and Moore (1996)	Environmental Audit
CMPS&F Environmental (1998)	Preliminary Environmental Investigation
HLA (2006)	Defence Integrated Distribution System Baseline Investigation
ERM (2006)	Technical Advice Document (prepared by Andrew Kohlrusch) in relation to the Earth Tech report (2006)

2.7 Potential for contamination at the Moorebank IMT site

Based on the Moorebank IMT site history, there is the potential for contamination to have occurred due to military training activities, demolition and reconstruction of building across the Moorebank IMT site and the use and storage of potentially harmful chemicals such as fuels.

2.8 Summary of areas of potential concern

Based on a review of available environmental information pertaining to the Moorebank IMT site, 28 key areas of potential concern (AOPC) were defined. These AOPC were incorporated into the ESA design within the SAQP, following agreement with AECOM.

AOPC’s were ranked based on the former and current land uses and the potential for contamination to be present as follows:

‘Low risk’ areas were characterised by administrative or residential buildings including the officer’s mess, the military museum, parade ground, sports grounds and the golf course. Low risk is considered to be areas where there is limited potential for contamination to exist.

‘Medium risk’ areas were characterised by known or suspected waste fill, drainage lines, engineering stores (currently or historically used for chemical storage) and areas associated with munitions training (including bomb disposal, firefighting and practice mine field areas). Medium risk is considered to be areas where there is potential for contamination to have occurred due to current or historical site uses.

‘High risk’ areas were characterised by areas of fuel storage and use (including known underground storage tanks (USTs)), areas used for plant and/or vehicle storage and maintenance and an area where it is known from previous investigations that groundwater has been impacted by chlorinated hydrocarbons. High risk is considered to be areas where there contamination is known to be present or where there us a high potential contamination to have occurred due to current or historical site uses.

The AOPC and associated contaminants of potential concern are summarised in Table 2.7. Definitions of the contaminants of potential concern acronyms are provided below the table. These areas are presented in Figure 4 section 18.

Table 2.7 Potential contaminant sources/contaminants

AOPC description	Area (m^2)	Details	Contaminants of potential concern	Risk rank[1]
1. ABB boundary area	35,775	Eight notices have been identified for the ABB facility via contaminated land public registers that state that the ABB premises are contaminated by chemical wastes including PCBs.	TRH, BTEX, PAH, SVOCs, VOCs metals, PCBs	H
2. Vehicle storage/ maintenance area	31,610	Former Pickles auction house, a vehicle wash bay and associated drainage pit exists in the area. A non-operational UST is also present in the north-west corner.	TRH, BTEX SVOC, VOC, PAHs	H
3. Drainage line outflow	37,595	Potential area of buried demolition wastes containing asbestos in the vicinity of the drainage line outlet. Possible PCBs and DCE contamination from up gradient drainage pathways.	Asbestos, TRH, Metals, PCBs, TCE, DCE	M
4. Former sewage treatment plant (STP)	37,255	Stockpiles of demolition rubble overgrown by grass associated with the demolished STP with two depressions suspected of being sewage sludge disposal pits are present. ACM may be present within the rubble.	Asbestos and metals and nutrients	M
5. Bomb disposal training area	66,200	Bomb shells were buried in this area for the purpose of training soldiers in the detection, location and removal of UXO. Although ordnance removal occurs after training exercises, this process has not been well documented historically. Unrecorded shells (not with detonators of explosives) or other explosive ordnance waste (EOW) may be present in this area.	Fill, metals, explosives and UXO/EOW	M
6. Dog agility training area	16,810	The former Lake Sisinyak in this area has been partially filled. Anecdotal evidence has indicated that disposal bores and pits may be present, historically used for the disposal of medical supplies. Buried fill, waste metal and ACM may be present in fill.	Asbestos, metals, UXO/EOW	M
7. Bunded explosives magazine	1,830	Bund wall may contain contaminated fill material.	Asbestos, metals, explosives, UXO/munitions	M
8. Bridging yard	67,500	A grit blasting and spray painting facility exists, as well as an historical disposal pit consisting of a 2 m deep trench that is understood to have been filled with general waste during the 1970s. The area is currently used for the storage of plant/bridge training equipment and training personnel in the construction of bridge structures.	TRH, metals, BTEX, PAH, VOC and asbestos	M
9. Fuel/ oil storage area	3,655	Unbunded storage of fuels, lube oils, degreasers was observed. One operational UST is present.	TRH, BTEX, PAH, metals	H
10. Museum storage yard	30,365	Outside area used for the storage, repair and restoration of historical military vehicles and equipment with some contained storage of oils, lubricants and paints.	Metals, TRH, BTEX, PAH, VHCs	L
11. Bomb demonstration, ‘dust bowl’ and former fire training areas	108,415	Historical fill potentially present in this area. Current operations involve earth moving training using heavy plant and machinery. Firefighting training occurred here historically.	TRH, PAH and Metals and AFFF	M

AOPC description	Area (m^2)	Details	Contaminants of potential concern	Risk rank[1]
12. Vehicle wash bay	1,590	Four wash bays exist in this area with a sediment trap and oil/water separator.	TRH, BTEX, anionic surfactants, PAHs, VHCs and metals	M
13. Plants, roads and air fields yard (PRA) (diesel UST and bowser)	28,415	This area is used for the maintenance and refuelling of all plant and equipment used at the Steele Barracks. There is a single bowser with one 22 kL diesel UST. Three other USTs and an AST, understood to be used for waste oil storage are present.	TRH, BTEX, PAH and metals	H
14. Former Chatham Village	58,700	An historical asbestos dump is believed to be present in the former footprint of Chatham Village which was demolished in the early 1990s.	Asbestos, PAHs and metals, UXO/EOW	M
15. Field engineering store	14,520	Hardstand area used for the storage of metal sheeting, containers and structural metal objects.	TRH, Metals, PAH, SVOC, VOC	L
16. Former NBC store/ bunker/HQ	9,175	Various chemicals have been stored historically. Based on available information, radioactive materials have not been stored here since 1990. A surface radiological survey undertaken in 2006. No radioactive sources or contaminants were found.	VOC, SVOC, formaldehyde, delousing agents, CS gas	L
17. Practice mine field and bomb disposal area	6,615	This area is where plastic mines that release smoke or dye are triggered for training exercises. Anecdotal evidence suggests bomb shell casings may also be present.	Metals and explosives, UXO, EOW	M
18. Former Jacquinot Court	21,970	Formerly the SME married quarters, currently used for training exercises. Two old buildings exist. Asbestos has been identified within the building fabric. There is a grass covered stockpile demarcated by barbed wire thought to be asbestos waste. Based on anecdotal advice from site personnel, no live explosives are used.	Asbestos and metals	M
19. Golf course	184,000	No previous investigations undertaken in this area. This area may have been used for munitions training or waste burial prior to development as a golf course.	Metals, TRH, BTEX, VOC, PAHs, UXO, EOW	L
20. Former fire training area	16,750	Historically used to establish fires fuelled by various hydrocarbon ignition sources in car bodies, pans or above ground storage tanks. Since cessation of this training, it is understood that the top 1 m of soil has been removed and replaced with imported fill. The area is currently grassed with sparse trees.	TRH, PAH, metals, AFFF and anionic surfactants	H
21. Small arms range	4,750	Area used for general training purposes including the firing of blank bullets. There is the potential that live rounds may have been used historically.	TRH, BTEX, VOC, PAH, anionic surfactants, metals, UXO, EOW	H
22. Combat engineering store	17,535	Water purification chemicals and equipment are stored. Historically, two bunded sheds were used for the storage of oils and fuels with anecdotal information suggesting that a number of spills occurred historically.	Metals, TRH, BTEX, SVOCs and formaldehyde	M

AOPC description	Area (m^2)	Details	Contaminants of potential concern	Risk rank[1]
23. Parade ground	21,450	Deemed to be a low risk area based on current and historical land use as a parade ground however subsurface conditions remain to be confirmed.	Metals, PAH and Asbestos	L
24. Military museum	3,365	Deemed to be a low risk area based on current and historical land use, however, subsurface conditions remain to be confirmed.	Metals, TRH, BTEX, VOC, PAHs	L
25. Administration and accommodation	273,200	Deemed to be a low risk area based on current and historical land use, however, subsurface conditions remain to be confirmed.	Metals, PAH and Asbestos	L
26. Playing fields	87,000	Deemed to be a low risk area based on current and historical land use. Munitions training and waste burial may have occurred in such areas historically. Subsurface conditions remain to be confirmed.	Metals, PAH and Asbestos, UXO, EOW	L
27. Non-operational UST	4,585	It is understood that a former UST was present in this area. No information regarding the exact location or size was forthcoming.	Metals, TRH, BTEX and PAH	H
28. Pre-existing buildings, north-east corner	61,820	Currently sparse bushland, barracks type structures appear to be present in historical aerial photographs. Subsurface conditions remain to be confirmed.	Asbestos and metals	M

(1) H: High; M: Medium; L:Low

ABB: ABB Power Transmissions Pty Ltd

ACM: asbestos containing materials

AFFF: aqueous film forming foams

BTEX: benzene, toluene, ethylbenzene and xylenes

EOW: explosive ordnance waste

Metals: includes arsenic, cadmium, chromium, nickel, lead, zinc, copper and mercury

Nutrients: includes ammonia, nitrate, nitrite, Total Kjeldahl Nitrogen (TKN) and phosphate

OCP: organochlorine pesticides

OPP: organophosphate pesticides

PAHs: polycyclic Aromatic Hydrocarbons

PCBs: polychlorinated biphenyls

SVOC: semi volatile organic compounds

TRH: total recoverable hydrocarbons

UXO: unexploded ordnance

VOC: volatile organic compounds

2.9 On-site storage of hydrocarbon products

Based on information within the HLA AST and UST Management Plan (2005), several hydrocarbon storage tanks are present within the Moorebank IMT site. Details are summarised in Table 2.8.

Table 2.8 Summary of storage tanks within the Moorebank IMT site

Tank ID	Type (stored)	Location description	Age (years)	Details
Non-operational				
0367/B_UST_001	UST abandoned (unknown)	North of building 30	>30	SWS. NCP
3767S_UST_008	UST decommissioned (unknown)	South of building 70	Not known	
Operational				
3767S_AST_002	AST (waste oil)	West of building 16	Not known	
3767S_UST_003	UST (waste oil)	East of building 16	>20	SWS. NCP
3767S_UST_004	UST (waste oil)	East of building 16	>20	SWS.NCP
3767S_UST_005	UST (waste oil)	North of building 141	>20	SWS. NCP
3767S_UST_006	UST (unknown)	West of building 23	>20	SWS. NCP
SWSS0285	UST (unknown)	West of building 20	Not known	
44467	UST (diesel fuel)	South of building 14	>25	SWS. NCP No bowser protection

SWS: single walled steel
NCP: no cathodic protection

In addition to on-site fuel infrastructure, it is known that a number of USTs and aboveground storage tanks (ASTs) are present within the DNSDC located immediately hydraulically up gradient, to the east consisting five ASTs (two operational and three non-operational) and 27 operational USTs. The locations of known USTs and ASTs are presented in Figure 5 section 18.

The Phase 2 ESA was designed to target known USTs in order to assess soil and groundwater conditions in the vicinity of fuel and waste oil storage tanks.

3. Physical setting

3.1 Geology

3.1.1 Regional soils and geology

The surface geology of the Moorebank IMT site comprises Quaternary and Tertiary alluvium consisting of silt, sand and gravels from quaternary fluvial deposition.

The soil landscape consists of Quaternary and Tertiary terraces of the Nepean River and the Georges River. The soils comprise poorly structured orange to red clay loams, clays and sands with the potential for ironstone nodules to be present.

The Department of Mineral Resources Penrith 1:100,000 Series Geological Sheet 9030 (1991) showed dark grey to black Ashfield Shale of the Wianamatta Group which are typically black to dark grey shales and laminates from the Triassic period, underlain by Triassic Hawkesbury Sandstone in the north-western area of the Moorebank IMT site, comprising mainly medium to very coarse grained quartz sandstone. The Ashfield Shale strata dip towards the north-west.

3.1.2 Site specific geology

The Parson Brinkerhoff site investigations found that surficial geology comprised localised fill with variable alluvial deposits consisting clay, sandy silty clay, sandy clay, sand, clayey sand, silty sand, silty clay and gravelly sand. The geological conditions encountered are consistent with conditions reported within the environmental logs in the Earth Tech report (2006).The majority of fill encountered during the investigation is considered to be locally derived reworked natural material with localised occurrences of anthropogenic fill containing concrete and brick gravels and/or road base gravels and sands.

Significant volumes of imported fill was not encountered during the investigation; however anecdotal evidence suggests that imported fill may be present beneath the former Lake Sisinyak in the central area of the Moorebank IMT site (Area 6). The presence, origin, depth, extent or period of infilling in this area is unknown.

Where present, fill depths ranged between 0.5 and 1 m BGL with an average calculated fill depth of 0.6 m based on data gathered from both the Earth Tech (2006) and Parsons Brinckerhoff (2011) investigations. The inferred extent of fill is presented in Figure 14 section 18.

The maximum extent of fill material encountered at the Moorebank IMT site during previous investigations is 3.2 m. Due to the physical limitations of the test pitting method used in some areas of the Moorebank IMT site (i.e. collapse of test pit excavations), the vertical extent of fill in some areas, particular the former STP are (Area 4) and the dustbowl area (Area 11) was not fully delineated therefore it must be considered that in some areas, fill material will extend to depths beyond 3.2 m BGL.

Shale or sandstone bedrock was not encountered during fieldworks.

3.2 Topography

The site is generally flat to gently undulating with some localised steep topography associated with the river terraces in the north-west of the Moorebank IMT site, along the banks of the Georges River.

A review of topographical data provided by the Department of Lands Spatial Information Exchange (http://gsp.maps.nsw.gov.au/viewer.htm) showed that the Moorebank IMT site lies at an approximate elevation between 4 and 18 m Australian Height Datum (m AHD). The lowest elevations are associated with the terraces of the Georges River. The majority of the Moorebank IMT site lies at an approximate elevation of 12 to 14 m AHD.

3.3 Acid sulfate soils

A review of the ASS risk maps from the online CSIRO Australian Soil Resource Information System showed an extremely low probability of ASS for the majority of the Moorebank IMT site although high probability of ASS occurrence was shown within the immediate corridor of the Georges River.

Whether or not a particular land use activity will contribute to any acidification hazard in an area by exposing ASS will depend on the extent of soil disturbance, and the depth of occurrence of ASS materials. The environmental risk associated with ASS will depend on the type of land use activity proposed. Should areas noted to have a high probability ASS occurrence remain relatively undisturbed, potential ASS impacts would be unlikely.

3.4 Hydrology

The Moorebank IMT site is adjacent to the Georges River located immediately west of the western site boundary, which flows north-east towards Chipping Norton Lake before meandering back to flow south-east towards Botany Bay.

The majority of the surface water from the Moorebank IMT site is directed via overland flow and a network of open surface drains and underground pipes towards the Georges River with some localised flow into surface water ponds and to the Anzac Creek present in the south-western portion of the Moorebank IMT site. The site is located in the Southern Sydney Catchment Management Board area.

Surface water ponds are present across the Moorebank IMT site with two of the largest retention ponds present in the north-east and central areas. Historically a lake (Lake Sisinyak) existed in the central area which has now been in filled. The presence, origin, depth, extent or period of infilling in this area is unknown.

Several wetlands are located in the north-western part of the MIT site mainly comprising artificial wetlands (detention ponds). The depths and construction details of these ponds are not known but it is assumed that that the wetlands are dependent on shallow groundwater flow.

An open concrete lined drain located on the boundary between Steele Barracks and Moorebank Barracks transects the Moorebank IMT site from east to west. It is understood that this drainage line conveys some surface water runoff from the DNSDC facility to the east and from the Moorebank IMT site discharging to the Georges River via a gross pollutant trap (GPT) (located at the western end of Area 3).

The western boundary of the Moorebank IMT site is below the 20 and 100 year flood levels extending to the to the eastern line of the dustbowl area (Area 11) and covering much of the vegetated area along the Georges River Terrace indicating that there is the potential for flooding from the adjacent Georges River.

3.5 Hydrogeology

3.5.1 Regional hydrogeological setting

Alluvial deposits occur in valleys, creeks and river beds in the region. The alluvial deposits are shallow, discontinuous and relatively permeable and are likely to be responsive to rainfall and stream flow. The shallow alluvium is likely to be hydraulically connected to the Georges River. Wetlands in the northern part of the Moorebank IMT site confirm shallow groundwater conditions.

The Hawkesbury Sandstone is a dual porosity regional aquifer system that occurs across the whole of the Sydney Basin. Groundwater flow is variable throughout the Hawkesbury Sandstone, and is generally dominated by secondary porosity and fracture flow associated with structures such as faults and fracture zones. The primary porosity of the rock matrix is generally low.

Regionally and locally, the shale has a low hydraulic conductivity and groundwater with the shale has high salinity and thus behaves as an aquitard, restricting groundwater flow into the underlying Hawkesbury Sandstone unit.

The Hawkesbury Sandstone is an important aquifer in the region, but is not considered in detail here since the Ashfield Shale aquitard is likely to act as a barrier for groundwater flow between the overlying alluvial aquifer and the underlying sandstone aquifer.

3.5.2 Local hydrogeological setting

There are two main groundwater systems in the Moorebank IMT site:

- a shallow, unconfined aquifer in the Quaternary and Tertiary alluvium present across the entire IMT site; and
- a deeper regional aquitard in the Ashfield Shale.

The Ashfield Shale is considered to be a low-permeability unit that can store groundwater and also transmit it slowly from one aquifer to another. Based on the environmental logs reviewed from previous investigations at the Moorebank IMT site (HLA 2003), the thickness of this unit varies across the Moorebank IMT site, ranging from approximately 3 to 5 m in the south to approximately 5 to10 m in the north-east.

Locally, it is considered likely that groundwater flow is along the interface of the shale and alluvium following the gradient of the shale.

3.5.3 Groundwater database search

A search of the NSW Office of Water (NOW) licensed borehole register (accessed by Parsons Brinckerhoff in November 2010) showed that 19 registered bores were present within a 1 km radius of the Moorebank IMT site. Table 3.1 provides a summary of groundwater bores and associated groundwater levels collated from bore records held by NOW.

Table 3.1 Groundwater database summary

Bore ID	Purpose	Approx. distance (m) and direction	Easting	Northing	Date completed	SWL[1] mBTOC[2]	Screened within	Total depth (m)
GW016682	Monitoring	730 west	308691	6242741	09/01/1961	3.9	Alluvium	12.0
GW016829	Monitoring	410 west	308350	6243074	02/01/1958	4.2	Alluvium	22.8
GW108802	Monitoring	140 west	307099	6239299	04/21/2008	NK	Sandstone	29.8
GW108804	Monitoring	170 west	307015	6240274	04/22/2008	NK	Shale	11.0
GW109798	Monitoring	100 west	306970	6240724	01/29/2007	NK	Shale/sandstone	29.8
GW109799	General use	510 south-west	306736	6240430	01/29/2007	NK	Sandstone	23.7
GW109803	General use	580 north-east	307124	6240002	02/10/2009	NK	Sandstone	5.4
GW109805	Waste disposal	550 east	306467	6240130	01/29/2007	NK	Alluvium	3.9
GW110386	Monitoring	100 north	307864	6242396	09/06/2005	6	Alluvium	8.5
GW110387	Monitoring	100 north	307897	6242475	09/07/2005	8	Alluvium	9.0
GW110388	Monitoring	100 north	307799	6242460	09/07/2005	7.6	Alluvium	8.5
GW110389	Monitoring	100 north	307916	6242407	09/06/2005	7.9	Alluvium	10.0
GW110390	Monitoring	100 north	307849	6242487	09/06/2005	7.2	Alluvium	9.0
GW110391	Monitoring	100 north	307916	6242439	09/05/2005	7.5	Alluvium	10.0
GW110392	Monitoring	100 north	307902	6242504	09/05/2005	7.3	Alluvium	10.0
GW110393	Monitoring	100 north	307931	6242475	09/05/2005	7.8	Alluvium	10.0
GW110394	Monitoring	100 north	307802	6242402	09/06/2005	9.4	Alluvium	8.7
GW110395	Monitoring	100 north	307830	6242502	09/07/2005	6.8	Alluvium	8.5

SWL: standing water level

m BGL: metres below ground level

The majority of identified bores were monitoring bores associated with the ABB Transmissions facility to the north and Glenfield Landfill to the west. The two general use (domestic) bores identified in the search are located up gradient of the Moorebank IMT site.

A map of the identified licensed bores is presented in Figure 6 section 18. Results of the bore search are presented as Appendix A2.

3.5.4 Aquifer properties

Although Parsons Brinckerhoff has not undertaken any hydraulic testing at the Moorebank IMT site, a previous study was undertaken by HLA Envirosciences (2003). The results are summarised in Table 3.2.

Table 3.2 Summary of aquifer properties based on previous hydraulic testing

Aquifer	Source	Hydraulic conductivity range (m/day)
Alluvium	HLA (2003)	3.4×10^{-3} to 1.1×10^{-1}
Ashfield Shale	HLA (2003)	1.1×10^{-2} to 8.2×10^{-2}
Hawkesbury Sandstone	HLA (2003)	1.3×10^{-3} to 2.7×10^{-3}

3.5.5 Gauged groundwater levels and flow direction

Groundwater level ranges based on licenced bores and previous investigations are presented in Table 3.3.

Table 3.3 Summary of groundwater levels in different aquifer units

Aquifer	Groundwater level range (m BGL)		
	Alluvium	Ashfield Shale	Hawkesbury Sandstone
Registered bores	0.9 to 5.1	-	-
HLA (2003)	2.7 to 11	-	-
GHD (2004)	1.4 to 14.7	3.0 to 5.4	7.0 to 8.2
Earth Tech (2006)	4.8 to 13.3	-	-
Parsons Brinckerhoff (2011)	5.2 to 12.4	-	-

Based on previous investigations, the local groundwater flow direction is considered to be towards the north-west towards the Georges River which flows to the north along the western side of the Moorebank IMT site.

On a regional scale, groundwater flow in the alluvium is likely to be generally north-north-east following the flow direction of the Georges River. Regional groundwater flow direction in the Ashfield Shale is likely to be to the north-west, influenced by the dip of the strata.

3.6 Groundwater quality

Table 3.4 details salinity information held by NOW for licensed bores within the vicinity the Moorebank IMT site (wells within a 5 km radius of the site boundaries).

Table 3.4 Summary of groundwater salinity information

Bore number	Easting	Northing	Salinity	Screened within
GW017321	309953	6242582	Good (500–1000 µS/cm)	Quaternary Alluvium
GW017325	309878	6242457	Good (500–1000 µS/cm)	Quaternary Alluvium
GW017343	310382	6245518	Brackish (3001–7000 µS/cm)	Ashfield Shale
GW102015	303949	6243093	Brackish (3001–7000 µS/cm)	Ashfield Shale
GW102641	308873	6243885	Good (420 µS/cm)	Tertiary Alluvium
GW107018	311237	6240818	Brackish (3800 µS/cm)	Hawkesbury Sandstone
GW108346	306023	6238008	Brackish (7000 µS/cm)	Hawkesbury Sandstone

The results show that salinity in the alluvium is generally low. In contrast, groundwater within the Ashfield Shale is much more saline (brackish), typically exceeding 3,000 mg/L total dissolved solids (TDS). The measured salinities for the Hawkesbury Sandstone are also high and these are likely to be influenced by groundwater within the overlying Ashfield Shale.

4. Potential contamination sources

4.1 Potential on-site sources of contamination

Table 2.7 summarises the potential areas of potential concern and the contaminants of potential concern that were identified during the Phase 1 ESA.

Potential on site sources include:

- Buried wastes and waste stockpiles resulting from stockpiling and burial of materials from on-site demolition activities over time (such removal of barrack structures for the north-eastern portion of the Moorebank IMT site, removal of the Chatham Village area and the adaptation of Jacquinot Court from occupied living quarters to a military training facility.
- Leaks from the storage/use of hazardous chemicals such as fuels and waste oils in areas such as the bridging yard and PRA yard where historically activities such as refuelling and grit blasting have occurred and where there are a number of engineering maintenance workshops associated with the SME.
- Building materials containing hazardous materials such as asbestos within above ground structures.
- Residual contamination from long term use of the Moorebank IMT site as a military training facility incorporating activities such as munitions training, bomb disposal and arms firing ranges, such as surface and buried items of military origin (including UXO and EOW) and military artefacts.
- Contamination from ongoing site operations including the use of heavy earth moving plant and machinery regularly used on the ‘dust bowl’ area for excavation training and within the bridging yard.
- Residual contamination from detonation of explosives used in military training operations and training activities in bomb disposal and fire training areas where materials have historically been set alight and extinguished using surfactants.

4.2 Potential off-site sources of contamination

Based on the Phase 1 ESA and observations made during the Moorebank IMT site inspection, the following industrial operations in the vicinity of the site were identified as potential off-site sources of contamination.

4.2.1 ABB Power Transmissions Pty Ltd

ABB Power Transmissions Pty Ltd (ABB) is located to the north of Moorebank Barracks on the eastern bank of the Georges River. An online search of the NSW EPA contaminated land record database returned eight notice records (three former and five current) for ABB. Notices detailed that chemical wastes including polychlorinated biphenyl (PCB) contamination were considered to be present at the premises. Based on the relatively high hydraulic conductivity of alluvial sands encountered during previous investigations at Moorebank Barracks, inferred groundwater flow direction and immediate proximity, it is considered that there is potential for the migration of mobile contaminants from the ABB premises to the Moorebank IMT site via groundwater migration pathways.

4.2.2 Defence National Storage and Distribution Centre

Land to the east comprising the Defence National Storage and Distribution Centre (DNSDC) is known to have a number of operational USTs and refuelling areas. Based on the HLA 2002 report reviewed during Phase 1 ESA (entitled Soil and Groundwater Investigation Precinct H (DNSDC) Moorebank Defence Land), contamination impacts have been identified in groundwater directly up gradient of the Moorebank IMT site, in particular TRH, BTEX compounds and elevated dissolved heavy metals (including cadmium, copper, zinc, nickel and lead). The most elevated TRH concentrations were reported in groundwater sampled from monitoring wells located along the western site boundary of the DNSDC, particularly in the south-western area of the DNSDC in close proximity to the refuelling area where USTs are known to be present.

Based on the westerly inferred groundwater flow direction, the likely relatively high hydraulic conductivity of the alluvial geology encountered and the known mobility of the contaminants already identified in groundwater at the DNSDC (HLA 2002), it is considered that there may be potential for the migration of mobile contaminants from the DNSDC site towards the Moorebank IMT site.

4.2.3 Moorebank Business Park

Moorebank Business Park is situated immediately to the north of the DNSDC on the corner of Moorebank Avenue and Anzac Road. The site comprises commercial premises that were completed in 2007 and including Toyota, Electrolux and BMW warehousing and showroom facilities. There is no evidence to suggest that this area presents a potential off-site source of contamination and is considered unlikely due to the relatively recent redevelopment of the this site.

4.2.4 Glenfield Waste Services

Glenfield Waste Services (GWS) is an active landfill and waste transfer facility located to the southwest of the Steele Barracks on the western bank of the Georges River. Such a land use would have the potential to cause environmental impacts due to the flow of potentially contaminated groundwater within and beneath waste fill towards the Georges River.

For environmental and geotechnical reasons it is considered that the environmental risks associated with redevelopment of GWS lands as part of the Moorebank IMT development would be high. Construction methods (such as piling) may undermine the integrity of the engineered landfill layers (if present). Damage to engineered barriers would potentially present an environmental risk by creating preferential pathways for leachate and perched groundwater to enter the groundwater and the Georges River. There may also be risk associated with landfill gas. Based on the current preferred design option, the development does not extend to this area.

5. Data quality objectives

Systematic planning and verification is critical to successful implementation of a contaminated site investigation and remediation project. A process for establishing data quality objectives (DQOs) for an investigation has been defined by the United States Environmental Protection Agency (US EPA). That process has been adopted by the Australian Standard: AS4482.1-2005 and referenced by the National Environment Protection Council (NEPC) 2013, National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No.1) (NEPM). The NSW EPA in its Guidelines for the NSW Site Auditor Scheme (2nd Edition) (2006) requires the Auditor, when conducting a site audit, to ensure that the data from the Moorebank IMT site assessment is reliable and representative of the site conditions.

The DQO process has been applied to sampling activities undertaken at the Moorebank IMT site. It is a seven-step iterative planning approach used to plan for environmental data collection activities. It provides a systematic approach for defining the criteria that a data collection design should satisfy, including when, where, and how to collect samples or measurements, determination of tolerable decision error rates and the number of samples or measurements that should be collected.

The seven step process for planning the assessment program to obtain adequate and defensible data is discussed in Table 5.1.

Table 5.1 Data quality objectives

Step	Purpose of DQO	DQO input for the proposed Moorebank IMT site
Step 1 State the problem	To summarize the contamination problem that will require new environmental data and to identify the resources available to resolve the problem. There are three primary activities: ▪ describe the contamination problem that presents a potential threat or unacceptable risk to human health and the environment; ▪ establish the DQO planning team; and ▪ identify the resources and organisation or management issues needing resolution.	The problem is that past and current uses of the Moorebank IMT site may have resulted in soil, groundwater, surface water and/or sediment contamination as well as the presence of surface and buried items of military origin such as UXO and EOW, which may preclude future site use the site. The purpose of the assessment is to: ▪ evaluate areas of potential environmental concern and gather data to determine the current condition of the Moorebank IMT site; ▪ determine whether the soil and groundwater contamination identified (if any) poses a potential risk to human health or the environment; ▪ determine whether remediation and/or management actions are required, in the context of the proposed development and future land use; and ▪ determine whether the identified contamination or the required management and/or remediation measures are likely effect the feasibility of the proposed development.
Step 2 Identify the decisions	To identify the decisions that requires new environmental data to address the contamination problem. There are four activities in this step: ▪ identify the principal study question; ▪ define the alternative actions that could result from the resolution of the principal study question; ▪ combine the principal study question and the alternative actions into a decision statement; and ▪ organise multiple decisions, if warranted.	The principal study question is: Is it feasible to redevelop the Moorebank IMT site for future use as an intermodal transport terminal? In order to answer this question, the multiple decisions to be addressed are: ▪ Are contaminants present within the surface soils or natural soils beneath that will pose a risk to future site users and the surrounding environment? ▪ Is water and sediment quality within the water retention ponds suitable for re-use or release into the receiving environment? ▪ Have on-site or off-site activities impacted the water quality within Georges River? ▪ Do items of military origin such as UXO or EOW exist in surface soils or buried on-site? ▪ Has contaminated material been buried or used for filling activities on site? If so, to what extent and has imported fill or buried waste impacted the underlying natural soils? ▪ Do asbestos containing materials (ACM) exist on the surface of the Moorebank IMT site and in the subsurface in such a volume or state that would be considered an unacceptable risk to human health? ▪ Has groundwater on site been impacted by current of historic site activities? ▪ If groundwater contamination exists, is it migrating off site and does this pose an unacceptable risk to the potential receptors identified? ▪ Do contaminant concentrations exceed the relevant regulatory assessment criteria? ▪ Does the contamination identified restrict the proposed future commercial industrial use? ▪ Are remediation or management actions required?

Step	Purpose of DQO	DQO input for the proposed Moorebank IMT site
Step 3 Identify inputs to the decisions	To identify the information required to support the decision and to specify which inputs require new environmental measurements. There are four activities in this step: ▪ identify the information that will be required to resolve the decision statement; ▪ determine the sources for each item of information identified; ▪ identify the information needed to establish the action level; and ▪ confirm that appropriate analytical methods exist to provide the necessary data. To make effective decisions in accordance with the DQO process, certain informational inputs are required. The type of informational inputs that are necessary depends on the approach used to resolve the decision statement (i.e. sampling, modelling, or a combination of these approaches).	To establish the extent of the identified contamination and the presence/absence of potential contamination in AOPCs identified in the Phase 1 ESA, a targeted investigation including some additional locations to fill spatial data gaps in areas that had not been investigated previously (such as the golf course) was undertaken. The sampling regime was based on a source targeting approach also allowing for lateral coverage. The distribution of wells across the Moorebank IMT site was designed to provide information on up gradient and down gradient groundwater conditions. Sampling locations with the Parsons Brinckerhoff 2011 investigation included 10 hand auger locations, 40 test pits, 22 soil bores, conversion of 21 soil bores to groundwater monitoring wells, 26 selected existing groundwater monitoring wells, 8 surface waters and 7 sediment samples. In addition environmental data derived from the Earth Tech 2006 investigation report including soil classification, subsurface condition descriptions (including results from the UXO assessment and seismic refraction survey), PID readings and laboratory data. A discussion of reliance on previous site data is provided in section 7.4. Soils, sediments, groundwater and surface water were analysed for a range of contaminant of potential concern including TRH, BTEX compounds, PAH, heavy metals, PCBs, VOCs, SVOCs, explosive compounds, AFFF, anionic surfactants, OPPs, OCPs and asbestos. It is noted that herbicides were not included in the analytical suite for 2011 as based on the relatively short half-life of such contaminants in surface soils and based on the absence of herbicides within the analytical results of the Earth Tech 2006 investigation, with results reported below the PQL. Parsons Brinckerhoff have obtained the raw laboratory data, and have reviewed this data and field data provided within the Earth Tech (2006) report to verify that is valid and appropriate to be used for the objectives of the investigation. The quality assurance processes followed to verify the data is documented in section 11. Analytical results were compared to the assessment criteria detailed in section 6.

Step	Purpose of DQO	DQO input for the proposed Moorebank IMT site
Step 4 Define the study boundaries	To define the spatial and temporal boundaries that the data must represent to support the decision. There are seven activities in this step: ▪ specify the characteristics that define the population of interest; ▪ define the geographic area to which the decision statement applies; ▪ divide the population into strata that have relatively homogeneous characteristics (when appropriate); ▪ determine the time frame to which the decision applies; ▪ determine when to collect data; ▪ define the scale of decision making; and ▪ identify any practical constraints on data collection.	The site covers an area of approximately 220 ha. Twenty eight areas that have been identified in which there is considered to be the potential for contamination to exist. The areas are described in detail in section 2. The boundaries of each of the 28 investigation areas are shown in Figure 4 section 18. The site boundary and the associated lot boundaries are presented in Figure 2 section 18. Groundwater monitoring wells were installed to a maximum depth of 16 m BGL targeting the alluvial aquifer. The alluvial aquifer was targeted as this was considered to be the key aquifer of interest in terms of potential contamination, due to the properties of the high conductivity groundwater known to be present regionally within the underlying Shale and Sandstone which is known to act as an aquitard. Installation design was subject to the local sub surface conditions encountered. Test pits were advanced 0.5 m into natural soils or to a maximum depth of approximately 3.0 m BGL, whichever occurred first. Soil samples were generally collected at the near surface, 0.5 m BGL, 1.0 m BGL and at approximate 1.0 m depth intervals thereafter. A minimum of one sample from each location was submitted for laboratory analysis. If, at any location, visual indications of contamination were identified (such as odour or staining) this material was sampled and scheduled for analysis. The vertical extent of the ESA is discussed in detail in section 8.2. Practical constraints on data collection were largely associated with administrative or security permissions associated with working on Defence land, limited access at the times required due to operational Defence activities (such as training exercises) and the physical site setting which constrained access in some areas (such as dense vegetation, localised areas of steep topography and the golf course and playing ovals).
Step 5 Develop a decision rule	To develop a logical 'if...then...' statement that defines the conditions that would cause the decision maker to choose among alternative actions. There are four activities in this step: ▪ specify the statistical parameter (such as mean, median, maximum, or proportion) that characterizes the population of interest; ▪ specify the action level for the decision; ▪ confirm that measurement detection limits will allow reliable comparisons with the action level; and ▪ combine the outputs from the previous DQO steps and develop a decision rule.	Historical information, site observations, field data (including the findings of the UXO assessment and geophysical survey) and analytical data was used to assess the nature and extent of the contamination at the Moorebank IMT site. This included data from both the Parsons Brinckerhoff (2011) and the Earth Tech (2006) investigations. Contaminants identified on-site were compared against the site assessment criteria detailed in section 6. Statistical assessment of the data was used, as required, to support the need or otherwise for remediation. These decision rules include the 95% upper confidence limit (UCL) for the data set being less than site assessment criteria, the standard deviation of the data set being less than 50% and no one sample concentration being greater the 250% of the Moorebank IMT site assessment criteria. Statistical analysis was primarily undertaken using data from the areas of potential concern that were defined and where more severe contaminant impacts were identified. Furthermore, the field and laboratory QA/QC of all data used within the investigation is a fundamental part of this process and is detailed further in section 11.

Step	Purpose of DQO	DQO input for the proposed Moorebank IMT site
Step 6 Specific limits on decision errors	To ensure the quality of a dataset, data has to be precise, complete and comparable in order for decisions on the data to be made.	Analytical results will be assessed against site assessment criteria as outline in section 6. The data will also be assessed against various quality attributes such selectivity, precision, completeness and comparability. In accordance with the Guidelines for the NSW Auditor Scheme (2nd Edition), data will be evaluated to determine any limitations within the dataset. This will include the use of limits regarding limits for relative percentage differences (RPD) between primary and QA/QC data, rinsates, spikes, duplicates.
Step 7 Optimise the design for obtaining data	To identify a resource-effective sampling and analysis design for generating data that can reasonably satisfy the DQOs. There are six activities in this step: ▪ review the DQO outputs and existing environmental data; ▪ develop general data collection design alternatives; ▪ formulate the mathematical expressions necessary for each design alternative; ▪ select the sample size that satisfies the DQOs for each design alternative; ▪ select the most resource-effective design that satisfies all DQOs; and ▪ document the operational details and theoretical assumptions for the selected design.	This assessment was designed after considering the findings of the previous investigations, observations recorded during the Moorebank IMT site inspection, accessibility of specific areas of the Moorebank IMT site and ecological constraints. Where additional areas of potential contamination were visually identified on site, additional samples were collected. Observations and PID screening during excavation works were used to further establish the presence of potential contamination. Where possible, photographs were taken. The design selected is considered to be suitable for the overall objectives of the ESA which are to: ▪ gather sufficient information to evaluate whether the contamination identified would preclude commercial/ industrial use of the Moorebank IMT site; and ▪ provide inputs at the concept feasibility stage on which broad scale cost estimates can be calculated for remedial works and/or management actions required to address contamination impacts identified to facilitate the construction of an IMT.

6. Site assessment criteria

6.1 Soil assessment criteria

To assess the presence of soil contamination at the site, assessment criteria and investigation methodologies have been adopted from the NEPC 2013, *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1)* (NEPM).

Revision A of this document was produced in 2011, at which time the results of analytical sampling from the Phase 2 investigation undertaken by Parsons Brinckerhoff and other available historical data were compared to then-current guideline criteria which have now been superseded by the NEPM (2013). Under Revision B (this document), the screening assessment of analytical results has been guidelines. However, for total recoverable hydrocarbons (TRH) the NEPM (2013) specifies criteria for different hydrocarbon fractions than those previously used (in accordance with the former NEPM, 1999), making a direct comparison impossible. An indicative comparison has been undertaken, with conservative grouping of hydrocarbon fractions to encompass the revised fractions.

Applicable health screening levels (HSLs), health investigation levels (HILs) and ecological investigation and screening levels (EILs and ESLs) from the NEPM (2013) have been used for this site assessment. These investigation levels are not clean up criteria, they are used as a Tier 1 risk assessment to evaluate if unacceptable risks may be present at the site. Any contaminants which have concentrations greater than the investigation levels should be further assessed using a Tier 2 risk assessment.

The HSLs depend on specific soil physicochemical properties, land use scenarios, and the characteristics of building structures. They apply to different soil types, and depths below surface to >4 m BGL.

EILs and ESLs, for assessing the potential risk to plants and terrestrial ecosystems, are also presented in the NEPM (2013). EILs and ESLs depend on specific soil physicochemical properties and land use scenarios and generally apply to the top 2 m of soil. EILs are site specific and are determined by calculating an ambient background concentration (ABC) and an added contaminant limit (ACL) for the site, which are added together to get the EIL. The ABC and ACL are based on other properties of the soil, including pH, cation exchange capacity (CEC) and clay content. In the absence of data of these specific soil properties, the most conservative value has been adopted for the purpose of this assessment. As the site has been proposed for commercial/industrial development it is considered of limited terrestrial ecosystem value.

The Cooperative Research Council for Contamination Assessment and Remediation of the Environment (CRC CARE) Technical document no. 10 (Friebel and Nabedaum 2011) provides soil HSLs for select petroleum hydrocarbons where direct contact is deemed likely, such as surface soil (to 1 m) and for intrusive maintenance workers working in the shallow trenches (<1 m).

Assessment and characterisation of the Moorebank IMT site has also considered the 95% upper confidence limit (UCL) of the arithmetic mean of contaminant concentrations which have been compared to the nominated criteria. Assessment follows the method in NEPC (2013), whereby the standard deviation is less than 50% of the relevant screening level and no single value is above 250% of the relevant screening level.

With regards to any aesthetic impacts, odours and staining were noted during the investigation and samples were collected and analysed based on such field observations. Hydrocarbon staining can be present even where analytical results are reported to be below site soil criteria. Where there is a potential for future exposure to site users, stained or odorous materials may require excavation.

Considering the proposed future site use, analytical results have been assessed against the threshold levels that are relevant for commercial/industrial land use. The criteria that will be used to assess the analytical data are summarised in Tables 6.1 and 6.2.

Table 6.1 Soil HSLs for vapour intrusion

Chemicals	Commercial/industrial (HSL D)			
	SAND[1]			
	0 to <1 m	1 m to <2 m	2 m to <4 m	≥4 m
F1: TRH C_6-C_{10} less BTEX	260	370	630	NL
F2: TRH >C_{10}-C_{16} less naphthalene	NL	NL	NL	NL
Benzene	3	3	3	3
Toluene	NL	NL	NL	NL
Ethylbenzene	NL	NL	NL	NL
Xylene	NL	NL	NL	NL
Naphthalene	NL	NL	NL	NL

Values provided in mg/kg

NL – not limiting i.e. the soil vapour source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario

(1) Soil type: sand is adopted here as a conservative approach.

Table 6.2 Soil investigation levels

Chemicals	HILs (1)	ESLs (2)	EILs (3)	Management limits (4)
	Commercial/ Industrial D	Commercial/ Industrial coarse soil		Commercial/Industrial coarse soil
F1: TRH C_6-C_{10} less BTEX	-	215	-	-
F2: TRH >C_{10}-C_{16} less naphthalene	-	170	-	-
TRH C_6-C_{10}	-	-	-	700
TRH C_{10}-C_{16}	-	-	-	1,000
F3: >C_{16}-C_{34}	-	1,700	-	3,500
F4: >C_{34}-C_{40}	-	2,500	-	5,000
Benzene	-	75	-	-
Toluene	-	135	-	-
Ethylbenzene	-	165	-	-
Xylene	-	180	-	-
Naphthalene	-	-	370	-
Benzo(a)pyrene	-	0.7	-	-
Carcinogenic PAHs (6)	40	-	-	-
Total PAHs	4,000	-	-	-
Arsenic	3,000	-	100	-

Chemicals	HILs (1)	ESLs (2)	EILs (3)	Management limits (4)
	Commercial/ Industrial D	Commercial/ Industrial coarse soil		Commercial/Industrial coarse soil
Cadmium	900	-	-	-
Chromium (VI)	3,600	-	-	-
Chromium (III)	-	-	310	
Copper	240,000	-	140	-
Lead	1,500	-	1800	-
Mercury	730	-	-	-
Nickel	6,000	-	55	-
Zinc	400,000	-	110	-
PCB Total	7	-	-	-
Organochlorine pesticides				
DDT + DDE + DDD	3,600	-	640	-
Aldrin and dieldrin	45	-	-	-
Chlordane	530	-	-	-
Endosulfan	2,000	-	-	-
Endrin	100	-	-	-
Heptachlor	50	-	-	-
Perfluorooctanoic acid (PFOA)	16(5)		-	-
Perfluorooctanoic sulfonate acid (PFOS)	6(5)		-	-

(1) NEPM (2013) Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1A(1) - Health investigation levels for soil contaminants.

(2) NEPM (2013) Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1B(6) – Ecological screening levels for TRH fractions F1–F4, BTEX and benzo(a)pyrene in soil.

(3) EILs: NEPM (2013) Schedule B1, Soil specific added contaminant limits for aged zinc (Table 1B(1)), copper(Table 1B(2)), chromium III and nickel(Table 1B(3)) and generic added contaminant limits for lead irrespective of their physiochemical properties (Table 1B(4)), fresh DDT and fresh naphthalene in soils irrespective of their physiochemical properties, commercial and industrial.

(4) NEPM (2013) Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1B (7) - Management limits for TRH fractions F1–F4 in soil.

(5) USEPA RSL regional screening level for residential soil (2010).

(6) Carcinogenic PAHs: HIL is based on the eight carcinogenic PAHs and their toxicity equivalent factor relative to benzo(a)pyrene.

\- denotes that there is no threshold value available.

PFOA and PFOS are persistent in all media in the environment and can bioaccumulate and biomagnify in terrestrial and marine mammals. These chemicals are emerging environmental pollutants with relatively limited toxicity information. There is not currently an Australian guideline for perfluorinated chemicals in soils, therefore the US EPA regional screening level (RSL) for residential soil has been adopted.

It is noted that the final development design is likely to incorporate some conservation which will not constitute accessible soils as it is understood that there will be no public access to these areas, therefore no assessment has been made relating to recreational open space screening criteria.

6.2 Acid sulfate soil criteria

Acid sulfate soils (ASS) are usually found in estuarine environments up to 10 m AHD and generally consist of clays and sands containing pyritic material. ASS are the common name given to soils containing iron sulfides. When exposed to oxygen, soils containing iron sulfides produce sulfuric acid and often release toxic quantities of iron, aluminium and heavy metals. ASS can have major environmental, economic, engineering, and health impacts and may constrain development, construction and other activities in affected areas.

A review of the ASS risk maps from the online CSIRO Australian Soil Resource Information System showed an extremely low probability of ASS for the majority of the Moorebank IMT site although high probability of ASS occurrence was shown within the immediate corridor of the Georges River. The ASS risk map is presented in Figure 7, section 18.

The assessment criteria for field and laboratory testing have been derived with reference to the Acid Sulfate Soils Management Advisory Committee (ASSMAC) Assessment Guidelines (1998). Action criteria for ASSMAC are based on texture and clay content of the soil being analysed and the likely total volume of soil to be disturbed.

For the purpose of this investigation the adopted action criteria is for medium texture soils (sandy loams to light clays) with over 1,000 tonnes to be disturbed. The criteria are outlined in Table 6.3.

Table 6.3 ASSMAC (1998) adopted action criteria

Test	Units	Action criteria for medium textured soils (medium to heavy clays and silty clays)
S_{POS}	%	0.03
TPA/TSA	mol H^+/tonne	18

S_{POS}: peroxide oxidisable sulfur
TPA: total potential acidity
TSA: total sulfuric acidity

Should analytical results exceed these criteria and where excavation works are proposed where there is potential for ASS, an ASS management plan should be prepared and development consent obtained. For projects that disturb >1,000 tonnes of ASS soil with oxidisable sulfur criteria of less than or equal to 0.03%, a more detailed management plan and development consent would be required.

6.3 Waste classification criteria for soils

In order to assess the likely waste classification of soil excavated from the Moorebank IMT site, analytical results for soils will also be compared to the values presented within the NSW Department of Environment, Climate Change and Water (DECCW) *Waste Classification Guidelines* (2009). The two measurable properties of contaminants used to classify waste are:

- the specific contaminant concentration (SCC) of any chemical contaminant in the waste expressed as milligrams per kilogram (mg/kg)
- the leachable concentration of any chemical contaminant using the toxicity characteristics leaching procedure (TCLP) expressed as milligrams per litre (mg/L).

The SSC test is an initial screening test for the classification of waste. Based on the SCC test alone, the concentration for each contaminant must be below the threshold concentrations as set out in the Waste Classification Guidelines. If a contaminant exceeds the SCC contaminant threshold values for general solid or restricted solid waste, further assessment using TCLP analysis may be used to determine the leachable concentration and class of waste.

If the SCC and TCLP values are exceeded for general solid waste, the waste must be classified as restricted solid waste. If the SCC and TCLP are exceeded for restricted waste, the waste must be classified as hazardous waste.

Where asbestos is positively identified within waste material, this may be classified as ‘special waste’. However, if asbestos is mixed with other waste materials to form asbestos waste it must be assessed in accordance with the SCC and TCLP test described above and disposed of at a waste facility that can lawfully receive asbestos wastes.

The SCC and leachable concentration (LC) contaminant thresholds for general solid waste and restricted solid waste are set out in the Table 6.4.

Table 6.4 Waste classification criteria

Analyte	SCC (without TCLP)		SCC (with TCLP)		SCC (with TCLP)	
	Maximum values for classification without TCLP		Maximum values for leachable concentration and SCC when used together			
	General Solid	Restricted Solid	General Solid		Restricted Solid	
			LC	SCC	LC	SCC
Arsenic	100	400	5	500	20	2,000
Cadmium	20	80	1	100	4	400
Chromium	100	400	5	1,900	20	7,600
Lead	100	400	5	1,500	20	6,000
Mercury	4	16	0.2	50	0.8	200
Nickel	40	160	2	1,050	8	4,200
Benzene	10	40	0.5	18	2	72
Benzo(a)pyrene	0.8	3.2	0.04	10	0.16	23
Trichloroethylene	10	40	0.5	18	2	72
Total xylenes	1,000	4,000	50	1,800	200	7,200

All values in mg/kg unless otherwise stated
Copper and Zinc: no threshold values specified in waste guidelines
SCC: specific contaminant concentration
TCLP: toxicity characteristic leaching procedure
LC: leachable concentration (in ug/L)

6.4 Sediment assessment criteria

Contaminated sediments that accumulate beneath surface water bodies and within drainage lines may contain substances that can adversely affect human health or the environment. Sediments may act as a source and a sink of dissolved contaminants and have the potential to influence surface water quality and aquatic ecosystems.

The ANZECC Fresh and Marine Waters Quality Guidelines (2000) recommend a hierarchical approach to the assessment of sediments based on an initial assessment of total contaminant concentrations against the Interim Sediment Quality Guidelines (ISQG) followed by further investigations/analysis to determine bioavailability and toxicity of contaminants (as appropriate).

Where total concentrations of metals exceed the ISQG low criteria, no action is required. Where total concentrations exceed the ISQG low criteria but are less than ISGQ high criteria, an assessment against background concentrations should be made. Where reported concentrations exceed the low and high and background values, assessment of the bioavailability of the contaminants should be undertaken. Where the bio-available concentrations are below the ISQG low criteria, no further action is required. If concentrations exceed the ISQG low criteria, toxicity testing is required and contaminants that are found to be toxic would require remediation.

The adopted sediment assessment levels are presented in Table 6.5. It is important to note that these are not threshold values at which an environmental problem is likely to occur if exceeded, rather, if the trigger values are exceeded, further action may be required as described above.

Table 6.5 Adopted assessment criteria – sediments (mg/kg)

Analyte	ISQG[1] Low[2] (trigger value)	ISQG High[3] (trigger value)	Adopted assessment criteria
Arsenic	20	70	20
Cadmium	1.5	10	1.5
Chromium	80	370	80
Copper	65	270	65
Lead	50	220	50
Mercury	0.15	1	0.15
Nickel	21	52	21
Zinc	200	410	200
PCB	23	-	23
Total PAHs	4,000	45,000	400
Benzo(a)pyrene	430	1,600	430

All values in mg/kg.

(1) ISQG: Interim Sediment Quality Guidelines.

(2) ISQG Low: Probable effects, concentrations below which biological effects would rarely occur (i.e. no further action would be required).

(3) ISQG High: Probable effects, concentrations below which biological affects would possibly occur (i.e. further action may be required).

6.5 Groundwater and surface water investigation levels

For assessing groundwater and surface water quality, it is necessary to evaluate the potential uses of groundwater in the vicinity of the Moorebank IMT site being investigated. Potential uses could include:

- groundwater discharge to water bodies sustaining aquatic ecosystems, (such as the Georges River which flows along the Moorebank IMT site boundary and the Anzac Creek)
- irrigation of crops, parks and gardens (although there is no indication that this is occurring in the vicinity of the Moorebank IMT site based on the results of a licensed bore search undertaken as part of the Phase 1 ESA)
- potential downstream recreational users of the Georges River.

The concentrations of contaminants presented as groundwater investigation levels (GILs) are applicable for assessing ecological risks and human health risks from direct contact (including consumption) with groundwater. The GILs are the concentrations of a contaminant in groundwater above which further investigation or a response should be undertaken. GILs are based on Australian Water Quality Guidelines 2000, Australian Drinking Water Guidelines 2011 and Guidelines for Managing Risk in Recreational Waters 2008. The GILs provide values for drinking water and protection of fresh and marine ecosystems. The GILs do not provide data for toluene, ethylbenzene and PAHs; however, as the GILs are based on the ANZECC (2000) Fresh and Marine Waters Quality Guidelines, ANZECC freshwater low reliability trigger values for toluene, ethylbenzene and PAHs have been considered. The threshold concentrations presented in the ANZECC (2000) Fresh and Marine Waters Quality Guidelines are considered applicable for the protection of aquatic ecosystems of the receiving waters. As these guidelines apply to receiving waters, it is generally conservative to apply these to groundwater discharging to receiving waters. As the receiving waters (Georges River and Anzac Creek) are freshwater bodies, freshwater trigger values are considered most applicable for screening the concentrations of COCs identified in groundwater and surface water at the Moorebank IMT site.

The groundwater investigation levels are presented in Table 6.6.

Table 6.6 Groundwater investigation levels

Analyte	Freshwater ecosystem[1] (µg/L)	Drinking water[2] (µg/L)
Benzene	950	1
Toluene	180	800
Ethylbenzene	80	300
m- & p-xylene	200 (as p-xylene)	–
o-xylene	350	–
Total xylene	–	600
Arsenic (as As^{V})	24	10
Cadmium	0.2	2
Chromium (VI)	1	50
Copper	1.4	2,000
Lead	3.4	10
Mercury	0.06	1
Nickel	11	20
Zinc	8	-
Total PAHs	3	-
Benzo(a)pyrene	-	0.01
Naphthalene	16	-
PFOA[3]	-	0.4[3]
PFOS[3]	-	0.2[3]
1,1,2-TCE	6,500	-
1,2-DCE	-	3
Vinyl Chloride	-	0.3

Analyte	Freshwater ecosystem(1) (µg/L)	Drinking water(2) (µg/L)
Formaldehyde	-	500

(1) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1) – Schedule B1 Investigation levels for soil and groundwater derived from the ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality, protection of 95% of freshwater ecosystem.

(2) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1) – Schedule B1 Investigation levels for soil and groundwater derived from the health values of the Australian Drinking Water Guidelines (NHMRC 2011).

(3) There is not currently an Australian guideline for perfluorinated chemicals in groundwater, therefore, the US EPA tap water screening level has been adopted as a conservative guideline for assessment, USEPA screening value for tap water (2001).

- No threshold value available.

All values in µg/L.

Schedule B1 also provides a framework for assessing the human health risk from petroleum compounds and fractions via the inhalation and direct contact pathways through the development and implementation of HSLs. The adopted carbon fraction ranges for the HSLs are based on TRH analysis after subtraction of BTEX compounds.

The HSLs have been developed for sand, silt and clay soils based on soil texture classifications and criteria are listed for several depth intervals. Where there is reasonable doubt as to the appropriate soil texture to select, either a conservative selection should be made (i.e. sand) or laboratory analysis carried out to determine particle size and hence soil texture sub-class.

The groundwater HSLs that been adopted for this ESA are summarised in Table 6.7.

Table 6.7 Groundwater HSLs for vapour intrusion

Chemicals	Commercial/industrial (HSL D) (1)		
	SAND		
	2 m to <4 m	4 m to <8 m	8 m +
F1: TRH C_6-C_{10} less BTEX	6,000	6,000	7,000
F2: TRH >C_{10}-C_{16} less naphthalene	NL	NL	NL
Benzene	5,000	5,000	5,000
Toluene	NL	NL	NL
Ethylbenzene	NL	NL	NL
Xylene	NL	NL	NL
Naphthalene	NL	NL	NL

(1) NEPC (2013) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1) - Schedule B-1 Investigation Levels for Soil and Groundwater - Table 1A(4) Groundwater HSLs for vapour intrusion - HSL D.

Values provided in µg/L.

NL: not limiting as the maximum potential vapour concentration is below the acceptable risk level.

It is important to note that these screening values are not threshold values at which an environmental problem is likely to occur if exceeded, rather, if trigger values are exceeded, further action is required. This may include further site-specific investigation to assess whether or not there is an actual problem or management/remedial action.

7. Sampling and analysis program

7.1 Sampling rationale for intrusive site works

Twenty eight AOPCs were defined during the Phase 1 ESA. These areas were considered to have the greatest potential for contamination to be present due to historical and current site uses.

The proposed sampling locations were selected based on a targeted sampling approach to target potential source areas (such as underground fuel storage infrastructure) and to augment the existing site dataset (Earth Tech 2006).

Some sample locations outside of the AOPCs (denoted as ‘0’) were selected to provide additional site coverage. In addition, some existing groundwater monitoring wells drilled as part of previous environmental investigation works were sampled.

In addition to the investigation locations presented in Table 7.1, all investigation results for locations situated within the Moorebank IMT site from the Earth Tech report have been used within the assessment. It is considered that the combined dataset is appropriate to meet the overall objectives of the feasibility study. A discussion on the validity and reliability of the 2006 data and suitability of data to meet the objectives of the investigation is presented in section 11. A full list of all locations is provided within Appendix A4.

A description and rationale for sample locations (as per the SAQP) has been summarised in Table 7.1 below. The locations of the AOPCs are shown in Figure 4 section 18.

Table 7.1 Parsons Brinckerhoff (2011) sample locations

AOPC	Sample ID[1]	Location	Targeting	Rationale
1	MWBHB1 (nc), MWBHB5, MWBHB7 (nc), MWBHB9, MWBHB11, MWBHB13, MWBHB3 (nc)	ABB Power Transmissions boundary.	TCE/DCE groundwater.	Existing wells sampled to establish the current status of TCE in groundwater. TCE consistently identified in groundwater historically.
2	PB_MW03, PB_MW04, PB_MW05, PB_MW18, MW115	Vehicle storage/ maintenance area.	One non-operational UST and potential migration of contaminants from off-site sources via groundwater.	An additional four groundwater monitoring wells installed to assess the contamination status of groundwater in the vicinity of the non-operational UST and along the eastern site boundary. One existing well sampled.
3	PB_TP06, PB_TP07, PB_SS02, PB_SS03, PB_HA02 (nc), PB_HA03 (nc). PB_HA01 (nc), PB_TP05 (nc), PB_SW10 (nc), PB_SW11 (nc)	Gross pollutants trap (GPT). Adjacent to the drainage line outflow. Within the drainage line outflow.	Soil Impacts from materials contained within the GPT, Fill material comprising building rubble, plastics, metal, glass and asbestos and PCB and DCE and potentially contaminated sediments and waters from within the drainage channel.	Three hand augers locations (due to restricted excavator access). Three test pit locations sampled to assess if subsurface material in the vicinity of the drainage line. Two sediment and two surface water samples were collected, to assess sediment and surface water quality within the drainage line.
4	PB_TP08 (nc), PB_TP09	Former sewage treatment plant (STP).	The former STP footprint for demolition wastes.	Two test pits proposed to investigate asbestos, grit screenings and metals from demolition of the STP.
5	PB_TP10, BHC-1	Southern portion of the bomb disposal training area.	Fill material and UXO and groundwater.	One test pit proposed as no previous assessment undertaken in the south-west corner of Area 5. One existing well sampled.
6	PB_TP11	Dog agility training area.	Potential fill.	One test pit to assess the depth of the fill material in the area.
7	PB_HA11 (nc)	Bunded explosives magazine.	Fill used to create the bund wall.	No previous assessment has been undertaken of the bund wall, therefore one hand auger proposed.
8	MW022, PB_MW07, PB_TP38, PB_TP40, PB_TP15 to PB_TP18	Bridging yard.	Impacts from workshop and yard storage and training activities.	One existing monitoring well sampled and another installed. Five test pits proposed to assess fill conditions in areas not previously investigated.
9	PB_MW16, PB_MW17, PB_TP19 (nc)	Fuel/ oil storage area (within bridging yard).	Operational UST and fuel storage area with bridging yard.	Two groundwater monitoring wells proposed to assess the contamination status of the groundwater in the vicinity of the operational UST. One test pit proposed to visually assess subsurface conditions.

AOPC	Sample ID[1]	Location	Targeting	Rationale
10	PB_MW06, PB_TP39, MW085	Museum storage yard.	Metal impacts in the groundwater.	One existing monitoring well sampled (hydraulically down gradient of Area 4 (former STP), one new well down gradient of USTs in Area 9 UST and one test pit sampled to visually assess subsurface conditions.
11	MW108, PB_TP12 to PB_TP14, PB_TP37, PB_SS10 (12), PB_SS07 (nc), MW106 (nc), MW107 (nc), BHA-1	Bomb demonstration, dust bowl and former fire training areas, water retention dam east of Area 11.	Fire training areas, fill material and potential ASS, water and sediment and potential contaminant impacts from AFFF and TRH in the groundwater	Five test pits in the northern portion as this area has not been investigated previously. Surface water and sediment sample collection to assess quality. Four existing monitoring wells sampled to provide more recent groundwater data.
12	PB_MW09, PB_MW11, PB_MW12, MW103, BHD-4 (nc)	Maintenance workshop and vehicle wash bay (within PRA yard)	USTs and maintenance areas.	Two existing monitoring wells sampled and another three drilled to provide more recent groundwater data.
13	PB_MW10, PB_MW19, PB_MW20, MW086	Plants, roads and air fields yard (PRA) (including diesel UST and bowser).	Two operational USTs and one operational AST.	Three additional groundwater monitoring wells down gradient from the USTs and AST and one existing well sampled to assess potential hydrocarbon impacts in groundwater.
14	PB_TP21 to PB_TP23	Former Chatham Village.	Fill material and minor arsenic impacts in surface soils.	Three test pits located in areas within the former Chatham Village to provide site coverage. No monitoring wells are proposed as investigations in this area are targeted shallow soil impacts (asbestos and metals in fill).
15	MW109 (nc)	No additional locations were proposed in this area as it was considered that adequate coverage of this area was achieved by Earth Tech (2006) investigation. It was not considered that duplication of sampling in this area would add value for site characterisation.		
16	MW009	Former NBC store/bunker/HQ.	Chemical storage areas.	One existing monitoring well sampled to provide more recent groundwater data.
17	None	UXO FVS investigations undertaken due to the potential for UXO/EOW waste to exist in this area. Although there is no evidence to suggest that live munitions or explosives have been used historically, there may be a perceived risk associated with UXO waste. SRS also undertaken to assess the extent of fill/ presence of burials in the subsurface.		
18	None	No additional locations were proposed in this area as it was considered that adequate coverage of this area was achieved by Earth Tech (2006) investigation. It was not considered that duplication of sampling in this area would add value for site characterisation.		

AOPC	Sample ID[1]	Location	Targeting	Rationale
19	PB_HA04 to PB_HA07, PB_HA09, PB_HA10. PB_SW07, PB_SS05. PB_SW09, PB_SS06	Golf course and dam.	Potential fill, water and sediment.	Six hand augers to assess whether fill material is present. Method selected to minimise ground disturbance. Two geophysical transects were undertaken to provide additional lines of evidence in relation to subsurface conditions (fill or burials). Surface water and sediment sampled to assess water quality entering the Moorebank IMT site via the drainage channel and in the down gradient drainage channel.
20	MW2 (nc), MW083, MW1A (nc)	Former fire training area and small arms range.	Firefighting chemicals and metals.	Three existing monitoring wells proposed to be sampled.
21	None	No additional locations were proposed in this area as it was considered that adequate coverage of this area was achieved by Earth Tech (2006) investigation. It was not considered that duplication of sampling in this area would add value for site characterisation.		
22	PB_MW15, MW096 (nc), PB_SS08, PB_ SS09	Combat engineering (CE) store.	Waste oil UST and chemical store.	One additional groundwater monitoring drilled as elevated concentrations of TRH was detected in groundwater (2006). One existing well to be sampled and drainage line sediments down gradient of the CE stores were collected.
23	PB_SB01	Parade ground.	Potential fill.	One soil bore to assess sub surface conditions.
24	None	Military museum.	Intrusive works in and around the military museum were considered disproportionate to the potential risk (low risk) completed in this area.	
25	PB_TP31	Administration and accommodation.	Potential fill.	One test pit completed for site coverage.
26	PB_HA08 (nc), PB_TP20, PB_TP24 to PB_TP26, PB_TP33	Playing fields.	Potential fill.	Five test pits and one hand auger location for site coverage.
27	PB_MW13, PB_MW14, PB_TP32	Non-operational UST.	One UST.	Two groundwater monitoring wells drilled and monitored to assess groundwater quality in the vicinity of the former UST and one test pit to visually assess sub surface conditions.
28	PB_MW01, PB_SS01 (nc), PB_SW08 (nc), PB_TP01 to PB_TP04	Pre-existing buildings in the north-east corner.	Potential for fill associated with former Barracks.	Four test pits completed in order to visually assess potential for fill to be present in the subsurface. One groundwater monitoring well installed adjacent to the northern boundary to assess up gradient/ background conditions. Surface water and sediment collected from the retention dam.

AOPC	Sample ID[1]	Location	Targeting	Rationale
Other areas	PB_MW08, PB_MW21	Eastern fence line (west of DNSDC).	Eastern boundary of the Moorebank IMT site.	Two groundwater monitoring wells installed adjacent to the eastern boundary to assess groundwater quality down gradient of the known USTs present within DNSDC.
	PB_MW02. PB_TP27, PB_TP29	North of Area 3 (Drainage line).	Assessing groundwater quality.	One ground water monitoring well installed for site coverage and two test pits to visually assess sub surface conditions.
	PB_TP28, PB_SS04, PB_SW06	North of Area 6 (Dog training area and former Lake Sisinyak).	Potential fill and potentially impacted water and sediments.	One test pit completed for site coverage. Surface water and sediment sampled to assess water quality in the retention dam
	PB_TP30	South of Area 11.	Potential fill.	One test pit completed for site coverage.
	PB_TP34.	East of Area 20.	Potential fill.	One test pit completed for site coverage.
	PB_TP35	South-western corner.	Potential fill.	One test pit completed for site coverage.
	PB_TP36	South-east of Area 15.	Fill material.	One test pit completed for site coverage.
	BHE – 1, MW084 (nc)	North-east of Area 26.	Groundwater quality on eastern site boundary.	Two existing monitoring well will be re-sampled to provide more recent groundwater data.
	BHK – 3 (nc)	South-east corner of the Moorebank IMT site.	Groundwater quality on eastern site boundary.	One existing monitoring well will be re-sampled to provide more recent groundwater data.
	BHC-2 (nc)	Near Area 10.	Metal impacts in the groundwater.	One existing monitoring well will be re-sampled to provide more recent groundwater data.
	PB_SW01, PB_SW02 (nc), PB_SW03 (nc), PB_SW04, PB_SW05	Georges River.	Closest off site sensitive ecological receptor.	Five surface water samples have been proposed including up gradient and down gradient of the Moorebank IMT site to gather background water quality data for the Georges River.

nc: denotes that the location was not completed; justification is provided in Table 7.5
HA: hand auger
MW: monitoring well
SW: surface water
SS: sediment sample
SB: soil bore
TP: test pit
SRS: seismic refraction survey
FVS: field validation survey

7.2 Sampling rationale for non-intrusive site works

7.2.1 Unexploded ordnance survey

In conjunction with Parsons Brinckerhoff intrusive works, UXO specialist contractor G-Tek were appointed to undertake a study to determine the presence of military derived metallic items including UXO and explosive ordnance waste (EOW) at the Moorebank IMT site. The objectives were to:

- Review existing studies, reports, plans, databases and other relevant information including a review of historic air photographs to determine areas within the Moorebank IMT site that, from historical usage, may present a risk of containing remnant UXO/EOW or munitions of concern (MOC).
- Conduct a field validation survey (FVS) within accessible areas of the Moorebank IMT site to define the likely nature and extent of any remnant UXO or munitions MOC.
- Conduct interviews with personnel (as available) to gather site specific information on the history of ordnance use at the Moorebank IMT site.
- Provide UXO/EOW support to Parsons Brinckerhoff as part of the Phase 2 ESA intrusive works (point clearance at each test pit and drilling location prior to breaking ground to safeguard intrusive investigations).
- Report on the outcomes of the assessment and to provide professional advice relating to the required UXO or MOC remediation and management options and requirements.

The survey consisted of a search of parallel lines of 1 m in width and 20 m apart using Minelab F3 metal detectors. Where a positive result is received by the detector, the ground surface is manually removed using hand tools to identify the source of the detection. All items are logged noting any relevant items of military origin encountered. UXO items are retained as reference material.

The areas selected for FVS were primarily the accessible areas of the Moorebank IMT site which had not been selected for previous UXO related works. Following the air photo review, FVS was extended to include the southern portion of the Moorebank IMT site to determine if the past usage had included EOW. Some areas were excluded from the FVS including areas in close proximity to buildings, accommodation blocks and dog kennels (as not to disturb occupants), areas of dense vegetation where access was restricted and areas where the ground had already been widely disturbed (plant training area ‘dust bowl’ adjacent to the Georges River).

A rationale for each area selected for the UXO survey are summarised in Table 7.2. The areas subject to the UXO FVS survey are presented in section 18 Figures 8a through 8d.

Table 7.2 Rationale for selection of UXO FVS survey areas

AOPC	Description	Rationale
Areas surveyed as part of 2011 investigation		
14	Former Chatham Village	Potential for the area to have been used as a close training area in the past.
26	Playing fields/ovals	Potential for the area to have been used as a close training area in the past.
15	Field engineering store and adjacent area	Potential for the area to have been used as a close training area in the past.
17	Practice minefield and bomb disposal area	Munitions are known to have been used in this area historically.

AOPC	Description	Rationale
18	Former Jacquinot Court area	Area is currently and was historically used as a close training area.
19	Golf course	Track system evident in 1965–1970 aerial photos may be indicative of a 'training village'.
-	South of Area 22	Track system evident in 1965–1970 aerial photos may be indicative of a 'training village'.
Areas surveyed not targeted as part of 2011 investigation		
21	25 m small arms range	UXO survey was undertaken in this area during 2006 investigation. Metallic items of military origin were confirmed.
5	Bomb disposal training area (SW0190)	UXO survey was undertaken in this area during 2006 investigation. Metallic items of military origin were confirmed.
13	Former practice mine field (SW0182)	UXO survey was undertaken in this area during 2006 investigation. Metallic items of military origin were confirmed.

7.2.2 Geophysical surveys

A seismic refraction survey (SRS) was undertaken by geophysical survey specialists Earth Technology Solutions Pty Ltd in selected open areas at Steele and Moorebank Barracks.

The objective of the survey was to provide an indication of potential fill in areas where ground disturbance was not possible due to the sensitive nature of certain areas and current site operations (such as the golf course and playing ovals).

The purpose was to delineate the base of buried fill material over site transect profiles where fill was considered likely to be present based on previous experience of Defence sites. Based on the specialist advice received from Earth Technology Solutions Pty Ltd, SRS was determined to be the most suitable method to determine the base of fill and potential burials.

The seismic refraction method consists of striking a steel plate with a triggered sledge hammer to produce a seismic source. The hammer is connected to a seismograph which, via a network of geophones, measures the seismic velocity of the seismic source as it travels through various materials in the subsurface. The seismograph records the seismic response digitally. The digital information is later used to determine the likely composition and compaction of materials in the sub surface environment.

The minimum size of target or subsurface feature that can be detected with SRS, based on 2 m geophone spacing, is typically 5 to 6 m in length and approximately 5 to 1 m depth therefore is considered sufficient to detect significant pits and trenches of buried waste material that may be present.

The SRS geophysical survey method can be limited in situations where there is little difference density between the fill or buried material and natural soil. If fill is mostly very compacted soil then it may not provide a seismic velocity contrast with the natural ground. In the contact of the Moorebank IMT site, burials are considered more likely to be unconsolidated deposits of buried demolition waste and unspecified military derived wastes therefore this limitation is not considered to be applicable in the context of this investigation.

Seven seismic transects were undertaken as described in Table 7.3. A surface survey of seismic transect line was undertaken by a qualified surveyor. Ground elevations were used to plot cross sections of inferred subsurface materials. The geophysical survey transects are presented in Figures 8a through 8d section 18.

Table 7.3 Rationale for selection of SRS geophysical survey areas

AOPC	Description (Earth Technology Solutions Pty Ltd transect reference)	Rationale
-	Area of open space to the south of Area 1 (transect 5)	Site coverage and to identify any potential disposal pits.
11	Dust bowl (transect 1)	Estimate the extent of fill and to identify any potential disposal pits.
26	Playing fields/ovals (transects 2,3 and 4)	Site coverage – intrusive investigation not approved due to Defence operational activities.
19	Golf course (transects 6a, 6b, 7a and 7b)	Site coverage ground disturbance not approved due to active golf course.

Other geophysical techniques capable of detecting the targets of interest (individual waste burial pits/ trenches, areas of deposited fill containing construction and demolition waste, EOW and/or burned refuse), such as electromagnetic (EM) induction or ground penetrating radar (GPR) may also be appropriate for achieving the objective of the geophysical survey. The suitability of each method is dependent on a number of factors including the size of the areas requiring screening, proximity to buried services and above ground structures, the condition of the existing ground surface and the expected soil/fill property contrast (i.e. electrical resistivity/dielectric permittivity, density, presence of magnetic material). EM can be adversely affected by utility services and structures and surface ferrous wastes with non-ferrous wastes material showing limited electrical resistivity contrast. GPR can also be adversely affected by services and structures and the delineation of fill can be ambiguous.

A sub-surface imaging survey was undertaken during the Earth Tech 2006 Investigation. A combination of geophysical methods was used with variable success. Methods included:

- Geometrics G-858 Duel Sensor Magnetometer – has a high sensitivity at a high sampling rate. This instrument was utilised on site for the detection of buried magnetic objects.
- RAMAC Ground Penetrating Radar – A RAMAC/GPR system was used with the X3M control unit and a range of shielded antennas. The distance down the line was measured using a wheel odometer. The radar system was used in reflection mode with the antenna elements orientated perpendicular to the survey path. Data was recorded onto the Monitor computer for processing and interpretation at the end of the survey.
- The Foerster Ferex 4.032 Analogue Gradiometer Magnetometer capable of detecting 25 lb projectile at 2 m and buried ferrous object to a depth of 6 m. This instrument was used to conduct a search potential UXO risk areas and other ferrous objects, in sites where tree cover or terrain was unsuitable for other geophysical methods.

Table 7.4 provides a brief summary of the previous geophysical investigations undertaken and the outcomes as detailed in the Earth Tech report (2006).

Table 7.4 Previous geophysical investigations (Earth Tech 2006)

Earth Tech area (Parsons Brinckerhoff AOPC)	Target	Results
SW0180 Former Chatham Village (Area 14)	Historical burial sites such as fill pits and demolition spoil associated with the former buildings of Chatham Village.	A number of linear anomalies were identified within the area which was later confirmed to be underground services. No distinct structures resembling trenches containing metallic fill were observed.
SW0189/SW0191 Board of Survey Disposal Pits (Area 6 dog training area/ Area 10, museum storage yard)	Historical burial sites particularly ferrous waste that may be indicative of a disposal pit.	Hand survey undertaken using a Foerster Ferex Magnetometer. A GPS-magnetometer survey of the areas was not possible due to interference from the adjacent fence line.

Earth Tech area (Parsons Brinckerhoff AOPC)	Target	Results
SW0195/SW0198 Waste Disposal Area/Asbestos Waste Disposal Area (Area 11, dust bowl, Area 14, Former Chatham Village)	To determine the extent of fill in historical burial sites define the extent of the fill area.	GPR survey was attempted but underlying road base and highly conductive fill material deemed this method unsuitable in area SW0195. Anomalies detected during the geophysical survey of SW0198 were investigated and found to include buried scrap metal, concrete, bricks and timber.
SW0203 Waste Disposal Area (Area 4 former STP)	Historical burial sites to confirm whether waste disposal or defined burial pits were present.	The geophysics identified a number of anomalies within the area which were recommended for further intrusive investigation.
NWDA Waste Disposal Area (Area 20, former firefighting training area)	Historical burial sites to confirm whether waste disposal or defined burial pits were present.	The magnetometer identified a series of anomalies along the western edge of the survey area, which were attributed to the metallic retaining wall. Similarly anomalies identified toward the eastern edge of the survey area where attributed to the CGI underground bunkers present in the area.

Of the anomalies detected during the Earth Tech 2006 geophysical survey, all were attributed to harmless metal fragments, star pickets and ferrous clays. The majority of the metal anomalies identified were found within 0.3 m of the surface.

GPR was considered for use during the Parsons Brinckerhoff 2011 investigation but based on the time restraints and considering the mixed success of the GPR and EM methods used during the 2006 investigation, SRS was considered to be the most appropriate method based on the specialist advice received from Earth Technology Solutions Pty Ltd. The use of GPR in conjunction with SRS may have been a more effective approach in correlating the data gathered and may have provided more certainty in interpreting the inferred results of the seismic survey. However, for the purposes of this investigation, Parsons Brinckerhoff considers that the data gathered is sufficient at the feasibility assessment stage to detect larger/major areas of buried material.

7.3 Summary of SAQP deviations

The site is currently an active military establishment therefore Parsons Brinckerhoff was required to adhere to all Defence requirements whilst undertaking fieldwork. It was not possible to undertake some of the proposed sampling as per the SAQP due to access limitations and restriction of ground disturbance activities in some areas.

The final sampling locations took into consideration site conditions (such as the presence of underground and aboveground services) and sampling was adapted following discussion with Defence personnel to minimise on-site disruption. Table 7.5 provides a summary and justification for each deviation from the agreed SAQP approach.

Table 7.5 Summary of deviations from the SAQP

AOPC	Location	Alternative	Type	Comment/justification
0	BHK-3	None	Existing well	Outside of IMT site, locked gate (no access)
	BHC-2	None	Existing well	Dry
	PB_SW02	PB_SW01	Surface water	No access due to river terrace (unsafe)
	PB_SW03	PB_SW04	Surface water	No access due to river terrace (unsafe)
1	MWBHB1	MWBHB2	Existing well	Dry. Adjacent well sampled
	MWBHB3	MWBHB4	Existing well	Dry. Adjacent well sampled
	MWBHB7	MWBHB8	Existing well	Dry. Adjacent well sampled
3	PB_HA01	None	Hand Auger	No access due to slope/dense vegetation
	PB_HA02	None	Hand Auger	No access due to slope/dense vegetation
	PB_HA03	None	Hand Auger	No access due to slope/dense vegetation
	PB_SW10	None	Surface water	No access due to slope/dense vegetation
	PB_TP05	None	Test pit	No access due to terrace/dense vegetation
4	PB_TP08	PB_TP09	Test pit	No access due to terrace/dense vegetation
7	PB_HA11	None	Hand Auger	Disturbance of magazine bund not approved
9	PB_TP19	PB_MW06	Test pit	Location same as re-positioned PB_MW06
	PB_MW06	None	PB well	Re-positioned borehole from proposed location
11	MW106	MW108	Existing well	Dry. Adjacent well sampled
	MW107	MW108	Existing well	Dry. Adjacent well sampled
	PB_SS07	None	Sediment	No access due to slope/dense vegetation
12	MWBHD-4	MW103	Existing well	Lost/destroyed. Adjacent well sampled
13	PB_MW20	PB_MW10	PB well	Drilled but not sampled due obstruction
15	MW109	MW009	Existing well	Lost/destroyed. Adjacent well sampled
20	MW2	MW083	Existing well	Dry. Adjacent well sampled
	MW1A	MW083	Existing well	Lost/destroyed. Adjacent well sampled
22	MW096	PB_MW15	Existing well	Lost/destroyed. Adjacent well sampled
23	PB_SB01	Relocated	Soil bore	Repositioned as instructed by site personnel
26	PB_HA08	None	Hand auger	Omitted
28	PB_SS01	None	Sediment	No access due to slope/dense vegetation
	PB_SW08	None	Surface water	No access due to slope/dense vegetation

Three additional locations were added based on site observations (PB_HA12 to PB_HA14). These locations were selected based on site observations, generally from where small stockpile type features were observed.

A summary of all investigation locations sampled during Parsons Brinckerhoff intrusive works compared to the intended scope detailed in the SAQP is presented below in Table 7.6.

Table 7.6 Summary of investigation locations

Location type	Proposed	Completed (sampled)
Existing well	26	19
New well	21	21 (20)
Test pit	40	37
Hand auger	11	10
Sediment	9	7
Surface water	12	8
Soil bore	1	1

Deviations from the SAQP as described above are not considered to have significantly affected the objectives or outcomes of the investigation. In the majority of cases where it was not possible to sample groundwater from existing monitoring wells as proposed, an alternative well in the vicinity was sampled therefore despite the reduction in the number existing of groundwater wells sampled, Parsons Brinkerhoff considers that there is sufficient data to adequately characterise groundwater conditions in these areas.

Final sample locations including survey transect lines are presented in section 18, Figures 8a through 8d.

7.4 Reliance on historical data

For the purposes of this assessment, reliance has been placed on soil, sediment and selected groundwater data presented within the Earth Tech report (2006).

During the 2006 investigations, within the Moorebank IMT site, 239 soil locations, 4 sediment locations and 22 groundwater wells were sampled.

Groundwater data from 2006 has been used for comparison with 2011 results. Groundwater is likely to be more temporally variable due the mobility and volatility of groundwater contaminants. Re-sampling of existing wells was undertaken by Parsons Brinckerhoff in 2011 in order to assess current groundwater conditions beneath the Moorebank IMT site.

Soil results from the Earth Tech report have been incorporated with Parsons Brinckerhoff (2011) data. There is no evidence to suggest that significant changes in operational use of the Moorebank IMT site has occurred since 2006, therefore data is considered to be relevant and valid for assessing the spatial distribution of contaminants in soils.

All Earth Tech raw data files for primary and field duplicate samples were obtained directly from ALS laboratories and incorporated with Parsons Brinckerhoff 2011 data into an environmental data management software program (ESDAT). This process was followed in order to reduce the potential for human error in data transcription.

An assessment of all laboratory data was undertaken to verify the results of the Parsons Brinkerhoff (2011) and Earth Tech (2006) investigations. Matrix spikes, controls samples, surrogate results were assessed against project DQOs and DQIs. A qualitative assessment of the Earth Tech report was also undertaken in order to evaluate the quality of the data in terms of field QA/QC procedures to verify that fieldworks were undertaken using standard industry procedures and methods. The results of this assessment are presented in section 11.

Some data was not used within the current assessment as was spatially outside of the current investigations area, namely all data form Earth Tech Areas SW0178 (sewage disposal and dumping area), SW0210 (explosives confidence range) and MTF (mask testing facility) areas located beyond the southern boundary of the current IMT site.

In addition to the independent verification of Earth Tech data by Parsons Brinckerhoff, it is understood that the Earth Tech report was independently reviewed by NSW accredited Site Auditor Mr Andrew Kohlrusch of GHD (previously of ERM), who was engaged as Technical Advisor (TA) by Defence for the environmental assessment at Steel Barracks, Moorebank. The sampling design, execution and reporting were all subject to TA review.

A copy of the final TA letter/sign off documentation relating to the Earth Tech report (2006) could not be located by Defence or MIC. Auditor comments on the draft report were located and provided to Parsons Brinckerhoff. There were no data non-compliances noted within the auditor comments.

In the absence of a final sign off letter being available to Parsons Brinckerhoff, relating to the Earth Tech data, a meeting was arranged between Parsons Brinckerhoff, MIC, AECOM and Mr Kohlrusch of GHD to discuss adequate reliance in relation to the 2006 data quality and validity. Mr Kohlrusch confirmed that the validity of the data contained within the Earth Tech report had been verified and was considered to be of sufficient quality to fulfil the objectives of the investigation. In the absence of the final TA sign off for the Earth Tech report, a statutory declaration has been provided by Andrew Kohlrusch to this effect. A copy of the statutory declaration is provided as Appendix A15.

8. Fieldwork

Service clearance, UXO clearance, drilling, soil sampling, groundwater monitoring well installation and well development works were undertaken between 25 January and 10 February 2011.

Gauging and sampling of existing groundwater wells was undertaken between 27 January and 2 February 2011. Groundwater monitoring of newly installed wells was undertaken between 16 and 22 February 2011. Surface water samples and sediments were collected between 3 February and 10 February 2011.

The UXO FVS was conducted on 22 and 23 December 2010 and additional areas in the south of the Moorebank IMT site were surveyed on 26 April 2011. The SRS was undertaken on 16 and 18 February 2011.

8.1 Preliminaries

Site access protocols were followed to gain access to the Moorebank IMT site. Security clearance passes were obtained from Defence for all Parsons Brinckerhoff site personnel and subcontractors. All works were undertaken in accordance with the necessary permissions and permits.

A desktop search for underground services using the dial before you dig service was undertaken prior to intrusive investigations. Asset owners with services in the near vicinity of the Moorebank IMT site notified by the service were the Roads and Traffic Authority (RTA, now Roads and Maritime Service), AAPT Powertel NSW, APA Gas, Jemena Gas, Optus, Integral Energy, Sydney Water and Telstra.

Utility plans provided by Defence were also obtained and referenced on site when selecting final locations for intrusive works.

Sampling locations were cleared by a suitably qualified service locator (Locaters) using information/plans provided by the asset owners and Defence and cleared for potential UXO items by specialist contactor G-Tek Pty Ltd. Non-destructive drilling (NDD) techniques (water boring) were employed for all drilling locations to a depth of 1.2 m BGL.

8.2 Soil sampling

Soil sampling was undertaken using a combination of sampling methods. These are presented in Table 8.1. Collected samples were stored on ice in an Esky and transported under chain–of-custody to a NATA accredited laboratory for the proposed analysis.

Soils were logged by an environmental scientist experienced in working on contaminated sites. Any visual signs of contamination (i.e. staining or asbestos) were noted and logged accordingly.

A visual inspection of the ground surface for ACM (such as bonded asbestos of fragments of fibrous cement sheeting) was undertaken in the vicinity of each sample location. Any suspected ACM was sampled for laboratory analysis. All soil samples that were not immediately scheduled for analysis were stored in the laboratory in the event that additional analyses were required.

Boreholes, test pits and hand auger locations were surveyed using a hand held GPS with coordinates recorded to the Universal Transverse Mercator (UTM) projection.

Excess soil was deposited in 205 litre drums and disposed of by a licensed waste contractor to an appropriate disposal facility. Waste disposal documentation is provided in Appendix A16.

8.3 Groundwater sampling

8.3.1 Monitoring well installation

Twenty one boreholes (PB_MW01 through PB_MW21) were drilled to depths between 9 m BGL to 16 m BGL using a track mounted Geoprobe rig and pushtube to from the base of the NDD hole (1.2 m BGL) to approximately 5 m BGL, followed by a truck mounted rig using a solid flight auger to the maximum depth of exploration.

All monitoring wells were installed using threaded Class 18 flush-jointed polyvinyl chloride (PVC) casing and screened with machine-slotted PVC pipe with a minimum outside diameter of 50 mm. The length of the screened section was adjusted specifically for each monitoring well (detailed in environmental bore logs). PVC plugs were used to cap the bottom and top of each well during installation to keep out debris.

A sand pack was installed in the annulus between the bore and the well screen. The sand pack comprised a clean inert granular (well sorted in diameter 1 2 mm in average grain size) silica material to 0.5 m above the slotted section. A 0.5 m bentonite seal was placed above the sand pack. The annulus was then grouted from the bentonite seal to the surface. Monitoring wells were completed by finishing the well flush with the ground surface and installing gatic covers. No organic solvents or glues were used during construction or installation of the monitoring wells.

Following installation, wells were developed to remove fines from the borehole and to promote the flow of groundwater from the surrounding formation into the well for subsequent sampling. Development was undertaken using dedicated disposable high density polyethylene bailers, generally within 24 hours of completion in accordance with the Parsons Brinckerhoff standard practice (based on standard industry practice and the ARMCANZ (2003) Minimum construction requirements for water bores in Australia, 2nd Edition). During development five well volumes were removed from each well where sufficient recharge was present.

Table 8.1 Soil and sediment sampling method summary

Location type	Method	Maximum depth	Sampling from
Test pits	Backhoe (13 tonne)	3.0 m BGL or 0.5 m into natural ground whichever is encountered first	Excavator bucket
Hand auger	Steel hand auger	1.0 m GL or as far is physically practical to a depth not to exceed 3.0 m BGL or until refusal	Base of the auger
Soil bores	Geoprobe with push tube	3.0 m BGL or 0.5 m into natural ground whichever is encountered first. Where waste fill is present boreholes may be advanced beyond 3 m BGL for the purposes of vertical delineation of the fill extent	Push tube casing
Soil bores for conversion to monitoring wells	Geoprobe with push tube to 5 m BGL then Hydropower using solid flight auger	15 m BGL or to approximately 2 m below the seasonal groundwater table or to refusal, whichever is encountered first	Push tube casing (near surface) and directly from the auger (deeper natural material)
Sediments	Steel grab sampler or clean glass jar	Surface	Sediments taken from the base of drainage lines via a grab sampler or by hand

Soil samples were collected from:

- the ground surface (0–150 mm) in unpaved areas or immediately below the paving where hard stand was present
- a depth of 0.3–0.5 m BGL and at a depth of 1.0 m BGL and at 1.0 m intervals thereafter to the total depth of the excavation or soil bore or within natural ground, (whichever comes first)
- where visual observations of potentially asbestos containing materials (ACM) or fragments were made
- where changes in lithology or visual or olfactory evidence of contamination (odours and elevated photo-ionisation detector (PID) readings) were noted.

Dedicated disposable nitrile gloves were worn and sampling equipment was cleaned by washing with a phosphate-free detergent (Decon 90) and tap water followed by a final distilled water rinse. Equipment was cleaned before the collection of each soil sample. To verify decontamination procedures were effective a rinsate sample was taken by rinsing the hand auger head with distilled water and decanting the run-off into laboratory-supplied containers.

Soil samples were placed in 250 ml glass jars with Teflon lined caps leaving minimal headspace. A duplicate soil sample was screened with a Minirae 2000 PID to assess whether volatile organic compounds (VOCs) were present. The PID was calibrated at the beginning of each day of fieldworks prior to use using fresh air and 100 ppm isobutylene calibration standard. PID readings were used to aid in selecting soil samples for laboratory analysis.

If a monitoring well became dry before five well volumes had been removed, the well was considered to be adequately developed.

Groundwater monitoring wells were accurately surveyed by a licensed surveyor for both location (latitude and longitude) and height (m AHD). Coordinates were recorded to the UTM projection. GPS coordinates are detailed in the environmental logs.

The monitoring wells were not registered with NOW as this is not a requirement for Commonwealth land.

Environmental logs with details of well installations are provided in Appendix A3. Construction logs for all existing wells sampled as part of this Phase 2 ESA are also included within Appendix A3 for reference.

8.3.2 Groundwater gauging and sampling

After development, monitoring wells were left for a minimum of seven days for the formation to equilibrate. Newly drilled monitoring wells were gauged and sampled in accordance with standard industry practice and the Parsons Brinckerhoff documented standard field procedures (detailed within the SAQP).

Groundwater monitoring wells were gauged prior to sampling with an interface probe to detect possible light non-aqueous phase liquids (LNAPLs) and dense non-aqueous phase liquids (DNAPLs) such as petroleum hydrocarbons.

The wells were then purged by removing a minimum of three well volumes of water from each well using a bailer. Purging was undertaken to ensure that a sample representative of in situ groundwater conditions was obtained.

Monitoring of field parameters was undertaken during purging and parameters were systematically recorded, including pH, reduction/oxidation potential (redox) electrical conductivity (EC), dissolved oxygen (DO), temperature and a visual assessment of turbidity. Sampling commenced when field parameters of the purged water had stabilised as follows:

- +/- 10% temperature
- +/- 10% DO
- +/- 10% redox potential
- +/- 3% EC
- +/- 0.5 pH.

Groundwater samples were obtained using dedicated disposable weighted polyethylene bailers. Nitrile gloves were changed between each sampling episode to minimise the potential for cross contamination. Samples were decanted into new laboratory-supplied containers with Teflon coated lids and labelled with a water proof pen. Samples were sent (on ice) to the selected National Association of Testing Authorities (NATA) accredited laboratories via a courier under appropriate ‘chain of custody’ documentation.

All purged water (including water generated during well development) was deposited into 205 L drums which were later removed by a licensed waste contractor for off-site disposal to a licensed waste facility. Waste disposal documentation is provided in Appendix A16.

8.4 Surface water sampling

Surface water samples were obtained using a stainless steel bucket to collect a 5 to 10 L volume of water. Water was decanted into laboratory supplied containers. The bucket was decontaminated with Decon 90 and nitrile gloves were changed between each sampling episode to minimise the potential for cross contamination. Field parameters were recorded as for groundwater. The coordinates of each sample location were recorded using a hand held GPS unit.

8.5 Sediment sampling

Sediment samples were collected using a stainless steel trowel to deposit sediment into laboratory supplied containers. The trowel was washed with Decon 90 and rinsed with clean water between each sampling episode to minimise the potential for cross contamination. The coordinates of each sample location were recorded using a hand held GPS unit.

8.6 Laboratory analysis

Primary samples and intra-laboratory duplicate samples were dispatched to ALS Laboratories (ALS) in Smithfield NSW. Inter-laboratory duplicate samples were dispatched to Envirolab in Chatswood, NSW. Laboratories used were NATA accredited.

A summary of each analytical method, with the method detection limits, holding times and laboratory accreditation status is presented in Table 8.2 (waters) and Table 8.3 (soils).

Table 8.2 Laboratory methods summary – waters

Parameter	Reference/technique	Limit of reporting (mg/L)	Maximum holding time (days)	NATA accreditation
TRH (C_6-C_{36})/BTEX	P&T-GC/MS - GC/FID	TRH 20–100 µg/L BTEX 1–2 µg/L	7	Yes
PAHs (Ultra-trace)	USEPA 3640/8270 - GC/MS-SIM	0.05–0.1 µg/L	7	Yes
Metals (As, Cd, Cr, Cu, Ni, Pb, Zn)	ICP/MS	0.0001–0.01 µg/L	28	Yes
Mercury	CV/FIMS	0.0001 µg/L	28	Yes
VOCs	USEPA 5030/8260 P&T-GC/MS	1–50 µg/L	14	Yes
SVOCs	USEPA 3510/8270 GC/MS	2–20 µg/L	7	Yes
PCBs	USEPA 3510/8270 GC/ECD/ ECD/MS	1 µg/L	7	Yes
PFOS/PFOA and 6:2 FTS	LC/MS-MS	0.02–0.1 µg/L	365	Yes
VHCs	USEPA 5030/8260 P&T-GC/MS	5–50 µg/L	14	Yes
Anionic Surfactants (MBAS)	APHA 5540 B&C	0.1 µg/L	4	Yes
Formaldehyde	In-house	0.1 µg/L	2	Yes
pH – Water	APHA 4500-H+ B	0.01 pH units	0.25	Yes
Salinity	2510 B/Calculation	**1 µg/L**	28	Yes

Table 8.3 Laboratory methods summary – soils

Parameter	Reference/technique	Limit of reporting (mg/kg)	Maximum holding time (days)	NATA accreditation
Moisture	EA055 - In-house	1%	14	Yes
TRH(C_6-C_{36})/BTEX	S-4 -GC/FID, P&T-GC/MS	TRH: 10-100 BTEX: 0.2-0.5	TRH 14 (extract) 40 (analyse) BTEX 14	Yes
PAHs	EP075B (SIM) - GC/MS - SIM	0.5	14 (extract) 40 (analyse)	Yes
Eight metals (As, Cd, Cr, Cu, Ni, Pb, Hg, Zn)	S-2 -USEPA 200.2 (mod)/ ICP/AES	1-5	182	Yes
Hg	USEPA 200.2 (mod)/ CV/FIMS	0.1		
VOC	EP074A-G - USEPA 5030/8260 P&T-GC/MS	0.2 – 5	14	Yes
SVOC	EP075A-J USEPA 3510/8270 GC/MS	0.5-5	14 (extract) 40 (analyse)	Yes

Parameter	Reference/technique	Limit of reporting (mg/kg)	Maximum holding time (days)	NATA accreditation
PCB	EP066 - USEPA 3510/8270 GC/ECD /ECD/ MS	0.1	14 (extract) 40 (analyse)	Yes
Asbestos	EA200 AS 4964-2004	Absence/Presence	Indefinite	Yes
OC/OP Pesticides	S-12 GC/ECD/FPD-MS	0.05–0.2	14 (extract) 40 (analyse)	Yes
Explosives	EP203 - USEPA 8330 LC/MS	0.1–1	7 (extract) 40 (analyse)	Yes
PFOS/PFOA and 6:2 FTS	EP231 - LC/MS-MS	0.0005–0.005	14	Yes
VHC	EP074D-G - USEPA 5030/8260 P&T-GC/MS	0.5–5	14	Yes
Anionic Surfactants (MBAS)	EP050 - APHA 5540 B&C	1	180 (extract) 2 (analyse)	Yes
Formaldehyde	EP010 - In-house	2	180	Yes
SPOCAS	EA-029 - AS4969	Various	365 (extract) 90 (analyse)	Yes

8.6.1 Soil

A minimum of one soil sample from each investigation location was selected for laboratory analysis based field observations and headspace screening results using a PID.

Selected representative soil samples were analysed for a range of contaminants of potential concern (COPCs) including TRH, BTEX compounds, PAHs, heavy metals, PCBs, VOCs, SVOCs, asbestos, AFFF (PFOA and PFOS), OPPs, OCPs and compounds associated with explosives. Tests were also carried out on selected soils for particle size distribution (PSD) and to determine the potential presence of ASS (SPOCAS).

Once all soil analytical data had been received, an initial screening of results was undertaken to identify sample concentrations exceeding the NSW DECCW Waste Classification Guidelines Part 1: Classifying Waste (2009), in particular the Specific Contaminant Concentrations (SCC) values for general solid waste. Samples exceeding these criteria were rescheduled for Toxicity Characteristics Leaching Potential (TCLP) analysis.

8.6.2 Groundwater

A total of 39 groundwater samples were analysed for a range of potential contaminants of concern including TRH, BTEX compounds, PAHs (ultra-trace), dissolved heavy metals, PCBs, VOCs, SVOCs, anionic surfactants, AFFF (PFOA and PFOS), pH and salinity.

8.6.3 Sediment

A total of seven sediment samples were analysed for a range of potential contaminants of concern including TRH, BTEX compounds, PAHs, heavy metals, PCBs, VOCs and SVOCs.

8.6.4 Surface water

A total of eight surface water samples were analysed for a range of potential contaminants of concern including TRH, BTEX compounds, PAHs, dissolved heavy metals, PCBs, VOCs and SVOCs.

8.6.5 Preparation of duplicate samples

Duplicate samples were collected during fieldworks using the same sample collection, storage and transportation procedure as for primary samples.

For soils, duplicate samples were collected from the same strata as primary samples, from as close to the primary sample as practical and using the same sample collection procedure. Duplicate and replicate samples were not collected from a mixed soil sample to avoid loss of volatiles.

For groundwater, blind and split samples were collected using the bailer. Water from each bailer fill was evenly distributed between collection bottles and repeated until the bottles were filled.

QA samples were submitted for the same analytes as the primary sample.

8.6.6 Quality assurance and quality control

Laboratories used met in-house compliances under the respective ISO 9001 quality assurance programs are NATA registered for all analysis undertaken and performed their own internal QA/QC programs.

Soil and groundwater field and laboratory QA/QC samples were analysed as follows:

- intra-laboratory duplicate samples at a rate of 1 in 10 primary samples;
- inter-laboratory duplicate samples at a rate of 1 in 20 primary samples;
- trip blanks at a rate of 1 per site per day of fieldworks; and
- equipment rinsate blanks at a minimum rate of 1 per day of fieldworks.

9. Investigation results

9.1 Subsurface conditions

A summary of the general subsurface profile encountered on-site during 2011 intrusive works is presented in Table 9.1.

Table 9.1 General stratigraphical log

Depth (m BGL)	General soil description
0.0–3.2	FILL: Generally brown, black and grey clay, sand and with road base, crushed sandstone and concrete gravels and brick fragments.
3.0–7.5	ALLUVIUM: Sand and sandy clay, silty clay and clayey sand.
1.0–7.5	ALLUVIUM: Clay inter-bedded with sandy clay, gravelly clay and clayey sand lenses.
3.5–16.0	ALLUVIUM: Sand, sandy clay, clayey sand and silty sand and silty clay.

Natural material (alluvium) was encountered in all locations. Groundwater was not encountered in test pits or hand auger locations, but was encountered during drilling works. Detailed logs are presented in Appendix A3.

9.1.1 Volatile organic compound screening

Head space analysis of volatile compounds was undertaken on all soil samples collected using a calibrated PID. The majority of samples returned a PID reading of 0.0–1.0 parts per million (ppm).

Elevated PID readings (above 20 ppm) are presented in Table 9.2.

Table 9.2 Volatile organic compound screening summary

Location	Depth (m BGL)	PID reading (ppm)
PB_MW02	0.2	29
PB_MW04	0.5	24
PB_MW05	0.3	506
PB_MW05	0.5	227
PB_MW05	1.8	75
PB_MW07	0.3	22
PB_MW09	0.5	25
PB_MW09	8.0	560[1]
PB_MW16	0.3	23
PB_MW17	0.3	22
PB_MW17	0.5	49
PB_MW18	0.2	29
PB_MW18	0.5	21

Location	Depth (m BGL)	PID reading (ppm)
PB_MW19	0.5	32
PB_TP40	0.5	43

1 Analytical results for this sample showed concentrations of TRH and BTEX below the LOR. The PID was calibrated on 1 February 2011. The field log did not note any visual or olfactory evidence of contamination and PID results from both 7 m and 9 m were 0.0 ppm. This result is therefore considered as anomalous, possibly due to transcription error in the field.

9.1.2 Visual indications of contamination and odour

Surface soils and subsurface materials encountered were generally observed to be free from aesthetic degradation. Vegetation covering the Moorebank IMT site appeared to be in good condition with no obvious visual evidence of plant stress.

With the exception of hydrocarbon odours noted during the drilling of well PB_MW05 (Area 2), no notable odours were encountered during excavation works.

9.2 Fill

9.2.1 Composition of fill

The majority of fill encountered across the Moorebank IMT site appeared to comprise reworked natural material with the exception of some discreet areas of buried demolition/anthropogenic fill materials including asbestos. A summary of the type, composition and location of these fill materials encountered across the Moorebank IMT site is presented in Table 9.3.

Table 9.3 Summary of anthropogenic fill composition

Monitoring zone	Inferred fill type	Location	Description of matrix	Fill depth (m BGL)	Description
Area 0, North of Area 3	Demolition waste	PB_TP29	Sand	1.0	Asbestos cement sheeting fragments, tree branches and concrete gravels
Area 4, Former STP	Demolition waste	PB_TP09	Sandy Clay	0.3	Clayey sand loamy, dark brown, organic rich, contains some bricks and concrete gravel fragments
	Demolition waste	SW0183 TP007	Clayey Sand	0.5	Concrete, ceramic pipe, copper pipe and electrical cable
	Asbestos sheeting	SW0203 TP060	Sand	0.4	Ceramic/clay pipe shards, rusted metal, abundant asbestos sheeting and fragments
	Asbestos sheeting	SW0203 TP061	Sand	0.2	Abundant asbestos sheeting found at 0.1 m
	Anthropogenic fill	SW0203 TP063	Sandy Clay	0.3	Rootlets at top 0.2 m. Reinforced concrete, rusted metal, ceramic tiles and glass
	Anthropogenic fill/ Asbestos sheeting	SW0203 TP064	Sand	0.3	Asbestos sheeting, rootlets at surface, some glass and concrete
	Anthropogenic fill/ Asbestos sheeting	SW0203 TP065	Clayey Sand	2.1	Scrap metal, asbestos, glass, golf balls
	Anthropogenic fill/ Asbestos sheeting	SW0203 TP071	Clayey Sand	0.7	Steel piping remnants at 0.2 m. Tyres, bricks, asbestos pieces throughout
	Demolition waste	SW0183 TP010	Sandy Clay	0.5	Metal pipe, asbestos pipe at 0.3 m. Pipes heading in an NE direction towards STP. 3010A is typical soil sample. 3010B is material around asbestos and metal pipe
Area 6, Dog Training area and Former Lake Sisinyak	Demolition waste	SW0188 TP014	Silty Sand	3.0	Reinforced concrete blocks, bricks and large boulders
	Buried waste	SW0190 TP083	Clayey Sand	1.2	Metal drum, star pickets and reinforced concrete at ~1.2 m
Area 8, Bridging yard	Buried waste	SW0204 TP030	Clayey Sand	2.5	Wire, plastic, rubber, pipe, old tyres and concrete
	Demolition waste	SW0204 TP036	Gravelly Sand	2.0	Some timber pieces noted, brick and concrete fragments and metal
	Demolition waste	SW0204 TP038	Gravelly Sand	2.6	Concrete and glass fragments throughout. Pieces of timber and reinforced concrete at 0.5 m
	Surface waste	SW0204 TP045	Clayey Sand	0.5	Black shiny grit on surface (likely to be associated with grit blasting operations)

Monitoring zone	Inferred fill type	Location	Description of matrix	Fill depth (m BGL)	Description
Area 10, Museum storage yard	Demolition waste	SW0191 TP001	Clayey Sand	1.2	Concrete, wire pieces, metal posts and timber
	Buried waste	SW0191 TP030	Sandy Clay	0.5	Very heterogeneous layer. Ashy-charcoal present
	Demolition waste	SW0191 TP047	Clayey Sand	2.0	Brick, concrete and scrap metal, large piece of concrete at 2.0 m
Area 11_Dust bowl	Demolition waste	SW0195 MW108	Sand	1.4	Road base/blue metal gravel, concrete, bitumen and timber
	Demolition waste	SW0195 TP041	Gravelly Clayey Sand	1.5	Timber planks, concrete cobbles and gravels
	Buried waste	SW0195 TP043	Gravelly Clayey Sand	1.5	Concrete cobbles and 12 gauge spent shotgun shells within fill
	Demolition waste	SW0195 TP044	Gravelly Sand	1.4	Concrete gravels and cobbles, metal star pickets, rootlets, brick fragments and wire throughout
	Demolition waste	SW0195 TP045	Gravelly Clayey Sand	1.0	Angular concrete cobbles and boulders, rounded cobbles, plastic, timber, abundant metal wire and cable waste at 1.0 m
	Demolition waste	SW0195 TP046	Clayey Sand	0.6	Road base gravels, sheets of rusted metal, timber planks, concrete blocks, bricks and plastic
	Demolition waste	SW0195 TP047	Gravelly Clayey Sand	1.2	Metal wire, concrete, timber and bricks
	Demolition waste	SW0195 TP048	Gravelly Sand	1.2	Pipe, ceramic tiles and bricks, concrete tiles and boulders at 0.4 m
	Demolition waste	SW0195 TP049	Clayey Gravelly Sand	1.2	Concrete blocks, timber, metal pieces, copper piping throughout
	Demolition waste	SW0195 TP050	Sandy Gravel	0.5	Timber and concrete
	Buried waste	SW0195 TP067	Clayey Sand	1.7	Gravels, glass, wood metal and concrete throughout. At ~ 1.0 m, some timber pieces, metal, bricks. Slight hydrocarbon odour at 1.7 m, tar-like substance noted combined with timber mulch
	Buried waste	SW0195 TP068	Sandy Clay	1.7	Grass on surface. Concrete boulders and cobbles, timber, scrap metal, tree roots and metal tyre rim observed within strata
	Demolition waste	SW0195 TP069	Clayey Sand	1.8	Sandstone gravels and cobbles throughout. At 0.5 m: piece of asbestos pipe. Sample 2069B is an asbestos sample. Timber pieces, chip board Large piece of concrete 1 x 0.5 m, scrap metal, bricks, timber, large tree branches and plastic

Monitoring zone	Inferred fill type	Location	Description of matrix	Fill depth (m BGL)	Description
	Demolition waste	SW0195 TP070	Clayey Sand	1.5	Electrical cable, concrete and asphalt at 0.5 m .Large pieces of concrete at northern end of test pit. Boulders and electrical conduit
	Demolition waste	SW0195 TP071	Clayey Gravelly Sand	1.8	Concrete blocks and reinforced concrete bricks, cobbles and boulders throughout large piece of concrete at 0.5 m
	Demolition waste	PB_TP12	Clayey Sand	3.0	Cobbles of concrete, small gravel-sized brick and gravel as fragments of chalk
	Demolition waste	PB_TP13	Clayey Sand	1.0	Concrete brick with some crushed rock up to 25 mm diameter
	Demolition waste	PB_TP14	Clayey Sand	3.2	Gravels of chalk and occasional cobbles of concrete
Area 13_PRA Yard	Anthropogenic fill	SW0207 SB084	Clayey Sand	1.6	Concrete pieces throughout. Possible sewage backfill
Area 14_Former Chatham Village	Demolition waste	SW0180 TP075	Clayey Sand	0.9	Metal pipe and concrete

9.2.2 Extent of fill

During the 2011 ESA, fill material was encountered in 30 of the 68 sampling locations to a maximum depth of 3.2 m BGL. Fill generally consisted of brown, black and grey clay and sand with road base material, crushed sandstone, concrete gravels and brick fragments. Similar fill materials were encountered during the 2006 investigation.

Table 9.4 provides a summary of the extent of fill encountered at the Moorebank IMT site based on 2006 and 2011 data.

Table 9.4 Summary of fill presence

	2006		2011		All data	
Total soil investigation locations (available logs)	239		68		307	
Fill	174	(73%)	31	(46%)	205	(67%)

The vertical extent of fill varied spatially across the Moorebank IMT site. Deeper areas of fill were generally found to be present within the 'dust bowl' (Area 11). This is expected considering the use of this area as a heavy plant and earthmoving training area, where soil is continuously reworked during training exercises.

Table 9.5 summarises the proportions of fill depths that were recorded based on the 205 exploratory locations where fill was encountered, from both 2006 and 2011 ESAs.

Table 9.5 Summary of fill depths

Depth of fill encountered	No. of locations	Percentage of fill location
Over 3 m depth (to a maximum of 3.2)	12	6%
2.1–3.0 m depth	14	7%
1.1–2.0 m depth	42	20%
0.5–1.0 m depth	55	27%
<0.5 m depth	82	40%

Based on the evidence gathered to date, it is considered that across the majority of the Moorebank IMT site surficial fill is generally limited to less than 1.0 m depth. The lateral distribution of fill encountered during 2006 and 2011 works is presented in Figure 14, section 18.

9.2.3 Estimation of fill volumes on-site

Potential fill across the Moorebank IMT site has been broadly estimated in Table 9.6, based on the likely lateral and vertical extents derived from existing available field logging data.

Calculation estimates have been based on an approximated total site area of 1,931,000 m^2 minus the densely vegetated portions of the Moorebank IMT site which are proposed to be retained as part of the current preferred design. This equates to approximately 637,230 m^2. The theoretical estimate is that of the total site area of 933,570 m^2 has the potential for fill to be present in the sub surface environment. Based on 2006 and 2011 ESAs, fill was encountered in 67% of intrusive investigation locations on-site, therefore, it has been assumed that, for the purposes of the calculation estimate, that fill is not likely to be present across 33% of the total site area.

The maximum extent of fill encountered during both site investigations was 3.2 m BGL therefore for the purpose of the calculation, this number has been used as the maximum depth, although it is possible that deeper areas of fill may be present in localised areas that have not been assessed or identified.

Fill volumes have been calculated for arbitrary fill depths to estimate the likely fill volume if 100% of the Moorebank IMT site area were to contain 100% fill to the full extent of the arbitrary depth. The volume has then been adjusted based on the percentage of locations where this fill depth was actually encountered during intrusive works.

Table 9.6 Estimation of fill volumes

Lateral extent of fill			
Vertical extent of fill (m BGL)	**Fill volume if 100% of the site area was to have fill to this depth (m^3)**	**Actual cover of fill this depth based on 2006/2011 intrusive investigation results (%)**	**Likely fill of this depth across the site (m^3)**
3.2	2,987,424	6	179,245
2.9	2,707,353	7	189,515
1.9	1,773,783	20	354,757
0.9	840,213	27	226,858
0.4	373,428	39	145,637
Total potential volume of fill across whole site (m^3)			**1,096,011**

Although 1,096,011 m^3 has been estimated as the potential total approximate fill volume existing on-site based on the broad assumptions laid out above, it must also be considered that only limited, isolated significant impacts have been identified in soils (generally limited to near surface soils) and that fill composition in many areas consisted of reworked natural materials. Based on this, it is considered that much of the fill material present would be suitable for reuse on-site (if deemed to be geotechnically suitable for founding purposes and subject to appropriate asbestos management during the construction phase).

In addition, the Moorebank IMT site is generally flat in most areas so cut and fill activities that may be required to facilitate the development design level is likely to be limited to localised areas of the Moorebank IMT site with steep topography. It is therefore anticipated that if this volume of fill were to exist in the subsurface, the majority of this material would not require excavation to facilitate the redevelopment of the Moorebank IMT site and could remain in situ, subject to adequate capping or containment.

The calculated potential fill figure is considered to be a conservative ‘worst case’ value. The volumes of waste material likely to be generated will require refinement once the detailed development design has been completed.

9.3 Seismic refraction testing

Seismic refraction testing was completed by Earth Technology Solutions Pty Ltd. The objective of this was to provide an indication of likely fill in the sub-surface at a number of transects across the Moorebank IMT site. Seven seismic lines were completed on 16 and 18 February 2011.

Areas 3 (drainage line outflow), 6 (Former Lake Sisinyak), 8 (Bridging Yard) and 10 (Museum Yard) were not included in the SRS (or UXO) investigations. Access to Area 3 was generally restricted by steep topography and dense vegetation making surveying difficult. Test pits were completed in accessible areas in order to provide information of the likely subsurface conditions. Areas 8 and 10 contained an abundance of ferrous material including military artefacts and large metal structures. The presence of such items limited the

effectiveness of the geophysical survey techniques used. Access to Area 6 was also limited by dog training activities and defence access restrictions to this area.

Four layers of differing seismic velocities were interpreted ranging from 320 m/s to 3,900 m/s consistent with a range of material from fill and topsoil to very high strength rock. A general interpretation is presented in the Table 9.7.

Table 9.7 Summary of sub surface seismic velocity ranges

Seismic layer	Velocity range (m/s)	Interpretative comments (based on velocities and extrapolation with test pit logs)
1	320–580	Seismic velocities consistent with fill and topsoil
2	550–1,300	Seismic velocities consistent with alluvium
3	1,000–2,200	Seismic velocities consistent with alluvium (hard) and extremely weathered sedimentary rock (very low to low strength)
4	2,200–3,900	Seismic velocities consistent with slightly weathered fresh rock (medium to very hard strength)

Based on a correlation with the subsurface materials encountered within test pits and hand auger locations adjacent to the seismic cross sections, seismic layers and interpreted velocities were used to provide an indication of likely material type. A summary of this interpretation is presented in the Table 9.8.

Table 9.8 Summary of sub surface seismic transects

Seismic line	Surface layer thickness range (m)	Refractive index (m/s)	Interpretative comments (based on velocities and extrapolation with test pit logs)
1	5 to 9	350–560	FILL: Clayey Sand (TP12 and TP14)
2	0.5 to 3.0	350–560	TOPSOIL: Sandy Clay and Clayey Sand (TP24, TP25 and TP26)
3	0.5 to 2.5	340–550	TOPSOIL: Sandy Clay (TP20)
4	0.5 to 2.0	320–480	TOPSOIL: Sand (TP10)
5	0.0 to 1.5	340–460	TOPSOIL: Clayey Sand (TP27)
6 (A & B)	0.5 to 2.5	330–580	ALLUVIUM: Sand (HA07 and HA10)
7 (A & B)	1.0 to 2.5	330–560	TOPSOIL/ALLUVIUM: Sand (HA05 and HA06)

The range of seismic velocities obtained for fill and topsoil at the Moorebank IMT site was not unique and therefore it was difficult to delineate the extent of fill at the Moorebank IMT site compared to potential fill materials based on seismic velocities alone.

Depending on the composition and compaction of subsurface materials, buried fill pits can be identified by an increase in depth and decrease in seismic velocity of the surface layer due to voids and lack of compaction. During the seismic survey there were no regions of increased depth and anomalously low seismic velocity identified within the selected profiles suggesting the absence of burial pits in these areas.

Transect locations are shown in Figures 8a through 8d section 18. The full report and information on the seismic refraction method is provided in Appendix A13.

9.4 Explosive ordnance assessment

An explosive ordnance (EO) survey was completed by G-Tek. The objective of this was to define the likely nature and extent of any remnant UXO/EO at the Moorebank IMT site, to provide support to Parsons Brinckerhoff intrusive investigations. The extent of the survey was designed to enable G-Tek to gather sufficient information in order to provide specialist advice on the likely remediation requirements in respect of UXO/EO.

Areas selected for survey were based on a review of aerial photographs to search for visual indications or evidence of active and inactive/historical training areas. Areas of potential concern with regards to UXO were identified as the explosive ordnance disposal area, dog training area, practice mine detection area, demolitions training area and open areas such as the sports ground/ ovals and golf course where munitions training may have been conducted historically.

The FVS was conducted within open areas of Steele Barracks. Approximately 30 linear km of searching was conducted using a five person team. Each team member searched parallel lanes nominally 1 m wide and 20 m apart. Each team member was equipped with the Minelab F3 metal detector which emits an aural cue (i.e. a sound of varying pitch and intensity depending on the size of the item) in the presence of metal to depths of 450 mm below the surface.

Each cue was intrusively investigated using hand tools until the metallic source was identified. Identified ordnance related items were removed and retained by G-Tek. Scrap metal materials were generally left in situ. The line of search was continuously recorded by the team leader with using a GPS device.

A summary of the findings is provided below:

- Based on a review of the Defence National UXO database the Moorebank IMT site is not in an area with potential risk of UXO.
- Based on a review of historic aerial photos a number of potential munitions training areas were identified that were considered likely to have been used historically to train engineers, such as arms ranges and close training areas.
- Finds during the FVS included over 400 blank and empty fired cartridge cases, blank joining links,1 inch signal cartridge bases and smoke grenade fly off levers and a number of small arms ammunition (SAA) projectiles. Cartridge cases and blank SAA identified included .22 inch, .223 inch .303 inch, 7.62 mm and 5.56 mm, indicating that training within the Moorebank IMT site had been conducted since WWII to the present.
- A component from a 36M grenade was identified which indicates a grenade or grenade fuse may have been utilised within the Moorebank IMT site, potentially prior to occupation by SME.

The G-Tek report concluded that:

- Other than propellant/primers in unfired/misfired SAA blank cartridge cases, the Moorebank IMT site does not have a potential to contain remnant UXO or EO containing high explosive or other energetic material.
- The open areas of the Moorebank IMT site contain explosive ordnance waste (EOW), particularly blank ammunition as a result of close training activities over a long period of time.
- Heavily vegetated areas have a higher potential for remnant EOW from close training activities than the open areas assessed during FVS as training in vegetated areas is common but clean-up of spent EOW is more difficult.
- Despite the identification of a grenade component during the Moorebank IMT site survey, based on a review of historical documents and aerial photographs, there is no evidence to suggest the existence or likely location of a formal grenade range.

Spatial representation of EO finds is presented in Figure 15 section 18. A copy of the EO report is provided in Appendix A12.

9.5 Groundwater conditions

A total of 39 wells were monitored during 2011 fieldwork. It was proposed that 40 wells would be monitored however it was not possible to sample PB_MW20 due to an obstruction in the well at approximately 4 m BGL which prevented the bailer from reaching groundwater and obtaining a sample. Attempts were made to purge and sample groundwater at this location (using dedicated Waterra tubing with a foot valve attachment) but this alternative method was also unsuccessful and a sufficient volume of water could not be obtained for sampling. The groundwater conditions encountered at the Moorebank IMT site are summarised in Table 9.9.

Table 9.9 Summary of groundwater conditions

Depth to groundwater	Standing water levels ranged between 5.19 and 12.41 m BGL (between 1.68 and 9.11 m AHD). PB_MW20 and MW108 gauging data has been excluded as obstructions were present which prevented accurate gauging of groundwater.
LNAPL	LNAPL was not identified in any of the wells gauged. During purging there was not any evidence (such as odours, sheens or oily globules) of LNAPL observed.
Groundwater occurrence	Based on the results of this investigation groundwater was encountered within the silty clay and sandy clay, silty sand and sand.
Groundwater flow direction	Groundwater beneath the Moorebank IMT site is inferred to flow generally west towards the Georges River.
Hydraulic conductivity	Based on literature values hydraulic conductivity ranges from 9 x 10-7 to 1 x 10-10 m/s (Domenico & Schwartz 1990).
Hydraulic gradient	Based on gauging undertaken in 2011 the hydraulic gradient is estimated to be between 0.0004 to 0.007.
Effective porosity	Based on literature values, the effective porosity ranges between 25% (sand) to 61% (silt or clay).
Calculated groundwater velocity	The groundwater velocity for the Moorebank IMT site was calculated to be between 2×10^{-7} and 0.008 metres per year.
Groundwater quality	▪ Electrical conductivity for wells ranged from 83.6 to 7,920 µs/cm indicating fresh to brackish conditions. ▪ Redox ranged from between -51 and 312 mV indicating slightly reducing conditions. ▪ pH ranged between 3.45 to 6.12 indicating groundwater beneath the Moorebank IMT site is slightly to moderately acidic. ▪ Temperature ranged from 14.7 to 23.2^{o}C. ▪ Dissolved oxygen ranged between 1.32 to 5.13 ppm indicating that groundwater is moderately to well oxygenated. ▪ Turbidity was variable across the Moorebank IMT site from low to high based on visual assessment. Total dissolved solids were calculated to be between 41.8 and 4,752 mg/L indicating that the groundwater quality beneath the Moorebank IMT site ranges from potable to stock water.
Site groundwater variability	Previous groundwater gauging was undertaken by ET in 2006. When compared to 2011 gauging data, groundwater standing water levels have risen by an average of 0.5 m across the Moorebank IMT site since 2006.

Groundwater gauging tables are presented in Appendix A6. Groundwater elevations gauged in 2011 and inferred groundwater contours are presented in Figures 9a and 9b section 18.

9.6 Surface water field conditions

Field parameters were collected at each surface water sampling location using a water quality meter. A summary of the results is presented below.

- pH ranged between 6.47 to 9.37 indicating neutral to alkaline conditions;
- electrical conductivity ranged from 65.4 to 528 µs/cm indicating fresh water;
- temperature ranged from 20.3 to 30.4^{o}C; and
- dissolved oxygen ranged between 4.02 to 8.44 ppm (excluding the result for PB_SW05 which is considered to be anomalous as maximum saturation dissolved oxygen concentration is exceeded) indicating that surface waters are well oxygenated.

10. Analytical results

As the overall rationale of the this Phase 2 ESA was to augment the existing data pertaining to the contamination status of the site, the analytical results for the Earth Tech investigation (2006) and the Parsons Brinckerhoff investigation (2011) have been considered in this section to provide a more comprehensive dataset for discussion and evaluation.

10.1 Soil samples

The number of soil sample locations undertaken and samples analysed in AOPC are summarised in Table 10.1.

Table 10.1 Summary of soil locations and samples

AOPC	2011 locations	2011 sample count	2006 locations	2006 sample count	Total locations	Total samples	Natural samples	Fill samples analysed
0	12	28	7	9	19	37	25	12
2	4	11	15	20	19	31	19	12
3	2	4	0	0	2	4	3	1
4	1	2	24	33	25	35	19	16
5	1	1	12	12	13	13	3	10
7	1	3	6	8	7	11	4	7
8	7	11	22	38	29	49	23	26
9	2	5	0	0	2	5	3	2
10	2	4	14	23	16	27	16	11
11	4	8	33	49	37	57	19	38
12	3	9	0	0	3	9	8	1
13	3	10	19	28	22	38	18	20
14	3	6	19	23	22	29	19	10
15	0	0	12	13	12	13	4	9
16	0	0	14	14	14	14	5	9
17	0	0	3	4	3	4	4	0
18	0	0	5	6	5	6	3	3
19	6	8	0	0	6	8	8	0
20	0	0	17	23	17	23	15	8
21	0	0	5	12	5	12	3	9
22	1	3	16	23	17	26	15	11
23	1	1	0	0	1	1	0	1
25	1	2	2	2	3	4	1	3

AOPC	2011 locations	2011 sample count	2006 locations	2006 sample count	Total locations	Total samples	Natural samples	Fill samples analysed
26	6	11	0	0	6	11	5	6
27	3	6	0	0	3	6	4	2
28	5	10	0	0	5	10	6	4
Totals	**68**	**143**	**245**	**340**	**313**	**483**	**252**	**231**

10.2 Soils analytical results

10.2.1 Soil results summary

Based on data from the Earth Tech (2006) and Parsons Brinckerhoff (2011) investigations, the number of primary soil samples collected, maximum concentrations and the number of samples exceeding the investigation criteria have been summarised in Table 10.2.

Table 10.2 Summary of soil analytical results

Analyte	No. of results 2006/2011	No. of detects 2006/2011	Maximum concentration (mg/kg)	Samples exceeding health screening criteria	Samples exceeding ecological screening criteria	Results exceeding management criteria
TRH C_6-C_9	232/77	13	78	0	0	0
TRH C_{10}-C_{14}	232/77	14	9,230	6[1]	9[1]	2[1]
TRH C_{15}-C_{28}	232/77	28	1,930	0	0	4[1]
TRH C_{29}-C_{36}	232/77	23	13,700	0	0	2[1]
Benzene	236/81	1	0.2	0	0	0
Toluene	236/81	3	1.7	0	0	0
Ethylbenzene	236/81	2	1.3	0	0	0
Xylene	236/81	8	0.4	0	0	0
Arsenic	317/99	48	69	0	0	n/a
Cadmium	317/99	12	5	0	0	n/a
Chromium	317/99	370	212	0	0	n/a
Copper	317/99	171	6,530	0	10	n/a
Lead	317/99	340	2,900	1	1	n/a
Mercury	317/99	20	52	0	0	n/a
Nickel	317/99	251	180	0	14	n/a
Zinc	317/99	299	14,900	1	36	n/a
PCB (Total)	0/5	0	<0.1	0	0	n/a
Total PAHs	176/104	14	14.4	0	0	n/a
Benzo(a)pyrene	176/104	3	1.1	0	0	n/a
Naphthalene	176/104	1	2.4	0	0	n/a
Phenanthrene	176/104	7	2.3	0	0	n/a
Fluoranthene	176/104	7	3.2	0	0	n/a
Formaldehyde	13/1	0	<2.0	0	0	n/a

Analyte	No. of results 2006/2011	No. of detects 2006/2011	Maximum concentration (mg/kg)	Samples exceeding health screening criteria	Samples exceeding ecological screening criteria	Results exceeding management criteria
TCE	43/37 (80)	0	<0.5	0	0	n/a
DCE	43/37 (80)	0	<0.5	0	0	n/a
Pesticides	35/36 (71)	0	<0.5	0	0	n/a
Chlordane	28/17 (45)	1	0.06	0	0	n/a
Explosives	19/45 (64)	2	10.3	-	-	n/a
PFOA	0/2 (2)	1	0.0059	-	-	n/a
PFOS	0/2 (2)	1	0.418	-	-	n/a
MBAS	0/4 (4)	0	<50	-	-	n/a
Asbestos	68	6	n/a	-	**-**	**n/a**

1 TRH criteria comparison is based on conservative groupings of previously assessed TRH fractions

10.3 TRH

A summary of detections exceeding the adopted assessment criteria is presented as Table 10.3 and in section 18, Figure 10.

Table 10.3 Summary of TRH exceedances (soil)

Location	Area	Depth m BGL	Matrix description	Analyte	Conc. (mg/kg)	Exceeds
PB_MW05	Area 2 Vehicle storage and maintenance	1.8	NATURAL (Sandy Clay)	C_{10} to $_{14}$	460	HSL D[1] and ESL
		5.8	NATURAL (Sandy Clay)	C_{10} to $_{14}$	200	ESL
SW0201_SB036	Area 2 Vehicle storage and maintenance	0.2	FILL (Clayey Sand)	C_{15}-C_{28}	4,200*	PHML
				C_{29}-C_{36}	8,260	PHML[1]
SW0204_TP039	Area 8 Bridging yard	1.5	FILL (Sand)	C_{10} to $_{14}$	310*	ESL
		2.2	FILL (Sand)	C_{15}-C_{28}	270*	ESL
SW0191_TP032	Area 10 Museum storage yard	1.0	FILL (Clayey Sand)	C_{10} to $_{14}$	380*	HSL D[1] and ESL
SW0195_TP067	Area 11 Dust bowl	1.7	FILL (Clayey Sand)	C_{10} to $_{14}$	540*	HSL D[1] and ESL
				C_{15}-C_{28}	9230*	PHML
				C_{29}-C_{36}	13,700	PHML
SW0207_SB074	Area 13_PRA Yard	0.2	FILL (Gravelly Sand)	C_{10} to $_{14}$	1,930	PHML and HSL D[1]
				C_{15}-C_{28}	6,940	PHML
SW0185_TP001	Area 20_Former FTA	1.0	FILL (Clayey Sand)	C_{10} to $_{14}$	1,160	PHML
				C_{15}-C_{28}	3,530*	PHML
SW0185_TP005	Area 20_Former FTA	1.5	NATURAL (Silty Sand)	C_{10} to $_{14}$	430*	HSL D[1] and ESL

Samples with a SW prefix were sampled in 2006

HSL D: based on NEPM (2013) Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1A(3) –Health screening levels for vapour intrusion (commercial and industrial)

ESL: Ecological screening level based on NEPM (2013) Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1B(6) – Ecological screening levels for TRH fractions F1 – F4, BTEX and benzo(a)pyrene in soil.

PHML: Petroleum hydrocarbon management limit based on NEPM (2013) Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1 B (7) - Management limits for TRH fractions F1-F4 in soil.

* Indicates impact has been vertically delineated based on results of an underlying sample.

PID: photoisonisation detector result taken from the headspace sample at the time of sampling. Values are in ppm.

1 Exceedance is potential based on conservative TRH fraction grouping.

It is noted that the majority of TRH detections were marginal exceedances of the adopted HIL and ESL criteria (within the same order of magnitude) and were reported in surficial fill samples in areas where hydrocarbon sources are likely to have been present, including areas where vehicle and plant is used (Area 11, dust bowl, and Area 20, fire training area), stored (Area 8, Bridging yard 8, and Area 10, Museum storage yard) or maintained (Area 2, Vehicle storage and maintenance, and Area 13, PRA Yard) and in the vicinity of USTs (PB_MW05). In general, PID results gathered in the field from the duplicate head space bags were elevated in most samples in which elevated TRH was reported by the laboratory. The exception is for shallow samples where PID results were generally less than 1 ppm. This is considered to be attributable to the fact that volatile compounds within shallow disturbed fill material would likely already have volatilised.

The HSL exceedances identified for TRH C_{10}-C_{15} represented potential exceedances only in all cases, based on the combination of TRH C_6-C_9 and TRH C_{10}-C_{16} fraction compared to the TRH C_6-C_{10} HSL. This is a conservative comparison, as it assumes that the entire detected C_{10}-C_{16} concentration represents C_9-C_{10}.

The petroleum hydrocarbon 'management limits' represent the maximum values that should remain in a site following evaluation of human health and ecological risks and risks to groundwater resources and apply to all soil depths. These limits are to consider the formation of LNAPLs, fire and explosion risks and damage to buried infrastructure.

Hydrocarbon impacts identified on-site are considered likely to be attributable to surface leaks and spills where detected in shallow soils, and where deeper (>1 m) are likely to be attributable to impacts from USTs.

10.3.1 BTEX

BTEX concentrations were reported below the laboratory PQL for the majority of soil samples analysed. Only minor detections of BTEX were reported in soil, all of which were below the respective adopted assessment criteria.

10.3.2 Heavy metals

In general, metals results from 2006 and 2011 were generally comparable, illustrating that the 2006 data is reliable, valid and robust. This correlation of data was anticipated due to the immobility of metals in clay soils coupled with their persistence in the environment.

Table 10.4 provides a summary of metal impacts detected in soils across the Moorebank IMT site.

Table 10.4 Summary of metals results in soil fill/natural

	Material	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Number of detects	FILL	18	9	169	113	166	11	134	163
	NATURAL	30	3	200	55	172	9	116	134
Minimum detect	FILL	5	1	2	5	5	0.1	2	5
	NATURAL	5	1	2	5	5	0.1	2	5
Maximum detect	FILL	52	3	212	6,530	2,900	5.3	180	14,900
	NATURAL	37	5	40	467	180	52	93	409
Average concentration	FILL	3.9	0.55	11	64	44	0.087	12	160
	NATURAL	3.4	0.53	10	7.9	15	0.44	3.9	19

	Material	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Median concentration	FILL	2.5	0.5	8	8	14	0.05	4	25
	NATURAL	2.5	0.5	7	2.5	11	0.05	2	7

All values expressed in mg/kg
Based on 2006 and 2011 data

Analytical results for arsenic, chromium, cadmium and mercury were reported at concentrations below relevant HILs and EILs. All other metal concentrations were reported below the relevant HILs for all other samples, with the exception of one soil sample collected from SW0204_TP045 at 0.05 m BGL located in Area 8, bridging yard, which exceeded the HIL and EIL for lead.

Copper (10 samples), nickel (14 samples) and zinc (36 results) concentrations were reported above the relevant EILs that were adopted for the investigation.

The maximum copper, lead and zinc concentrations were reported in sample SW0204_TP045 collected from at 0.05 m BGL. The maximum nickel concentration was reported within sample SW0204_SB021 collected from 0.3 m BGL. Both of these locations are situated within Area 8 (bridging yard) in close proximity to a grit blasting facility. These exceedances have been vertically delineated by analysis of soil samples collected from between 0.6 and 2.0 m BGL with all reported results below the relevant ESLs. Sample location SW0204_TP045 is presented in Figure 11, section 18.

The majority of the results exceeding the adopted EILs for copper related to soils characterised as gravelly sand fill collected from within Area 13 (PRA Yard) from depths ranging between 0.2 and 0.5 m BGL. It is considered that elevated copper with this area it attributable to gravelly fill material that has been used beneath the PRA yard. These exceedances have been vertically delineated by analysis of soil samples collected from within the PRA Yard at depths between 1.2 and 1.4 m BGL with all results reported below the ESL for copper.

EILs have been applied for selected metals and are applicable for assessing risk to terrestrial ecosystems. As the site has been proposed for commercial industrial development and considered of limited terrestrial ecosystem value. Furthermore, in the absence site specific soil physicochemical properties (such as pH and cation exchange capacity (CEC) values) the adopted EILs that have been applied to the 2006 and 2011 data sets for screening purposes are the most conservative values available within the guidelines. Based on the fact that the majority of the exceedances are only marginally above the most conservative criteria (reported concentrations generally within an order of magnitude of the screening value), it is considered likely that the majority of the reported metals concentrations are not likely to exceed the EILs with the application of site specific calculations relating to ambient background concentrations (as described in section 2.5.7 in Schedule B1 of the NEPM (2013)).

10.3.3 PAHs

A total of 281 samples were analysed for PAHs. PAH concentrations were reported to be below the laboratory practical quantitation limit (PQL) for the majority of soil samples analysed. Only minor detections of PAHs were reported, all of which were below the respective adopted assessment criteria.

10.3.4 PCBs

Five soil samples were analysed for PCBs. All reported concentrations were below the laboratory PQL.

10.3.5 VOCs and SVOCs

All concentrations were reported to be below the laboratory PQL for both VOCs and SVOCs for all soil samples analysed.

10.3.6 Pesticides

A total of 71 samples were analysed for OCPs and OPPs. All results for these contaminants were reported to be below the laboratory PQL, with the exception of soil sample PB_MW05 where 0.06 mg/kg of the organochlorine compound cis-chlordane was reported at a depth of 0.3 m BGL.

10.3.7 Explosives

A total of 64 soil samples were analysed for explosive compounds. All concentrations were reported to be below the laboratory PQL for all soil samples analysed.

10.3.8 Anionic surfactants

A total of four samples were analysed for anionic surfactants (MBAS). Results were reported to be below the laboratory PQL for all soil samples analysed.

10.3.9 Aqueous film forming foams

Two soil samples were analysed for perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) to indicate the presence of residual contamination from aqueous film forming foams (AFFF) used in fire training activities. Reported results for PB_TP37 (0.5 m BGL) showed 0.0059 mg/kg of PFOA and 0.418 mg/kg of PFOS. This location is at the southern end of the dust bowl area in an area used for fire training activities (Area 11). There are no NSW or national based site assessment criteria available for these compounds, therefore the USEPA RSLs for residential soils have been adopted as a screening value, applying a conservative approach. The concentrations detected in soils were below the USEPA RSL for PFOA and PFOS (16 mg/kg and 6 mg/kg respectively).

10.3.10 Asbestos

A total of 68 samples from the Moorebank IMT site were analysed for asbestos in soil. Samples were generally selected where areas of fill material was observed. Asbestos fibres were detected in eight of the samples submitted for analysis as follows.

- Chrysotile (blue) asbestos fibres were detected in samples PB_TP29 at 0.1 m BGL, SW0191_TP030 at 0.2 m BGL, SW0203_TP060 at 0.3 m BGL and SW0183_TP010 at 0.3 m BGL.
- Chrysotile (white) and amosite (brown) asbestos fibres were detected in samples SW0195_TP069 at 0.5 m BGL, PB_MW03 at 0.2 m BGL.

Asbestos was generally detected in samples form locations where fibrous cement sheeting was visually observed. The spatial distribution of soils sampled for asbestos and the detections identified are presented in section 18, Figure 13.

10.3.11 Particle size distribution

Particle size distribution analysis was undertaken on selected soils sampled from between 0.1 to 1.0 m BGL. Soil generally consisted clay/silt (31-58%), sand (31-66%) and gravel (3-17%). Materials can be generally classified as sandy clays and clayey sands.

10.3.12 Acid sulfate soils results and discussion

The suspended peroxide oxidation combined acidity and sulfate (SPOCAS) method was selected for testing for acid sulfate soil. Nine selected soil samples were analysed.

ASS samples are generally selected based on field indicators including iron staining, potential waterlogged material and the presence of any sulfurous odours. In this case, most of the samples selected had higher than average moisture and notable iron staining or mottling. ASS soil samples were placed in zip-lock bags to minimise contact with the air and moisture loss from the sample and were immediately placed on ice to reduce the possibility of sulfide oxidation and were dispatched to the laboratory. Results are summarised in Table 10.5.

Table 10.5 Acid sulfate soil results

Location	Depth	Description	S_{POS}	TAA	TPA	TSA	a-Net acidity without ANCE
			%S	mole H^+/t	mole H^+/t	mole H^+/t	mole H+/e
PB_TP11	1.2	Clayey sand	0.02	<2	<2	<2	<10
PB_TP12	3.0	Clayey sand	0.02	<2	<2	<2	<10
PB_TP20	0.05	Sandy clay	0.02	6	33	27	10
PB_TP20	0.4	Gravelly sand	0.03	17	67	50	21
PB_TP20	1.0	Sandy clay	0.05	23	33	10	31
PB_TP27	2.0	Clayey sand	0.03	18	17	<2	21
PB_TP29	2.0	Clayey sand	0.16	91	101	9	100
PB_TP37	3.0	Sand	0.02	<2	<2	<2	10
PB_MW14	13.0	Clayey sand	0.06	33	264	231	36

ANCE: Acid Neutralizing Capacity
S_{POS}: Peroxide Oxidisable Sulfur (Net acidity (sulfur units)
TAA: Total Actual Acidity
TSA: Total Sulfidic Acidity
TPA: Total Potential Acidity

Laboratory analytical results for four of the samples tested (TP11_1.2, TP12_2.0, TP20_0.05 and TP37_3.0) reported percentages of potential oxidisable sulfur (S_{POS}) below the adopted site assessment criteria (0.03%), indicating that sulfidic materials at these locations are unlikely to warrant a concern in terms of acid generating potential.

Laboratory analytical results for five of the samples tested reported percentages of potential S_{POS} equal to or above the adopted criteria indicating that sulfidic materials are present in soils at these locations. Reported Total Potential Acidity (TPA) values for five of the samples were above the adopted site assessment criteria (18 moles H+/ tonne), indicating that soils are acid generating, predominately non-sulfidic in nature (cf. low S_{POS} concentrations). Where TPA is elevated and S_{POS} values are reported to be only marginally above the criteria, this may indicate that the sulfur present is unlikely to be readily oxidisable or has been previously oxidised. For example in TP20, significantly larger TPA values than S_{POS} values may indicate previously oxidised sulfur or the presence of organic acidity.

Standing groundwater levels at the Moorebank IMT site are between approximately 5.2 and 9.1 m BGL. It is considered likely that above this depth, sulfur is not likely to be readily oxidisable or has been previously oxidised.

Both S_{POS} and TPA exceeded the assessment criteria in soils sampled from locations PB_TP20 (0.4 and 1.0 m BGL), TP29 at 2.0 m BGL and PB_MW14 at 13.0 m BGL.

ASS generates sulfuric acid when exposed to oxidising conditions. As this material is relatively shallow fill, and the groundwater table is below 6 m BGL, it is considered that for three of the four samples which are present in the shallow unsaturated zone, material is likely to have been exposed to an oxidising environment therefore the potential for oxidation of sulfides is likely to be reduced.

Based on the results for PB_MW13 at 13.0 m BGL, where the groundwater table was gauged to be at approximately 9.1 m BGL, it is likely potential ASS be present below the water table. Soil samples located above 13.0 m BGL were not analysed. It is therefore possible that the overlying soils may also be acid generating if exposed during site redevelopment.

Based on these results, it is considered that subsurface materials encountered at the Moorebank IMT site may pose an acid generation risk if exposed to oxygen during redevelopment. As the water table impedes oxidation of potential iron sulfides in the subsurface, dewatering/lowering of the groundwater table during redevelopment may result in oxidising conditions at depth.

During redevelopment, further testing of excavated soils may be necessary to confirm the presence and extent of acid generating lithology. Should further testing confirm the presence of ASS, off-site disposal would need to be in accordance with the NSW DECC (2008) Waste Classification Guidelines Part 4: Acid Sulfate Soils. ASS results are presented in section 18 Figure 16.

10.3.13 Waste classification by toxicity characteristics leaching potential

In order to assess the likely waste classification of any soil at the Moorebank IMT site for the future, analytical results have been compared to the NSW DECC (2009) Waste Classification Guidelines Part 1: Classifying Waste as outlined in section 6.1.2.

Based on results from 2006 and 2011, 31 samples exceeded the general soils waste guideline based on Specific Contaminant Concentration (SCC) (without toxicity characteristics leaching potential (TCLP)). Of these, eight samples exceeded the restricted solid waste guideline based on SCC (without TCLP). Of these samples, six were scheduled for TCLP analysis. The results of the TCLP analysis confirmed that five of the six samples could be classed as general solid waste and one would be classified as restricted solid waste due to elevated lead concentrations. A summary of the TCLP results are provided in Table 10.6.

Table 10.6 TCLP results

Location depth	Analyte	Detection –SSC (mg/kg)	TCLP result (mg/L)	Waste classification
SW0204_TP045_0.05 m	Chromium	212	<0.1	GSW
	Lead	2,900	0.3	RSW
	Nickel	79	<0.1	GSW
PB_TP18_0.2 m	Chromium	141	<0.1	GSW
	Nickel	107	<0.1	GSW
PB_TP15_0.1 m	Nickel	151	0.2	GSW
PB_SS09 (sediment)	Nickel	79	<0.1	GSW
PB_MW19_0.2 m	Nickel	78	0.1	GSW
PB_MW17_0.3 m	Nickel	55	<0.1	GSW

SSC: specific contaminant concentration
GSW: general solid waste
RSW: restricted solid waste
TCLP: toxicity characteristic leaching procedure

Where soils exceed the general solid waste SSC threshold, these generally consist of material sampled from sub surface fill.

Based on the available analytical results, it is considered that materials generated during site excavation intended for off-site disposal in the areas assessed would likely to be classified as general solid waste. It is considered that the majority of fill material in the areas assessed would be generally classified as general solid waste with localised areas of waste that may be classified as restricted solid waste.

Where asbestos is positively identified within waste material, this may be classified as ‘special waste’. However, if asbestos is mixed with other waste materials to form asbestos waste it must be assessed in accordance with the waste classification guidelines and disposed of at a waste facility that can lawfully receive asbestos wastes.

Where ASS is positively identified in soil, soils will need to be classified and appropriately managed and/or disposed of in accordance with NSW DECC Waste Classification Guidelines, Part 4, Acid Sulfate Soils (2008).

Further analysis of materials should be undertaken following excavation and stockpiling, including TCLP analyses to confirm waste classifications for any wastes generated during redevelopment prior to reuse/ disposal.

10.4 Sediment analytical results

A summary of sediment analytical results is provided in Table 10.7. The values below were compared to the interim sediment quality guideline (ISQG) criteria detailed in section 6.2.

Table 10.7 Sediment analytical results

Analyte	No. of primary samples	No. of detects	Max. conc. (mg/kg)	Samples exceeding ISQG low trigger value
TRH C_6-C_9	10	2	4	n/a
TRH C_{10}-C_{36}	10	7	5,570	n/a
Benzene	5	0	-	n/a
Toluene	5	0	-	n/a
Ethylbenzene	5	0	-	n/a
Xylenes	5	2	0.9	n/a
Arsenic	11	5	12	None
Cadmium	11	2	5	SW0204_SD041 (4 mg/kg), SW0204_SD042 (5 mg/kg)
Chromium	11	10	53	None
Copper	11	8	76	SW0204_SD041 (4 mg/kg), SW0204_SD042 (76 mg/kg)
Lead	11	8	50	None
Mercury	11	4	0.5	PB_SS05 (0.5 mg/kg), PB_SS06 (0.2 mg/kg), PB_SS04 (0.2 mg/kg) and SW0192_SD112 (0.2 mg/kg)
Nickel	11	10	79	SW0204_SD041 (41 mg/kg), SW0204_SD042 (41 mg/kg), and PB_SS09 (79 mg/kg)

Analyte	No. of primary samples	No. of detects	Max. conc. (mg/kg)	Samples exceeding ISQG low trigger value
Zinc	11	11	718	PB_SS03 (718 mg/kg), PB_SS08 (446 mg/kg), SW0204_SD042 (342 mg/kg), SW0192_SD113 (293 mg/kg), PB_SS09 (285 mg/kg), PB_SS02 (249 mg/kg), and SW0192_SD112 (231 mg/kg)
PCB	3	0	-	None
B(a)P	6	0	-	None
Total PAHs	9	0	-	None

A number of the reported concentrations were reported above the ISQG high trigger value, including nickel concentrations in sediment sample PB_SS09 and all reported zinc concentrations. Where this trigger value is exceeded, biological effects could possibly occur as a result of sediment concentrations.

TCLP analysis was undertaken on sediment sample PB_SS09. Based on the leachability test results, metal concentrations detected were found to be relatively immobile. In addition, nickel and zinc concentrations were not found to be elevated in surface water based on analytical results from 2011, which may provide further evidence to suggest that the metals concentrations reported in sediments has limited bioavailability. Elevated concentrations of nickel and zinc that exceed the ISQG criteria are considered to be representative of natural and anthropogenic background sediment concentrations.

Should sediments from the Moorebank IMT site require off-site disposal during redevelopment, based on available results, these sediments would likely be classified as general solid waste. Further analysis of materials should be undertaken to confirm the correct waste classifications for any wastes generated during site redevelopment prior to reuse/ disposal.

Heavy metals in sediments that exceed the adopted investigation criteria are presented in section 18 Figure 12.

10.5 Groundwater analytical results

A total of 39 wells were sampled during 2011. In 2006, 22 wells within the Moorebank IMT site were sampled. The number of primary groundwater samples collected, analytes tested for maximum concentration and number of samples exceeding the adopted investigation levels are summarised in Table 10.8.

Table 10.8 Summary of groundwater analytical results (2011)

Analyte	No. of samples	No of detects	Min. conc.(µg/L)	Max. conc. (µg/L)	Samples exceeding GIL (1)	Samples exceeding GIL (2)
Hydrocarbons						
Total recoverable hydrocarbons	39	1	<20	340	-	-
BTEX compounds	39	0	<5	-	-	-
Metals						
Arsenic	33	5	<1	3	-	-
Cadmium	33	13	<0.1	1.5	3	0
Chromium	33	8	<1	7	7*	0

Analyte	No. of samples	No of detects	Min. conc.(µg/L)	Max. conc. (µg/L)	Samples exceeding GIL (1)	Samples exceeding GIL (2)
Copper	33	25	<1	79	21	0
Lead	33	16	<1	114	8	2
Mercury	33	0	<0.1	<0.1	33(3)	0
Nickel	33	32	<1	168	15	10
Zinc	33	30	<5	408	28	-
PAHs						
Benzo(a)pyrene	38	1	<0.05	0.07	-	0
Naphthalene	38	10	<0.1	0.4	-	0
Other						
PCBs	8	0	<1	-	0	0
TCE	31	2	<5	297	-	-
Cis 1,2 DCE	31	1	<5	22	-	-
Formaldehyde	2	2	<0.1	200	-	0
PFOA	5	3	<0.02	1.4	^	-
PFOS	5	4	<0.02	23.2	^	-
MBAS	3	0	<100	-	-	-

^: no Australian Guideline available.

* GIL based of chromium IV screening value.

1) Exceeds NEPC (2013) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1) - Schedule B-1 Investigation Levels for Soil and Groundwater - Table 1C Groundwater Investigation Levels (GILs) – Freshwater.

(2) Exceeds (1) and the investigation Level for Drinking Water; NEPC (2013) National Environmental Protection (Assessment of Site Contamination).

(3) Laboratory limit of reporting is above the GIL therefore all concentration could potentially exceed the GIL for freshwater.

Summary tables of all groundwater laboratory results have been included in Appendix A5 and copies of all laboratory certificates have been included in Appendix A8.

10.5.1 TRH

A total of 39 samples were analysed for TRH during 2011 works.

TRH C_6 – C_9 was reported in groundwater sampled from well MW_BHB2 (340 µg/L) located in Area 1 (ABB boundary area). This detection is considered likely to be associated with the chlorinated hydrocarbon compounds also detected in this area.

TRH C_{10}–C_{36} was detected in 16 of the 39 samples analysed. Detections were reported between 50 and 845 µg/L in groundwater sampled from the following locations:

- PB_MW15 in Area 22 (CE store) where a number of USTs are present up gradient
- PB_MW16 and PB_MW17 in Area 9 (fuel/oil storage)
- PB_MW13 and PB_MW14 in Area 27 (non-operational UST)
- PB_MW09 and PB_MW19 in Area 13 (PRA yard)
- PB_MW03, PB_MW04 and PB_MW05 in Area 2 (vehicle maintenance) in the vicinity of a former UST

- PB_MW01 in Area 28 (former buildings)
- PB_MW08 and PB_MW21 (Area 0, other areas) which are located adjacent to the eastern site boundary down gradient of off-site USTs present in DNSDC facility to the east.

All detections of TRH were reported at concentrations below the adopted criteria.

10.5.2 BTEX

A total of 39 samples were analysed for BTEX during 2011 works. All reported results for BTEX were below the laboratory PQL.

10.5.3 Dissolved heavy metals

Cadmium, chromium, copper, lead, nickel and zinc concentrations were detected above the respective GILs. Arsenic and chromium concentrations were reported below the respective adopted site assessment criteria. Mercury was not detected above the laboratory PQL in any of the groundwater samples analysed. The most elevated dissolved metals concentrations in groundwater were generally reported in groundwater samples collected from monitoring wells within Area 13 (PRA Yard).

Concentrations of dissolved lead and nickel exceeded the respective drinking water GILs.

Dissolved heavy metals results are presented in Figures 17, 17a, 17b and 17c, section 18.

10.5.4 PAHs

The most elevated PAH detections were reported in groundwater sampled from well PB_MW14 in Area 27 (non-operational UST), where benzo(a)pyrene was reported above the drinking water GILs. All other detections were either below the laboratory PQL or below the respective site assessment criteria.

As the drinking water GIL for benzo(a)pyrene is below the laboratory detection limit used for the 2011 investigation, concentrations of benzo(a)pyrene may exceed the GIL for drinking water.

10.5.5 PCBs

All reported concentrations were below the laboratory PQL for all eight groundwater samples that were analysed for PCBs.

10.5.6 VOCs and SVOCs

A total of 29 groundwater samples were analysed for SVOCs. All SVOCs were reported below the laboratory detection limit with the exception of MW085 (Area 10, museum storage yard) where 0.2 µg/L of 2-methylnaphthalene was detected.

A total of 31 samples were analysed for VOCs. The following detections were reported:

- Chloroform (TCM) in groundwater sampled from well PB_MW18 (6 µg/L) located in Area 2 (vehicle storage and maintenance)
- Cis-1,2-dichloroethene in groundwater sampled from well MW_BHB2 (22 µg/L) located in Area 1 (ABB boundary)
- TCE in groundwater sampled from well MW_BHB2 (297 µg/L) and of TCE MW_BHB4 (18 µg/L) both located in Area 1 (ABB boundary).

All other VOC compounds were reported below the laboratory detection limit. However, it is noted that the PQL for vinyl chloride was an order of magnitude above the Australian Drinking Water Guideline of 0.3 µg/L therefore vinyl chloride (a breakdown product of TCE) may also be present in groundwater.

There is additional historical data pertaining chlorinated hydrocarbons in groundwater in Area 1 (ABB boundary) from the Earth Tech 2006 report and in other older reports that were reviewed as part of the Phase 1 ESA. Relevant data has been summarised in Table 10.9.

Table 10.9 Historical TCE detections in groundwater

	MW_BHB1 *(HLA, 2002)*	MW_BHB1 *(URS, 2003)*	MW_BHB1 *(GHD, 2004)*	MW_BHB2 *(GHD, 2004)*	MW_BHB2 *(Earth Tech, 2006)*
TCE	1,470	886	576	406	613
1,2,cis DCE	122	61	38	23	50

Based on the results, TCE has consistently been detected in groundwater wells located in Area 1. There is a generally decreasing trend in TCE concentrations over time, indicating that the contaminant may be degrading. Results for chlorinated hydrocarbons in groundwater are presented in Figure 18, section 18.

10.5.7 Formaldehyde

A total of two samples were analysed for formaldehyde. Groundwater from MW009 (Area 16, NBC store) was analysed in 2006 and 2011 and concentrations were reported at concentrations of 400 µg/L and 200 µg/L respectively. Formaldehyde was also detected in sample PB_MW15 (Area 22, CE store) at a concentration of 100 µg/L. Concentrations were below the Australian Drinking Water Guideline (500 µg/L).

10.5.8 Anionic surfactants (MBAS)

A total of three samples were analysed for MBAS and all reported concentrations were below the laboratory PQL. Four groundwater samples were analysed for MBAS in 2006 with one detection (200 µg/L) in groundwater sampled from MW2 (Area 21, small arms range). However MW2 was recorded as lost/ destroyed located during 2011 fieldwork.

10.5.9 AFFF

Five groundwater samples were analysed for PFOA and PFOS to establish if residual AFFF used in fire training activities was present in groundwater.

PFOA was detected in three groundwater samples from BHA-1 (0.91 µg/L), MW083 (1.4 µg/L) and MW108 (0.17 µg/L) and PFOS was detected in four groundwater samples from BHA-1 (1.57µg/L), MW083 (23.2 µg/L) MW108 (0.43 µg/L) and PB_MW07 (0.07 µg/L).

BHA-1 and MW108 are located with Area 11 (dustbowl and former FTA), MW083 is located in Area 21 (small arms range) and PB_MW07, located in Area 8 (bridging yard).

As no Australian guidelines exist for PFOS and PFOA, the assessment values have been adopted from the USEPA guidelines for tap water, which is a conservative approach. With the exception of groundwater collected from PB_MW07, all detections of PFOA and PFOS in groundwater sampled were above the USEPA guidelines for tap water (0.2 and 0.4 respectively).

AFFF concentrations in groundwater are presented in Figure 19 section 18.

10.6 Soil results comparison

Parsons Brinckerhoff has undertaken additional analysis of soils in the vicinity of some previous Earth Tech (2006) investigation locations to provide a point of comparison and verification for temporal correlation between 2006 and 2011 analytical results. Subsurface conditions encountered and reported contaminant concentrations were generally similar in each area over both the 2006 and 2011 investigations. All results are presented in Appendix A4 with general soil descriptions provided and in order of investigation area (AOPC) listed.

10.7 Groundwater results comparison

Groundwater field and laboratory results from 2006 and 2011 ESAs have been compared, to assess the temporal changes in groundwater conditions. Comparison tables are presented in Appendix A5 and Appendix A6.

Groundwater levels across the Moorebank IMT site have generally risen since 2006, with an average groundwater level rise of 0.56 m based on the available gauging data. Field parameters were recorded to be generally similar for each of the comparison wells in both monitoring rounds which indicate that groundwater conditions beneath the Moorebank IMT site have remained relatively unchanged since 2006.

Contaminant concentrations were also generally similar, with TRH, BTEX and, PAHs reported below the PQL in both monitoring rounds. Dissolved metals concentrations groundwater reported in 2011 were in the same order of magnitude as concentrations reported in 2006, with the exception of MW083 (Area 21, former FTA). Concentrations of dissolved cadmium (0.8 µg/L), copper (79 µg/L), lead (114 µg/L), nickel (19 µg/L), and zinc (215 µg/L), have increased from concentrations near to the limit of detection in 2006 to above the adopted site assessment criteria in 2011.

Groundwater pH, dissolved oxygen, redox, and electrical conductivity parameters were consistent between monitoring rounds, therefore it is not possible to attribute these results to changes in groundwater conditions at this location.

In summary, the relatively similar datasets indicate that the groundwater regime has not significantly changed from 2006 to 2011. Furthermore, this comparison and subsequent correlation indicates that the Earth Tech 2006 data is reliable and valid.

10.8 Surface water results

A summary of surface water results are presented in Table 10.10.

Table 10.10 Surface water analytical results

Analyte	No. of samples*	No. of detects	Min. conc.	Max. conc.	Samples exceeding GIL
TRH C_6–C_9	7	0	-	-	-
TRH C_{10}–C_{14}	7	1	<50	260	-
TRH C_{15}–C_{28}	7	1	<100	470	-
TRH C_{15}–C_{28}	7	1	<50	340	-
BTEX compounds	5	1*	-	12	-
Arsenic	8	0	-	-	-
Cadmium	8	0	-	-	-

Analyte	No. of samples*	No. of detects	Min. conc.	Max. conc.	Samples exceeding GIL
Chromium	8	0	-	-	-
Copper	8	8	1	2	5
Lead	8	0	-	-	-
Mercury	8	0	-	-	-
Nickel	8	8	1	14	3
Zinc	8	5	7	16	4
Total PAHs	5	0	-	-	-
PCBs	6	0	-	-	-
TCE	**2**	**0**	**-**	**-**	**-**

*: toluene detection
All values in µg/L

Copper, nickel and zinc concentrations in surface water were reported marginally above the freshwater GIL, with reported concentrations at the same order of magnitude as the respective adopted assessment criteria. Concentrations were generally similar in surface waters sampled from across the Moorebank IMT site.

11. Quality assurance/quality control

11.1 Data quality indicators for analytical data

This section details the quality assurance processes that were followed to verify the data generated from the Parsons Brinckerhoff (2011) and the Earth Tech (2006) investigations are appropriate for the purposes of the investigation.

11.1.1 Data quality objectives and indicators

The data quality objectives (DQOs) for sampling techniques and laboratory analyses of collected representative soil and groundwater samples defines the acceptable level of error required for the investigation. The DQOs have been assessed with reference to data quality indicators (DQIs) as presented in Table 11.1.

Table 11.1 Data quality indicators

DQI	Description	Achieved by	Applicability
Completeness	The measure of the amount of usable data from a data collection activity. Valid chemical data are the values that have been identified as acceptable or validated.	Assessment of the total acceptable samples against the total number of samples taken, expressed as a percentage.	The data tables and logs from both investigations were consistent and all critical locations were sampled.
Comparability	The confidence that data may be considered to be equivalent for each sampling analytical event, i.e. the confidence with which one data set can be compared with another.	Qualitative assessment of QA/QC procedures. Comparison of field sampling procedures, analytical procedures, laboratory sample preparation procedures, analytical procedures and reporting units. These factors must be known and similar to established protocols.	The sampling was in general accordance with the sampling and analysis procedures described in the SAQP and as per standard industry procedures. Each sample was analysed using identical methods for each analyte and laboratory LORs were consistent over each laboratory batch. A check laboratory was used to provide data so make a comparative assessment of variability between laboratories.
Representativeness	The confidence that the data are representative of each media present on the Moorebank IMT site. Expresses the degree to which sample data accurately and precisely represents a characteristic of a population or an environmental condition.	Qualitative assessment sampling points. Controlled through selecting sampling locations that exemplify site conditions and obtaining suitable samples.	Sample selection and analysis was conducted in order to meet the specific objectives of the project. Analysis for the contaminants of concern was selectively conducted on soil, sediment, groundwater and surface water samples as presented in the analytical tables. A combination of targeted and random sampling locations to fill in spatial data gaps were selected based on the historical information available, the previous investigation (Earth Tech 2006) and observations made during the Moorebank IMT site walkover. The final sampling locations took into consideration the presence of operational infrastructure and underground/ aboveground services. Consistent and repeatable sampling techniques and methods were utilised throughout the sampling.
Precision	The quantitative measure of the variability (or reproducibility) of data Measures the reproducibility of measurements under a given set of conditions.	Expressed as relative percentage differences (RPDs), assessed by determining the RPDs between the original and duplicate samples tested, Validity of the data is questioned if the RPD limits are exceeded and upon further investigation a reason cannot be determined.	Work was conducted in accordance with Parsons Brinckerhoff and Earth Tech standard procedures. The precision of the data was assessed by calculating the RPDs of duplicate samples. The criteria used for the assessment of RPDs for non-volatiles and semi volatiles (typically 30–50%) follow the guidelines given in AS 4482.1 (2005). As per the industry requirements for DQOs set out in the NEPM, if duplicate results were not within acceptable RPD range limits, the cause has been further investigated to provide justification.
Accuracy	The quantitative measure of the closeness of reported data to the true values. Accuracy can be undermined by such factors as field contamination of samples poor preservation or preparation techniques.	Assessment of the laboratory QA/QC analytical results (laboratory control samples laboratory spikes and analyses against reference standards). Accuracy of field works can be assessed by examining the level of contamination detected in equipment blanks.	Work was conducted in accordance with Parsons Brinckerhoff and Earth Tech SOPs.

11.2 Field data quality

Field sampling procedures conformed to Parsons Brinckerhoff internal QA/QC protocols to prevent cross contamination, preserve sample integrity and allow for collection of suitable data of satisfactory useability from which technically sound and justifiable decisions can be made. The Parsons Brinkerhoff (2011) and the Earth Tech (2006) field QA/QC sampling program comprised:

- blind duplicates sent to the primary laboratory ALS (approximately 1 in 10 samples);
- blind triplicates sent to the check laboratory Envirolab (approximately 1 in 20 samples);
- one equipment rinsate (per day); and
- one trip blank per day.

A summary of duplicate samples is presented in Table 11.2.

Table 11.2 Duplicate sample summary

Primary sample	Depth (m BGL)	Intra-laboratory duplicate (blind duplicate)	Inter-laboratory duplicate (blind triplicate)	Analytes
Soils 2011				
PB_MW19	0.2	PB_MW19_0.2 QA1	PB_MW19_0.2QA2	TRH, BTEX, PAH, metals
PB_MW11	0.5	PB_MW11_0.5 QA1	-	TRH, BTEX, metals
PB_MW07	0.3	PB_MW07_0.3 QA1	-	TRH, BTEX, metals
PB_MW06	0.5	PB_MW06_0.5 QA2	-	
PB_MW17	0.3	PB_MW17_0.3 QA1	PB_MW17_0.3 QA2	TRH, BTEX, PAH, metals
PB_MW05	1.2	PB_MW05_1.2 QA1	-	TRH, BTEX, PAH, metals
PB_MW05	6.0	PB_MW05_5.8-6.0-QA01	PB-MW05-5.8-6.0-QA02	TRH, BTEX, PAH, metals
PB_MW09	6.0	PB_MW09_5.8-6.0 QA01	-	TRH, BTEX, PAH, metals
PB_TP34	0.05	PB_TP34_0.05	-	TRH, BTEX, metals, pesticides
PB_MW15	1.4	PB_MW15_1.4-1.5_QA1	PB_MW15_1.4-1.5_QA02	TRH, BTEX, metals, SVOC, VOC
Soils 2006				
25mSAR_TP080	0.5	1080B	1080C	Metals
25mSAR_TP081	0.7	1081C	-	Metals
NWDA_TP074	1.5	1074C	1074D	TRH, BTEX, PAH, metals
SW0153_MW013	10.5	2013B	2013C	VOC, formaldehyde
SW0179_TP059	0.5	1059C	1059D	Metals, OPP, OCP, asbestos
SW0180_TP081	0.3	3081B	3081C	Metals, OPP, OCP
SW0181_SB006	0.5	1006B	-	TRH, BTEX, PAH, metals, SVOC
SW0183_TP003	0.3	3003B	3003C	TRH, BTEX, metals
SW0183_TP004	0.5	3004B	3004A	TRH, BTEX, metals
SW0184_TP025	1.0	3025B	3025C	TRH, BTEX, PAH, metals

Primary sample	Depth (m BGL)	Intra-laboratory duplicate (blind duplicate)	Inter-laboratory duplicate (blind triplicate)	Analytes
SW0185_TP004	1.5	2004C	-	TRH, BTEX, PAH, metals, VOC, surfactants
SW0185_TP005	0.5	2005B	-	TRH, BTEX, PAH, metals, VOC, surfactants
SW0185_TP005	1.5	2005D	-	TRH, BTEX, PAH, metals, VOC, surfactants
SW0185_TP008	1.6	2008D	-	TRH, BTEX, PAH, metals, VOC, surfactants
SW0187_TP016	0.2	3016B	3016B	Metals, OCP, OPP, asbestos
SW0187_TP019	0.2	3019B	-	Metals, OCP, OPP
SW0187_TP020	0.2	3020B	-	Metals, OCP, OPP
SW0189_TP013	0.5	3013B	3013B	TRH, BTEX, PAH, metals
SW0190_TP056	0.2	3056B	3056C	Metals
SW0190_TP072	0.2	3072A	-	Metals
SW0191_TP030	0.2	2030B	-	TRH, BTEX, PAH, metals
SW0191_TP032	2.6	2032F	-	TRH, BTEX, PAH, metals
SW0193_TP053	1.0	1053C	1053D	Formaldehyde
SW0195_TP042	0.5	1042C	1042D	TRH, BTEX, PAH, metals
SW0195_TP068	0.5	2068B	-	TRH, BTEX, metals, asbestos, explosives
SW0203_TP072	1.0	1072D	1072E	TRH, BTEX, metals
SW0204_TP043	0.1	2043B	-	TRH, BTEX, metals
SW0204_TP046	0.3	2046C	2046D	TRH, BTEX, metals
Groundwater 2011				
MW085	-	DUP02	-	Metals, PAH, TRH, BTEX
PB_MW07	-	DUP05	Trip04	Metals, PFOA, PFOS, PAH, TRH, BTEX, VOC
PB_MW13	-	DUP 03	-	Metals, PAH, SVOC, TRH, BTEX, VOC

Primary sample	Depth (m BGL)	Intra-laboratory duplicate (blind duplicate)	Inter-laboratory duplicate (blind triplicate)	Analytes
PB_MW09	-	DUP 04	Trip03	Metals, PAH, TRH, BTEX, VOC
BHE_1	-	DUP06	-	Metals, PAH
MW_BHB11	-	DUP01	Trip01	PCB, SVOC, TRH, BTEX, VOC
Groundwater 2006				
SW0207_MW076		2076X		TRH, BTEX, PAH, metals, VOC, surfactants
MW083		1083X	1083Y	TRH, BTEX, PAH, metals, VOC

The RPDs for soils were calculated for the primary and duplicate samples for assessment of the data quality in particular for assessment of the reproducibility of the analytical data measurements or 'precision' given the adopted field and laboratory methods.

The RPDs were calculated using the formula below:

$$RPD\% = \frac{|Ro - Rd|}{|(Ro + Rd)/2|} \times 100\%$$

Where Ro is the primary sample and Rd is the primary duplicate.

The RPD values were compared to the 30–50% RPD acceptance criterion outlined in Australian Standard AS 4482.1-2005 (for non-volatiles and semi volatiles). For volatile compounds no published RPD acceptance criteria exists however RPDs of <100% are considered acceptable. RPDs for results less than the PQL were not calculated. In instances where results were greater than the PQL for the one sample but below PQL for the corresponding primary or duplicate sample a result equal to the PQL value was adopted where necessary in order to make a calculation possible.

11.3 Field quality assurance (Parsons Brinckerhoff 2011)

The results for internal and external laboratory QA/QC procedures are provided within the laboratory analysis reports in Appendix A8. Table 11.3 summarises conformance to specific QA/QC procedures.

Table 11.3 Field quality assurance for Parsons Brinkerhoff investigation 2011

Quality assurance	Conformance	Comment
Fieldwork was undertaken by experienced field engineers	Yes	Qualified and experienced environmental scientists with 2 to 5 years' experience of fieldworks.
Standard field sampling sheets used	Yes	Details recorded included Parsons Brinckerhoff staff and contractors present time on/off site weather conditions calibration records and comments.
Appropriate sample handling undertaken	Yes	Samples were taken in accordance with standard Parsons Brinckerhoff practices. Samples were stored in chilled Eskies on-site and during transport via courier to the laboratory. A COC form was completed on-site and sent with the samples. The laboratory confirmed receipt of the samples, condition on delivery and the scheduled analysis.
Decontamination of field sampling equipment undertaken	Yes	Dedicated nitrile gloves were used and equipment was decontaminated by washing with phosphate free detergent (Decon 90) and clean water rinse between each sample event to reduce the potential for cross contamination.
Collection of rinsate water from decontaminated field equipment	No	One rinsate was collected and analysed for each day of the works. The majority of results for the rinsate samples that were analysed were below laboratory PQLs. The exceptions were: ▪ PB_070211W (1,640 µg/L of TRH C_{10}-C_{36}); and ▪ PB_220211 (290 µg/L of TRH C_{10}-C_{36}). These rinsates were associated with PB_SW06 and groundwater MW05 respectively. SW06 was the only sample collected on 07/02/11 using a dedicated metal bucket therefore cross contamination between samples is not possible. It is thought that PB_220211 was mislabelled and should have been a blind duplicate sample.

Quality assurance	Conformance	Comment
		Dedicated nitrile gloves and bailers were used during groundwater sampling therefore the rinsate collection would not be required. This is further supported by the fact that the concentration of TRH C_{10}-C_{36} of groundwater sample MW05 taken on 22 February 2011 is 340 µg/L. Dedicated clean nitrile gloves and equipment were used for the collection of each water sample during site works therefore it is not considered that these results would have significantly affected the data outcomes.
Holding times met	Majority	Appropriate holding times were met in the majority of sample batches for each analyte. Some minor holding time exceedances (16 days from sampling until analysis) were reported for SVOC and explosive compound analyses as follows: PB_MW17_0.3, PB_MW19_0.2, PB_TP22_0.3, PB_TP33_0.3, PB_TP35_0.1, and PB_TP36_0.1.
PQLs less than assessment criteria	Yes	With the exception of B(a)P and anthracene all PQLs were less than the adopted assessment criteria.
All analyses NATA accredited	Yes	All laboratories used (ALS and Envirolab Consulting) are NATA accredited.
Carrying of trip blank samples during sampling episodes	Yes	Trip blank samples were carried during field works (at a rate of one per batch of samples dispatched to the laboratory) to assess contamination through field activities and transport. Results were below laboratory PQLs.
Field intra-laboratory duplicate samples collected and analysed to represent 1 in 10 of sample population	Yes	Field intra-laboratory duplicates were analysed for all contaminants of concern at the rate of approximately 1 in 10 of primary samples.
Inter-laboratory duplicate samples collected and analysed to represent 1 in 20 of sample population	Yes	Field inter-laboratory duplicate samples were analysed for contaminants of concern at the rate of approximately 1 in 20 of primary samples.
Intra-laboratory and inter-laboratory duplicates RPDs within limits set by AS 4482.1 - 30–50% (100% for volatiles)	Majority	Field duplicates were generally within the acceptable RPD limits. Exceedances are presented in Table 11.4.

11.4 RPD results

The majority of field intra-laboratory duplicates and inter-laboratory duplicates were within the acceptable RPD limits. The samples that exceeded RPDs during the 2011 investigation are presented in Table 11.4.

In addition, intra-laboratory duplicates from the Earth Tech report (2006) have also been assessed to provide an indicative indication of the reliability of data. These are presented in Table 11.5. A complete set of RPD tables are presented within Appendix A5.

Table 11.4 RPD exceedances – Parsons Brinkerhoff 2011

Matrix	Primary sample	Laboratory duplicate	RPD exceedance (%)
Soil	PB_MW11_0.5	PB_MW11_0.5 QA1	Cr (67)
Soil	PB_MW19_0.2	PB_MW19_0.2QA2	Zn (58)
Soil	PB_MW15_1.4-1.5	PB_MW15_1.4-1.5_QA02	Cu (133)
Water	PB_MW13	DUP03	Pb (133)
Water	PB_MW09	DUP 04	Cd (153)
Water	PB_MW09	Trip 03	Cd (73), Cu (80), Pb (76), TRH C_{15} - C_{28} (89)
Water	PB_MW07	Trip 04	PFOS (67), TRH C_{15} - C_{28} (89)

Table 11.5 RPD exceedances – Earth Tech 2006

Matrix	Primary sample	Laboratory duplicate	RPD exceedance (%)
Soil	SW0181_SB006	1006B	Cr (80), Cu (75), Pb (53),
Soil	SW0185_TP005_0.5	2005B	Cr (92)
Soil	SW0185_TP005_1.5	2005D	Cr (74)
Soil	SW0191_TP032	2032F	Pb (158)
Soil	SW0191_TP030	2030B	Ni (52)
Soil	SW0204_TP046	2046C and 2046C	Ni (66)
Soil	SW0183_TP003	3003B and 3003C	Pb(82), Hg (67)
Soil	SW0183_TP004	3004B and 3004A	Ni (96), Cu (105)
Soil	SW0187_TP020	3020B	Cr (67), Cu (94), Ni (109), Zn (75)
Soil	SW0190_TP056	3056B and 3056C	Zn (55)
Soil	25mSAR_TP080	1080B and 1080C	Cu (100), Zn (127)
Water	SW0207_MW076	2076X	Cd (67)

The majority of RPD exceedances reported are considered likely to be attributable to the reported concentrations being close to the laboratory LORs, where laboratory precision and accuracy are inherently low. Where detections are greater than the LOR, this has been attributable to the heterogeneity of soil samples resulting in slight variations in metals detections. Based on the results of laboratory QA/QC samples and the sampling and handling procedures used for the collection and analysis of soil samples the data was considered representative and appropriate for use in this assessment.

11.5 Summary of laboratory QA/QC

An assessment of all laboratory QA/QC data was undertaken to verify the results of the Parsons Brinkerhoff (2011) and Earth Tech (2006) investigations. Matrix spikes, controls samples and surrogate analytical results were assessed against project and laboratory recovery targets. These are presented in Table 11.6.

Table 11.6 Laboratory QA/QC review

Data set	Matrix	Total analyses	Results exceeding project recovery limits	Results exceeding laboratory recovery limits	% compliance (project DQIs)	Lab % compliance
Regular control samples (target recovery is 70–130% for soil and 80–120% for water)						
2006	Soil	2111	20	39	99%	98%
	Water	492	0	0	100%	100%
2011	Soil	3828	255	62	93%	99%
	Water	2986	869	74	71%	98%
Surrogate control samples (target recovery is 70–130%)						
2006	Soil	315	4	1	98%	99%
	Water	85	7	2	92%	98%
2011	Soil	402	24	13	94%	97%
	Water	326	136	37	58%	90%
Regular matrix spike recoveries (target recovery is 70–130% for soil and 80–120% for water)						
2011	Soil	1719	95	37	95%	98%
	Water	613	8	3	99%	100%
Surrogate matrix spike recoveries (target recovery is 70–130%)						
2011	Soil	707	76	4	89%	99%
	Water	194	19	2	90%	99%

Matrix spike recoveries were generally between 70% to 130% recovery for organics and 80%–120% recovery for inorganics. Recoveries for PFOA and PFOS as well as some SVOCs were marginally outside of these threshold values. The majority of matrix spike recoveries were reported to be within recovery limits, however there were some non-conformities. Sample heterogeneity may preclude compliance to the matrix spike recovery criterion.

Reported surrogate recoveries were outside the targets (70–130%) for some groundwater and soil samples. Where recoveries were greater than the upper data quality objective this indicates that the target analytes will be detected but the concentrations may be exaggerated. Where recoveries were less than the lower limit, target analytes may not have been detected if present at low concentrations; Sample chemistry may have interfered with the capability of the methods to detect and quantify some target analytes (matrix interference), however, not all surrogates for any given sample were outside of the acceptable range, therefore it is not considered that individual surrogate recovery results influenced the overall data quality.

Control sample recoveries were generally reported to be between 70% to 130% recovery for soil and 80% to 120% recovery for waters.

Method blanks results were reported to be below the laboratory LORs.

11.6 Data quality compliance summary

A summary of the compliance with project DQIs is presented in Table 11.7.

Table 11.7 Data quality indicators and compliance

Item	Objectives	Parsons Brinckerhoff 2011	Earth Tech 2006
Environmental Consultant	The Environmental Consultant should maintain Quality Assurance Systems certified to AS/NZS ISO 9001:2000.	Yes	Yes
Procedures	Completion of investigation works, interpretation of the data obtained and preparation of the technical report.	Yes	Yes
	All work conducted in accordance with relevant statutory OH&S and environmental sampling guidelines as well as standard environmental field procedures.	Yes	Yes
Sampling	Collection of samples undertaken by appropriately qualified and experienced personnel.	Yes	Yes
	Collection of samples undertaken following standard field procedures which are based on industry accepted standard practice and in general accordance (for soil) with the Australian Standard AS4482.1 (2005) Guide to the Sampling and Investigation of Potentially Contaminated Soil.	Yes	Yes
	Chain of custody documentation used to ensure the integrity of the samples from collection to receipt by the analytical laboratory.	Yes	Yes
Field equipment (PID, water quality meter)	Equipment used was serviced and calibrated as per the manufacturer requirements.	Yes	Yes
	Equipment was calibrated at the beginning of each day of fieldwork and during the day (as required).	Yes	Yes
Equipment decontamination	Decontamination of equipment undertaken after each sampling episode.	Yes	Yes
	Rinsate blanks to be non-detect for the potential contaminants.	Majority	Yes
	One rinsate blank per day.	Yes	No[1]
Transportation	With appropriate sample preservation holding time and chain of custody.	Yes	Yes
	One trip blank per sample batch sent to laboratory.	Yes	Yes
	Trip blanks to be non-detect for the contaminants of concern.	Yes	Yes
Field QA/QC - sampling to industry standard procedures	Approximately 1 in 10 intra-lab duplicates.	Yes	Yes
	Approximately 1 in 20 inter-lab laboratory duplicates.	Yes	Yes
	1 trip blank per sampling event.	Yes	Yes
	1 trip spike per batch of volatiles.	Yes	Yes
	1 equipment rinsate per sampling event.	Yes	Yes
	Field and laboratory acceptable limits are between 30–50% RPD for non-volatiles and semi volatiles as stated by AS 4482.1–2005.	Majority	Majority

	Non-compliances are documented in respective reports.	Yes	Yes
Laboratory analysis	Analysis was carried out by laboratories with NATA certification for all the required analysis.	Yes	Yes
	Detection limits are sufficient to enable comparison against the appropriate guidelines.	Yes	Yes
Acceptable limits for QA/QC samples	Surrogates: 70% to 130% recovery.	Yes	Yes
	Matrix Spikes: 70% to 130% recovery for organics or 80%–120% recovery for inorganics.	Yes	Yes
	Control Samples: 70% to 130% recovery for soil or 80% to 120% recovery for waters.	Yes	Yes
	Duplicate Samples: <4 PQL - +/- 2PQL 4-10PQL – 0.-25 or 50%RPD >10PQL – 0-10 or 30%RPD.	Majority	Majority
	Method Blanks: zero to <PQL.	Yes	Yes
	Are any exceedances to acceptable limits documented and discussed in the report.	Yes	Yes
Reporting	Report generally complies with the NEPC National Environment Protection (Assessment of Site Contamination) Measure (1999).	Yes	Yes

1. Only one rinsate blank completed as all equipment was dedicated with no potential for cross contamination

11.7 Data useability

Based on a review of the available laboratory QA/QC information, the indicators either all complied with the required standards or showed variations that are not considered likely to have significantly affected the quality of the data obtained. Parsons Brinckerhoff therefore considers that the sample collection documentation handling storage and transportation procedures utilised are of an acceptable standard and the analytical results provided by the laboratories over both the Parsons Brinkerhoff (2011) and Earth Tech (2006) investigations are deemed reliable and complete. Data is considered to be representative and appropriate for use in this assessment.

12. Discussion

Based on 2006 ESA and 2011 ESA data, soil impacts include TRH, heavy metals and AFFF. Groundwater impacts identified consist of TRH, dissolved heavy metals, AFFF, cis-1,2 DCE and TCE.

TRH was found to exceed ecological and/or management limits, and to potentially exceed HSLs, in Area 2 (PB_MW5, SW0201_SB036), Area 8 (SW0204_TP039), Area 10 (SW0191_TP032), Area 11 (SW0195_TP067, SW0207_SB074) and Area 20 (SW0185_TP001, SW0185_TP005). Ecological criteria and HSL comparisons were conservative as the data required for a complete assessment under the revised NEPM was not available; however, the results indicate that the potential for vapour intrusion risk and/or ecological impact may exist. The exceedances of management limits indicate that the TRH impact in soil may present an ongoing risk of LNAPL formation, explosive atmospheres or damage to sub-surface structures.

No heavy metals were detected above the relevant HILs for soil based on 2011 data across the Moorebank IMT site. The most elevated detections of heavy metals were generally located around the bridging yard (Area 8) and PRA yard (Areas 12 and 13) where a grit blasting facility and vehicle storage and maintenance area are located. Elevated metal concentrations in these areas are considered to be attributable to operational activities and are restricted to localised surface soils.

Based on the results of the Earth Tech 2006 investigation, there was only one exceedance of the HIL for lead reported within a surface soils sampled from Area 8 (bridging yard). This exceedance was vertically delineated and laboratory results indicated that surface the contamination at surface had not impacted underlying natural soils.

While concentrations of dissolved cadmium, copper, lead, nickel and zinc exceeding the adopted site assessment criteria were present in groundwater, concentrations were generally of similar magnitude across the Moorebank IMT site in up gradient and down gradient monitoring wells. Based on Parsons Brinckerhoff experience of similar sites in the locality, dissolved heavy metals are detected at concentrations that are generally consistent with those reported in groundwater in the region, therefore concentrations of elevated dissolved heavy metals reported in groundwater sampled at the Moorebank IMT site are considered to be indicative of regional background levels. Variations in the local geology and groundwater composition may be also contributing to the variations in the concentrations dissolved metals reported.

Based on the indicative risk assessment, the impacts to the off-site water body (Georges River) due to migration of impacted groundwater from the site are considered low given the section of the George River adjacent to the site is considered highly modified, and the river health rated as poor by the Community River Health Program. Further detail is provided in Appendix N.

It is considered that, based on the dissolved metals, TRH, TCE and perflourinated compounds identified in groundwater samples, groundwater is not suitable for potable use on site. The potential health risk to humans may be mitigated by restricting groundwater abstraction and use on site.

The generic groundwater investigation levels (ANZECC/ARMCANZ 2000) used in the screening assessment defines acceptable water criteria at the point of discharge or point of contact. As the groundwater unit beneath the Moorebank IMT site is in hydraulic continuity with the Georges River, attenuation of metals will occur in groundwater percolating through alluvium before reaching the surface water receptor.

Based on the above discussion, environmental and human health risks associated with reported chemical concentrations in groundwater are considered to be low. Surface water results do not indicate that migration of metals in groundwater is significantly impacting on the Georges River.

TRH impacts in soil are considered to be associated with areas of known underground fuel storage, usage or surface spills. TRH was not detected in groundwater sampled from any of the existing wells. However, TRH fractions C_{10}–C_{36} was detected in groundwater sampled from newly drilled monitoring wells, which were specifically installed in locations associated with known USTs.

Limited recent information is available on the condition, volumes and usage of the USTs that are operational at the Moorebank IMT site and no information pertaining to the non-operational USTs (i.e. decommissioning, removal or validation documents) were made available. Based on the 2005 HLA report, USTs are all single bunded tanks which are over 25 years in age with no cathodic protection. Should leaks from these tanks have occurred in the past, there may be localised soil and groundwater impacts. Results suggest that impacts may have occurred, based on the fact that TRH C_{10}–C_{36} was identified in groundwater sampled from wells installed in the vicinity of the known USTs.

Chlorinated hydrocarbon impacts have been confirmed in groundwater at the north-western portion of the Moorebank IMT site (Area 1, ABB boundary). Historical results presented in section 9.3.6 indicate there is a generally decreasing trend of TCE in groundwater. Based on the results of up gradient groundwater wells and a review of information pertaining to historical site uses, no potential on-site sources of chlorinated hydrocarbons have been identified. Therefore, the TCE and cis 1, 2 DCE detected in groundwater at the Moorebank IMT site are likely to be attributable to an off-site source.

Chlorinated hydrocarbon compounds such as TCE are commonly used as industrial solvents, particularly as a degreaser for metal parts. Considering that the Moorebank IMT site immediately adjacent to the northern boundary of the Moorebank IMT site is utilised for the manufacture of transformers, switchgear, cables and other associated power transmissions equipment, such products may have been used historically at the adjacent site. Additional well installation of groundwater monitoring wells within the Moorebank Barracks site boundary for further delineation of TCE impacts has not been possible due to the limiting extent of the northern fence line; therefore the likely source of this contamination has not been confirmed. To determine whether such contaminants are present in groundwater on the adjacent site, the Commonwealth may consider engagement with the adjacent site owners to facilitate a discussion in relation to this matter.

Due to the proximity of the TCE impacted groundwater to the Georges River (less than 10 m), the relatively high hydraulic conductivity of alluvial soils in this area (generally sandy clays) and the inferred direction of groundwater flow (towards the Georges River), off-site migration of contaminated groundwater may be occurring. Owners of land who become aware that the land has been contaminated must notify NSW EPA if the contamination meets the criteria set out in the NSW DECC (2009) Guidelines on the Duty to Report Contamination to enable the NSW EPA to determine whether or not contamination is significant enough to warrant regulation. The guidelines set out particular trigger levels for various contaminants. Although a trigger value for TCE is not listed in the NSW DECC (2009) Guidelines on the Duty to Report Contamination, a trigger value of 0.3 µg/L (based on the Australian drinking water standard) is listed for vinyl chloride which is a degradation product of TCE and DCE and is a known human carcinogen. The data currently available for vinyl chloride is not of a sufficient resolution (the standard limit of reporting is 50 µg/L) to determine whether concentrations in groundwater are above 0.3 µg/L. The guidelines also state that notification of the Moorebank IMT site is only required if a contaminant has entered groundwater and the concentration is above that specified in Appendix A of the Duty to Report guidelines and if the concentration of the contaminant will foreseeably continue to remain above the specified concentration. Further groundwater monitoring in this area may be required in order to determine if vinyl chloride is present at concentrations above 0.3 µg/L.

Should the eventual design of the IMT include construction activities within Area 1 where the TCE plume has previously been identified (likely associated with the northern rail access option), further assessment of potential vapour intrusion risks during and after construction may be required. It is anticipated that management of groundwater impacts identified in this area would potentially be limited to a monitored natural attenuation approach and it is therefore considered that the impacts identified are not likely to significantly affect the feasibility of the proposed use of the Moorebank IMT site.

Localised detections of formaldehyde were present in groundwater. As concentrations were below the drinking water GIL for formaldehyde (0.5 mg/L) the potential human health risk is considered to be negligible.

Perfluorinated chemicals (PFOA and PFOS) were detected in groundwater in areas of the Moorebank IMT site where firefighting activities were undertaken previously. It is noted that perfluorinated chemicals (PFOA and PFOS) were also identified in soil. PFOA and PFOS can be persistent in the environment and are emerging environmental pollutants with relatively limited toxicity information. In the absence of a suitable Australian guideline, the US EPA tap water RSLs for perfluorinated chemicals (PFOA and PFOS) was adopted. Concentrations in groundwater exceeded the adopted criteria, however it should be noted that the adopted criteria is a drinking water standard so exceedances are above conservative guidelines. Due to the absence of relevant guideline, these concentrations have not been assessed for commercial industrial end use.

Elevated heavy metals concentrations were identified in sediments and surface waters across the Moorebank IMT site above the adopted investigation criteria, however, it is not considered that management of sediments or surface water to address the contaminants of concern identified would affect the feasibility of the proposed development. Should removal of sediments and/or surface waters be required to facilitate the redevelopment of the Moorebank IMT site, disposal should be in accordance with relevant waste classification and/or licencing requirements.

Based on limited soil sampling for ASS and the fact that standing groundwater levels are likely to be below the extent of the proposed redevelopment footprint it is considered unlikely that PASS would affect the feasibility of the proposed development. Material in the shallow unsaturated zone is already exposed to an oxidising environment therefore the potential for oxidation of sulfides is likely to be reduced.

13. Site conceptual model and qualitative risk assessment

The site conceptual model (SCM) for the Moorebank IMT site has been refined based on the results of intrusive investigations and current information about the Moorebank IMT site. The SCM assesses the potential sources of impact contaminants of concern transport mechanisms and receptors. A visual interpretation of the SCM is presented in section 18 Figure 20.

For a potential risk to be present at a site the following components are required:

- a source (e.g. primary sources leaking fuel tanks; secondary sources impacted soils/groundwater);
- a receptor (e.g. on-site worker); and
- a transport mechanism between the source and receptor (e.g. vapour migration groundwater migration).

If a source, a receptor and a transport mechanism are all present then a complete exposure pathway exists. The objective of the qualitative risk assessment is to identify any actual or potentially complete exposure pathways.

13.1 Potential sources of contamination

Potential on site sources of contamination at the Moorebank IMT site include:

- surface soils impacted by operational defence activities;
- fuel and waste oil storage (existing ASTs and USTs);
- TCE impacted groundwater;
- buried fill potentially contaminated with asbestos;
- asbestos within the fabric of existing buildings; and
- residual aqueous film forming foam compounds in soil.

13.2 Potential exposure pathways

The anticipated primary transport media for migration of contaminants at this site include:

- leaching and migration of contaminants vertically into underlying groundwater systems and migration/ seepage;
- surface water flow to the Georges River and Anzac Creek;
- lateral migration of contaminated water through preferential pathways such as drainage lines or geological features;
- soil to human exposure routes (i.e. direct contact with soils (dermal contact, ingestion and inhalation);
- groundwater to human exposure routes (i.e. direct contact with surface water or groundwater via pumping to other areas of the Moorebank IMT site or abstraction of potentially impacted groundwater from the identified registered bores);

- soil to dust to human exposure routes (dermal contact, ingestion and inhalation due to dust migration); and
- vapour migration from soil or groundwater.

13.3 Potential receptors

Potential receptors for potential contaminants include:

- surface waters on and adjacent to the Moorebank IMT site (on-site ponds, Georges River and the Anzac Creek);
- groundwater beneath the Moorebank IMT site;
- current site users (such as defence personnel) and future site users (such as commercial workers or site visitors) and utility/construction personnel undertaking works at and in the vicinity of the Moorebank IMT site;
- potential downstream recreational users of the Georges River;
- current and future site users and utility/construction personnel undertaking works at the Moorebank IMT site; and
- potential down gradient users of abstracted groundwater for domestic use.

13.4 Potentially complete exposure pathways

An indicative risk assessment (RA) was conducted as part of the ESA, to provide an evaluation of the potential risks to human health and the adjacent water body (Georges River) due to the contaminants identified in soil and groundwater on-site.

The indicative RA focused on evaluating the potential risks to receptors at the Moorebank IMT site based on a commercial/industrial land use, with consideration for river front open space with public access (as a conservative approach). This assessment is provided as Appendix A14. A summary of the exposure analysis is provided in Table 13.1.

Table 13.1 Exposure analysis summary

Source media	Exposure scenario	Chemicals of potential concern	Receptor
Soil	Inhalation of chemical vapours volatilised into an indoor commercial space	TRH C_6-C_{10}	Commercial workers
Soil	Inhalation of chemical vapours volatilised into a shallow excavation trench	TRH C_6-C_{10}	Maintenance workers
Soil	Direct contact with impacted soil or dust generated from impacted soil	Perfluorinated compounds, heavy metals	Maintenance workers (utility and landscape)
Groundwater	Direct dermal contact with or ingestion of impacted groundwater (via abstraction wells)	TRH C_{10}-C_{36}, perfluorinated compounds, dissolved heavy metals	Potential on-site and off-site users of groundwater
Groundwater	Inhalation of chemical vapours volatilised into an indoor commercial space	TCE, DCE, VC	Commercial workers
Groundwater	Inhalation of chemical vapours volatilised into a shallow excavation trench	TCE, DCE, VC	Maintenance workers

A vapour assessment was undertaken and as a conservative approach, a lifetime exposure to COPC vapour by the populations of concern was assumed. A vapour intrusion model was used to predict the exposure concentrations of COPC (i.e. in indoor air for commercial worker and in a shallow trench for maintenance workers). The assumptions for the vapour intrusion model inputs are presented in Appendix A14.

The results of the indicative risk assessment indicated that the chemical concentrations in soil and groundwater currently identified at the Moorebank IMT site do not pose health risks to future users of the open space and workers at the Moorebank IMT site.

Where TCE has been identified in groundwater, groundwater was gauged at 7 m BGL therefore direct contact with the saturated zone is considered unlikely unless deep excavation were to occur in this area.

It is considered that groundwater beneath the Moorebank IMT site is not suitable for potable use due to the localised concentrations of TRH, dissolved metals, TCE and perflourinated compounds identified which exceed the criteria for potable use. Potential health risk to humans may be mitigated by restricting abstraction of groundwater for domestic use at the Moorebank IMT site. Based on a review of licensed borehole records, there are currently no known registered bores for domestic extraction purposes located within a 500 m radius of the Moorebank IMT site.

It is likely that the majority of the Moorebank IMT site is likely to be capped with concrete hardstand which is likely to mitigate any potential exposure risk to future site users, however a complete exposure pathway may exist to site workers during excavation and construction activities. For example, there is the potential for shallow soil contamination to become airborne if significant dust is generated during site redevelopment that may impact on and off-site human receptors through dermal contact and inhalation. It is considered that potential risk of exposure could be managed via implementation of appropriate management controls which should incorporated into a CEMP, which documents the appropriate management measures required for the protection of human health and the environment.

In summary, it is considered that potentially complete exposure pathways and associated risks could be appropriately managed through the use of a CEMP and the RAP (refer to Appendix F) and would not affect the feasibility of the Moorebank IMT site.

In the interests of financial and environmental sustainability, the remediation and management strategies (and associated cost estimates for remedial activities) should be development specific with engineering design solutions incorporated where possible to reduce the volumes of material requiring removal or disposal off-site.

14. Conclusions

Surficial geology encountered at the site generally comprised fill with variable alluvial deposits. Saturated horizons were encountered between 7 and 15 m BGL within the natural alluvium.

Based on analytical soil results, contaminant impacts were identified in shallow soils, generally consisting of localised detections of TRH, metals, PAHs, BTEX, DDD, DDE, chlordane, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS).

Soil results showed potential marginal and localised exceedances of the commercial land use HSLs for TRH fraction C_6 to C_{10}. Petroleum hydrocarbon management limits (PHML) were also exceeded for four samples collected from the vehicle storage and maintenance area (Area 2), the dust bowl (Area 11), the plant, road and airfield (PRA) yard (Area 13) and former fire training area (FTA) (Area 20). The PHMLs are to used consider the formation of LNAPLs, fire and explosion risks and damage to buried infrastructure and represent the maximum values that should remain in a site following evaluation of human health and ecological risks and risks to groundwater resources and apply to all soil depths. During future excavations these areas will need to be appropriately remediated and/or managed to remove any ongoing risks that may be associated with the TRH impacts identified.

Only one sample exceeded the adopted health investigation limit (HIL), for lead. Results were also assessed against the most conservative EILs provided within the NEPM (2013) and these limits were exceeded for copper, lead, nickel and zinc.

Soil contamination is limited to TRH and heavy metals impacts identified in near surface soils in localised areas of the site, associated with areas of operational plant and machinery (such as the bridging yard (Area 8) and PRA yard and wash bay (Areas 12 and 13)), the vehicle maintenance and storage area (Area 2), the former fire training areas (Area 20) and where underground storage tanks (USTs) are or were present. Where elevated concentrations of contaminants have been detected, these have generally been vertically delineated to indicate that natural soils are not contaminated and the soil contamination does not intercept the saturated zone.

Asbestos cement fragments have been identified in localised surface soils and within waste fill at the Moorebank IMT site and may present a hazard if not appropriately managed.

The identified chemical concentrations in soil do not pose health risks to future site users based on the proposed development design. A potential human health risk from the soil contamination identified may exist to excavation workers during redevelopment. However, it is considered that this risk can be adequately managed through the use of a construction environmental management plan (CEMP) that outlines site management procedures, exposure mitigation controls and occupational hygiene practices to be implemented during excavation works to mitigate potential exposure pathways.

The site is has been largely modified for use as a Defence site and is likely to be further modified based on the proposed IMT use. There is no evidence to suggest that the contamination identified in soils and groundwater on-site has affected the established riparian vegetation as no evidence of plant stress was noted. Although the adopted EILs were exceeded for TRH and metals, the screening values are considered conservative and the value of the site as a terrestrial ecosystem is considered to be limited based on the proposed design. On this basis, the chemical concentrations identified in soil on-site are not considered to pose significant risk to ecological receptors.

Based on available soil analytical results, it is considered likely that the majority of the soil excavated from the Moorebank IMT site during redevelopment would likely be classified as general solid waste. Where asbestos is present within excavated materials this would need to be managed as waste containing

asbestos. A waste classification should be completed for all excavated soil destined for reuse or disposal off-site.

Based on limited analytical results, soils with acid generating potential (ASS) are present in some locations at the Moorebank IMT site. Subsurface material may pose an acid generation risk if exposed to oxygen during redevelopment. This potential issue merits further investigation and would need to be addressed within an appropriate management plan prior to site redevelopment (developed with reference to the Acid Sulfate Soils Management Advisory Committee (ASSMAC) Assessment Guidelines (1998)), with active on-going management through the construction phase as prescribed within the plan (as required).

Following a qualitative analysis, a potentially complete exposure pathway has been identified for the chlorinated hydrocarbon contamination (TCE) identified in groundwater in the north-west of the Moorebank IMT site (Area 1). It is considered that a potential risk may exist to down gradient environmental receptors should contamination migrate off site to the Georges River.

It is considered that, based on elevated dissolved lead and nickel, TRH, TCE and perfluorinated compounds identified, the groundwater beneath the site is not considered to be suitable for potable use. The potential health risk to humans may be mitigated by restricting groundwater abstraction and use on site. Based on an indicative risk assessment, potential vapour risks associated with the TCE plume in groundwater (area 1) are negligible based on theoretical input values. Should the eventual design of the IMT include construction activities within area 1 (likely associated with construction of the northern rail access option), further assessment of potential vapour intrusion risks during and after construction may be required.

Based on the Community River Health Monitoring Program (2009 and 2010) the overall grade of freshwater areas in the mid Georges River has been consistently reported as poor. The report detailed that macro invertebrate communities are dominated by pollution tolerant species. The waterways in this part of the catchment have been affected by degraded water quality, Riparian vegetation and depleted macro invertebrates typically due to urbanisation. It is not considered that the soil and groundwater contamination identified at the Moorebank IMT site contributed significant additional impacts to the water quality within Georges River. Impacts due to potential migration of contaminated groundwater and surface water from the IMT site to the Georges River are considered to be low.

Based on the SRS undertaken, no burial pits or any indication of their presence was discovered in areas surveyed or excavated during intrusive works. Areas of buried fill may exist in other areas of the Moorebank IMT site that have not yet been identified, however, based on the fact that no grossly contaminated fill was identified in areas of the Moorebank IMT site already assessed, it is considered likely that fill materials encountered during site redevelopment can be managed via appropriate handling of excavated waste which should be detailed in the CEMP.

Ordnance related wastes (UXO and EOW) exist at the Moorebank IMT site. Specialist advice received from G-Tek (2011) however, indicated that the site has a very low potential to contain remnant UXO/EOW containing high explosive or other energetic material. Items of military origin have the appearance of UXO/EOW and may cause concern if encountered during redevelopment works but the occupational health and safety risk of such items is considered to be perceptual rather than actual.

Based on the available data, the site is considered suitable for industrial commercial use subject to implementation of the RAP measures in Appendix F and management controls during site development and post construction management where contamination issues may be ongoing to mitigate the potential risks that have been identified. It is acknowledged that there may be areas of the Moorebank IMT site where contamination may be present which has not been identified during previous investigations However, it is considered that this Phase 2 ESA incorporating anecdotal data from earlier investigations, provides sufficient information on which to base recommendations for remediation and management measures and to calculate broad scale cost estimates for the works to manage the contamination impacts.

15. Remediation action plan

A remediation action plan (RAP) has been developed and is provided in Appendix F, which addresses the following:

- requirements to decommission and remove of all on-site USTs;
- clearance/clean-up of spent UXO/EOW items prior to site development;
- management requirements for known waste fill and fill encountered during site development, including asbestos in soil; and
- requirements for additional monitoring relating to groundwater (associated with the TCE groundwater impacts identified the north-west of the site (area 1)), PASS and sediments and surface waters.

In addition the following management plans should be developed prior to site works commencing:

- CEMP to manage surface soils, excavated materials and incorporating measures to be implemented during redevelopment of the Moorebank IMT site to mitigate any potential human health risks; and
- UXO/EOW management plan which documents a procedure to manage military related finds encountered during redevelopment works.

The RAP has been developed to incorporate sustainability principles. The preferred option for remediation and management of buried waste fill maximises reuse of on-site resources and minimises the need for off-site disposal and subsequent importation of clean backfill materials. Where impacted soils are removed from excavations undertaken to fulfil the construction design, if they are not significantly contaminated or can be rendered uncontaminated through appropriate on-site processing and laboratory validation (and provided materials are geotechnically suitable, or can be made geotechnically suitable for reuse through segregation and or mechanical processing), this is the preferred and most sustainable option. This includes the screening and segregation of buried construction and demolition type waste fill components (such as wood, metals, rubble and ACM) and stockpiling on-site to allow for further processing and validation testing of material to determine its suitability for reuse as backfill material on-site or for removal off-site for recovery, recycling or disposal to landfill.

16. Statement of limitations

Scope of services and reliance of data

This report has been prepared in accordance with the scope of work/services set out in the contract, or as otherwise agreed, between Parsons Brinckerhoff and the client. In preparing this report, Parsons Brinckerhoff has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, Parsons Brinckerhoff has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Parsons Brinckerhoff will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Parsons Brinckerhoff.

Study for benefit of client

This report has been prepared for the exclusive benefit of the client and no other party. Parsons Brinckerhoff assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with in this report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in this report (including without limitation matters arising from any negligent act or omission of Parsons Brinckerhoff or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in this report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

Environmental conclusions

In accordance with the scope of services Parsons Brinckerhoff has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the Moorebank IMT site at the time of preparing the report including the presence or otherwise of contaminants or emissions. Also, it should be recognised that site conditions including the extent and concentration of contaminants can change with time.

Within the limitations imposed by the scope of services the monitoring testing sampling and preparation of this report have been undertaken and performed in a professional manner in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty expressed or implied is made.

Other limitations

To the best of Parsons Brinckerhoff's knowledge, the facts and matters described in this report reasonably represent the conditions at the time of printing of the report. However, the passage of time, the manifestation of latent conditions or the impact of future events (including a change in applicable law) may have resulted in a variation to the conditions.

Parsons Brinckerhoff will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

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18. Figures

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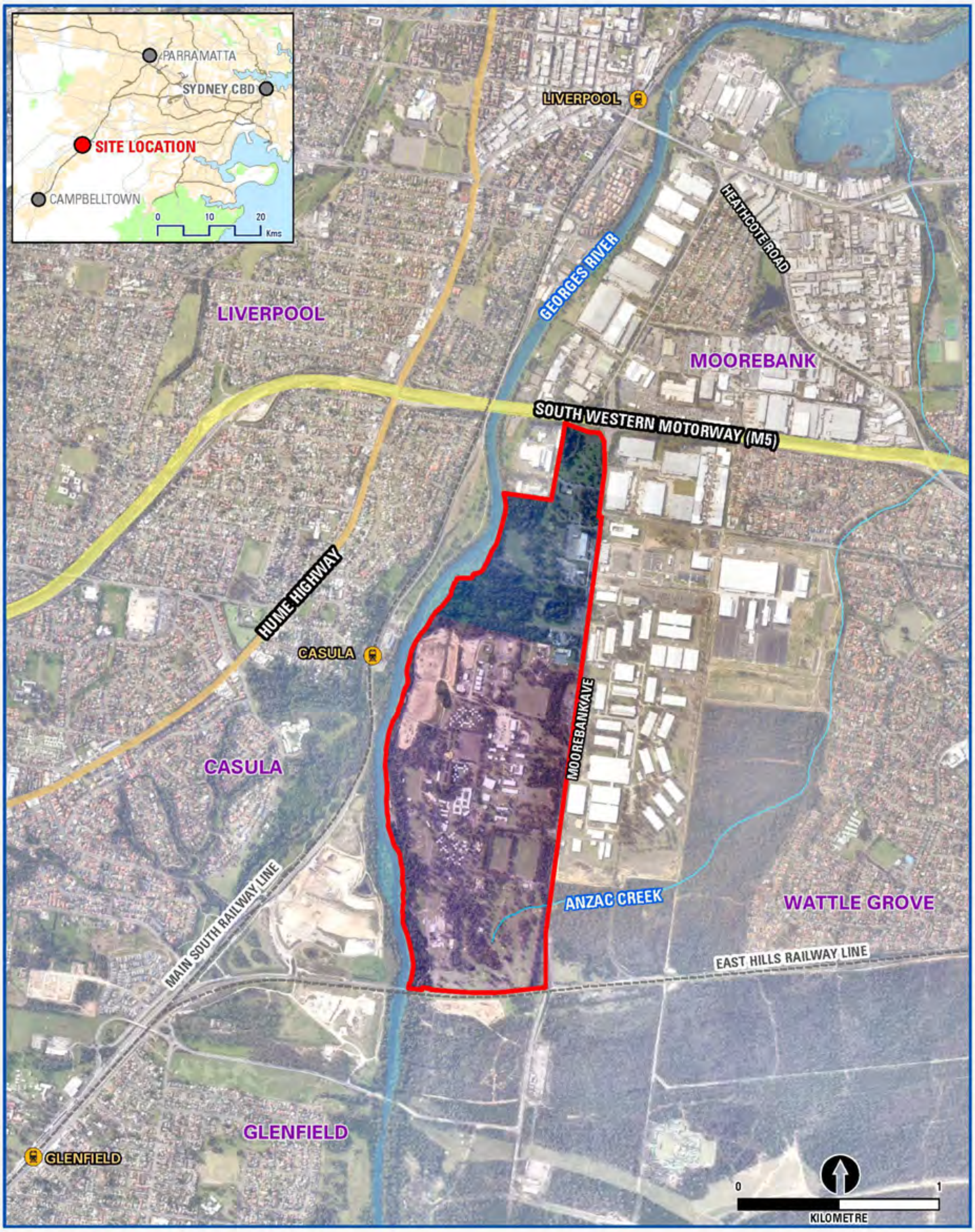

Moorebank IMT main site — Rail line & station

Moorebank barracks

Steele barracks

Figure 1: Site location plan

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Figure 2: Site area and surrounding features

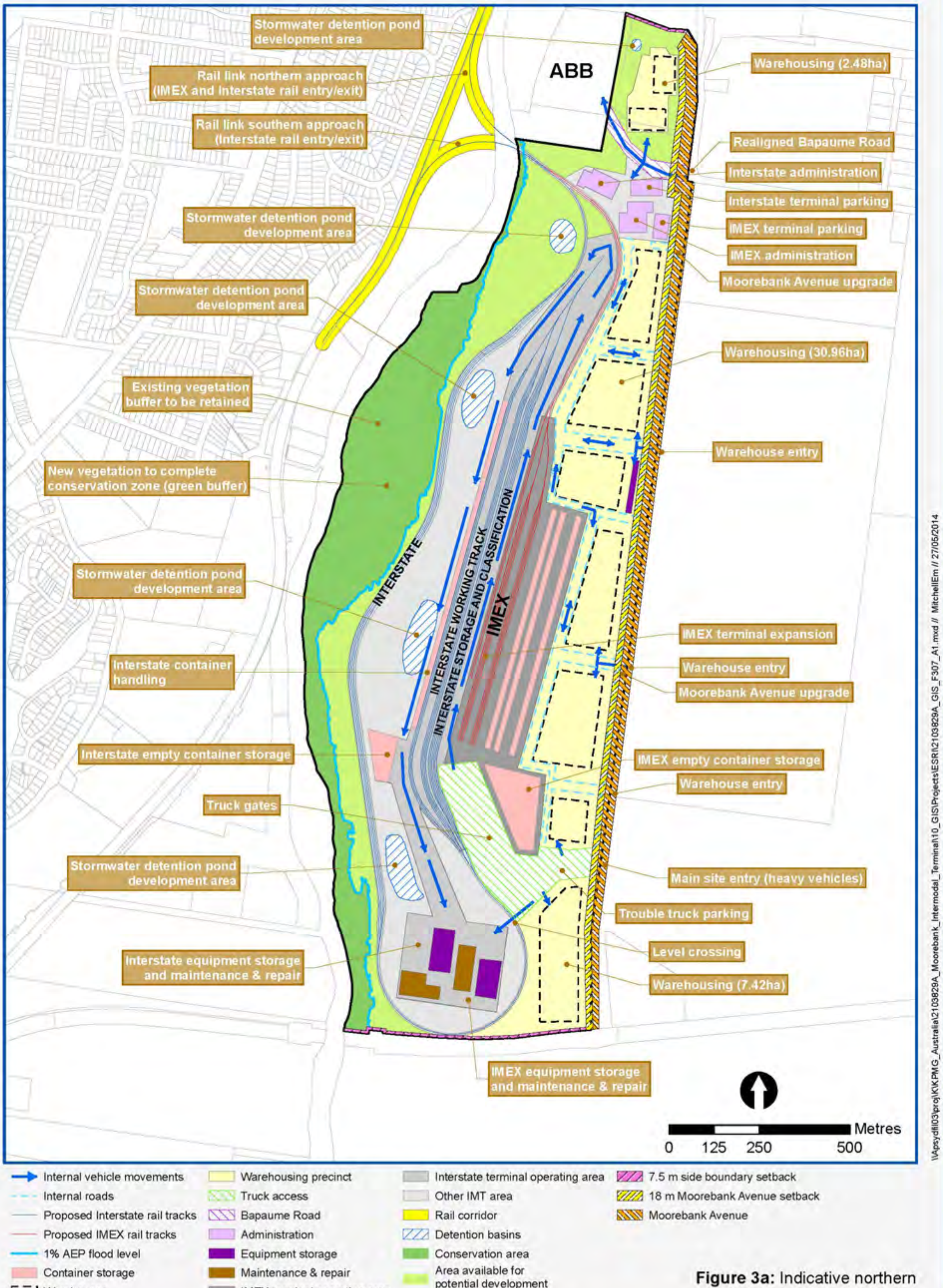

Figure 3a: Indicative northern rail connection concept layout

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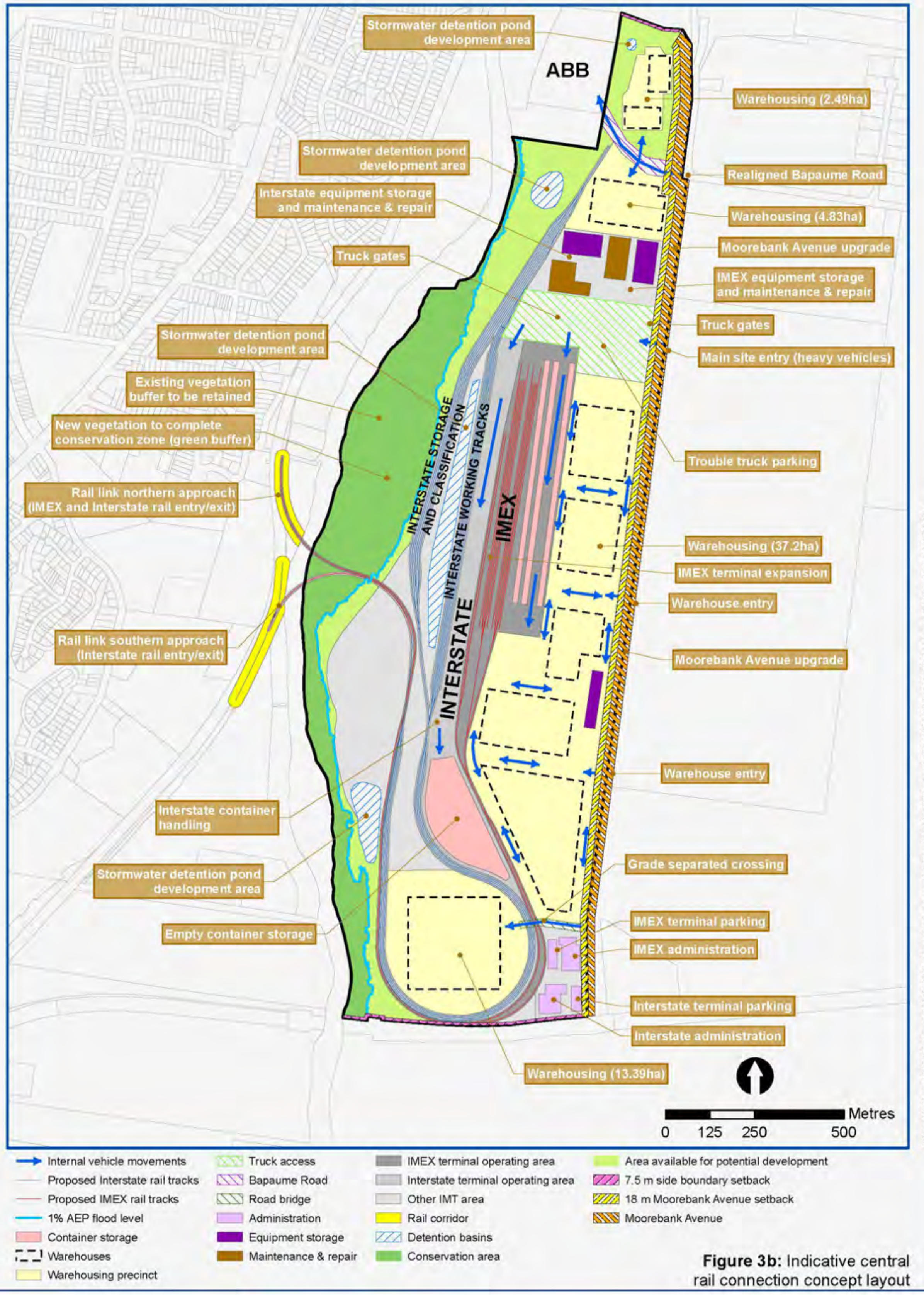

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Figure 3b: Indicative central rail connection concept layout

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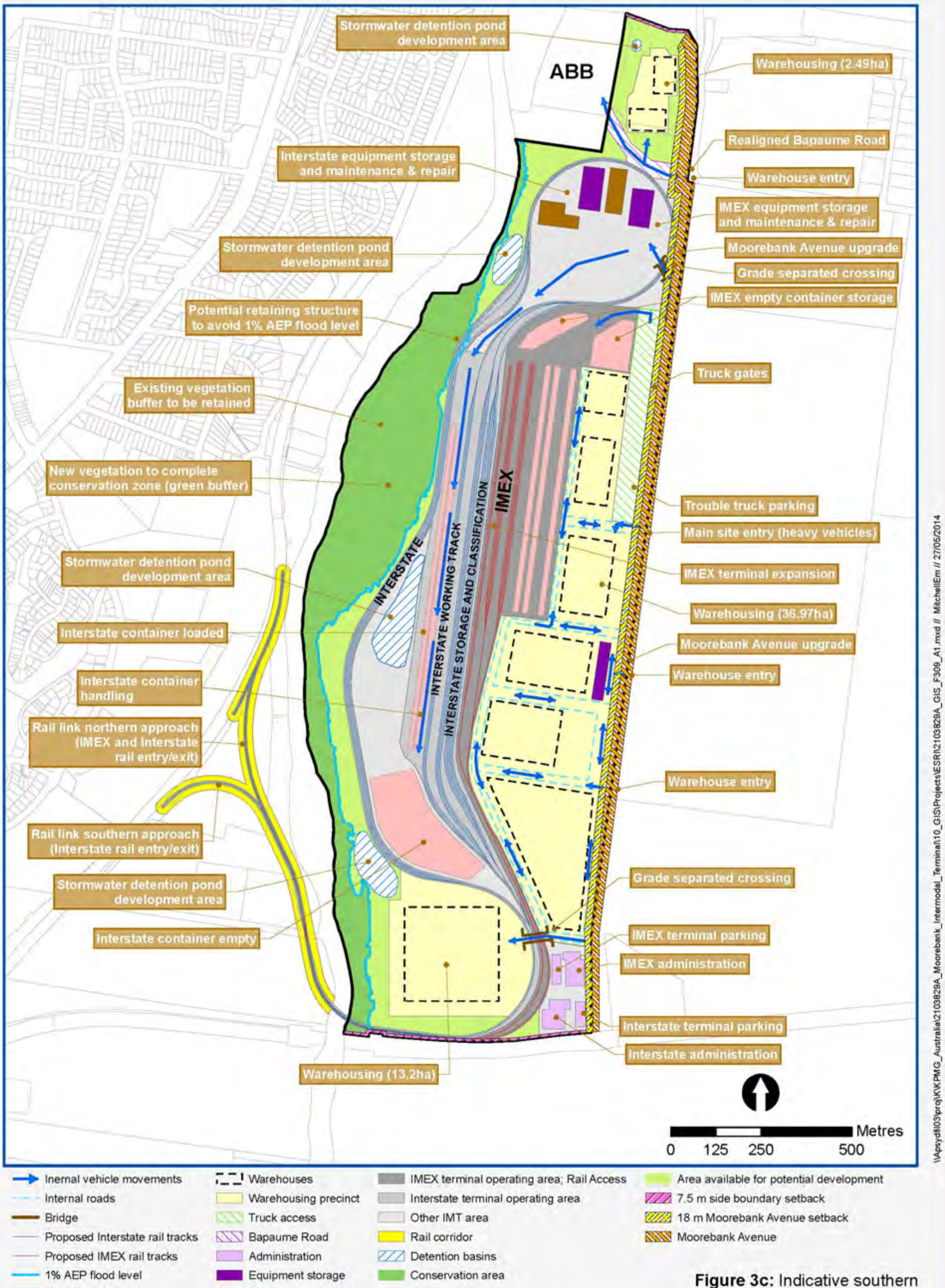
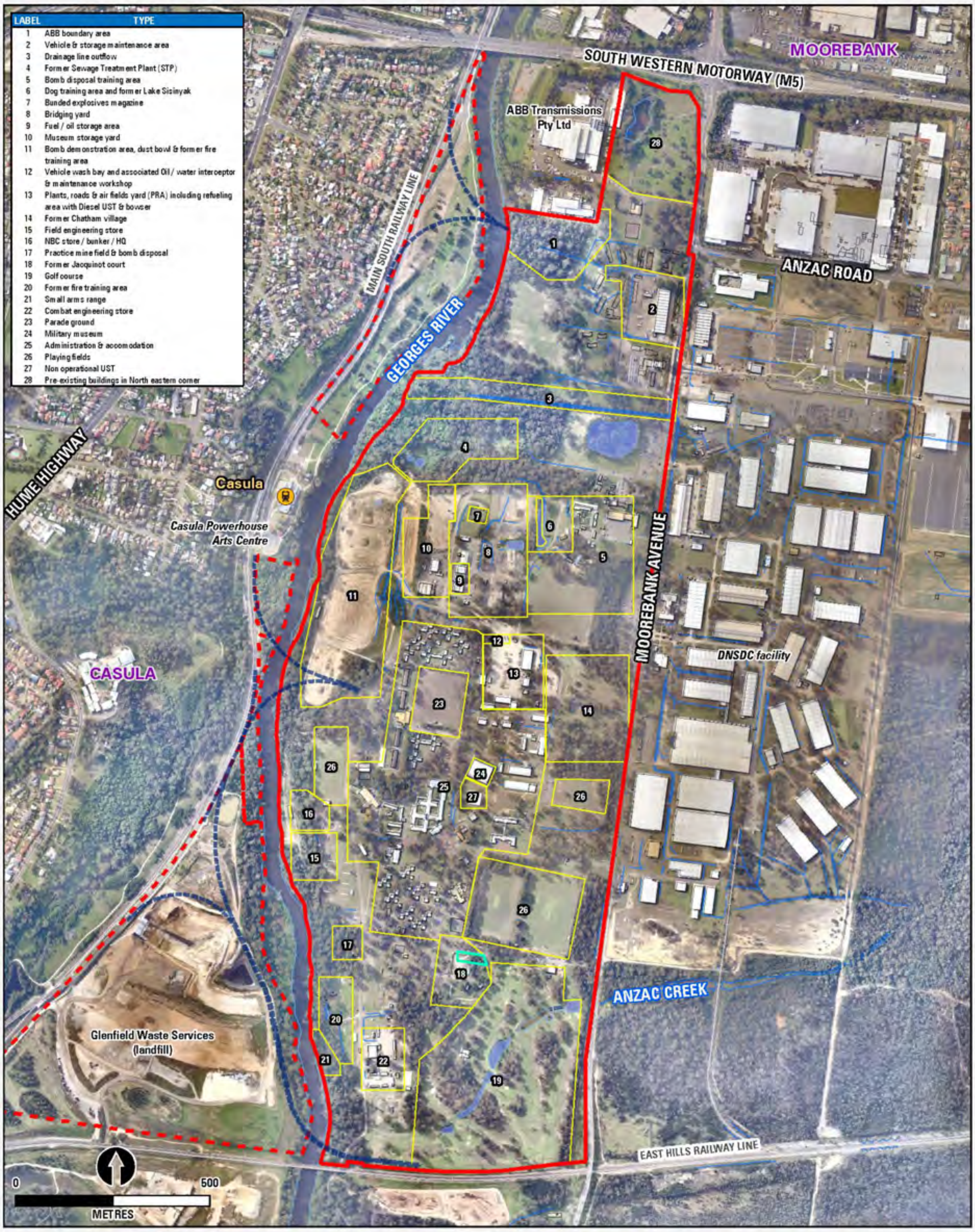
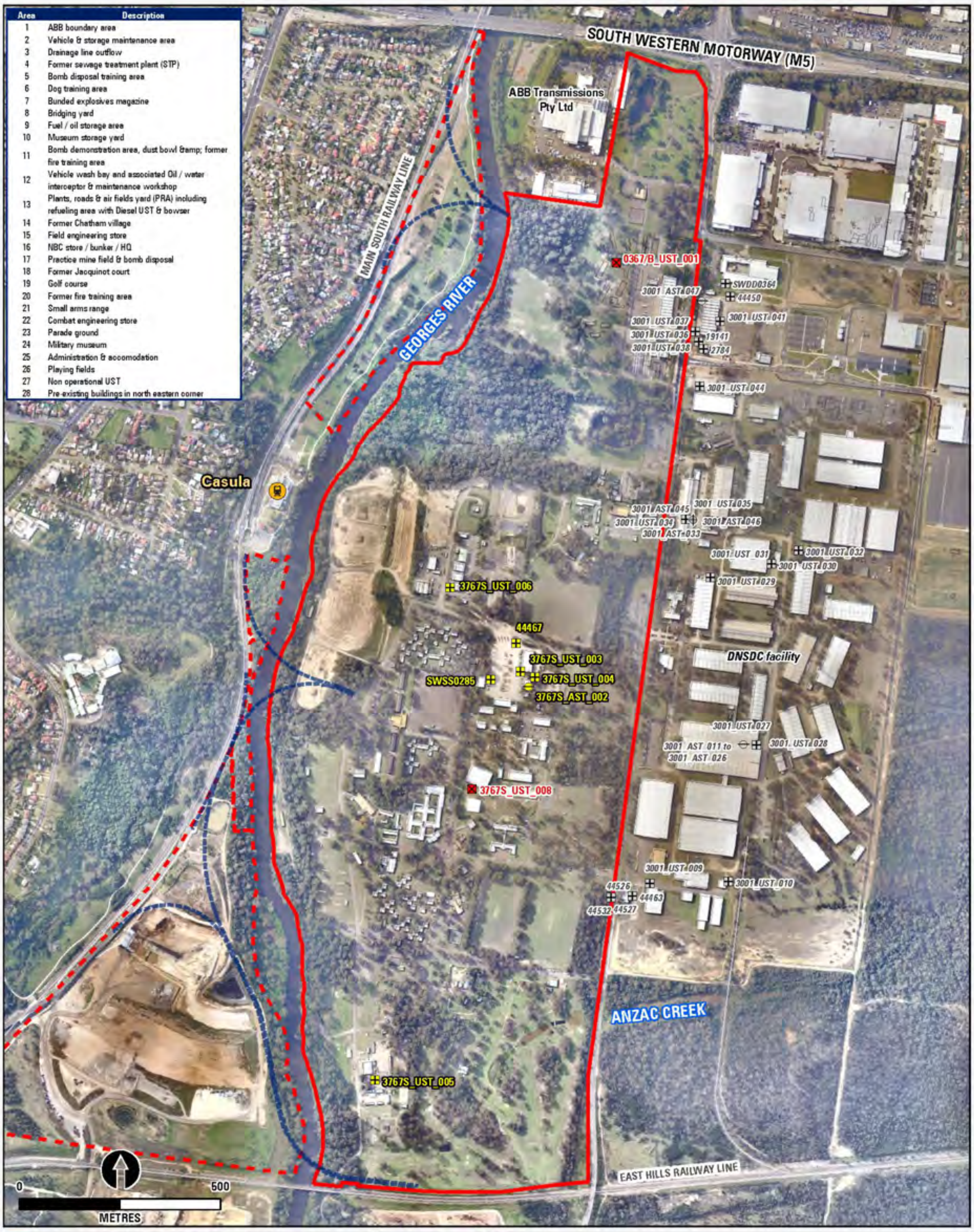


Figure 3c: Indicative southern rail connection concept layout



Moorebank IMT main site
Land associated with Moorebank IMT rail access options
CLM investigation areas
Suspected asbestos impacted soil mound
Footprint of rail corridor associated with the proposed rail access options
Rail line
Structures
Stormwater drainage
Water features / reticulation

Figure 4: Areas of potential concern based on Phase 1 ESA



Moorebank IMT main site

Land associated with Moorebank IMT rail access options

Footprint of rail corridor associated with the proposed rail access options

Rail line

Structures

Locations of USTs and ASTs

Non-operational UST

Operational UST

Non-operational AST

Operational AST

Operational UST (offsite)

Non-operational AST (offsite)

Operational AST (offsite)

Non-operational UST (offsite)

Figure 5: Existing fuel Infrastructure

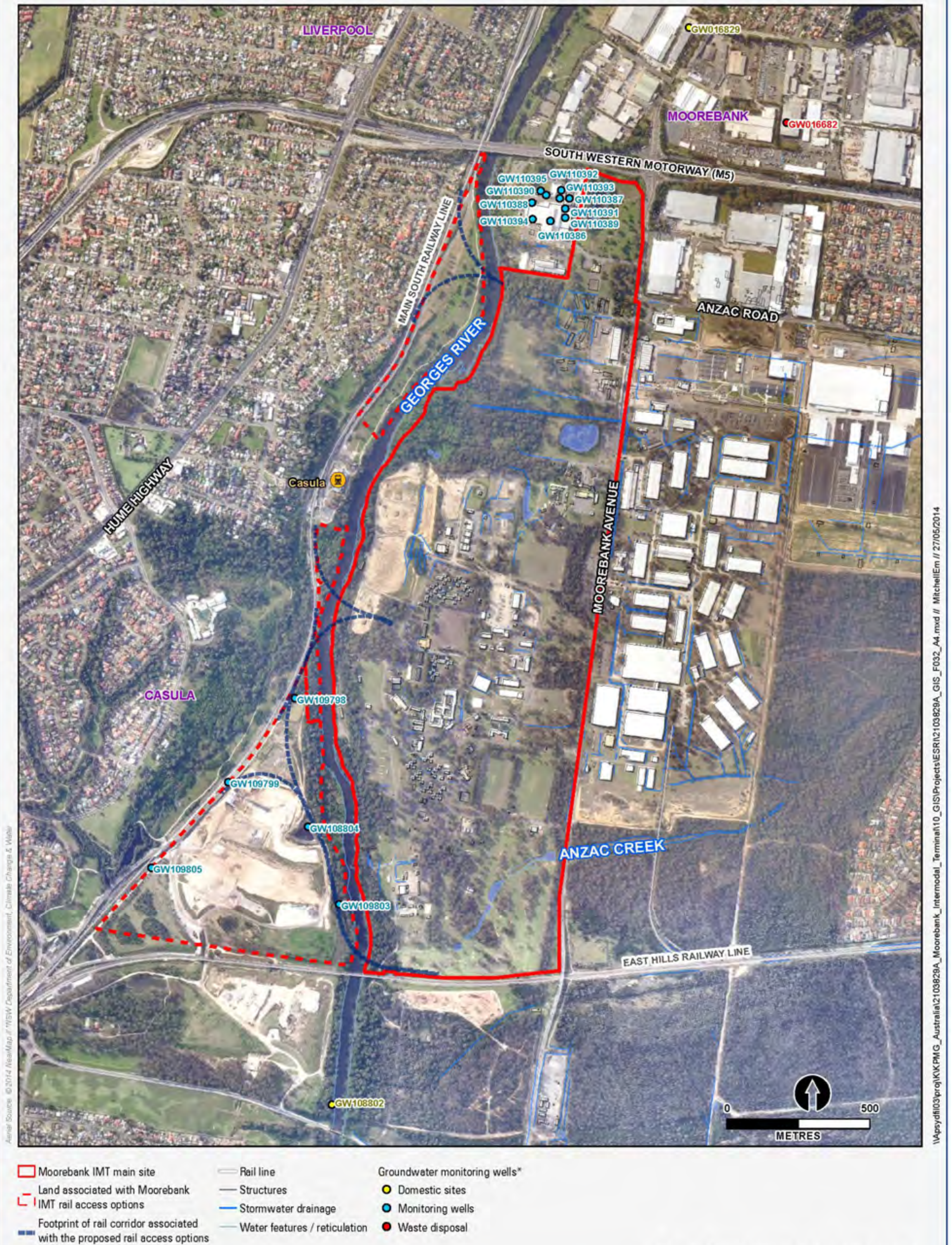


Figure 6: Licenced bore search results

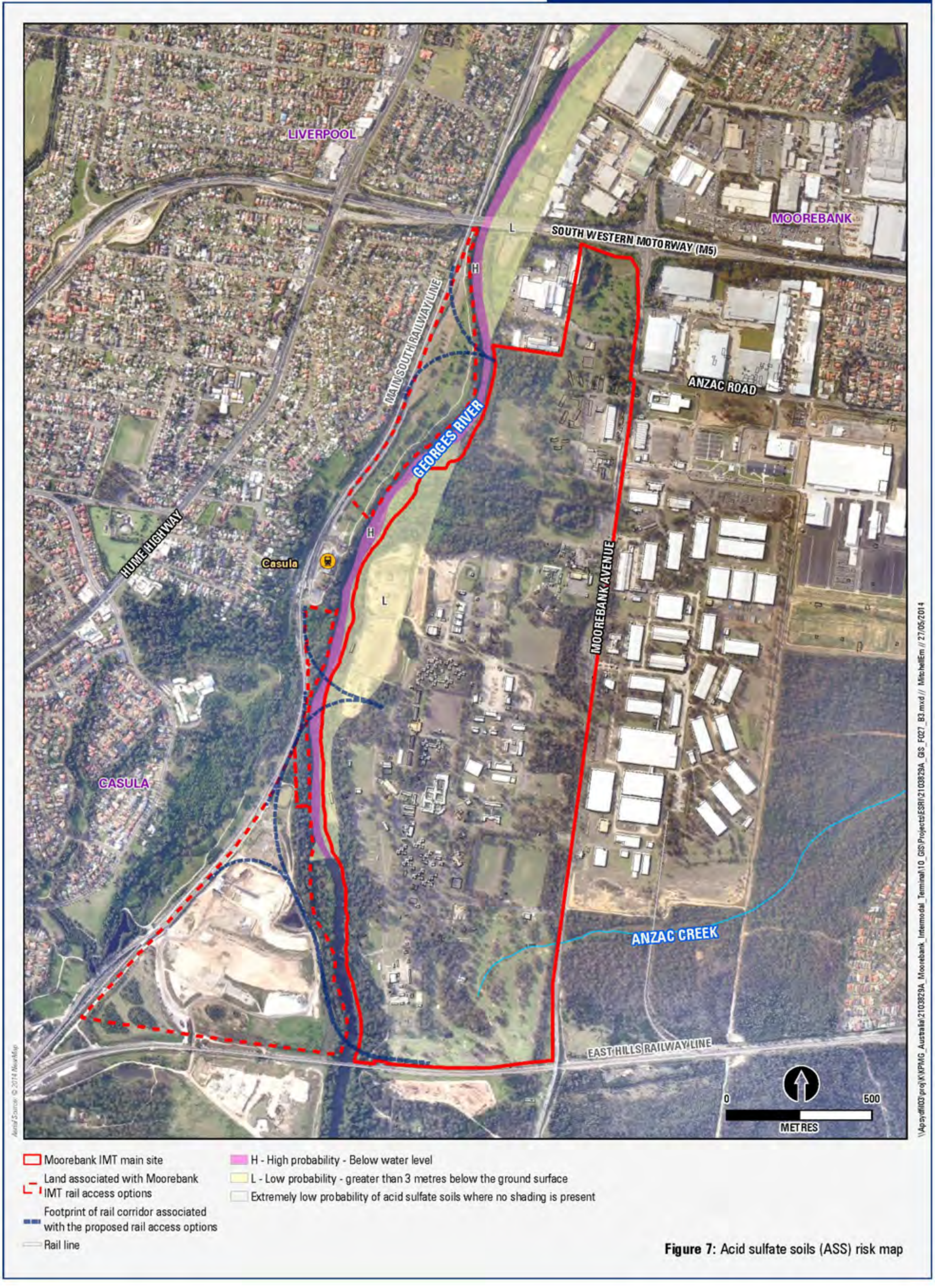


Figure 7: Acid sulfate soils (ASS) risk map

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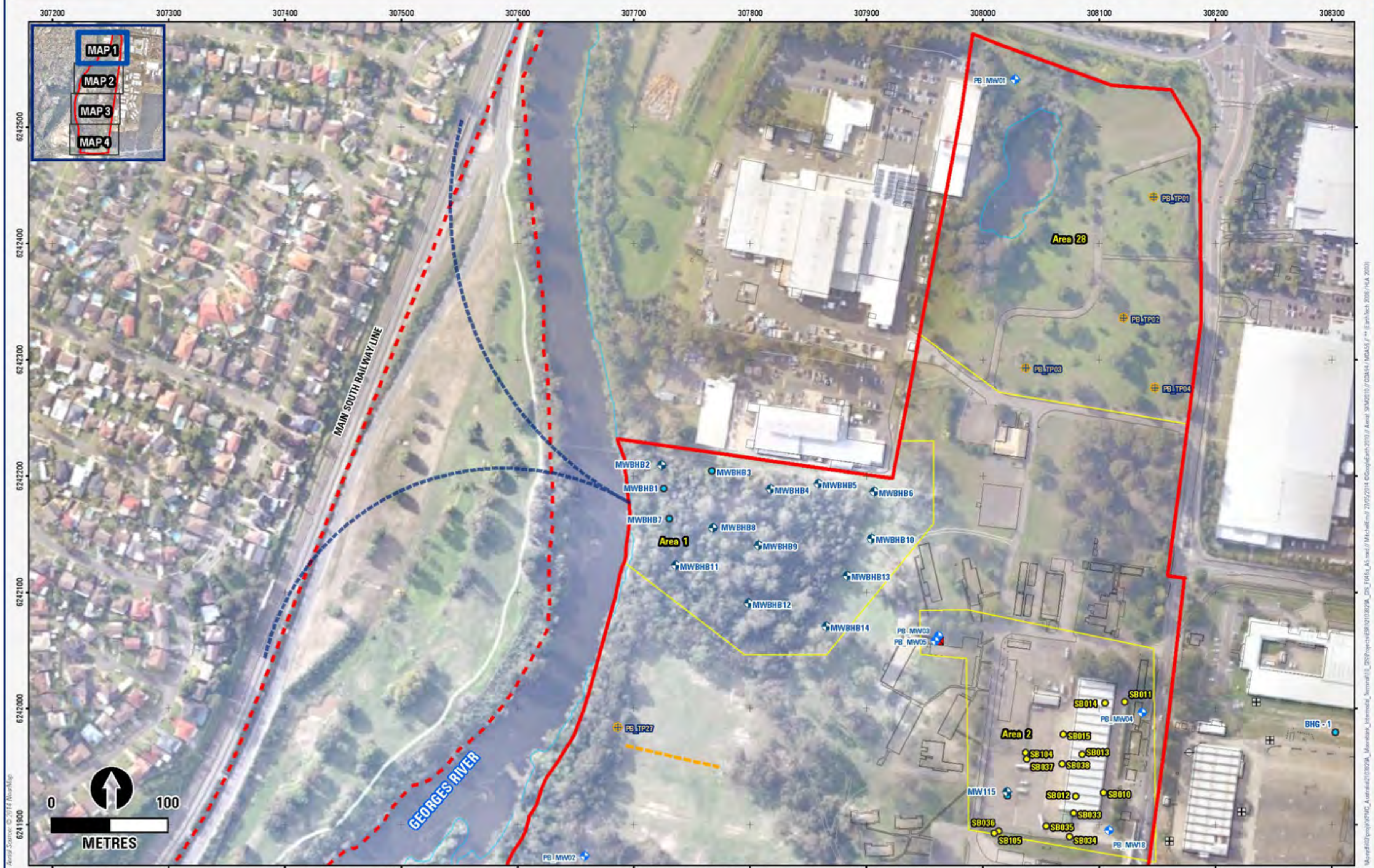

- Moorebank IMT main site
- Land associated with Moorebank IMT rail access options
- Footprint of rail corridor associated with the proposed rail access options
- CLM investigation areas
- Geophysical transects (22 Feb 2011)
- UXO transects (G-tek 2011)

Previous investigation locations**

- Monitoring well
- Sediment sample
- Soil bore
- Surface scrape
- Hand auger
- Test pit
- NOW monitoring wells

PB sampled locations (2011)

- Hand auger
- Monitoring well
- Sediment sample
- Soil bore
- Surface water
- Test pit

Previous locations of USTs

- Operational UST
- Non-operational UST
- Operational AST
- Non-operational AST
- Operational UST (offsite)
- Non-operational UST (offsite)
- Operational AST (offsite)
- Non-operational AST (offsite)

Figure 8a: Sampling locations (Earthtech 2006 & Parsons Brinckerhoff 2011)

Map 1

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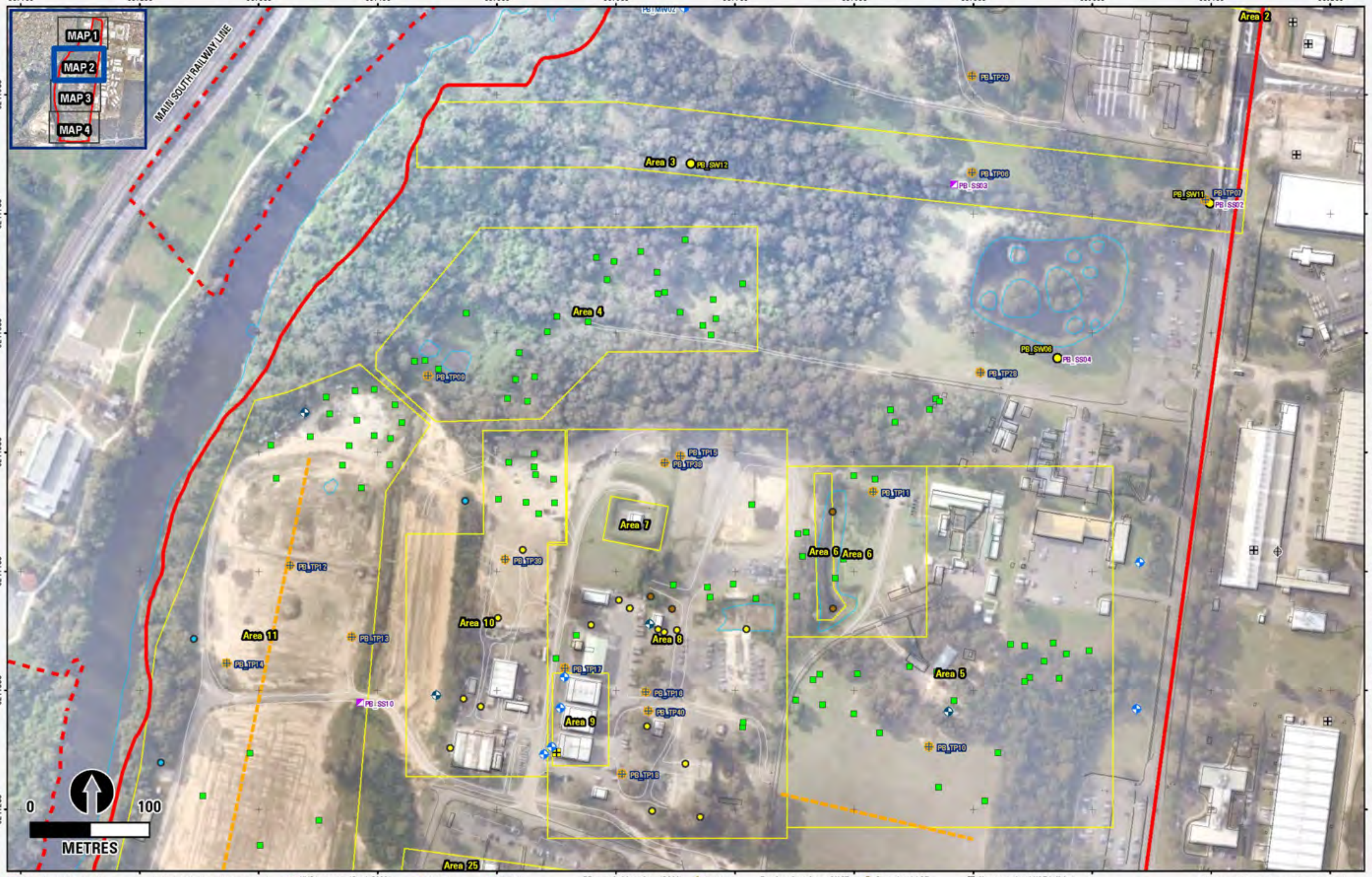

Moorebank IMT main site
Land associated with Moorebank IMT rail access options
Footprint of rail corridor associated with the proposed rail access options
CLM investigation areas
Geophysical transects (22 Feb 2011)
UXO transects (G-tek 2011)

Previous investigation locations**
Monitoring well
Sediment sample
Soil bore
Surface scrape
Hand auger
Test pit
NOW monitoring wells

PB sampled locations (2011)
Hand auger
Monitoring well
Sediment sample
Soil bore
Surface water
Test pit

Previous locations of USTs
Operational UST
Non-operational UST
Operational AST
Non-operational AST
Operational UST (offsite)
Non-operational UST (offsite)
Operational AST (offsite)
Non-operational AST (offsite)

Figure 8b: Sampling locations (Earthtech 2006 & Parsons Brinckerhoff 2011)
Map 2

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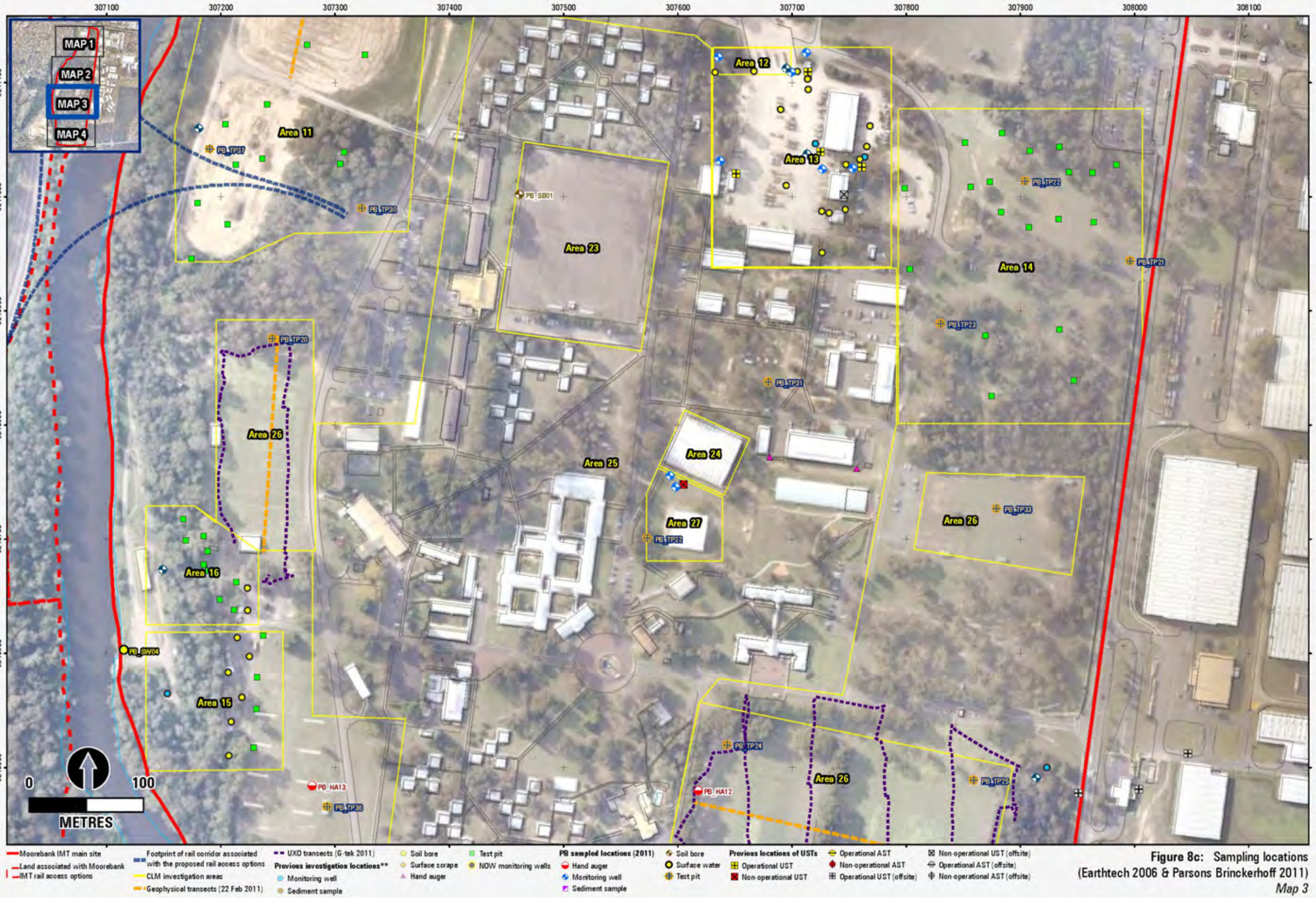

Figure 8c: Sampling locations
(Earthtech 2006 & Parsons Brinckerhoff 2011)
Map 3

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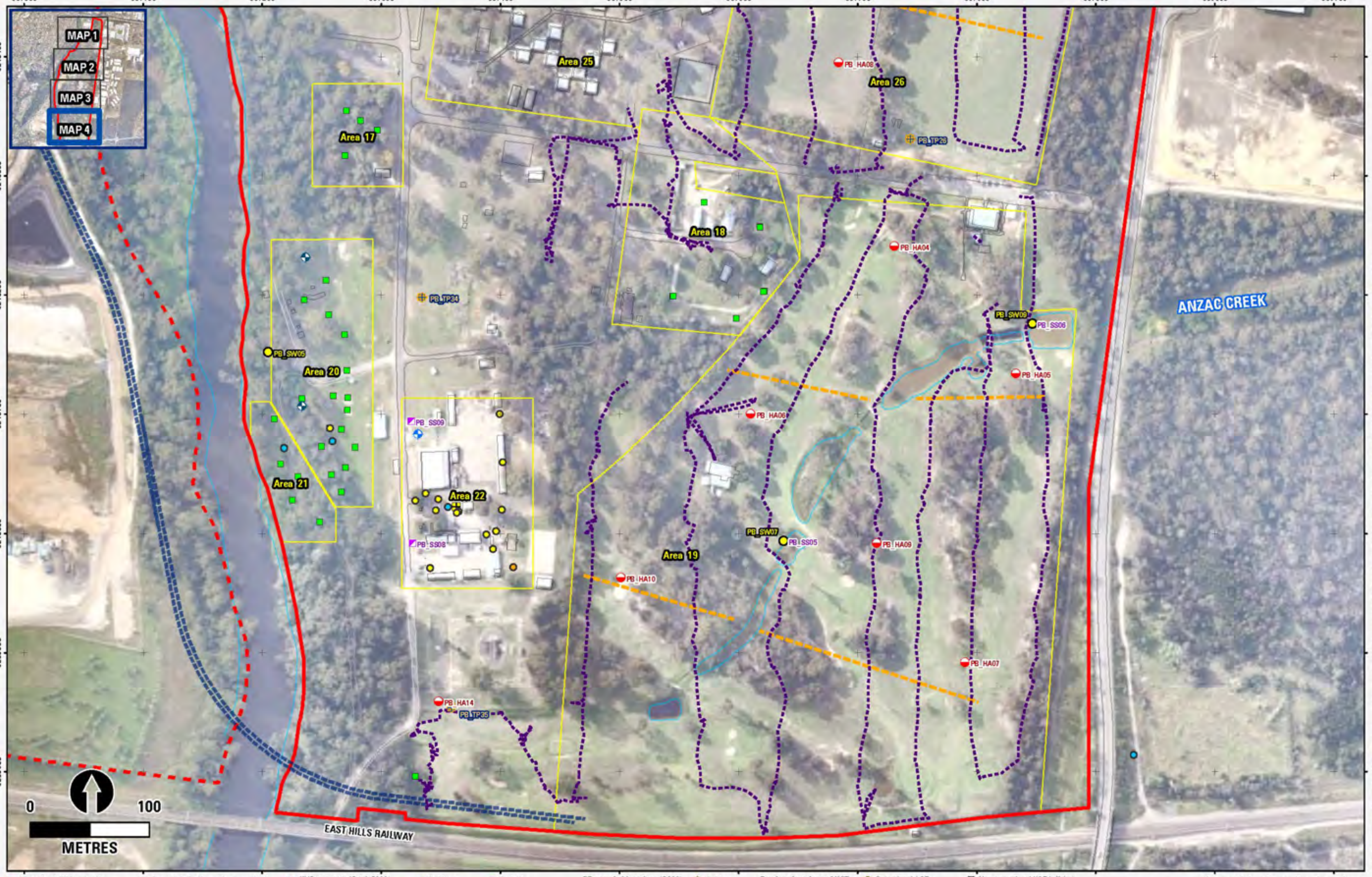
MOOREBANK INTERMODAL TERMINAL



Moorebank IMT main site
Land associated with Moorebank IMT rail access options
Footprint of rail corridor associated with the proposed rail access options
CLM investigation areas
Geophysical transects (22 Feb 2011)
UXO transects (G-tek 2011)

Previous investigation locations**
Monitoring well
Sediment sample
Soil bore
Surface scrape
Hand auger
Test pit
NOW monitoring wells

PB sampled locations (2011)
Hand auger
Monitoring well
Sediment sample
Soil bore
Surface water
Test pit

Previous locations of USTs
Operational UST
Non-operational UST
Operational AST
Non-operational AST
Operational UST (offsite)
Non-operational UST (offsite)
Operational AST (offsite)
Non-operational AST (offsite)

Figure 8d: Sampling locations (Earthtech 2006 & Parsons Brinckerhoff 2011)
Map 4

- Moorebank IMT main site
- Land associated with Moorebank IMT rail access options
- Footprint of rail corridor associated with the proposed rail access options
- Rail line
- Structures
- Drainage
- Inferred groundwater contours (mAHD)
- Inferred groundwater flow direction
- Spot height (mAHD)

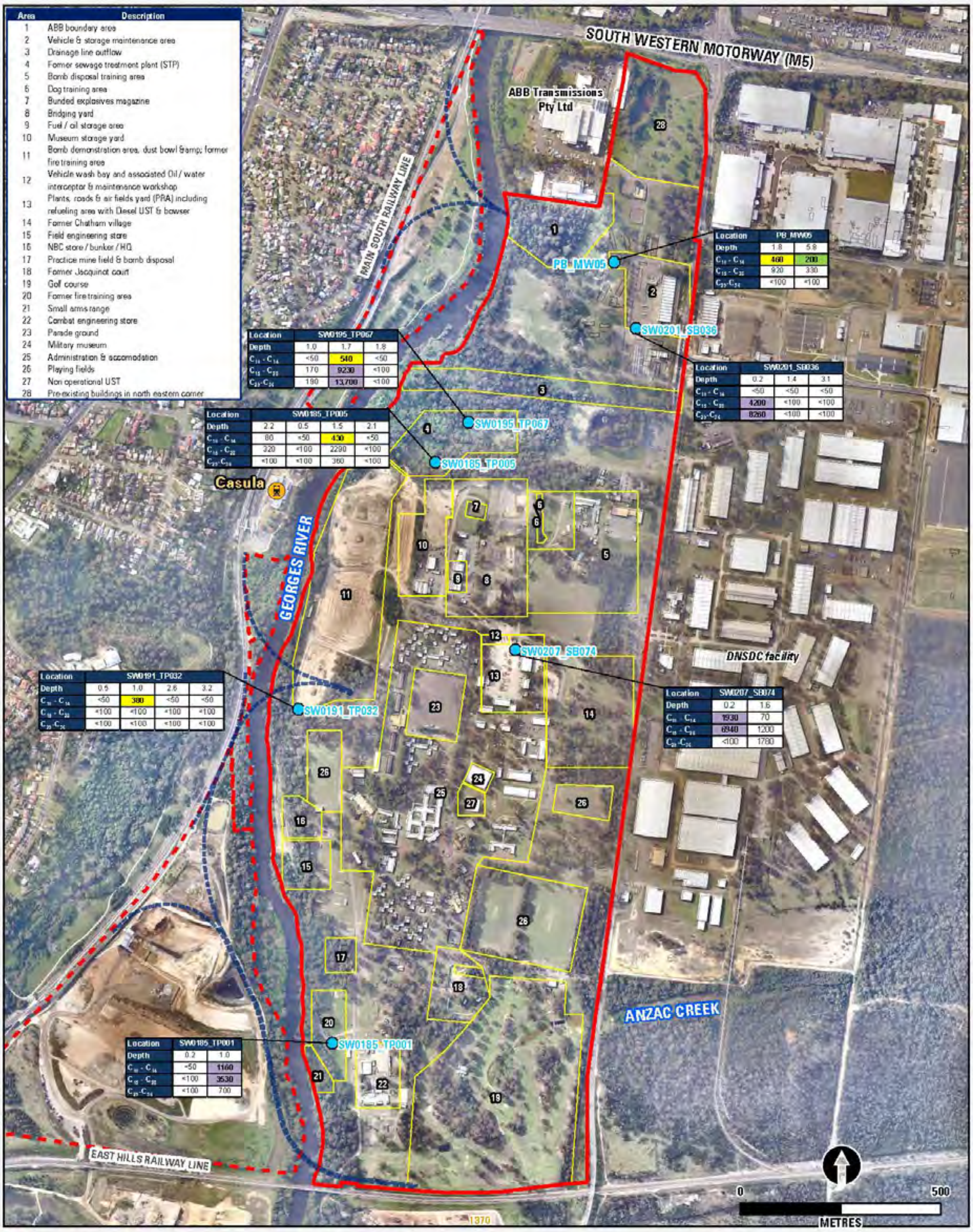
Based on groundwater levels gauged by Parsons Brinckerhoff January/February 2011

Figure 9a: Groundwater elevations and contour plan *(whole site)*

Moorebank IMT main site
Land associated with Moorebank IMT rail access options
Footprint of rail corridor associated with the proposed rail access options
CLM investigation areas
Rail line
Structures
Drainage
Groundwater contours (mAHD)
Inferred groundwater flow direction
Spot height (mAHD)

Note: *MW_BHB1, MW_BHB3, MW_BHB7 & MW_BHB12 were dry in Januray 2011*

Figure 9b: Groundwater elevations and contour plan *(area 1)*



Moorebank IMT main site
Land associated with Moorebank IMT rail access options
Footprint of rail corridor associated with the proposed rail access options
TRH site
CLM investigation areas
Rail line
Structures
Concentration potentially exceeds relevant soil ESL based on sample depth (2)
Concentration potentially exceeds relevant soil HSL (1) and ESL (2) based on sample depth
Concentration potentially exceeds relevant soil ESL, HSL and petroleum hydrocarbon management limit (3)

Notes:
All Values in mg/kg
(1) NEPM (1999) Revised 2013 Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1A(3) - Health screenings levels for vapour intrustion
(2) NEPM (1999) Revised 2013 Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1B(6) - Ecological screening levels for TPH fractions F1 - F4, BTEX and benzo(a)pyrene in soil
(3) NEPM (1999) Revised 2013 Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1B(7) - Management limits for TPH fractions F1 - F4 in soil

Figure 10: TRH C_{10} to C_{36} in soils

Moorebank IMT main site

Land associated with Moorebank IMT rail access options

Footprint of rail corridor associated with the proposed rail access options

Heavy metals site

CLM investigation areas

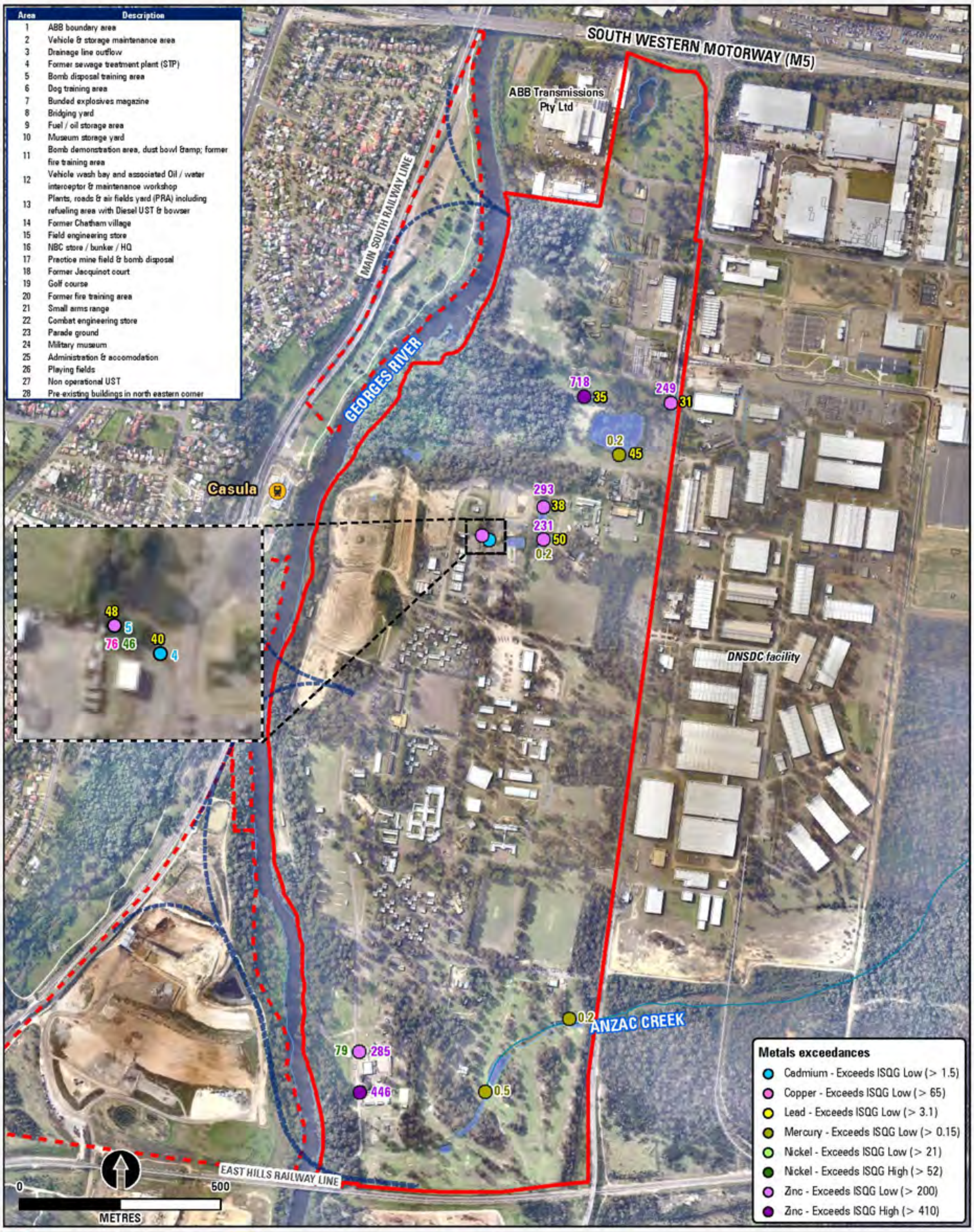
Rail line

Structures

Concentration potentially exceeds relevant soil HSL [1] and ESL [2] based on sample depth

Figure 11: Heavy metals exceeding the adopted health investigation levels

Notes:
All Values in mg/kg
(1) NEPM (1999) Revised 2013 Schedule B1 Guideline on Investigation Levels for Soil and Groundwater - Table 1A(1) - Health investigation levels for soil contaminants



Moorebank IMT main site

Land associated with Moorebank IMT rail access options

Footprint of rail corridor associated with the proposed rail access options

CLM investigation areas

Rail line

Structures

Water features / reticulation

Notes:
ISQG – Interim Sediment Quality Guidelines.
Low – Probable effects. concentrations below which biological effects would rarely occur.
High – Probable effects. concentrations below which biological effects would possibly occur.
All Values in mg/kg

Figure 12: Heavy metals exceeding the adopted assessment criteria in sediments

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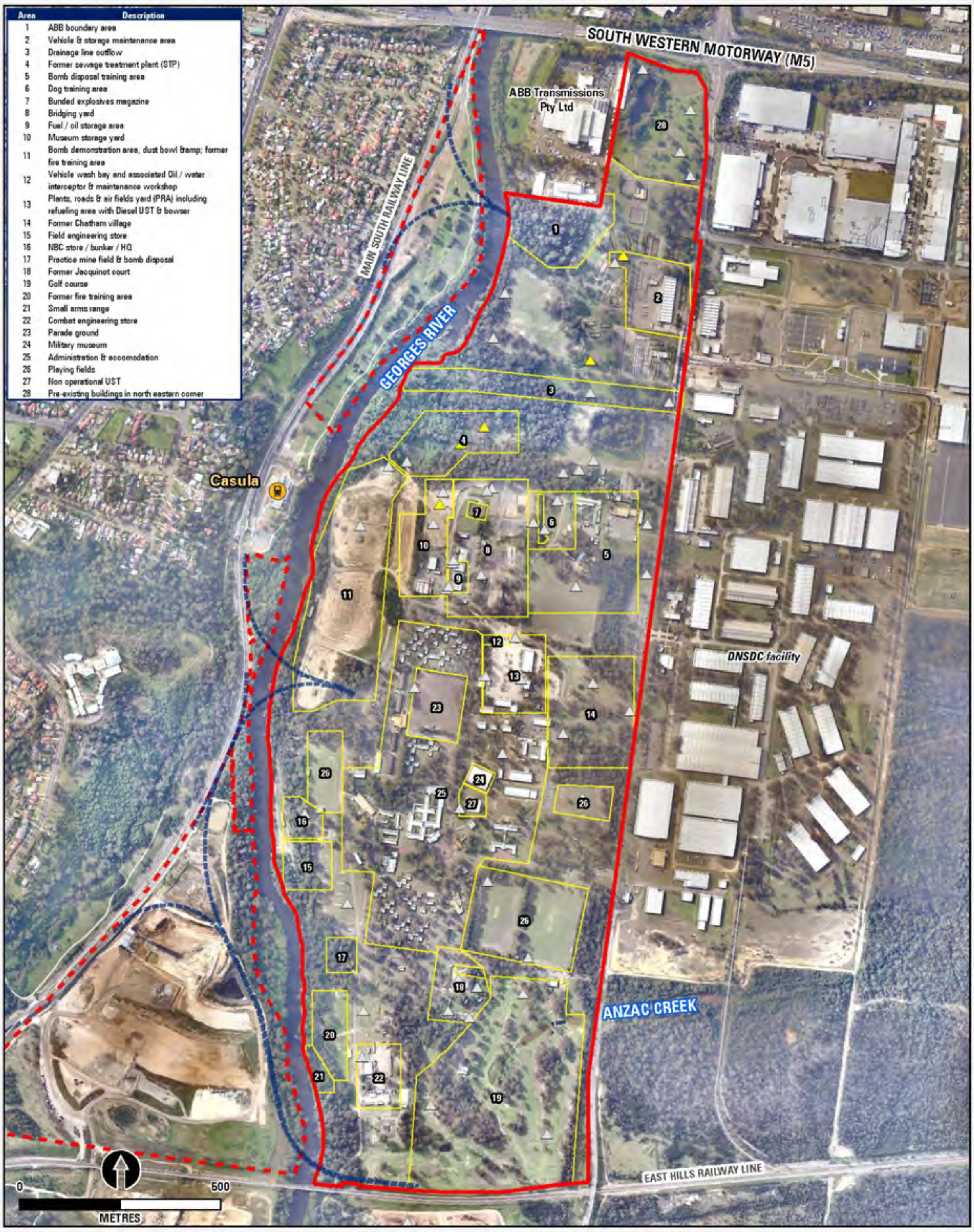
Area	Description
1	ABB boundary area
2	Vehicle & storage maintenance area
3	Drainage line outflow
4	Former sewage treatment plant (STP)
5	Bomb disposal training area
6	Dog training area
7	Bunded explosives magazine
8	Bridging yard
9	Fuel / oil storage area
10	Museum storage yard
11	Bomb demonstration area, dust bowl & former fire training area
12	Vehicle wash bay and associated Oil / water interceptor & maintenance workshop
13	Plants, roads & air fields yard (PRA) including refueling area with Diesel UST & bowser
14	Former Chatham village
15	Field engineering store
16	NBC store / bunker / HQ
17	Practice mine field & bomb disposal
18	Former Jacquinot court
19	Golf course
20	Former fire training area
21	Small arms range
22	Combat engineering store
23	Parade ground
24	Military museum
25	Administration & accomodation
26	Playing fields
27	Non operational UST
28	Pre-existing buildings in north eastern corner



Moorebank IMT main site

Land associated with Moorebank IMT rail access options

Footprint of rail corridor associated with the proposed rail access options

CLM investigation areas

Rail line

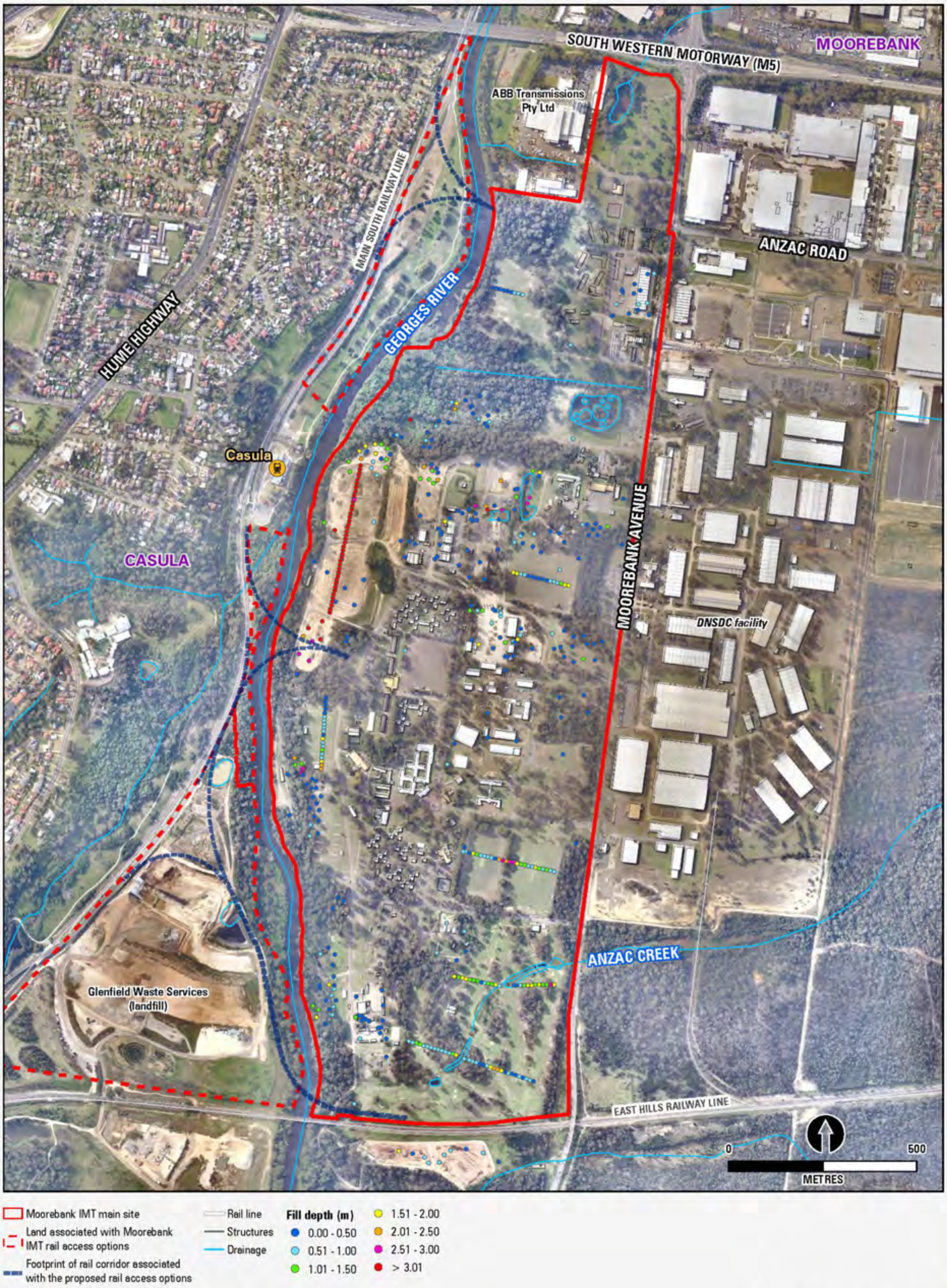
Structures

No asbestos detected

Asbestos detected

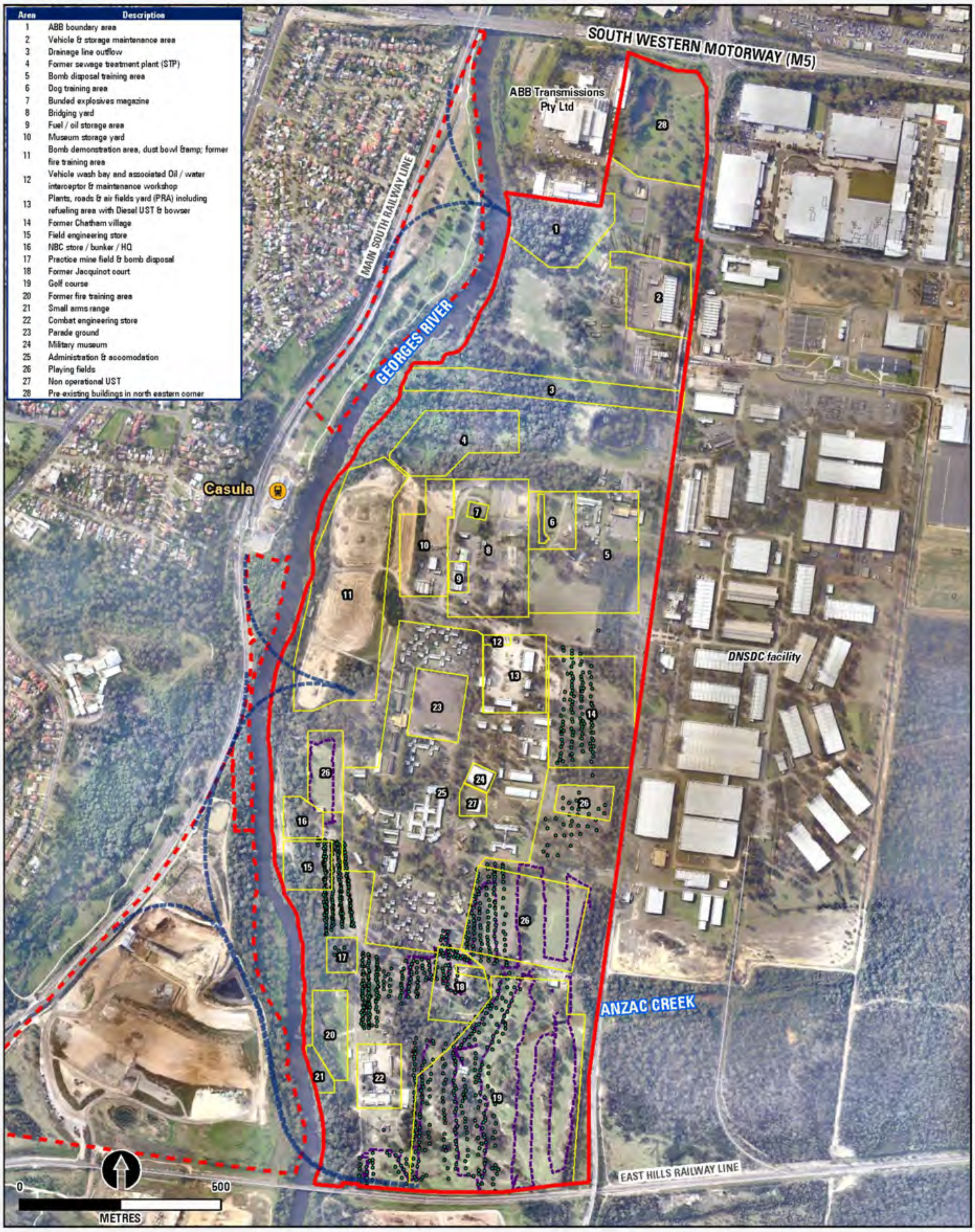
Notes:
GSW - General Solid Waste
RSW - Restricted Solid water
All Values in mg/kg

Figure 13: Asbestos in soils



Based on environmental logs (Eathtech 2006 and PB 2011) and geophysical transects (PB 2011)

Figure 14: Inferred extent of fill



Area	Description
1	ABB boundary area
2	Vehicle & storage maintenance area
3	Drainage line outflow
4	Former sewage treatment plant (STP)
5	Bomb disposal training area
6	Dog training area
7	Bunded explosives magazine
8	Bridging yard
9	Fuel / oil storage area
10	Museum storage yard
11	Bomb demonstration area, dust bowl & former fire training area
12	Vehicle wash bay and associated Oil / water interceptor & maintenance workshop
13	Plants, roads & air fields yard (PRA) including refueling area with Diesel UST & bowser
14	Former Chatham village
15	Field engineering store
16	NBC store / bunker / HQ
17	Practice mine field & bomb disposal
18	Former Jacquinot court
19	Golf course
20	Former fire training area
21	Small arms range
22	Combat engineering store
23	Parade ground
24	Military museum
25	Administration & accomodation
26	Playing fields
27	Non operational UST
28	Pre-existing buildings in north eastern corner

Moorebank IMT main site

Land associated with Moorebank IMT rail access options

Footprint of rail corridor associated with the proposed rail access options

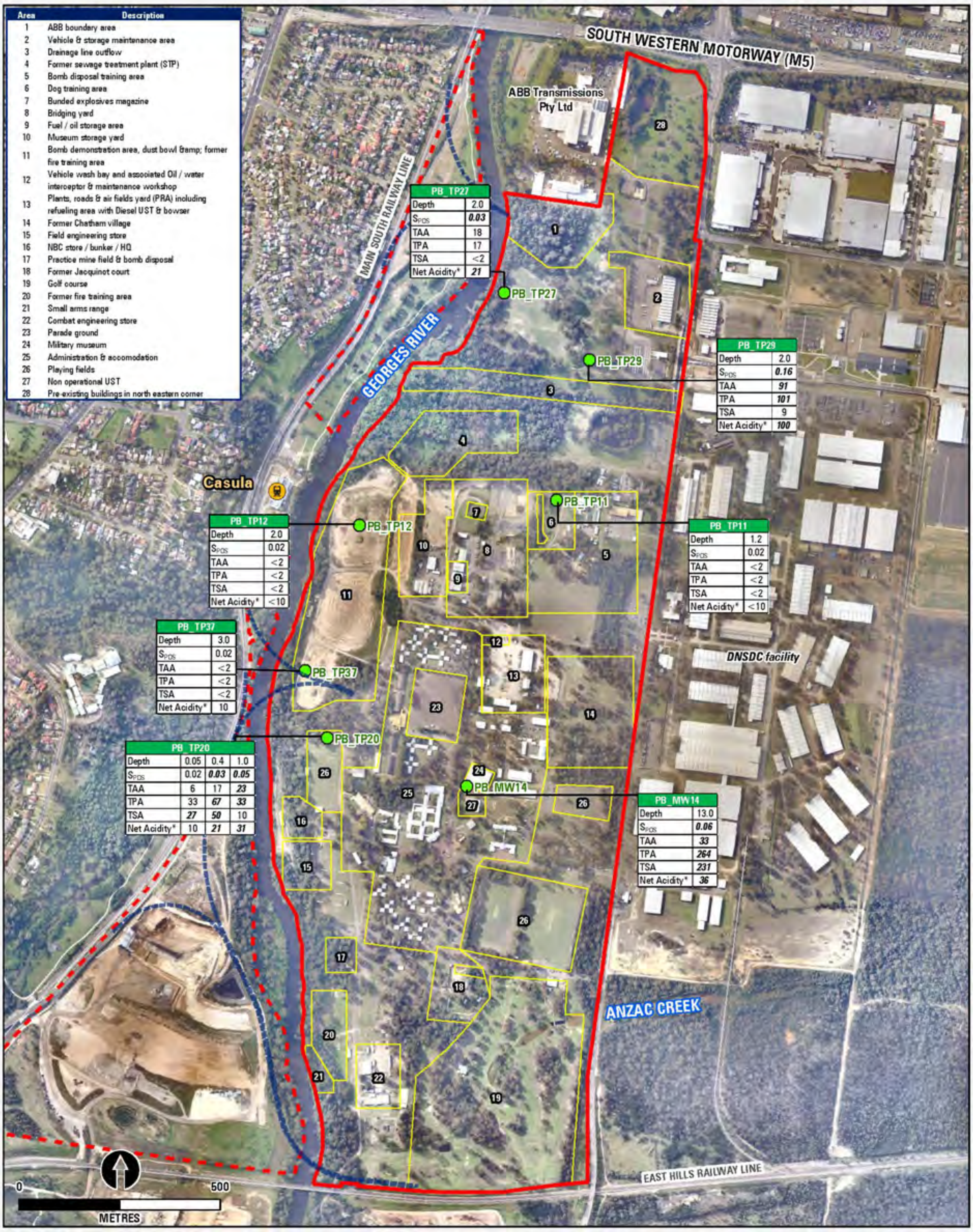
CLM investigation areas

Rail line

UXO transects (G-tek 2011)

UXO artifact finds (G-tek 2011)

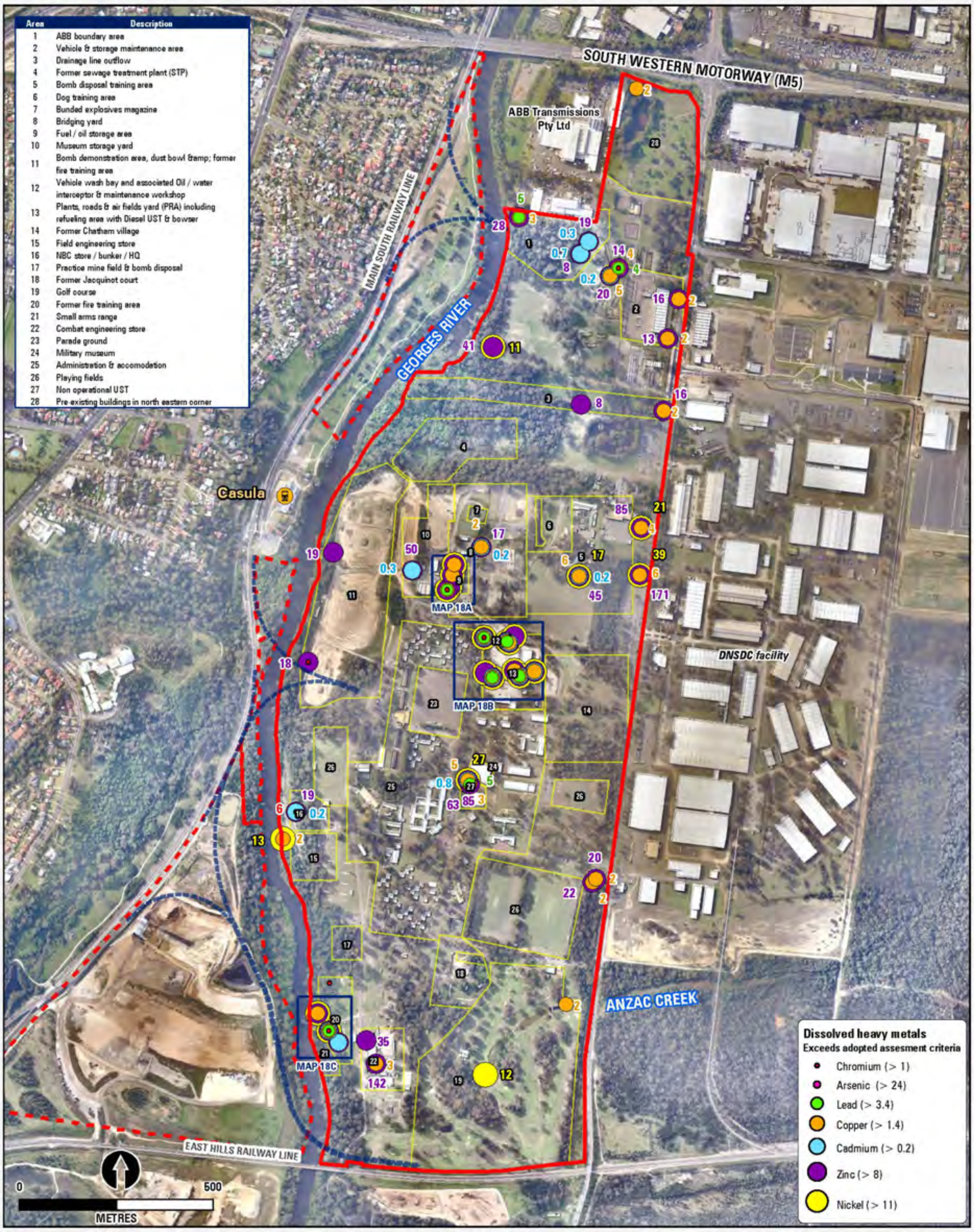
Figure 15: UXO/ EOW artefact finds (based on G-tek data)



- Moorebank IMT main site
- Land associated with Moorebank IMT rail access options
- Footprint of rail corridor associated with the proposed rail access options
- CLM investigation areas
- Rail line
- Structures
- Acid sulfate soil location

Notes:
All values in mole H+/t unless otherwise specified
*Net Acidity without ANCE
Depth in mBGL
SPOS - Peroxide Oxidisable Sulfur (Net acidity (sulphur units in %S)
TAA - Total Actual Acidity
TSA - Total Sulfidic Acidity
TPA - Total Potential Acidity
Bold indicates value exceeds the adopted criteria for ASS

Figure 16: Acid sulfate soil (ASS) results



Moorebank IMT main site

Land associated with Moorebank IMT rail access options

Footprint of rail corridor associated with the proposed rail access options

CLM investigation areas

Rail line

Structures

Notes:
Criteria based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) – trigger values for freshwater, 95% level of protection
Mercury results all 0.1 µg/L. These have not been displayed as adopted screening limit from mercury (0.06 µg/L) is above the laboratory detection limit
All Values in µg/L

Figure 17: Dissolved heavy metals in groundwater & surface water

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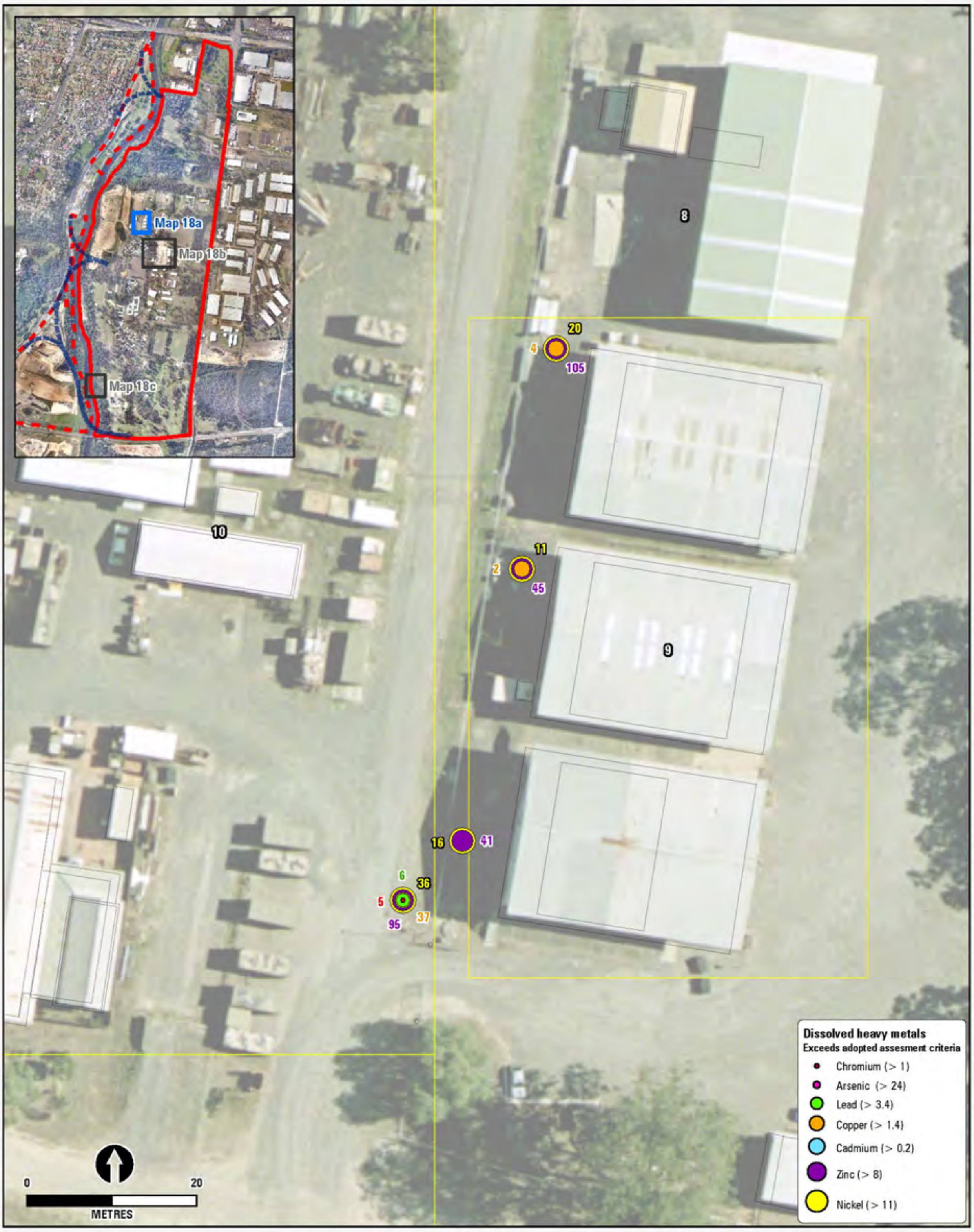

Moorebank IMT main site

Land associated with Moorebank IMT rail access options

Footprint of rail corridor associated with the proposed rail access options

CLM investigation areas

Structures

Notes:
Criteria based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) – trigger values for freshwater, 95% level of protection
Mercury results all 0.1 µg/L. These have not been displayed as adopted screening limit from mercury (0.06 µg/L) is above the laboratory detection limit
All Values in µg/L

Figure 17a: Dissolved heavy metals in groundwater & surface water

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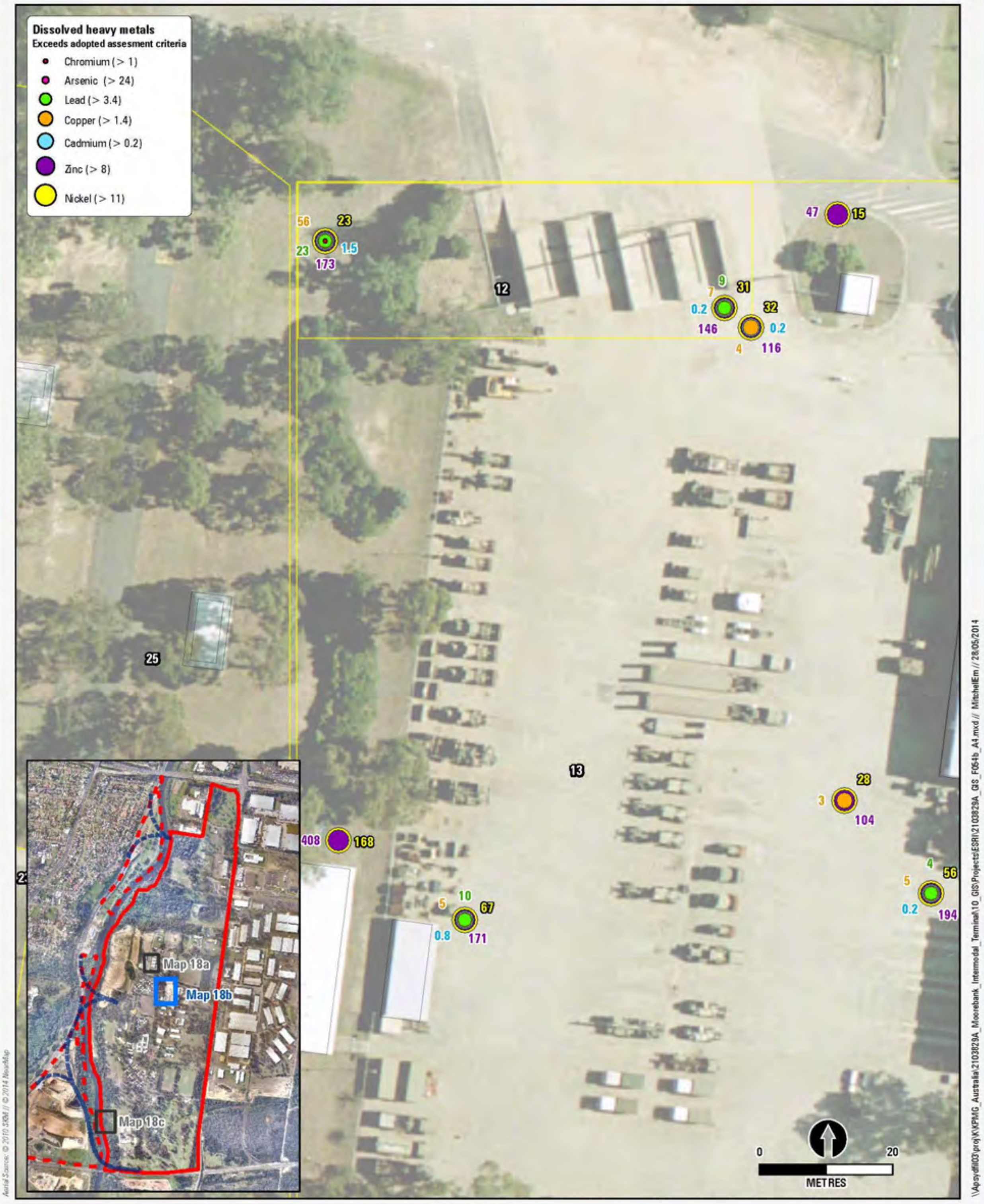


Moorebank IMT main site

Land associated with Moorebank IMT rail access options

Footprint of rail corridor associated with the proposed rail access options

CLM investigation areas

Structures

Notes:
Criteria based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) – trigger values for freshwater, 95% level of protection
Mercury results all 0.1 µg/L. These have not been displayed as adopted screening limit from mercury (0.06 µg/L) is above the laboratory detection limit
All Values in µg/L

Figure 17b: Dissolved heavy metals in groundwater & surface water

Moorebank IMT main site

Land associated with Moorebank IMT rail access options

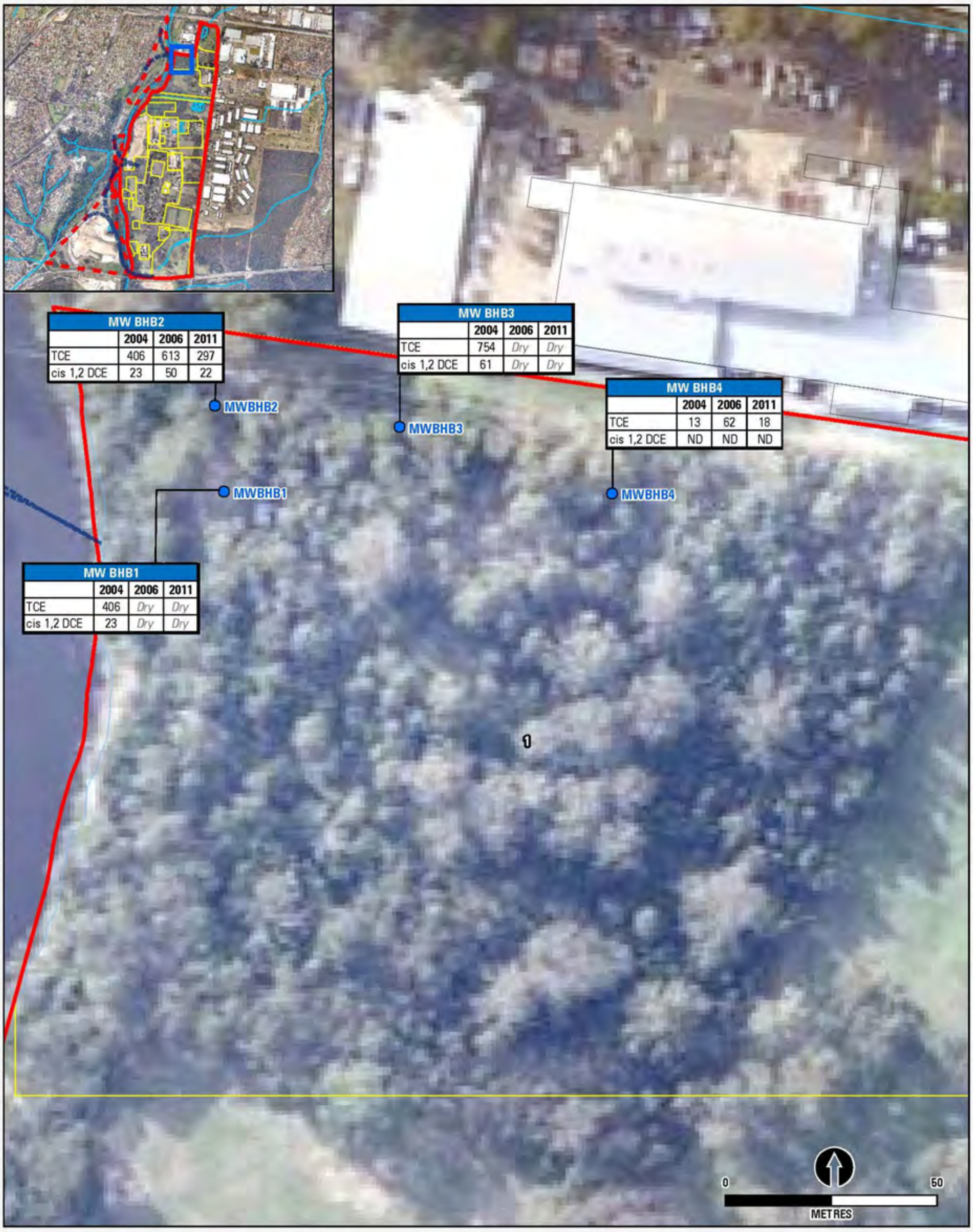
Footprint of rail corridor associated with the proposed rail access options

CLM investigation areas

Structures

Notes:
Criteria based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) – trigger values for freshwater. 95% level of protection
Mercury results all 0.1 µg/L. These have not been displayed as adopted screening limit from mercury (0.06 µg/L) is above the laboratory detection limit
All Values in µg/L

Figure 17c: Dissolved heavy metals in groundwater & surface water



- Moorebank IMT main site
- Land associated with Moorebank IMT rail access options
- Footprint of rail corridor associated with the proposed rail access options
- CLM investigation areas
- Monitoring well

Note:
- *All other samples results were reported below the laboratory PQL in 2004, 2006 & 2011.*
- *MW_BHB1, MW_BHB3, MW_BHB7 & MW_BHB12 were dry in January 2011*
- *All values in µg/L*

Figure 18: TCE in groundwater *(area 1)*

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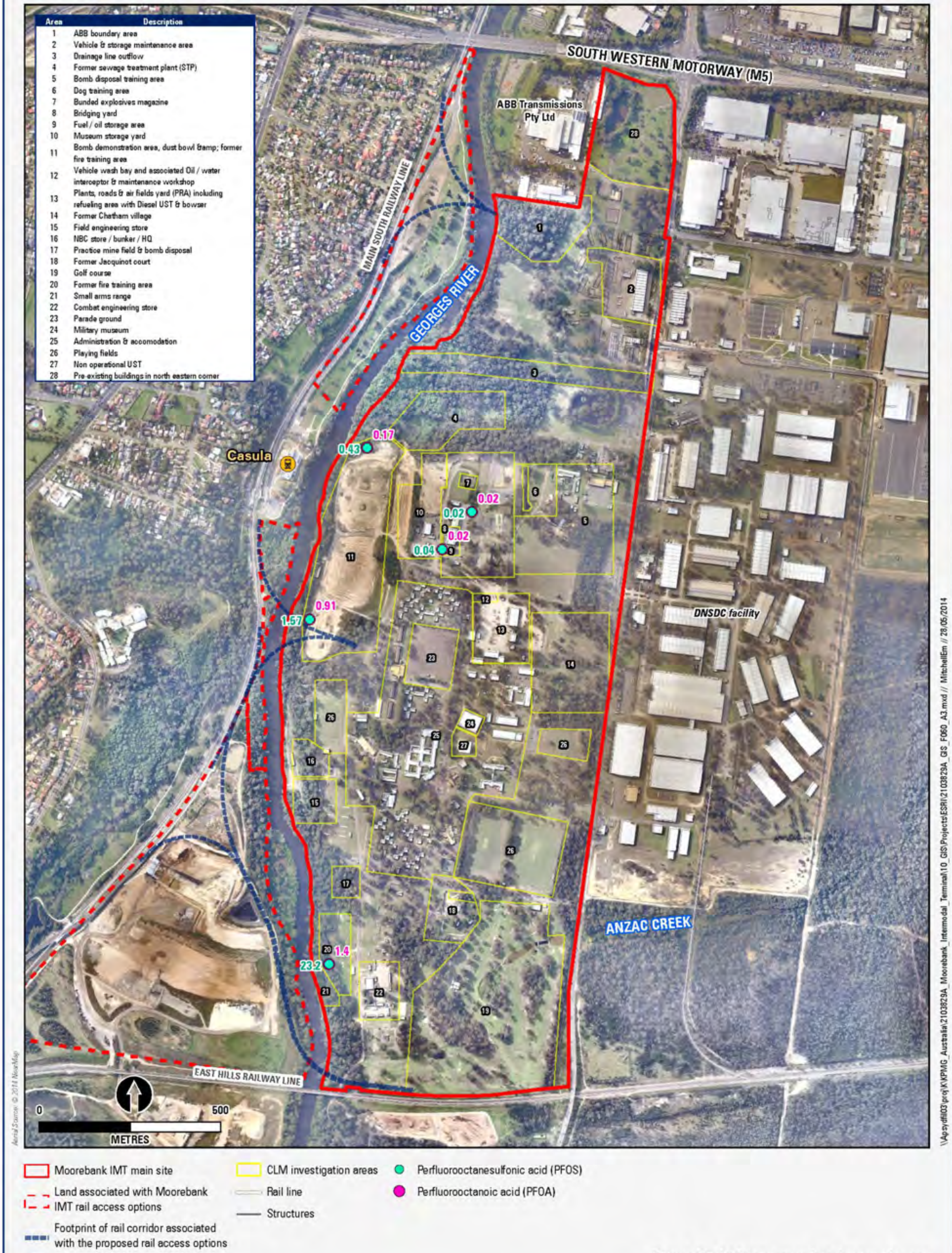

Notes:
Criteria based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) – trigger values for freshwater, 95% level of protection
All Values in µg/L

Figure 19: AFFF concentrations in groundwater

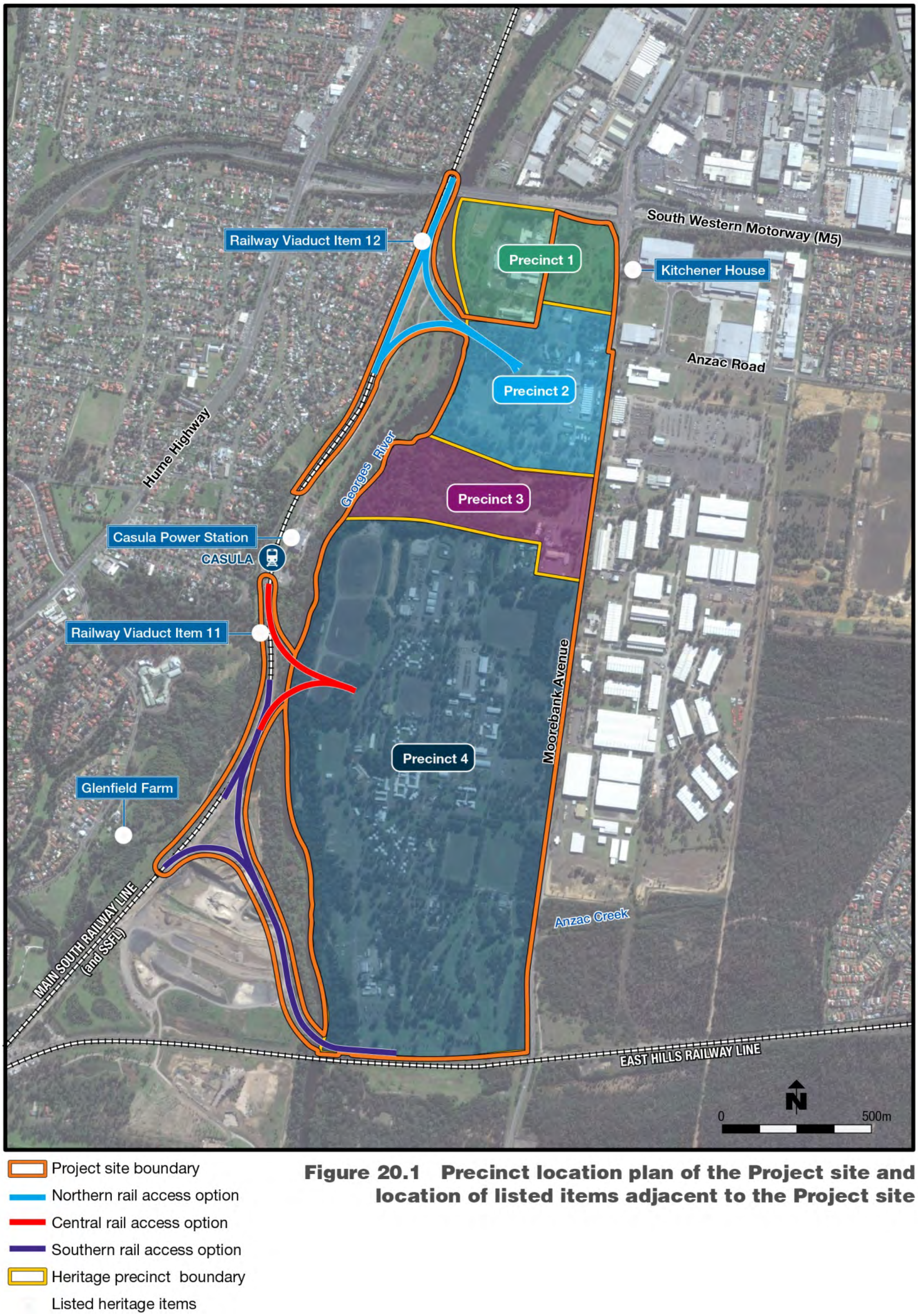

Figure 20.1 Precinct location plan of the Project site and location of listed items adjacent to the Project site