Maryland Development Company Pty Ltd
Environmental Site Assessment

Basin I
Links Road, St Marys, NSW

12 June 2018

54614/114674 (Rev 0)

JBS&G

www.jbsg.com.au

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Abbreviations

Term	Definition
ACM	Asbestos Containing Material
AF/FA	Asbestos Fines / Fibrous Asbestos
Bgs	Below Ground Surface
BTEX	Benzene, toluene, ethylbenzene and xylenes
B(a)P	Benzo(a)pyrene
DECCW	NSW Department of Environment, Climate Change and Water
DP	Deposited Plan
DQIs	Data Quality Indicators
DQOs	Data Quality Objectives
EIL/ESL	Ecological Investigation/Screening Levels
EPA	NSW Environmental Protection Authority
ESA	Environmental Site Assessment
HIL/HSL	Health Investigation/Screening Levels
LEP	Local Environmental Plan
LOR	Limit of Reporting
OCPs	Organochlorine pesticide
OEH	NSW Office of Environment and Heritage (includes EPA)
NOW	NSW Office of Water (formerly Department of Water and Energy, DWE)
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PID	Photo-ionisation Detector
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percentage Difference
SEPP	State Environmental Planning Policy
TRH	Total Recoverable Hydrocarbons
TCLP	Toxicity characteristic leaching procedure
VOCs	Volatile organic compounds

Executive Summary

JBS&G Australia Pty Ltd (JBS&G) was engaged by Maryland Development Company Pty Ltd (the client) to undertake environmental site assessment works at the proposed Basin I footprint (the site) located to the south west of the Central Precinct Development site, in St Marys, NSW. The site is legally defined as part lot 1002 DP1215087, has an approximate area of 5.75 hectares (ha) and is located within the former St Marys ADI site which was used for various munition filling and storage activities up until 1994.

An environmental site assessment has been completed which comprised a review of site history and the proposed development to develop data quality objectives (DQO's). On the basis of the DQO's an intrusive soil sampling and analysis program was completed across the proposed basin. An assessment of quality assurance / quality control found that the generated soil data is reliable to be used to characterise soil on the site.

Based on the findings of this assessment and subject to the limitations in **Section 11**, the site has been found suitable from a contamination assessment perspective for a future use to be developed as a Detention Basin. Remedial works are not required for soil within the extent of the site to facilitate the proposed use however it is recommended that an unexpected finds protocol be adopted during excavations works.

Surplus soils as will be generated by the substantial excavation works are proposed to be classified as virgin excavated natural material (VENM).

1. Introduction and Background

1.1 Background

JBS&G Australia Pty Ltd (JBS&G) was engaged by Maryland Development Company Pty Ltd (the client) to undertake environmental site assessment works at the proposed Basin I footprint (the site) located to the south west of the Central Precinct Development site, in St Marys, NSW. The site is legally defined as part lot 1002 DP1215087, has an approximate area of 5.75 hectares (ha) and is located within the former St Marys ADI site which was used for various munition filling and storage activities up until 1994.

As part of the environmental investigation and remediation program undertaken at the broader St Marys ADI site, it is understood that the current site has been subject to a number of previous environmental investigations and is covered by Site Audit Statement (SAS) CHK1001/1 – signed off as suitable for residential landuse including substantial vegetable gardens and poultry in 1996. Previous SAS are included in **Appendix A**. It is noted that the SAS was conducted over 20 years ago and is potentially no longer representative of the site condition.

It is understood that the client has submitted a development proposal relating to the construction of a regional detention basin at the site as associated with the proposed overall stormwater management strategy. It is further understood that a preliminary site investigation is required at the site to address Secretary's Environmental Assessment Requirements (SEARs) relating to the proposed development.

The environmental site assessment (ESA) has been completed in general accordance with guidelines made or approved by the NSW Environment Protection Authority (EPA) and relevant Australian Standards.

1.2 Objectives

The objective of the investigation is to characterise potential contamination at the site, and to draw conclusions regarding the suitability of the site for the proposed use, or make recommendations to enable such conclusions.

It was a further objective to collect sufficient data to enable the preparation of a waste management plan (WMP) relating to management of excess material generated during the basin construction works which will be prepared as a separate report.

1.3 Scope of Work

The agreed scope of works include:

- Review of historical reports, records and other available sources of the former ADI property to obtain information on potential areas of concern (AECs);
- Review of recent aerial imagery (from the period after historical works were completed);
- Online search of sites listed on CLM and POEO databases;
- Site inspection;
- Soil investigation; and
- Data assessment and preparation of this ESA report.

1.4 Proposed Development

The physical works to construct the basin involve the following:

- Excavation to provide the required shape and dimension of the basin;
- A 2m deep open water zone,
- A safety bench area to be planted with macrophytes all around the water edge, and
- Hydraulic controls at the inlet and outlet of the basin that are adequately lined to prevent erosion.

The proposed excavation volume for Basin I is approximately 110 000 m^3. The basin will have an approximate water volume of 110 ML. The inlet into Basin I will be from existing open channel at the boundary of the site. The existing creek on site where Basin I will be built will be replaced. As such Basin I is an on-line basin that receives surface runoff from a Council catchment at the boundary at Werrington Downs, approximately 250m downstream of Pasturegate Avenue. The outlet of Basin I discharges into the existing creek in the Regional Park area.

2. Site Condition and Surrounding Environment

2.1 Site Identification

The location of the site is shown in **Figure 1**, the site details are summarised in **Table 2.1** below.

Table 2.1 Summary Site Details

Lot Number	Part lot 1002 DP1215087
Street Address	Links Road, St Mary's, NSW (See **Figure 2**).
Site Area	Approximately 5.75 ha
Local Government Authority	Penrith City Council
Geographic Coordinates (MGA 56)	289633.367 E 6264812.37 N
Current Land-use **Proposed Land-use**	Vacant – grassed areas and woodland Regional detention basin

2.2 Site Description

A site inspection was carried out by JBS&G's trained and experienced environmental consultant Rob Sharp on 6 February 2018. The general site layout is provided in **Figure 2**.

The site comprised an irregular shaped parcel of land including grassed areas and heavy wooded areas. The site was dissected by a creek oriented and flowing approximately southwest to northeast, identified as an unnamed tributary of South Creek. Stagnant water was observed in the wetland present in the central portion of the site in alignment with the creek. Scattered rubbish likely transported via stormwater runoff was also observed in this area.

The northern portion of the site was generally flat and comprised open grassed areas. Four minor stockpiles were located in proximity of the north-eastern extent of the site, but are not present within the site. The stockpiles were overgrown and as such the constituents of these stockpiles could not be closely inspected. An earthen track was located to the north of the creek line, oriented approximately southwest to northeast.

The area to the south of the creek was occupied by thick vegetation comprising large trees with restricted access available. Minor soil stockpile (~10-20 m^3) was present in the eastern site extent potentially originated as cut material from the drainage lines.

No odours, staining or asbestos containing material (ACM) were observed during the inspection. No evidence of potential site filling or disturbance otherwise of the site was observed.

A photographic log is provided in **Appendix B**.

2.3 Surrounding Land Use

The surrounding landuses to the site are described below:

- North – Regional open space areas were located north of the site, followed by the Jordon Springs residential development;
- East – Densely vegetated areas followed by the Central Precinct development site were located to the east of the site. The Dunheved Golf Club and Dunheved Industrial Estate were located further east;
- South – Residential properties Werrington County are located to the south of the site; and
- West – Residential properties of Cambridge Gardens was located to the west of the site.

2.4 Topography and Hydrology

The site is generally flat with minor slopes toward local drainage lines and elevation ranging between 36 and 39 m AHD.

Precipitation at the site is anticipated to seep into unsealed areas with excess surface waters expected to flow overland into onsite surface water bodies.

As discussed above, an unnamed tributary of South Creek dissects the site. South Creek drains a very large catchment in western Sydney, originating at Narellan, over 30 km to the south. The catchment is a long narrow strip up to 8 km wide with an approximate area of 18,000 ha. The catchment includes residential, agricultural and industrial areas. The creek flows northwards from the development site through mainly agricultural areas before meeting the Hawkesbury River at Windsor, 18 km to the northeast.

2.5 Geology

Reference to the 1:250 000 Geological Series Sheet S1 56-5 for Sydney (NSW Department of Mines 1966) indicates that the site is underlain by Bringelly Shale, Minchinbury Sandstone and Ashfield Shale, part of the Wianamatta Group. The geological unit is comprised of shale with some sandstone beds.

Reference to the online ESPADE 2.0 tool hosted by the NSW Office of Environment and Heritage (OEH 2018[1]) indicates the site contains two soil landscapes. The eastern extent of the site including creek bed is underlain by alluvial South Creek soils whilst the remainder of the site is underlain by erosional Luddenham soils.

South Creek soils are found on floodplains, valley flats and drainage depressions of the channels on the Cumberland Plane. The landscape is usually flat with incised channels. The soils are often very deep layered sediments over bedrock or relict soils. Where pedogenesis has occurred structured plastic clays or structured loams in and immediately adjacent to drainage lines, red and yellow podzolic soils are most common terraces with small areas of, structured grey clays, leached clay and yellow solodic soils. Flood hazard, seasonal waterlogging, localised permanently high water tables, localised water erosion hazards, localised surface movement potential are associated limitations of the landscape.

Luddenham soils are typically characterised by undulating to rolling low hills on Wianamatta Group shales, often associated with Minchinbury Sandstone. Local relief is between 50–80 m, slopes 5–20%. The landscape is typically characterised by narrow ridges, hillcrests and valleys; extensively cleared tall open forest; shallow (<100 cm) dark podzolic soils) or massive earthy clays on crests; moderately deep (70–150 cm) red podzolic soils on upper slopes; moderately deep (<150 cm) yellow podzolic) and prairie soils on lower slopes and drainage lines. Limitations of soils in the Luddenham group are water erosion hazard, localised steep slopes, localised mass movement hazard, localised shallow soils, localised surface movement potential; localised impermeable highly plastic, moderately reactive subsoil.

As reported in ADI (1996a) the former ADI St Marys Property is underlain by shales of Bringelly Shale Unit part of the Liverpool Sub-group and Wianamatta Group of the Triassic epoch. These are overlain by alluvium of Quaternary age. The Bringelly Shale unit consisting mainly of grey hard shales within intervening siltstone forms the bedrock. The top of the shale, up to 5 m thick, is highly weathered and very friable in nature. The Quaternary Alluvium comprises predominately buff coloured silt, silty/sandy clays which is often lateritic in nature and mottled with yellow/red ochres and iron nodules. Quaternary Alluvium was deposited mainly in the central lowlands along the flood plains of

[1]ESPADE 2.0, NSW Office of Environment and Heritage, accessed 26 February 2018, http://www.environment.nsw.gov.au/eSpade2WebApp.

South Creek and Ropes Creek. Thickness of the alluvium within the development site is likely to range in thickness from approximately 6 to 10 m as these are the central lowlands.

2.6 Hydrogeology

A review of information obtained from the Department of Primary Industries Office of Water Groundwater Mapping Tools (NSW DPI 2018[2]) indicated there are no registered bores within 1.5 km radius of the site.

As reported in ADI (1996a) groundwater was observed at the former ADI St Marys property in an upper unconfined aquifer and a lower regional semi-confined aquifer. The quaternary alluvium and highly weathered shale occurring at depths ranging from 2 to 10 m below ground surface forms the shallow upper aquifer. The depth to the water table ranges from 2 to 7 m below ground surface depending upon the surface topography. The water table occurs in the sandy to silty clay above the weathered shale and/or shale bed rock. The groundwater flow pattern on a regional scale follows the general topography of the area, however, variation in the flow direction can occur locally based on the ground slope. On a broad scale the groundwater flows across the eastern and western sectors in towards the central lowlands of the former ADI St Marys Property and then northwards.

ADI (1996a) reported the lower aquifer is comprised of fractured shales at depths ranging 5 to 30 m below ground level. The shale bed rock forms a valley type structure across the former ADI St Marys property and the groundwater flow pattern is governed by this structure. The hydraulic conductivity of the lower aquifer varies greatly depending upon the interception of fracture zones.

Additionally, ADI (1996a) reported the groundwater in the shallow upper aquifer is fresh to brackish as well as saline (electrical conductivity (EC) 300 to 40 000 µS/cm). The groundwater from lower fractured shale aquifer is mainly saline (EC 6000 to 30 000 µS/cm). The groundwater pH ranges from 4.5 to 7 indicating slightly acidic conditions for both aquifers however at each sample point the shallow groundwater is consistently more acidic than deep groundwater. The dissolved oxygen concentrations are variable but generally less than 6 mg/L indicating slightly reducing conditions in both aquifers.

Furthermore, ADI (1996a) reported the general groundwater from both aquifers has high total dissolved solids (TDS 150 to 20 000 mg/L), slightly acidic pH and low dissolved oxygen concentration which makes it impractical for any domestic, agricultural or industrial use.

As detailed in the Stage 2 Decontamination Audit Report (Kidd 1999[3]), groundwater investigations were carried out from 1991, by Mackie Martin & Associates, who constructed and monitored 64 groundwater wells (later expanded to 154 by ADI) over the entire Property. The study identified two aquifers - one upper unconfined and one lower semi-confined. They proposed the lower, regional aquifer was in the fractured shale with the groundwater flow patterns reflecting the surface topography. The study surmised the upper, unconfined aquifer was composed of Quaternary alluvium and highly weathered shale at a depth of 2 to 10 m. Testing indicated the local permeability of the fractured shale aquifer is variable depending on the degree of fracturing but the average permeability was low (less than $1x10^{-6}$ m/sec). The permeability of the unconfined alluvial aquifer was also low due to the high clay and silt content of the alluvium.

The water table was typically 1.5 to 7 m below the ground surface in the alluvium and from 3 to 30 m in in the shale. On a regional scale, the groundwater flow pattern followed the surface water drainage patterns - the general flow was from the east and west towards the central lowlands and

[2] Groundwater Monitoring Overview Map, NW Department of Primary Industries, accessed 26 February 2018, http://allwaterdata.water.nsw.gov.au/water.stm .

[3] Stage 2 Decontamination Audit of ADI St Marys, Munitions Factory, Department of Urban Affairs and Planning, Christopher H Kidd, HLA-Envirosciences Pty Ltd, June 1999 (Kidd 1999)

then northwards. The groundwater movement was slow to very slow due to the low permeability and the gentle hydraulic gradients.

2.7 Acid Sulphate Soils

Review of the Natural Resource Atlas (DNR website[4]) indicated that there no known occurrence of acid sulfate soils in the vicinity of the site. No risk map for the area encompassing the site was provided as part of the acid sulfate soil risk map series, DLWC (1998).

2.8 Salinity

As detailed in the Water, Soil and Infrastructure Report, (SKM 2009[5]), Soil bore, groundwater and geophysical investigations in the Central Precinct indicate that shallow groundwater is of low salinity. It was concluded that the planned development is unlikely to result in surface salinisation and that the proposed measures, now complete, such as raising the ground level by filling and limiting infiltration, will further reduce this possibility.

Based on soil samples collected from the adjacent central precinct development site, it was concluded that although salt accumulated with depth, the soil profile in the Central Precinct was generally of low salinity. Additionally, soil and groundwater test results indicate relatively low salinity overall.

Based on the design plans for the Basin I construction, the basin will not be lined and the captured stormwater would be free to move into the groundwater body below. If captured stormwater does infiltrate the groundwater, it is not anticipated that salts would increase in soils as there would be no evaporative cause for salination. Additionally, the potential salinization by rising groundwater levels is also not considered to be an issue due to the low salinity levels in groundwater.

[4] Department of Natural Resources Atlas, www.nratlas.nsw.go.au accessed 7 April 2014
[5] *Water, Soils and Infrastructure Report*, St Marys Project, Central Precinct Plan, Sinclair Knight Merz, May 2009 (SKM 2009)

3. Site History

3.1 Summary Site History

The former St Mary's ADI Munitions facility covered an area of 1535 ha and was established in 1942 as part of a larger parcel of farmland resumed in 1941 by the Commonwealth for establishment of ammunitions factory to support the war effort (World War II). From 1955-57, a new munitions factory was constructed and a substantial part of the original factory was leased to private industry and became the present Dunheved Industrial Estate.

The St Marys Munitions factory was primarily a filling, or load and pack type, operation where explosives and propellant, manufactured elsewhere, were loaded into shells, bomb and rocket casings and stored in magazines awaiting deployment. Small amounts of some initiator explosives for detonators and fuses were manufactured on the property because they were too sensitive to travel. Some test firing of detonators, fuses and smaller occurred at designated areas as part of the manufacturing quality assurance program. All larger munitions were test fired at Army ranges elsewhere.

ADI conducted site contamination investigations at the property in the early 1990's and developed and conducted remediation programmes to allow future development of the site for residential and other development such as public open space. The property was divided into various sectors for investigation purposes and were subject to contamination investigation, remediation and validation over the period from September 1990 to October 1996. The current site is understood to fall within the former 'Western Sector'. It is noted that no areas of environmental concern were identified during the ADI investigation that fall within the current site. The site was reported as suitable for residential landuse including substantial vegetable gardens and poultry under the site audit statement (SAS) CHK1001/1. Relevant historical site figures are presented as **Appendix C**.

Whilst the ADI validation report prepared for the Western Sector (ADI 1994[6]) was not made available at the time of preparation of this report, relevant information has been summarised below with reference to the (SAS) CHK1001/1 and accompanying Site Audit Report (Kidd 1999).

The Western Sector covered an area of approximately 472.2 ha and was primarily used for storage of explosives and related chemicals and comprised 110 magazines, 17 chemical stores and 36 office buildings which were constructed in 1942. Buildings that contained ammunition was surrounded by earth mounds to dissipate impacts of an explosion. Prior to use by the Commonwealth, the area was used for cattle grazing purposes. Soil investigation undertaken following demolition of buildings identified primary contaminants including zinc and organochlorine pesticides (OCPs). Zinc was reported in one location within 'KMA Dams' and in three background soil samples. The OCP contamination was identified within 16 magazine footprints and within sediments of a brickwell. Water samples collected from the brickwell reportedly contained elevated OCPs. Further samples were reportedly collected by ADI which detected OCPs below the investigation criteria, however this data was not reviewed as part of the audit (Kidd 1999). Groundwater investigation in the vicinity of the Brickell, reported OCPs below detection limits.

Zinc impacted soils were reportedly excavated at Pit 027 (KMA) to a depth of 0.5 m resulting in a total of 10 m^3 for potential off-site disposal. However, the auditor could not confirm the validation of this excavation due to lack of validation data.

Approx. 300 m^3 of OCP impacted sediment was excavated from the brickwell whilst an unknown amount of soil was excavated from beneath the 16 magazine footprints. The soil was stockpiled on-

[6] Validation Report for the Western Sector, ADI St Marys Facility, ADI Limited November 1994

site and was disposed to a landfill off-site following NSW EPA approval in 1997. Groundwater was confirmed not to be impacted by the OCP impacted sediment identified in the brickwell.

As part of the validation process, 800 m^3 of material contained in earth mounds were validated as suitable to be used as backfill material across the property, however, the validation report reportedly indicated that 80,000 $m^3$of earth mounds were present at the ADI site in stockpile which the auditor required to be subject to testing at the time of use.

Additionally, ADI undertook a subsurface investigation and remediation for ammunition items metal detector to 300 mm depth within a 100m strip inside the perimeter fence line, a zone from the perimeter in the south east proceeding westerly to encompass possible munitions debris arising from test firing of 3.5" rockets from a location in the Southern Sector Wes and a 25m zone around all magazine buildings and laboratories.

3.2 Aerial Photograph Review

Copies of aerial photographs obtained from the Department of Land and Property Information are included in **Appendix D**. Relevant information from the aerial photograph review is summarised below:

- 1947 – The site comprised vacant undeveloped grass land. The northern portion appeared to be cleared evidenced by two lightly shaded rectangular areas. Some minor trees were observed in alignment with the creek. The surrounding area consisted of vacant rural land. Buildings and access road network likely associated with the munitions facility was observed to the north in the vicinity of the present-day Jordan Springs development.
- 1955 – The cleared area in the northern site extent appeared less prominent and covered in surface vegetation indicating disuse. Increased tree cover was observed along the creek line. An area of soil disturbance was observed adjacent to the northeastern site boundary likely associated with the earthen access roads which had been constructed to the north and west of the site. The surrounding land including the central precinct development site and the broader St. Mary's ADI site had been partially developed and contained a series of warehouse/office buildings and associated access roads with the balance occupied by undeveloped grassed areas and woodland.
- 1975 – The site and the surrounding landuse remained relatively unchanged from the previous 1955 aerial photograph.
- 1982 - The site remained relatively unchanged from the previous 1975 aerial photograph. Residential development of Werrington County was observed to the south of the site.
- 1991 - The site and the surrounding landuse remained relatively unchanged from the previous 1982 aerial photograph.
- 2002 – The site remained vacant and relatively unchanged from the previous 1991 aerial photograph. Increased tree cover was observed in the southern portion of the site. Staged decommission/demolition of the structures within the broader St Mary's ADI site was observed.
- 2009 – The site remained relatively unchanged from the previous 2002 aerial photograph. A fluorescent green shade was noted along the creek and wetland area potentially indicating increased algal growth. An access track/ footpath was observed to the north of the creek line oriented northeast to southwest.
- 2012 – the site remained relatively unchanged from the previous 2009 photograph. Earthworks associated with the Jordan Springs development was observed to the north of the site.

- 2017 – The site remained relatively unchanged with increased tree cover observed across the southern portion of the site. The Jordan Springs development had been completed and the Central Precinct Earthworks Stages were observed to the east of the site.

3.3 EPA Records

Search of the NSW EPA's public register under the Protection of the Environment Operations Act 1997 (POEO Act) was under taken (**Appendix E**). The search for the site identified there were:

- No transfer, variation, suspension, surrender or revocation of an environmental protection license; and
- No prevention, clean-up or prohibition notices were issued for the site;
- A search was also conducted through the EPA's public contaminated land register (**Appendix E**). The search did not identify any current or previous records of notices by the EPA, or notification to the EPA under Section 60 of the Contaminated Land Management Act 1997 (CLM Act), in relation to the site or immediately surrounding land.

4. Conceptual Site Model

4.1 Potential Areas and Substances of Environmental Concern

Based on the history review, previous investigations, general areas of environmental concern have been categorised and are presented in (**Table 4.1**).

Table 4.1 Areas of Environmental Concern and Associated Contaminants of Potential Concern

Area of Environmental Concern (AEC)	Contaminants of Potential Concern (COPC)
Former ADI commercial/industrial use	Heavy metals*, PAHs, TPH/BTEX, OCPs, PCBs, asbestos
Imported fill (if present) to create current site levels	Heavy metals, OCPs, PCBs, TRH, BTEX, PAHs and asbestos
Pre-existing stockpiled material (if present)	Heavy metals*, PAHs, TPH, OCPs, PCBs and asbestos.
Potential fly tipping of general waste nearby site boundaries (if present)	Heavy metals*, PAHs, TPH/BTEX, OCPs, PCBs, asbestos

* Heavy metals include As (Arsenic), Cu (Copper), Cr (Chromium), Cd (Cadmium), Ni (Nickel), Pb (Lead), Zn (Zinc) and Hg (Mercury).

Based on site history information provided in the site audit report (Kidd 1999), the broader St Mary's ADI site was historically used for agricultural/ grazing purposes. However, due to the site location and layout, it is considered unlikely that the site was used for broadacre agriculture or market gardening purposes. Therefore, contamination issues arising from historical application of pesticides and/or herbicides are considered not to be applicable to the site.

The site has undergone unexploded ordnance (UXO) clearance in the mid 1990s including sign off under SAS (CHK100/1) in 1996. Further, it is understood that manufacture of munition has not occurred at the site since that time. As such, UXO items are considered not to be a COPC at the site.

JBS&G previously completed an investigation for per/poly- fluoroalkyl substances (PFAS) at the Central Precinct development site and proposed Dunheved Precinct site as documented in JBS&G (2018[7]). The current site is located hydraulically upgradient of PFAS impacted areas identified during this investigation including Stockpile SP30 and the Dunheved Industrial Precinct. As such, PFAS is considered not to be a COPC in relation to the current site area.

The site inspection has identified stockpiled / potential filled materials present in proximity of the site, but no materials as present within the site. Further the intrusive investigation did not identify any evidence of fill based soils being present at the site. This causes potential contaminants as associated with stockpiled and/or fill materials to be highly unlikely for the site area.

4.2 Potentially Contaminated Media

Potentially contaminated media present at the site include:

- Fill material (including stockpiles) if present; and
- Natural soils underlying impacted fill materials (if present).

Fill material across the site is anticipated to be minimal given the site has largely remained vacant. Further the assessment works as completed did not identify any material that could be described as fill material.

Based on the known former site use for munitions testing and the unknown source of fill materials (if present), vertical migration of contamination from the fill and surface soils into the underlying natural soils may have occurred. Consequently, natural soils underlying impacted fill materials (if fill materials are present) have a moderate potential to be a contaminated media.

[7] PFAS Human Health and Ecological Risk Assessment, Former St Marys ADI Property, Central Precinct, Llandilo NSW, JBS&G Australia Pty Ltd, 54020/111425 (Rev D), 23 January 2018.

Groundwater has been previously investigated and signed off as part of the historical remediation and validation works conducted across the former ADI St Marys Property therefore groundwater is not considered to be a potentially contaminated medium.

4.3 Potential Exposure Pathway

Contaminants generally migrate from site via a combination of windblown dusts, rainwater infiltration, groundwater migration and surface water runoff. The potential for contaminants to migrate is a combination of:

- The nature of the contaminants (solid/liquid and mobility characteristics);
- The extent of the contaminants (isolated or widespread);
- The location of the contaminants (surface soils or at depth); and
- The site topography, geology, hydrology and hydrogeology.

The potential contaminants identified as part of the site history review and review of previous investigations are generally in a solid form (e.g. heavy metals, asbestos, etc). As the site is currently vegetated, there is a low potential for contaminates to have migrated via either windblown dust or surface water.

The potential for contaminants to migrate via groundwater is moderate to low, given the absence of any significant sources of contamination at the site.

Based on the contaminants of concern identified in various media as discussed above and proposed site development activities, the exposure pathways considered to be potentially complete for the site during and following development works include:

- Potential dermal and oral contact to impacted soils as present at shallow depths and/or accessible by earthworks contractors and future users of the of the site;
- Potential leaching of contaminants into surface water and impact to surface water bodies as proposed to be present within the site. Potential secondary direct contact to surface water bodies through recreational activities.

4.4 Receptors

Potential receptors of environmental impact include:

- Future recreational users of the open space areas of the site restricted to non-paved areas who may potentially be exposed to COPCs through direct contact with impacted soils and/or ingestion and/or inhalation of dusts / fibres associated with impacted soils. Additional potential secondary exposures as associated with the area of surface water to be established with the site development; and/or
- Excavation / construction / maintenance workers conducting activities at or in the vicinity of the site, who may potentially be exposed to COPCs through direct contact with impacted soils present within excavations and/or inhalation of dusts / fibres associated with impacted soils; and

Onsite ecological receptors at the site including flora and fauna, and similarly potential secondary contact to surface water as will occur within the site.

4.4.1 Preferential Pathways

For the purpose of this assessment, preferential pathways have been identified as natural and/or man-made pathways that result in the preferential migration of COPCs as either liquids or gasses.

Man-made preferential pathways may be present at the site, generally associated with fill materials at near surface depths. Fill materials are anticipated to have a higher permeability than the underlying natural soil and/or bedrock. However fill materials have generally not been identified at the site, and further are not present as a large expanse as would potentially constitute a preferential pathway.

Migration of contaminants if present would be more likely through the alluvial materials as consistent with the South Creek soils, then through the more clay based Luddenham soils as also present within the site.

Based on the site history review and detailed site inspection, COPC in the form of liquid or gas have not been identified. As such, contaminant migration via preferential pathways is considered to be unlikely.

5. Sampling and Analysis Plan

5.1 Data Quality Objectives

Data quality objectives (DQOs) are statements that define the confidence required in conclusions drawn for data produced for a project, and which must be set to realistically define and measure the quality of data needed.

Data quality objectives (DQOs) were developed for the investigation, as discussed in the following sections.

5.1.1 State the Problem

Due to time elapsed since the previous SAS (CHK1001/1) and the absence of historical intrusive investigation data for the current site, an environmental assessment including a soil investigation is required to assess the suitability of the site for the proposed construction of a regional detention basin. Assessments across other areas of the St Marys site have identified a range of contaminants, generally associated with the presence of fill materials.

5.1.2 Identify the Decision

Based on the decision making process for assessing urban redevelopment site detailed in DEC (2006), modified to meet the specific project objectives, the following decisions must be made:

- Are there any unacceptable risks to future site users or the environment from soil contamination?
- Are there any unacceptable health or ecological risks to offsite receptors?
- Are there any issues relating to the local area background soil concentrations that exceed appropriate soil criteria?
- Are there any impacts of chemical mixtures?
- Are there any odours or aesthetic issues?
- Is there any evidence of, or potential for, migration of contaminants from the site?
- Is a site management strategy required?

5.1.3 Identify Inputs to the Decision

Inputs to the decisions are:

- Review of historical reports and samples;
- Environmental soil data as collected by sampling and analysis and site observations made during this investigation, particularly with respect to the potential presence of stockpiled / fill materials on the site surface and the inspection of materials from sample locations to determine whether fill based soils have been used on the site;
- Assessment criteria to be achieved on the site as based on the intended land-use and project objectives, as defined by assessment criteria nominated in **Section 6**; and
- Confirmation that data generated by sampling and analysis are of an acceptable quality to allow reliable comparison to assessment criteria as undertaken by assessment of quality assurance / quality control (QA/QC) as per the data quality indicators (DQIs) established in **Section 5.1.6**.

5.1.4 Define the Study Boundaries

The study boundary comprises the footprint of proposed Basin as shown on **Figure 2**. It is noted that earlier advice was received of a far greater expanse of basin which resulted in additional sample locations being undertaken outside of the extent of the study boundaries. This data has been retained for the study as additional data to assist in the interpretation of background conditions.

Due to the project objectives, seasonality will not be assessed as part of this investigation. Data will therefore be representative of the timing and duration of the current investigation..

5.1.5 Develop a Decision Rule

Laboratory analytical data was assessed against EPA endorsed criteria as identified in **Section 6.**

The decision rules adopted to answer the decisions identified in **Section 5.1.2** are summarised in **Table 5.1**, as consistent with standard decision rules as adopted on urban redevelopment sites.

Table 5.1 Summary of Decision Rules

Decision Required to be made	Decision Rule
1. Are there any unacceptable health risks to onsite future receptors?	Soil analytical data will be compared against adopted EPA endorsed criteria. Statistical analyses in accordance with relevant guidance documents were undertaken, if appropriate, to facilitate the decisions. The following statistical criteria were adopted with respect to soils: Either: the reported concentrations were all below the site criteria; Or: the average site concentration for each analyte was below the adopted site criterion; no single analyte concentration exceeded 250% of the adopted site criterion; and the standard deviation of the results was less than 50% of the site criteria. And: the 95% upper confidence limit (UCL) of the average concentration for each analyte was below the adopted site criterion. If the statistical criteria stated above were satisfied, and an assessment of risk indicated no unacceptable risk the decision is no. Otherwise the decision is yes.
2. Are there any unacceptable health or ecological risks to offsite receptors?	Further to the decision rules above, data from soil sampling near site boundaries where potential receptors are located will be compared against adopted EPA criteria to determine if an unacceptable risk to offsite receptors exists. If there was the answer to the decision is yes Otherwise the decision is no.
3. Are there any issues relating to the local area background soil concentrations that exceed appropriate soil criteria?	If the 95% UCL of surface soils exceed published background concentrations (NEPC 1999), the decision was Yes. Otherwise, the decision was No.
4. Are there any impacts of chemical mixtures?	Were there more than one group of contaminants present which increase the risk of harm? If there was, the decision was Yes. Otherwise, the decision was No.
5. Are there any soil staining, odours or aesthetic issues?	If there were any ACM fragments on the ground surface, any unacceptable odours or soil discolouration, the decision was Yes. Otherwise, the decision was No.
6. Is there evidence of, or potential for, migration of contaminants from the site?	Consideration will be given to whether there are any elevated contaminant concentrations in soil in proximity to or at site boundaries and where site conditions may lead to the potential to migrate off site. If yes, the decision was Yes. Otherwise, the decision was No.
7. Is a site management strategy required?	Was the answer to any of the above decisions YES? If yes, a site management strategy is required. If no, a site management strategy is not required.

In addition to these rules, additional rules have been applied to the investigation to assist with informing the extent of sampling and analysis required to achieve the decision endpoints. These include:

- An assumption that in lieu of observation of fill material that soil samples will not need to extend to significant depths;
- An assumption in absence of fill materials, where surface samples are free of impact that deeper soils can be similarly considered to be free of impact and will not warrant analysis; and
- Assumption that in lieu of detection of any significant levels of impact in soils that there is no significant risk to groundwater.

Statistical Analysis

Statistical analyses of the data may be undertaken, if required, in accordance with relevant guidance documents. The following statistical criteria shall be adopted:

- The upper 95% confidence limit on the average concentration for each analyte (calculated for samples collected from consistent soil horizons, stratigraphy or material types) must be below the adopted criterion;
- No single analyte concentration shall exceed 250% of the adopted criterion; and

The standard deviation of the results must be less than 50% of the criterion.

5.1.6 Specify Limits of Decision Error

This step is to establish the decision maker's tolerable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data. Data generated during this project must be appropriate to allow decisions to be made with confidence.

Specific limits for this project have been adopted in accordance with the appropriate guidance from the NSW EPA, NEPC (2013), appropriate indicators of data quality (DQIs used to assess QA/QC) and standard JBS&G's procedures for field sampling and handling.

To assess the usability of the data prior to making decisions, the data will be assessed against pre-determined Data Quality Indicators (DQIs) for completeness, comparability, representativeness, precision and accuracy. The acceptable limit on decision error is 95% compliance with DQIs.

The pre-determined Data Quality Indicators (DQIs) established for the project are discussed below in relation to precision, accuracy, representativeness, comparability and completeness (PARCC parameters), and are shown in **Table 5.2**.

- **Precision** - measures the reproducibility of measurements under a given set of conditions. The precision of the laboratory data and sampling techniques is assessed by calculating the Relative Percent Difference (RPD) of duplicate samples.
- **Accuracy** - measures the bias in a measurement system. The accuracy of the laboratory data that are generated during this study is a measure of the closeness of the analytical results obtained by a method to the 'true' value. Accuracy is assessed by reference to the analytical results of laboratory control samples, laboratory spikes and analyses against reference standards.
- **Representativeness** –expresses the degree which sample data accurately and precisely represent a characteristic of a population or an environmental condition. Representativeness is achieved by collecting samples on a representative basis across the site, and by using an adequate number of sample locations to characterise the site to the required accuracy.

- **Comparability** - expresses the confidence with which one data set can be compared with another. This is achieved through maintaining a level of consistency in techniques used to collect samples; ensuring analysing laboratories use consistent analysis techniques and reporting methods.
- **Completeness** – is defined as the percentage of measurements made which are judged to be valid measurements. The completeness goal is set at there being sufficient valid data generated during the study.

If any of the DQIs are not met, further assessment will be necessary to determine whether the non-conformance will significantly affect the usefulness of the data. Corrective actions may include requesting further information from samplers and/or analytical laboratories, downgrading of the quality of the data or alternatively, re-collection of the data.

Table 5.2 Summary of Quality Assurance / Quality Control Program

Data Quality Objective	Frequency	Data Quality Indicator
Precision		
Blind duplicates (intra laboratory)	1 / 20 samples	<50% RPD
Blind duplicates (inter laboratory)	1 / 20 samples	<50% RPD
Laboratory duplicates	-	<50% RPD
Accuracy		
Surrogate spikes	All organic samples	70-130%
Laboratory control samples	1 per lab batch	70-130%
Matrix spikes	1 per lab batch	70-130%
Representativeness		
Sampling appropriate for media and analytes		-
Samples extracted and analysed within holding times.	-	organics (14 days), inorganics (6 months)
Trip spike (for volatiles)	1 per sampling event when sampling for volatile or semi-volatile COPC	70-130% recovery
Trip blank	1 per sampling event for ambient air sampling	<LOR
Rinsate	1 per sampling event where reusable sampling equipment used	<LOR
Comparability		
Standard operating procedures for sample collection & handling	All Samples	All samples
Standard analytical methods used for all analyses	All Samples	All samples
Consistent field conditions, sampling staff and laboratory analysis	All Samples	All samples
Limits of reporting appropriate and consistent	All Samples	All samples
Completeness		
Sample description and COCs completed and appropriate	All Samples	All samples
Appropriate documentation	All Samples	All samples
Satisfactory frequency and result for QC samples	All QA/QC samples	-
Data from critical samples is considered valid	-	Critical samples valid

5.1.7 Optimise the Design for Obtaining Data

Various strategies for developing a statistically based sampling plan are identified in EPA (1995[8]), including judgemental, random, systematic and stratified sampling patterns.

For sites larger than 5 ha, EPA (1995) recommends the use of stratified sampling where the site is divided into sub-areas according to geological and geographical features, nature of the contamination, former usage pattern of the site, intended future use of the sub area and other relevant factors. EPA (1995) further recommends that each sub-area can then be treated as an individual site and different sampling patterns and sampling densities applied.

The site is covered by SAS (CHK1001/1) signed off as suitable for residential land-use including substantial vegetable gardens and poultry in 1996. Based on the site history review, the site has remained vacant undeveloped land since that time. The site comprises vacant grassed areas in the northern portion and undeveloped woodland in the southern extent of the site.

The southern portion of the site has historically remained as a woodland and as such is considered to be a low risk area in relation to potential environmental contamination issues. The presence of the woodland would have precluded / restricted activities that may have caused contamination of the area (i.e. dumping of materials, placement of fill material etc). A limited number of sample locations were undertaken in the southern portion, relative to the remaining site area.

A total of 24 sample locations were undertaken across the site as testpits. These sample locations were generally broadly distributed across the site, with preferential placement within the open grassed areas, in proximity of off-site stockpiles located at the north-east of the assessment extent and in proximity of a drain line / low point as traversing the site.

An additional four sample locations were undertaken as Drain SP 01 to Drain SP 04 within the lower point of the drainage line through the site, of which two of these were submitted for analysis.

The soil sampling locations are shown on **Figure 3**.

As detailed above, groundwater has been previously investigated and signed off as part of the historical remediation and validation works conducted across the former ADI St Marys Property. In absence of any soil contamination being identified, a further groundwater investigation was not required within the Basin I site area.

5.2 Soil Sampling Methodology

Soil sampling was conducted on 14 March 2018 with the aid of hand tools (hand auger). It is considered that the use of hand tools, such as a hand auger, is appropriate given the shallow depth to natural soils (i.e. <0.5 m bgs). Natural soil samples, collected from the top of the natural soil profile were considered to be representative of the natural material which may be excavated to greater depths during construction of the basin (i.e. > 2 m) from a contamination perspective and for classification of potential surplus soils from the site. Soil sampling locations are shown on **Figure 3**.

Sample locations were extended to a typical depth of 0.8 m below ground surface (bgs). Soil samples were generally collected at sample intervals of 0-0.1 m and 0.3-0.4 m. Soils were inspected through the depth of the borehole. During the collection of soil samples, features such as seepage, discolouration, staining, odours and other indicators of contamination were noted on the bore logs provided in **Appendix I**.

Collected samples were immediately transferred to laboratory supplied sample jars/bags. The sample jars were then transferred to a chilled ice box for sample preservation prior to and during shipment to the testing laboratory. A chain-of-custody form was completed and forwarded with the

[8] *Sampling Design Guidelines.* NSW EPA. September 1995. (EPA 1995)

samples to the testing laboratory. Based upon field observations, samples were analysed in accordance with the laboratory schedule (**Table 5.3**).

All soil samples were further assessed in the field for the presence of potential volatile / hydrocarbon constituents by the use of a photo-ionisation detector (PID). PID screening results are further summarised in borelogs to **Appendix I**.

Not all samples collected were analysed. All samples will remain at the primary laboratory for a period of two months for possible future analysis (subject to holding times).

5.2.1 Decontamination

Prior to the commencement of sampling activities, any non-disposable sampling equipment, including sampling trowel/knife were cleaned with a water/detergent spray, rinsed with water and then air dried. The equipment was then inspected to ensure that no soil, oil, debris or other contaminants were apparent on the equipment prior to the commencement of works. Sampling equipment was subsequently decontaminated using the above process between each sampling location.

5.2.2 Duplicate and Triplicate Sample Preparation

Field soil duplicate and triplicate samples were obtained during the field works. The collected samples were divided laterally into three samples with minimal disturbance to reduce the potential for loss of volatiles and placed in three clean glass jars and sample bags as appropriate. Each sample was then labelled with a primary, duplicate or triplicate sample identification before being placed in the same chilled esky for laboratory transport.

5.3 Laboratory Analysis

JBS&G contracted Eurofins | MGT (Eurofins) as the primary laboratory for all the required analyses. The secondary laboratory for these analytes was Envirolab. All laboratories are NATA accredited for the required analyses.

In addition, the laboratories were required to meet JBS&G's internal QA/QC requirements. Laboratory analysis of samples was conducted as summarised in **Table 5.3**.

Table 5.3 – Sampling and Analytical Program

Area	No. of Locations	Analysis (excl QA/QC)
Basin I (5.75 ha)	24 hand augers (BI-01 to BI-24) 4 near surface drain samples (Drain SP01 to Drain SP04)	Heavy metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) – 34 samples TRH – 34 soil samples BTEX – 34 soil samples PAHs – 34 soil samples Asbestos – 26 soil samples (500 mL per NEPC 2013) + visual OCPs – 12 samples PCBs – 6 samples

In addition to the above analyses, for QA/QC purposes field duplicates and triplicates were analysed at a rate of 1/20 primary samples. A trip spike and trip blank sample was submitted with each batch of soil samples submitted to the laboratory.

It is notes that 25 samples were analysed from sample locations adjoining the basin site area and 21 from within the basin area, excluding QA/QC samples.

6. Assessment Criteria

6.1 Regulatory Technical Guidelines

The investigation will be undertaken with consideration to aspects of the following guidelines and technical documents, as relevant:

- National Environment Protection (Assessment of Site Contamination) Measure 1999 as amended 2013, National Environment Protection Council (NEPC 2013);
- Contaminated Sites: Sampling Design Guidelines, NSW EPA, 1995 (EPA 1995);
- Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites, NSW OEH, 2011 (OEH 2011);
- Contaminated Land Management: Guidelines for the NSW Site Auditor Scheme, 3rd Edition, NSW EPA, 2017 (EPA 2017);
- Guidelines for the Assessment Remediation and Management of Asbestos-Contaminated Sites in Western Australia, May 2009. Western Australia Department of Health 2009 (DOH 2009);
- Waste Classification Guidelines, NSW EPA, November 2014 (EPA 2014); and

6.2 Soil Criteria

Based on the proposed regional basin landuse for the site, concentrations of contaminants in the soil will be compared against published levels as presented in **Table 6.1**, sourced from the following:

- Health based Investigation Levels (HILs) and Health based Screening Levels (HSLs) for Public Open Space such as parks, playgrounds, playing fields, secondary schools and footpaths – NEPC 2013, HIL-C;
- Generic ecological investigation levels (EILs) based on NEPC (2013); and
- Ecological Screening Levels (ESLs) for TPH fractions, BTEX and benzo(a)pyrene in fine grained soil for urban residential and public open space land use (NEPC 2013).

It is noted that ecological criteria will be calculated using site specific criteria in accordance with NEPC (2013). These criteria will be presented following completion of ecological parameter analysis.

Where required, results will be statistically assessed in accordance with the method summarised in **Table 5.1**.

The results of asbestos observations and analysis will be assessed in general accordance with NEPC (2013) and WA DOH (2009) guidance.

In addition to the landuse assessment criteria above, assessment of aesthetics considerations will be conducted in accordance with (NEPC 2013) where one or more of the following were identified;

- Highly malodourous soil;
- Hydrocarbon sheen on surface water;
- Discoloured soils or soil staining;
- Monolithic deposits;
- Non-hazardous inert materials and foreign inclusions, such as building rubble;
- Putrescible refuse; and

- Soils containing residues from animal burials.

Table 6.1 Soil Investigation Criteria (all units in mg/kg)

	Limit of Reporting	Laboratory Method	Health Investigation/ Screening Levels Recreational/Public Open Space	Ecological Investigation/ Screening Levels Urban Residential and Public Open Space
METALS				
Arsenic	2.0	ICP-AES (USEPA 200.7)	300	100[7]
Cadmium	0.4	ICP-AES (USEPA 200.7)	90	-
Chromium	5.0	ICP-AES (USEPA 200.7)	300[1]	410[7]
Chromium (VI)	1.0	Alkali leach colorimetric (APHA3500-Cr/USEAP3060A)	-	-
Copper	5	ICP-AES (USEPA 200.7)	17,000	230[7]
Nickel	5.0	ICP-AES (USEPA 200.7)	1200	270[7]
Lead	5.0	ICP-AES (USEPA 200.7)	600	1100[7]
Zinc	5.0	ICP-AES (USEPA 200.7)	30 000	770[7]
Mercury (inorganic)	0.05	Cold Vapour ASS (USEPA 7471A)	80[2]	-
POLYCYCLIC AROMATIC HYDROCARBONS				
Carcinogenic PAHs (as B(a)P TPE)[3]	0.028	GCMS (USEPA8270)	3	-
Benzo(a)pyrene	0.5	GCMS (USEPA8270)	-	0.7[8]
Naphthalene	0.1	GCMS (USEPA8270)	NL[6]	170[7]
Total PAHs[4]	0.4	GCMS (USEPA8270)	300	-
BTEX				
Benzene	1.0	Purge Trap-GCMS (USEPA8260)	NL[6]	65[8]
Toluene	1.0	Purge Trap-GCMS (USEPA8260)	NL[6]	105[8]
Ethylbenzene	1.0	Purge Trap-GCMS (USEPA8260)	NL[6]	125[8]
Total Xylenes	3.0	Purge Trap-GCMS (USEPA8260)	NL[6]	45[8]
TOTAL RECOVERABLE HYDROCARBONS				
F1 C_6-C_{10}	10	TPH Purge Trap-GCMS (USEPA8260)	NL[6,]	180[8]
F2 >C_{10}-C_{16}	50	TPH Purge Trap-GCMS (USEPA8260)	NL[6]	120[8]
F3 >C_{16}-C_{34}	100	Purge Trap-GCFID (USEPA8000)	NL[6]	1300[8]
F4 >C_{34}-C_{40}	100	Purge Trap-GCFID (USEPA8000)	NL[6]	5600[8]
ORGANOCHLORINE PESTICIDES				
DDT + DDD + DDE	0.3	GCECD (USEPA8140,8080)	400	180[7]
Aldrin + Dieldrin	0.2	GCECD (USEPA8140,8080)	10	-
Chlordane	0.1	GCECD (USEPA8140,8080)	70	-
Endosulfan	0.3	GCECD (USEPA8140,8080)	340	-
Endrin	0.1	GCECD (USEPA8140,8080)	20	-
Heptachlor	0.1	GCECD (USEPA8140,8080)	10	-
HCB	0.1	GCECD (USEPA8140,8080)	10	-
Methoxychlor	0.1	GCECD (USEPA8140,8080)	400	-
PHENOLS				
Phenol	5	Distillation-Colorimetric (APHA 5530)	40 000	-
PCBs				
Total PCBs	0.7	GCECD (USEPA8140,8080)	1	-
Asbestos				
Asbestos (<0.1 m bgs)	0.1 g/kg	PLM / Dispersion Staining	No asbestos capable of being detected via the investigation, which comprises both visual identification and sample analysis by a NATA accredited laboratory	-
Asbestos FA/AF (>0.1 m bgs)	0.1 g/kg	PLM / Dispersion Staining	0.001%	-

	Limit of Reporting	Laboratory Method	Health Investigation/ Screening Levels Recreational/Public Open Space	Ecological Investigation/ Screening Levels Urban Residential and Public Open Space
Bonded ACM (>0.1 m)	0.1 g/kg	PLM / Dispersion Staining	0.05%	-
Asbestos Fibres	0.1 g/kg	PLM / Dispersion Staining	No respirable asbestos fibres of being detected via sample analysis by a NATA accredited laboratory	-

Notes:

1. Guideline values presented are for Chromium (VI) in absence of total Chromium values. Where total Chromium results are elevated, samples will be analysed for Chromium (VI).
2. Guideline values are for inorganic mercury. Where elevated mercury concentrations are encountered and/or site information suggests the potential presence of elemental mercury and/or methyl mercury, consideration of applicability would be needed.
3. Carcinogenic PAHs calculated as per Benzo(a)pyrene Toxicity Equivalent Factor requirements presented in NEPC 2013
4. Total PAHs calculated as per requirements presented in NEPC 2013.
6. Soil Health Screening Levels for Vapour Intrusion: Clay Soils. Values presented are those for 0 to <1 m bgs for recreational/ open space land use. Reference should be made to results tables for further detail of levels at greater depths.
7. EIL derived using assumed data using NEPC 2013 methodology, using the EIL calculator. Estimated CEC at 20 cmol/kg, pH at 7 and percentage clay content >10%.
8. ESLs for TPH fractions, BTEX and B(a)P in fine grained soil for urban residential and public open space land use.

NL: Non-limiting.

7. Quality Assurance/Quality Control

7.1 QA/QC Results

The QA/QC results for soil samples collected at the site are summarised in **Table 7.1** and discussed in **Section 7.2** below. It is noted that the data set presented below includes 21 samples collected from within the basin site and 25 samples collected from the adjoining site area as detailed on **Figure 3** and the analytical summary table attached. Samples were collected from within the original site area however as the design plans were revised after the completion of the field program, a number of the sample locations are now outside of the site boundary. The additional analytical results from samples collected outside the updated basin site area have been retained as they are considered to be both representative of soils within the basin site area and background soils concentrations. Detailed QA/QC results are included in **Appendix G.** Laboratory reports are included in **Appendix H**.

Table 7.1 Summary of Quality Assurance / Quality Control Program

Data Quality Indicator	Frequency	Results	DQI met?
Precision			
Soil Blind duplicates (intra laboratory)	>1 / 20 samples	2 in 34 primary samples with RPS ranging from 0-69 %	Partial[1]
Soil Blind triplicates (inter laboratory)	>1 / 20 samples	2 in 34 primary samples with RPS ranging from 0-82 %	Partial[1]
Laboratory Duplicates	>1/lab batch	0-<30 % RPD	Yes
Accuracy			
Surrogate spikes	All organic Analysis	63 – 147 % Recovery	Partial[1]
Laboratory Control Samples	>1/lab batch	70-130 % Recovery	Yes
Matrix spikes	>1/lab batch	71-125 % Recovery	Yes
Representativeness			
Sampling appropriate for media and analytes	All media/Analytes	All sampling conducted in accordance with JBS&G procedures	Yes
Laboratory blanks	>1/lab batch	<LOR	Yes
Samples extracted and analysed within holding times.	N/A	All samples were extracted and analysed within holding times apart from the trip spike, trip blank and rinsate blank	Partial
Trip spikes	1/lab batch	93-110 % Recovery	Yes
Trip blanks	1/lab batch	<LOR	Yes
Rinsate blank	1/sampling event	<LOR	Partial[1]
Comparability			
Standard operating procedures used for sample collection & handling	All samples	Field staff used same standard operating procedures throughout works	Yes
Standard analytical methods used	All samples	Standard analytical methods used as consistent with laboratory NATA accreditation	Yes
Consistent field conditions, sampling staff and laboratory analysis	All samples	Sampling was conducted by the same field staff members using standard operating procedures in the same conditions throughout the works. The laboratory remained consistent throughout the investigation.	Yes
Limits of reporting appropriate and consistent	All samples	Limits of reporting were consistent and appropriate.	Yes
Completeness			
Soil description & COCs completed	All samples	All borelogs and COCs were completed appropriately.	Yes
Appropriate documentation	All samples	All appropriate field documentation is included in the Appendices.	Yes
Satisfactory frequency/result for QA/QC samples	All samples	The QC results are considered adequate for the purposes of the investigation.	Yes
Data from critical samples is considered valid	All samples	Data from critical samples is considered valid.	Yes
Sensitivity			

Analytical methods and limits of recovery appropriate for media and the adopted site assessment criteria	All samples	Appropriate laboratory analysis methods and detection limits were considered to have been achieved during the field and laboratory phases of the investigation	Yes

7.2 QA/QC Discussion

7.2.1 Precision

Blind (intra-laboratory) Duplicates

Soil field blind (intra-laboratory) duplicates were analysed at a rate of 2 per 34 primary samples, above the required 1/20 DQI frequency. Acceptable RPD's have generally been reported apart from some elevated RPD's as based on analyte levels close to laboratory detection limits. RPD's can become elevated when based on analyte levels near to detection limits, and these elevated RPDs are not considered significant in context of the levels of the analytes relative to the associated assessment criteria. Detailed RPD analysis are provided in **Appendix G**.

Split (inter-laboratory) Duplicates

Soil field split (inter-laboratory) duplicates were analysed at a rate of 2 per 34 primary samples, above the required 1/20 DQI frequency. Acceptable RPD's have generally been reported apart from some elevated RPD's as based on analyte levels close to laboratory detection limits. RPD's can become elevated when based on analyte levels near to detection limits, and these elevated RPDs are not considered significant in context of the levels of the analytes relative to the associated assessment criteria. Detailed RPD analysis are provided in **Appendix G**.

Laboratory duplicates

All laboratory duplicates RPDs were within the acceptable range of less than 50%, within the JBS&G's acceptable range, and the laboratory QC Acceptance Criteria as defined in the Internal Quality Control Review.

7.2.2 Accuracy

Surrogate spikes

Surrogate spike recoveries were reported between 63% and 147%. A very limited number of surrogate recoveries were below the preferred JBS&G acceptable criteria (I.e. 70-130%), however were within the laboratories NATA accredited limits.

Several samples have reported over-recovery of surrogates, however the associated primary analytes are below detection limits. Over-recovery of surrogates is not considered significant where the associated primary analytes are below laboratory detection limits. The over-recovery of surrogate in these samples is not considered to compromise the data set.

Laboratory Control Samples

Laboratory control samples were conducted for each laboratory batch submitted and were all within JBS&G's acceptance criteria of 70-130%.

Matrix Spikes

Matrix spike samples were conducted for each laboratory batch submitted and were reported across a range of 71-128% and within the JBS&Gs prescribed range of 70-130%.

7.2.3 Representativeness

Sampling appropriate for media and analytes

The sampling methods were considered appropriate for soil media and the analytes targeted.

Laboratory Blanks

At least one laboratory blank was analysed for each analyte with each batch of samples. All levels of analytes in laboratory blanks were below detection limits.

Trip Spikes

Trip spike recoveries were between 93-110% and were all within the acceptable range of 70-130%. It is noted that the trip spike was analysed well outside the holding time for the sample. However for the substantial majority of the holding time exceedance the sample was retained in controlled conditions at the laboratory. The holding time exceedance is not considered to affect the usability of the trip spike sample.

Trip blanks

A trip blank was provided with each batch of samples. All levels of analytes in the trip blanks were below detection limits. Consistent with the trip spike, the trip blank was similarly analysed well outside holding times. Noting the absence of hydrocarbon constituents in other samples submitted for analysis, this is not considered significant.

Rinsate Samples

A rinsate blank sample was prepared with the field works and submitted with the sample batch for the investigation. The Rinsate blank was prepared from the hand auger. Levels of all analytes were below detection limits. As noted with respect to the trip blank and trip spike, organic analytes were analysed outside of holding times. However consistent with the absence of these analytes in the primary samples, this is not considered to significantly affect the quality of the dataset.

Holding times

All analyses have been extracted within holding times, apart from the trip spike, trip blank and rinsate blank. However these exceedances are not considered to significantly affect the dataset as discussed in the preceding sections.

7.2.4 Comparability

Common and consistent JBS&G Field Personnel were used to collect samples throughout the project. Field works have been undertaken in accordance with JBS&G field operating procedures. All required field forms and sampling logs have been appropriately completed by sampling personnel.

7.2.5 Completeness

Documentation

All documentation was completed to the required standard. Chain of custody forms are provided with laboratory documentation included in **Appendix H**.

Frequency for QA/QC Samples

The frequency of QA/QC samples is considered to be sufficient and meets the project DQI's.

7.3 Soil QA/QC Conclusions

The results of the field and laboratory QA/QC program indicates that the data obtained from this investigation generally met the predetermined DQIs or, where the DQIs were exceeded, did not indicate systematic sampling or analytical errors. As such the data is considered to be of adequate quality to be relied on for the purposes of assessing the environmental condition at the site.

8. Results

8.1 Field Observations

Field observations have been detailed in the borelogs prepared at each location as provided to field notes as **Appendix F** and borelogs as **Appendix I**. Soils have been identified as either silts or clays with no indication of fill materials or historical disturbance of the soil profile being present otherwise. Silts were more likely in proximity of the drainage line, including the three drain stockpiles (Drain SP01 to Drain SP03) as shown on **Figure 3**.

PID readings were all below instrument detection limits. There were no indicators of contamination observed in soils at any point of the site works.

8.2 Analytical Results

Soil summary analytical results are provided in **Table 1** as provided to the **Tables** section. Detailed laboratory reports and chain of custody documentation is provided in **Appendix H**.

Levels of all hydrocarbon based analytes were below detection limits. Levels of heavy metals were generally consistent with levels that would be anticipated as background levels in soils in western Sydney. Levels of asbestos were below detection limits in all samples.

On the basis of the field observations and the laboratory analysis of soils, it is concluded that the soils are consistent with virgin soils that have not been significantly impacted by any historical contaminating process.

9. Site Characterisation

The results are discussed in the following sections in relation to the identified decisions developed as part of the DQO process (**Section 5.1.2** and **5.1.5**).

9.1 Are there any unacceptable risks to future site users or the environment from soil contamination?

No, levels of analytes in soils are either below laboratory detection limits or otherwise at low levels as consistent with anticipated levels of those same constituents.

9.2 Are there any issues relating to the local area background soil concentrations that exceed appropriate criteria?

No, levels of heavy metals, the only detected analyte are consistent with anticipated background levels of these constituents in urban soils.

9.3 Are there any impacts of chemical mixtures?

There were no potential chemical mixtures identified during the investigation that may pose a management issue at the site.

9.4 Are there any odours or aesthetic issues?

No odours were observed at the site during the site works program. No evidence of fill or otherwise foreign material was identified during the site works.

9.5 Is there any evidence of, or potential for, migration of contaminants from the site?

There is no potential for migration of contaminants from the site as contamination has generally not been identified.

9.6 Is a management strategy required?

There is no management strategy required from the perspective of management of site contamination. However JBS&G also require to prepare a Waste Management Plan to satisfy planning requirements for the site. It is proposed that the surplus soils from the construction of the Basin will be classified as virgin excavated natural material (VENM).

10. Conclusions and Recommendations

Based on the findings of this assessment and subject to the limitations in **Section 11**, the site has been found suitable from a contamination assessment perspective for a future use to be developed as a Detention Basin. Remedial works are not required for soil within the extent of the site to facilitate the proposed use however it is recommended that an unexpected finds protocol be adopted during excavations works.

Surplus soils as will be generated by the substantial excavation works are proposed to be classified as virgin excavated natural material (VENM).

11. Limitations

This report has been prepared for use by the client who has commissioned the works in accordance with the project brief only, and has been based in part on information obtained from the client and other parties.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client, or amended in any way without prior approval by JBS&G, and should not be relied upon by other parties, who should make their own enquires.

Sampling and chemical analysis of environmental media is based on appropriate guidance documents made and approved by the relevant regulatory authorities. Conclusions arising from the review and assessment of environmental data are based on the sampling and analysis considered appropriate based on the regulatory requirements.

Limited sampling and laboratory analyses were undertaken as part of the investigations undertaken, as described herein. Ground conditions between sampling locations and media may vary, and this should be considered when extrapolating between sampling points. Chemical analytes are based on the information detailed in the site history. Further chemicals or categories of chemicals may exist at the site, which were not identified in the site history and which may not be expected at the site.

Changes to the subsurface conditions may occur subsequent to the investigations described herein, through natural processes or through the intentional or accidental addition of contaminants. The conclusions and recommendations reached in this report are based on the information obtained at the time of the investigations.

This report does not provide a complete assessment of the environmental status of the site, and it is limited to the scope defined herein. Should information become available regarding conditions at the site including previously unknown sources of contamination, JBS&G reserves the right to review the report in the context of the additional information.

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Document Status

Rev No.	Author	Reviewer	Approved for Issue		
		Name	Name	Signature	Date
A	Katie Linz / Matthew Parkinson	Matthew Parkinson CEnvP (SC)	Issue for Client Review		12/04/2018
B	Katie Linz / Matthew Parkinson	Matthew Parkinson CEnvP (SC)	Issue for Client Review		25/05/2018
0	Katie Linz	Greg Dasey	Greg Dasey		12/06/2018

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