STAGE 2 ENVIRONMENTAL SITE ASSESSMENT

Wyong Shire Council
Warnervale Town Centre

GEOTKARI02021AA-AL
31 March 2008

In accordance with Wyong Shire Council Contract:

CPA 108536

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SPECIALISTS MANAGING THE EARTH

31 March 2008

The General Manager
Wyong Shire Council
PO Box 20
WYONG NSW 2259

Dear Sir / Madam

RE: Proposed Warnervale Town Centre, Woongarrah

Stage 2 Environmental Site Assessment

Coffey Geotechnics is pleased to present the Stage 2 Environmental Site Assessment (ESA) for the proposed Warnervale Town Centre.

Should you have any questions regarding the report, please do not hesitate to contact the undersigned.

For and on behalf of Coffey Geotechnics Pty Ltd

Strider Duerinckx **per** **Michael Dunbavan**

Senior Engineering Geologist Principal

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EXECUTIVE SUMMARY

This document presents the Stage 2 Environmental Site Assessment (Stage 2 ESA) for a portion of the proposed Warnervale Town Centre (WTC) (the Site) prepared by Coffey Geotechnics Pty Ltd (Coffey). The Stage 2 ESA was undertaken on behalf of Wyong Shire Council (WSC) in accordance with Coffey proposal GEOTKARI02021AA-AG, dated 20 April 2007.

Based on the brief provided by WSC, it is understood that the proposed WTC development will include rezoning of an area bounded by Sparks Road and Hakone Road, and straddling the main Northern Railway Line, to allow the future development of commercial and residential precincts. The Stage 2 ESA was only undertaken on a portion of the proposed WTC extents (area of 33Ha) including Lot 521 DP594725 (9.052Ha), Lot 1 DP376264 (4.25Ha), Lot 54 DP7527 (5.665Ha), Lot 55 DP7527 (5.665Ha), Lot 51 DP561032 (2.023Ha), Lot 52 DP561032 (2.024Ha), Lot 1 DP375712 (0.337Ha), Lot 1 DP371647 (0.0607Ha), and Lot 4 DP7738 (4.045 Ha).

Within the Stage 2 ESA investigation area, the final layout of the WTC is not confirmed, but it is understood that the general features of the proposed development will include open spaces, environmental conservation, aquatic centre, town centre, business precinct, and a residential precinct. Development will involve extensive regrading of the Site as well as cuts of up to 8m on the elevated areas, and water bodies would be constructed by excavation.

The purpose of the Stage 2 ESA was to assess the suitability of the existing Site conditions for the proposed WTC redevelopment uses. This purpose was met by undertaking a Stage 2 ESA including preparation of a Sampling and Analysis Quality Plan (SAQP), excavation of test pits, drilling of boreholes, installation of monitoring wells across limited portions of the investigation area at identified Areas of Environmental Concern (AEC) based on a Phase 1 ESA previously undertaken for the site, a soil sampling and analytical regime, a groundwater sampling and analytical regime, and a landfill gas monitoring round.

The subsurface investigations indicated that typically undisturbed soil profiles were encountered in the forested margins of the investigation area, including silty sand topsoils underlain by residual sandy clays and shallow bedrock. Partially disturbed soil profiles were encountered in the former rural residential areas (Lot 51 and Lot 52) and the former nursery (Lot 521). These included localised filling from previous greenhouse cut pads, scatterings of surface and shallow subsurface nursery wastes, and foundations and disturbed soils associated with previous structures. Disturbed and partially cut/filled tracks across all lots on the investigation area were identified, associated with illegal dumping of wastes. Significant filling associated with the former quarry void/landfill was observed underlain by either residual clays or sandstone bedrock. Fill was identified from the surface to depths ranging between 0.3m to 5.5m depth. The fill typically consisted of 1-2m of sand dominated soils, underlain by various clay and/or sand dominated soils. Anthropogenic inclusions were generally observed in the underlying clayey fill , and mainly consisted of green wastes (cut and natural) and road wastes (concrete kerbing and piping etc), though a car body and fibro cement fragments were also recorded.

Groundwater was not encountered in topsoils or residual clays during the investigation. Groundwater inflows were recorded in some of the test pits and boreholes undertaken within the former landfill, typically within voids (car bodies, tyres, plastic bottles etc), perched on-top of clayey fill lenses or at the base of fill on-top of residual/bedrock. Groundwater levels were recorded at between 2m and 4.5m depth in the first round of groundwater monitoring, being deepest at MW1 (close to drainage line). Groundwater levels did not stabilise in the monitoring wells installed across the landfill, and continued to fall in all wells over the three dates recorded., attributed to a period of dry weather. The hydrogeological model developed for the former landfill was an intermittent infiltration of rainwater and runon water into the fill, migrating north-east towards the lowest fill level within the drainage alignment,

and exiting the former landfill into the drainage creek in that area. The inferred flow direction was relatively flat and irregular on the upper, level southern portion of the former landfill and down to the north-east in the lower irregular portion close to the drainage line. Groundwater was typically moderately acidic and fresh. Given the layout of the investigation area, no ‘background’ or upstream monitoring wells were able to be installed.

The landfill gas monitoring results indicate that hydrogen sulfide was not detected or detected at background concentrations in all monitoring points (no explosion or inhalation risks), and concentrations of volatile gases were low. Methane concentrations were variable with concentrations greater than the NSW EPA Guideline recorded in the four monitoring wells located on the upper southern portion of the former landfill. Explosion and asphyxiation risks were being generated by methane buildup in the monitoring wells, though insufficient data is available to fully assess risks across the surface of the landfill.

The analytical results indicated that

- Concentrations of cyanide, Organochlorine Pesticides (OCP) and Organophosphorus Pesticides (OPP) were generally not detected across the former nursery. One sample from ETP8 record very low concentrations of OCP adjacent to one of the former nursery sheds. It is possible that spillage of stored or applied pesticides occurred in that area. As only one investigation was undertaken adjacent to this building additional higher concentration OCP impacts may be present. Zinc was recorded at concentrations exceeding the Environmental Investigation Level (EIL) guideline at ETP5. The results show that runoff from building materials adjacent to the former dwellings and sheds are likely to have resulted in surface heavy metal impacts, but the concentrations are typically below EIL and Health Based Investigation Level (HIL) A (residential) guidelines. Low heavy metal (copper and zinc) impacts were recorded in water in all the dams, and low Total Recoverable Hydrocarbons (TRH) concentrations were recorded in water from Dam 2. The heavy metal concentrations are likely to be a combination of natural background levels as well as impacts derived from surface water runoff from the upslope former nursery, quarry and landfill. It is uncertain the cause of the TRH impacts in Dam 2, but may be the result of illegal dumping of rubbish in the dam, leaking of an old pump, or just surface water run-on;
- Concentrations of Lead greater than the HILA guidelines were recorded on the surface at three test pits down the eastern flank of the former quarry extents (Lot 55). This area is proposed to be redeveloped for a mixture of open space, environmental conservation and residential. Arsenic was recorded at concentrations exceeding the EIL guideline at EBH3 within Lot 521. The results show that either impacted fill was used as pavement subbase or runoff from building materials or nursery activities prior to placement of the bitumen surface may have resulted in heavy metal impacts along the roadway drainage swale and surface. Asbestos in fibres was identified in dumped rubbish on the surface of the former quarry (Lot 54) adjacent to the access track that leads south from the landfill onto Lots 51 & 52 (Asbestos1). Asbestos in soil was also detected on the surface of the former quarry adjacent to this area at HA35 and HA33. The extents of the surface impacts of asbestos in soil were not delineated during the investigation. Groundwater was not encountered in residual soils across the former quarry and groundwater would only be expected within bedrock at depth. Surface water runoff down from the former landfill through the drainage alignment of Lot 54 and Lot 55 was observed. As low TRH, Volatile Organic Compounds (VOC) and heavy metal concentrations were recorded in the groundwater in the landfill it is expected that these may be moving downslope through surface expression at the base of the former landfill into the drainage

alignment. No TRH impacts were recorded in these surface waters and heavy metal concentrations of chromium were at similar levels to groundwater in the landfill;

- Asbestos in fragments was recorded in fill across the former landfill, with detections in all four fragment samples collected and analysed from 2m depth or greater. Asbestos in soil was not recorded in the sandy surface capping layer itself. Zinc was recorded at 2.5m depth in one test pit (ETP88) in the former landfill at concentrations greater than the EIL, and concentrations of Benzo(a)Pyrene (BaP) were recorded at the surface and 2m depth in two locations (HA12 and ETP74) at or above the HILA. No asbestos was detected in waste stockpiles on the surface of the landfill, and concentrations of other inorganic and organic contaminants were less than the onsite EIL and HIL guidelines. Concentrations of heavy metals (chromium, copper and zinc) were recorded in groundwater at concentrations marginally greater than the ANZECC 95% protection of Aquatic Ecosystem Guidelines. Concentrations of TRH <3500ug/L and low concentrations of VOC (dichlorodifluoromethane and chloromethane) were recorded in groundwater across the landfill, in the area around the test pit where the car body was observed (ETP85) and in the portion of the landfill along the drainage alignment. Very low concentrations of anthracene at the guideline were also recorded in groundwater in one monitoring well. Methane was recorded to be collecting in air space above the groundwater level in the monitoring wells at concentrations greater than the NSW EPA Guideline in MW4, MW5, MW7 and MW8 located in the upper flat southern portion of the former landfill;
- No asbestos or other inorganic or organic contaminants were present at concentrations greater than the EIL or HILA guidelines on the track surface or adjacent sampled stockpiles in the forest area east former quarry (Lots 54 and 55). The concentration of arsenic in Composite 13 exceeded the adjusted EIL but was less than the adjusted HILA guideline;
- Concentrations of COC's analysed were less than EIL and HILA guidelines in all composite, stockpile and gully samples collected on the southern forested area (Lot 4);
- Concentrations of zinc and arsenic were recorded at 0.4m depth in two separate test pits (ETP75 and ETP93 respectively) on Lot 51, and at the surface in one test pit (ETP100) on Lot 52 at concentrations greater than EIL but less than HILA guidelines. These were associated with filling adjacent to the dam wall construction (ETP97) and former buildings (ETP93 and ETP100). Asbestos in fibro cement guttering was recorded in one stockpile adjacent to the dam on Lot 51 (SS92), and two stockpiles on Lot 52 (ST16 and ST17). Asbestos analyses in adjacent soils have not been undertaken as part of this investigation; and
- Concentrations of COC's analysed were less than EIL and HILA (residential) guidelines in all surface samples collected on the track on Lot 1 DP375712 and Lot 1 371647.

Overall the investigation area recorded low concentrations of the Contaminants of Concern (COC) investigated, generally at levels such that all proposed WTC landuses should be suitable with only minimal additional investigations or remediation given the size of the area investigated and the previous landuses undertaken. Groundwater contamination in the former landfill was recorded and needs to be managed in the future Asbestos impacts were recorded across the investigation area within filling in the landfill, stockpiled wastes and on the surface of adjacent soils. The asbestos investigation was limited and asbestos remains a COC that has not been fully assessed across the investigation area. Minor heavy metal impacts were identified across the site generally adjacent to former structures or runoff from these. Given statistical analysis most of these impacts would be reassessed as suitable for the proposed landuses with 95% confidence, but in areas of proposed residential or conservation use arsenic and zinc impacts in Lots 51 & 52, and lead impacts in Lot 55 may require further assessment or remediation.

In its current condition the investigation area is not suitable for the proposed landuses without further investigations. The further investigations that Coffey recommend are presented below.

Property/Landuse	Recommendation
All properties/landuses	During fieldwork of the Stage 2 it was observed that multiples points of access to the site were available, and illegal dumping of rubbish, including fibro cement sheeting is ongoing. Coffey recommend that the entire investigation area is secured to prevent further dumping and contamination of the surface of the area. Given the limited asbestos analyses undertaken to date, a conclusion on the extent of asbestos impacts associated with dumping of rubbish and burial in the landfill is not possible. Further investigations for asbestos across the investigation area are required. Once the proposed landuse and built environment over the investigation area is known, a Remedial Action Plan (RAP) be prepared to explore the appropriate remedial options for the identified dumped rubbish, subsurface impacts within the landfill, and surface impacts in the former nursery and rural-residential areas. These options may include preparation of a Site Management Plan (SMP) to manage ongoing contamination risks (such as buried asbestos in the landfill).
Former Nursery – Lot 521	Additional analyses for asbestos are undertaken across the surface of the former nursery and adjacent to buildings once demolished. Additional investigations for OCP impacts are undertaken in the vicinity of ETP8. Additional water sampling be undertaken to confirm TRH concentrations in Dam2 (former nursery), and soil/sediment analyses undertaken to assess concentrations of TRH in upslope or spillway soils.
Former Quarry – Lot 521, Lot 1, Lot 54 and Lot 55	Additional analyses for asbestos are undertaken across the surface of the former quarry beyond the limits of HA35-HA33, and in stockpiles along the access track and landfill margin. Further investigations into the bedrock aquifer downslope of the former landfill are undertaken to assess if migration of contaminants into the bedrock is occurring.
Former Landfill - Lot 1, Lot 54 and Lot 55	Additional analyses for asbestos are undertaken across the surface of the former landfill, within stockpiled waste materials and on the surface adjacent to dumped stockpiles.

EXECUTIVE SUMMARY

Property/Landuse	Recommendation
	Additional monitoring wells are installed to the base of fill in the north-western portion of the former landfill to assess for presence of groundwater and methane. Once the proposed landuse and built environment over the former landfill is known additional investigations are undertaken to assess the extent of landfill gas generation adjacent to the built structures and across the surface of the landfill in general. A plan of management may be required to to manage methane, which may include recommendations for capping and methane collection systems.
Eastern Forested Area – Lot 54 and Lot 55	Additional analyses for asbestos are undertaken across the surface adjacent to the stockpiles on the main access track margins.
Southern Forested Area – Lot 4	Additional analyses for asbestos are undertaken across the surface adjacent to the stockpiles on the access track margins. Further investigations into the bedrock aquifer downslope of the former landfill are undertaken to assess if migration of contaminants into the bedrock is occurring.
Former Rural Residential - Lot 51 and Lot 52	Additional analyses for asbestos are undertaken adjacent to stockpiles on Lot 51 and Lot 52.
Track – Lot1 DP375712 and Lot 1 DP371647	Additional analyses for asbestos are undertaken adjacent to stockpiles on the margin of the access track.

1 INTRODUCTION

This document presents the Stage 2 Environmental Site Assessment (Stage 2 ESA) for a portion of the proposed Warnervale Town Centre (WTC) (the Site) prepared by Coffey Geotechnics Pty Ltd (Coffey). The Stage 2 ESA was undertaken on behalf of Wyong Shire Council (WSC) in accordance with Coffey proposal GEOTKARI02021AA-AG, dated 20 April 2007. The Site is located to the north of Sparks Road at Woongarrah. The Site location is presented in **Figure 1.**

1.1 Proposed Development

Based on the brief provided by WSC, it is understood that the proposed WTC development will include rezoning of an area bounded by Sparks Road and Hakone Road, and straddling the main Northern Railway Line, to allow the future development of commercial and residential precincts.

As shown on **Figure 1**, The Stage 2 ESA was only undertaken on a portion of the proposed WTC extents. Within the Stage 2 ESA investigation area, the final layout of the WTC is not confirmed, but it is understood that the general features of the proposed development will include:

- Open space and aquatic centre on the former landfill area (Lot1 DP376264 and Lot 54 DP7527), the northern portions of the former rural-residential properties (Lot 4 DP7738, Lots 51&52 DP561032), and along the drainage alignment of Lot 55 DP7527;
- A commercial precinct on the former nursery (Lot 521 DP594725);
- A residential precinct on the former rural residential properties (Lot 4 DP7738 and Lots 51&52 DP561032), the access roadway (Lot 1 DP375712 and Lot 1 DP371467),and the former quarry margins (Lot 55 DP7527).

The majority of structures are likely to be one and two storey structures founded on high level footings. However, development will involve extensive regrading of the Site as well as cuts of up to 8m on the elevated areas, and water bodies would be constructed by excavation.

A concept plan of the proposed layout is presented in **Figure 2**.

1.2 Purpose of Assessment

The purpose of the Stage 2 ESA was to assess the suitability of the existing Site conditions for the proposed WTC redevelopment uses.

1.3 Objectives

The objectives of the Stage 2 ESA were to:

- Make an assessment of the nature and extent of contamination associated with the potential AECs and COCs identified in the Stage 1 ESA (Douglas Partners Ref: 41118A, March 2006); and
- Assess further investigation or remediation requirements for the Site to be considered suitable for the proposed future land uses.

The decision that is required to be made is:

- Does soil or groundwater contamination on the Site require remediation for the Site to be considered suitable for the intended land use?

1.4 Data Quality Objective Process

A Sampling Analysis and Quality Plan (SAQP) was prepared for the Stage 2 ESA (Ref: GEOTKARI02021AA-AI, dated 7 September 2007). The SAQP was prepared using the seven steps Data Quality Objectives (DQO) process detailed in the Guidelines for NSW Site Auditor Scheme (NSW DEC, 2006). The purpose of the DQO process is to confirm that the data obtained is suitable for the investigation. The SAQP outlines the DQO process and should be read in conjunction with this report. The seven steps are worked through the report in the section headers detailed in **Table 1**.

Table 1 - Data Quality Objective Steps

DQO Step	Relevant Title of Section
1.State the Problem	Section 1. Introduction
2.Identify the Decision	Section 1. Introduction
3. Identify Inputs to the Decision	Section 3. Site Features Section 4. Previous Investigations
4. Define the Study Boundaries	Section 3.1 Investigation Area Identification Section 6. Sampling and Analysis Plan & Methodology
5. Develop a Decision Rule	Section 5. Investigation Criteria
6. Specify Limits on Decision Errors	Section 6.2 Quality Assurance and Quality Control
7. Optimise the Design for Obtaining Data	Section 6. Sampling and Analysis Plan & Methodology

2 SCOPE OF WORKS

The scope of works for the Stage 2 ESA was detailed in the brief provided by WSC (as amended), and quoted on by Coffey (Ref: GEOTKARI02021AA-AG dated 20 April 2007). In summary the proposed scope of work included:

- A preliminary concept meeting with WSC prior to commencement of works;
- A desktop review of the previous environmental site assessments undertaken to date;
- Preparation of a Sampling and Analysis Quality Plan (SAQP) to be submitted for approval by the NSW EPA Accredited project Auditor; and

- A Stage 2 Environmental Site Assessment (ESA) across the nominated area including:
    - Preparation of a Site Specific Health & Safety Plan (SSSP);
    - Excavation of test pits, and drilling of hand augers and boreholes across the area;
    - Installation of monitoring wells and a round of groundwater monitoring;
    - Collection of targeted surface (track and gully) and stockpile soil samples;
    - Collection of discrete surface soil samples to make up 29 composites;
    - Collection of dam water samples;
    - A round of landfill gas monitoring;
    - Laboratory soil and groundwater analyses; and
    - Preparation of this report.

Given the complexity of the sampling and analytical strategy, the SAQP should be read in conjunction with this report. The final sampling and analytical strategy undertaken for the investigation was essentially that proposed, with minor adjustments to the scope to fit in with site conditions including modifying the ratio of test pits/hand augers/ boreholes, and modifying the number of monitoring wells.

3 SITE FEATURES

The following sections describe the 'Inputs to the Decision' and 'Define the Study Boundaries' for the investigation as identified in the DQO process of **Table 1**.

3.1 Investigation Area Identification

The investigation area is bounded by Sparks Road, Hakone Road and the Main Northern Railway Line and is a battle-axe in shape. It is understood that the Site is zoned 10A Investigation Precinct, and is generally in a disused state. The investigation area encompasses nine cadastral lots over an approximately 33Ha area as detailed in **Table 2**.

Table 2 - List of Cadastral Lots and Areas

Property	Total Area
Lot 521 DP594725	9.052 Ha
Lot 1 DP376264	4.25 Ha
Lot 54 DP7527	5.665 Ha
Lot 55 DP7527	5.665 Ha
Lot 51 DP561032	2.023 Ha
Lot 52 DP561032	2.024 Ha
Lot 1 DP375712	0.337 Ha
Lot 1 DP371647	0.0607 Ha
Lot 4 DP7738	4.045 Ha

3.2 Investigation Area Layout and Topography

The existing investigation area layout is presented in **Figure 3**.

Based on observations made by Coffey staff during the Stage 2 ESA and on information in the Stage 1 ESA report, the Site is currently unoccupied and comprises five main areas which typically correlate to the previous landuses:

- A disturbed, benched and irregular, and mainly cleared terrain on the ridgeline associated with the previous quarry and landfill;
- A disturbed and terraced terrain with little vegetation on the western slope of the ridgeline associated with the former nursery;
- Partly forested former paddocks north of the former nursery in the north-western portion of the Site;
- Relatively undisturbed bushland in the northern, north-eastern, eastern, and south-western portions of the Site along the former quarry margins; and
- A partly disturbed and cleared area in the south-eastern portion associated with the former rural-residential dwellings.

Access tracks are present:

- A single dirt and bluestone gravel/bitumen track cutting diagonally from Hakone Road south through to the top of the ridgeline (former landfill). Isolated piles of illegally dumped waste materials have been observed along this track and up to the northern edge of the former landfill. This track has a locked gate at Hakone Road;

- A rough dirt track cutting up from Sparks Road between Lot 4 DP7738 and Lot 51 DP561032 through to the southern edge of the former landfill. This track then circles along the southern edge of the former landfill, joining up with the track from Hakone Road. This track is ungated, and numerous stockpiles of older and more recently dumped domestic and building waste were observed along the margins of this track;
- A bitumen track cutting up from Hakone Road into Lot 521 DP594725 to the centre of the former nursery. This track is gated at Hakone Road, but the adjacent fence has been knocked down allowing vehicular access.

Given the two latter tacks, the investigation area is unsecured, and additional dumping of domestic and fibro-cement wastes was observed during the Stage 2 ESA.

The Site straddles a dominant ridgeline between Sparks Road and Hakone Road at Woongarrah. Surface slopes range from flat to 3° across the landfill, to 5°-11° radially down the flanks of the ridgeline.

Various photographs of the main features of the investigation area are attached in **Appendix A**, and comments are provided on **Figures 4 and 5**. The areas are described in more detail in the following sections.

3.2.1 Former Nursery

The former Nursery is located on Lot 521 DP594725. This portion of the investigation area is located on the western and north-western flank of the ridgeline and generally appears to have been unused for former quarrying activities. The area is divisible into three sub-portions, a relatively unused grazing paddocks and bitumen access track in the northern part, a central benched area with remnant greenhouse structures and buildings, and a southern relatively unused grassed area containing three farm dams.

The northern paddock area is fenced and contains native/introduced grasses and regrowth eucalypt trees. A small farm dam is located along the eastern boundary in the eastern paddock, and is fed by surface runoff from the paddock and access track. Very little surface rubbish was observed to be present in this area during the investigation. The groundsurface slopes at approximately 9° down to the north-west, reducing to approximately 5° in the north-western portion.

A bitumen access track cuts up to the south through this area and appears to have been the main access to the former nursery. The track forks part way up the slope providing access to the lower benched platforms and to the higher sheds, office and dwelling. The bitumen is degraded and breaking in parts, and a stormwater runoff swale runs alongside the upslope edge of the track.

The north-eastern edge of the central benched area contains a former brick and tile dwelling on a small cut/fill platform surrounded by minor landscaping. South of this dwelling on the crest of the ridge is a former fibro and Galvanised Iron (G.I.) office on a gravel pad. In this area also are the remains of a large steel potting/storage shed, greenhouses amenities blocks and other structures. All these structures are in a state of partial demolition and the groundsurface is scattered with potting trays and rubbish including a burnt out car.

To the west of the sheds a series of three benched pads step down the slope to the western boundary. The pads are relatively level separated by cut/fill embanks of approximately 20° slope and 2m height. Remains of hydroponic sheds and potting material is scattered across the surface of this area.

Three dams are present in the southern portion of the former nursery. The dams contain only minor weed growth and were observed to have relatively clear water. Some demolition waste (steel and wood) was observed around the margins of the dams. The surface slopes down to the south-west at approximately 6°.

3.2.2 Former Quarry/Landfill

The former quarry/landfill is located on Lot 1 DP376264 and Lot 54 DP7527. This portion of the investigation area is located on the crest of the ridgeline. Surface slopes are irregular, being relatively flat on the filled landfill portion, with steeper embankments (up to 27°) on fill margins. Surface slopes are to the east, south-east, south and south-west around the perimeter of the former landfill.

The former landfill can be divided into two portions. A higher relatively level bench area at RL 53mAHD in the southern and western portion, and a lower more irregular portion at RL 51m-53mAHD in the northern and north-eastern portion. These areas are delineated by a fill embankment that is aligned north-west through the landfill. In the north-eastern portion of the landfill the groundsurface drops down a series of steep embankments to the natural ground surface at RL 48mAHD. A small drainage culvert is located in this area including concrete pipe, and seep water from the base of the landfill was observed to be draining down through the culvert to a natural gully. A small, previously unidentified dam is located in that area (adjacent to EBH 15/MW3).

A dirt, gravel and bitumen access track cuts up to the former quarry/landfill from the north-east, and runs along the southern edge of the area. Numerous piles of domestic and demolition rubble were observed to be present along the southern edge of the access track in the irregular northern portion of the landfill. These include fibro-cement sheeting, steel, G.I., plastic, concrete, wood and trees. Weed vegetation is growing in this area including bananas and coral trees. Some concrete pipes are present along the remainder of the margins of the access track as it passes through the former landfill, and more illegal dumping of rubbish has occurred on the access track just to the south of the former landfill on the boundary between Lot 54 DP7527 and Lot 51 DP561032.

3.2.3 Northern Forested Area

The northern forested area is located between the former nursery and the main access track in from Hakone Road. The area is located within the northern portions of Lot 1 DP376264, and Lot 54 and 55 DP7527. The area is typified by a rocky ridgeline (the highest point in the investigation area) that extends to the north-east. Dominant slopes down to the north-west and south-east at 9° are observable, as well as a slope down to the north-east at the edge of the ridgeline close to the northern boundary of the investigation area. The area is moderately to heavily forested and typically shows only minimal signs of disturbance. A disturbed area consisting of piles of sandstone boulders is present in the area. Some minor stockpiles of quarry waste (sandstone, concrete, bitumen) are present on the western edge of the access track.

3.2.4 Eastern Forested Area

The eastern forest area is located between the main access track from Hakone Road and the former quarry/landfill and the eastern boundary of the investigation area. The area is located within the southern portion of Lot 54 DP7527, and the majority of Lot 55 DP7527. The area contains moderate to dense forest and the surface slopes down to the east at approximately 6°. A drainage gully is present in the centre of this area, and collects surface runoff and seepage water from the former quarry/landfill.

A disturbed area consisting of cleared vegetation and some sandstone boulders is present off the main access track in the centre of the area. Significant amounts of quarry waste stockpiles are present along the eastern margin of the main access track, including sandstone, gravel, bitumen, concrete pipes and culverts. Some intermittent dumped domestic and demolition waste are also present along the eastern margin of the access track including fibro cement sheeting and guttering.

3.2.5 Southern Forested Area

The southern forested area is located entirely within Lot 4DP77738, and is heavily forested with casuarina. The area is generally undisturbed though a small shed and farm dam are located in the south-western corner. The groundsurface slopes down from the edge of the ridge on the northern boundary of Lot 4 to the south at 9°, flattening out to a slope of 3° towards the southern boundary.

3.2.6 Former Rural-Residential

The former rural-residential area is located on Lots 51 and 52 DP 561032. A farm dam is located in the centre of Lot 51 along its western boundary. Except for a concrete slab on Lot 52 and remnant introduced vegetation, no remnant structures of the former buildings remain. Some benching of the groundsurface was observed downslope of the dam.

Lot 51 is mainly cleared, especially in the southern portion, and on the southern portion of Lot 52 is cleared, the remained is forested.

A dirt access track (Lot 1 DP375712 and Lot 1 SP371647) is present along the eastern margin of Lot 52, servicing the adjacent school and a residential development. This track peters out in the forested southern portion of Lot 55. No significant dumping of rubbish was observed along the margins of the track, but occasional piles of domestic refuse were observed.

A dirt access track is present between Lot 4 and Lot 51, and joins up with the ring track along the southern edge of the former quarry/landfill. Significant numbers of stockpiles (including additional piles placed during the period of the investigation) were observed in this area. The stockpiles mainly consisted of demolition and building waste and minor domestic refuse. Fibro cement sheeting and guttering was also observed.

3.3 Surrounding Landuse

Surrounding landuses include:

- Rural-residential properties downslope across Hakone Road to the north;
- Rural-residential properties downslope across Sparks Road to the south;
- A primary school and grazing land downslope to the east; and
- The main Northern Railway line downslope to the west.

No properties are located upslope of the site.

3.4 Local Geology and Hydrogeology

A review of the 1:25,000 Geological Survey Map of Wyong (unpublished) indicates that the investigation area is underlain by bedrock of the Tuggerah Formation of the Narrabeen Group. This formation consists of lithic sandstone, red-brown and grey-green claystone and siltstone, grey siltstone and laminite, and rare conglomerate. These rock types generally weather to sandy clay soils.

Groundwater is expected to be present within the sandstone bedrock and is likely to be flowing radially from the top of the ridgeline down parallel to the surface slope. Groundwater is expected to discharge at Woongarrah Creek located approximately 3km to the north-east of the Site and at Porters Creek located approximately 5km to the south-west of the Site. Based on past investigations, the groundwater level is anticipated to be encountered at the 20m depth range below the ground surface.

Perched groundwater within the filled former quarry void is also expected to be present. Leakage out from the former void into the regional groundwater or groundsurface is expected.

4 PREVIOUS INVESTIGATIONS

The following sections describe the ‘Inputs to the Decision’ available for the project as identified in the DQO process of **Table 1**.

Douglas Partners Pty Ltd previously undertook a Stage 1 ESA on the current investigation area and adjacent properties (Reference 41118A, March 2006). The assessment involved a Site visit and Site history review to identify potential areas of environmental concern (AECs) and chemicals of concern (COCs). The investigation revealed that:

- A number of limited environmental and geotechnical investigations had been previously undertaken across the Site including historical reviews, site walkovers, and limited intrusive sampling;
- A summary of historical ownership of land comprising the Site did not indicate any specific contaminating activities at the Site, although nursery and quarrying activities were present on some of the lots;
- A search of the NSW WorkCover Dangerous Goods records indicate that there were no records of the storage of dangerous goods relating to the Site;
- Portions of Lot 1 DP376264, Lots 54 & 55 DP7527, and Lot 521 DP594725 had been used for quarrying;
- Landfilling of the quarry occurred mainly across Lot 1 DP376264 and Lot 54 DP7527, and included filling with council wastes from the roadworks section, but illegal dumping of wastes (of unknown sources) may have occurred on those lots and adjacent;
- A wholesale plant nursery was present on Lot 521 DP594725 from around 1987 to 2002, and included three dams, a number of cut and fill platforms containing greenhouses and ancillary structures;
- Rural residential landuse had previously occurred on Lots 51 and 52 DP561032, though at the time of the investigation a small catchment dam had been filled and levelled and the buildings demolished;
- An access road was present along the south-eastern boundary of the Site and contained some surface filling (Lot 1 DP375712 and Lot 1 DP371647); and

- Minor surface filling was observed across the majority of lots inspected.

Copies of historical aerial photographs from 1954, 1975, 1984 and 1994 were obtained by Coffey during the Stage 2 ESA. These are presented in **Appendix B**.

Based on the historical review and site walkover a number of AECs and COCs were identified depending on the location and type of previous activity. The AECs and COCs are presented in Section 3 of this report.

Douglas Partners concluded that previous activities were likely to have resulted in the potential for surface contamination (fill, surface soils and sediments in dams). The landfilling in the former quarry had the potential to cause surface and subsurface soil impacts, groundwater impacts and vapours. The quarrying operations and subsequent landfilling had the greatest potential to affect the suitability of Stage 1 ESA investigation area for the proposed future landuse. It was recommended that a Stage 2 ESA be conducted to assess the AECs and COCs.

Discussions between Coffey staff and WSC indicated that landfilling in the quarry included mainly excess roadworks waste and green waste, though it was acknowledged that uncontrolled filling also occurred.

4.1 Potential Areas of Environmental Concern and Chemicals of Concern

The potential Areas of Environmental Concern (AECs) and Chemicals of Concern (COCs) identified in Douglas Partners Stage 1 ESA report are summarised in **Table 3**, together with additional COCs identified by Coffey on the basis of the available information.

Table 3 - Summary of Potential Areas and Chemicals of Concern

Lot	AEC-Area (Ha)	Potential AECs	COCs	Likelihood of Contamination
Lot 521 DP594725	3.4	Nursery Activities	Heavy Metals, OCP, OPP, Cyanide, Nutrients*, Asbestos (from buildings)*	Moderate to High
	2.0	Quarrying Activities	Heavy Metals, TPH, BTEX, PAH, Phenols, PCBs*	Low
	Unknown	Illegal Dumping	Heavy Metals, OCP, TPH, BTEX, PAH, Phenols, PCB, Cyanide, Asbestos, Sulfate	Moderate
	Unknown	Importation of Filling	Heavy Metals, OCP, TPH, BTEX, PAH, PCB, Asbestos	Low
Lot 1 DP376264 and Lot 54	5.2	Quarrying Activities	Heavy Metals, TPH, BTEX, PAH, Phenols, PCBs*	Low

Lot	**AEC-Area (Ha)**	**Potential AECs**	**COCs**	**Likelihood of Contamination**
DP7527	3.7	Landfilling	Heavy Metals, VOC/SVOC, VHCs*, Asbestos, Landfill Gases (TPH, BTEX, Phenols, Methane*)	Moderate to High
	Unknown	Illegal Dumping	Heavy Metals, OCP, TPH, BTEX, PAH, Phenols, PCB, Cyanide, Asbestos, Sulfate	Moderate to High
Lot 55 DP7527	3.0	Quarrying Activities	Heavy Metals, TPH, BTEX, PAH, Phenols, PCBs*	Low
	Unknown	Illegal Dumping	Heavy Metals, OCP, TPH, BTEX, PAH, Phenols, PCB, Cyanide, Asbestos and Sulfate	Moderate
Lot 51 DP561032	0.75	Surface Filling or Inclusion in Surface Soil	Heavy Metals, OCP, TPH, BTEX, PAH, PCB and Asbestos	Low to Moderate
		Illegal Dumping	Heavy Metals, OCP, TPH, BTEX, PAH, Phenols, PCB, Cyanide, Asbestos, Sulfate	Moderate
		Small Scale Greenhouses	Heavy Metals, OCP, OPP, Cyanide, Nutrients*	Low
Lot 52 DP561032	0.18	Surface Filling or Inclusion in Surface Soil	Heavy Metals, OCP, TPH, BTEX, PAH, PCB, Asbestos	Low
		Illegal Dumping	Heavy Metals, OCP, TPH, BTEX, PAH, Phenols, PCB, Cyanide, Asbestos, Sulfate	Moderate
		Importation of Filling	Heavy Metals, OCP, TPH, BTEX, PAH, PCB, Asbestos	Low
Lot 1 DP375712 and Lot 1 DP371647	0.4	Importation of Filling	Heavy Metals, OCP, TPH, BTEX, PAH, PCB, Asbestos	Low

Lot	AEC-Area (Ha)	Potential AECs	COCs	Likelihood of Contamination
NOTES: COCs added by Coffey Environments are indicated by "*" following the COC BTEX: Benzene, Toluene, Ethylbenzene, Xylenes Metals: Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel and Zinc OCP: Organochlorine Pesticides OPP: Organophosphorus Pesticides			PAH: Polynuclear Aromatic Hydrocarbons PCB: Polychlorinated Biphenyls SVOC: Semi-Volatile Organic Compounds TPH: Total Petroleum Hydrocarbons VHCs: Volatile Halogentated Compounds VOC: Volatile Organic Compounds	

5 INVESTIGATION CRITERIA

The following sections describe the 'Develop a Decision Rule' available for the project as identified in the DQO process of **Table 1**.

5.1 Decision Process

The decision making process for the investigation is as follows:

- If the results of the analytical and field data validation are acceptable, then the data will be deemed suitable for use in the context of this investigation;
- If concentrations of a COC in soil samples collected from a soil unit, or AEC, are below the investigation level, and the number and locations of soil samples are considered to provide representative data for the soil or AEC, then no further assessment is required with respect to that COC in that soil unit or AEC;
- If concentrations of a COC in one or more soil samples collected from area soil unit or AEC are above the investigation level, then either further assessment (to assess the extent of contamination) and /or remediation would be required to mitigate the risk posed by that COC. For soil units or AECs where there is sufficient data, statistical analysis (based on 95% UCL of the average concentration) may be used to assess the significance of the data;
- If all concentrations of a COC in groundwater samples collected are below the investigation level, or background concentration if this exceeds the published investigation level, then no further assessment, and/or remediation, is required with respect to that COC; and
- If concentrations of a COC in one or more groundwater samples collected from the investigation area are above the investigation level (or background concentration where appropriate), then development of site specific criteria, further assessment (to assess the extent of contamination) and/or assessment of risk of harm would be required to address that COC.

5.2 Soil Investigation Levels

The soil investigation levels were established in the SAQP and were based on the following references:

- NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme (Second Edition);
- NSW EPA (1994) Guidelines for Assessing Service Station Sites; and
- NEPC (1999) National Environmental Protection (Assessment of Site Contamination) Measure (NEPM).

Other references were used to supplement the above references where appropriate including USEPA (2004) Region 9 Preliminary Remediation Goals.

The NSW DEC (2006) *Guidelines for the NSW Site Auditor Scheme* (the Auditor Guidelines) and the NEPM present health based investigation levels for different land uses (eg. industrial / commercial, residential, recreational etc.) as well as provisional phytotoxicity based investigation levels.

The WTC is to be developed as a mixture of commercial, public open space and residential areas. Therefore, investigation levels applicable for the proposed landuses have been adopted including:

- Health-based investigation levels (HILs) for residential landuse (Column 1 of Appendix II in the Auditor Guidelines) have been adopted as the soil investigation levels for portions of the investigation area proposed to be utilised mainly for residential (including townhouse) landuse. Phytotoxicity is also required to be considered on a residential site;
- HILs for open space landuse (Column 3 of Appendix II in the Auditor Guidelines) have been adopted as the soil investigation levels for portions of the investigation area proposed to be utilised mainly for parks/open space landuse. Phytotoxicity is also required to be considered for open space land use; and
- HILs for commercial/industrial landuse (Column 4 of Appendix II in the Auditor Guidelines) have been adopted as the soil investigation levels for portions of the investigation are proposed to be utilised mainly for commercial or bulky goods landuse. Phytotoxicity is not required to be considered on a commercial/industrial site.

The Auditor Guidelines do not provide threshold levels for volatile petroleum hydrocarbon compounds. NSW EPA (1994) Guidelines for Assessing Service Station Sites provide an indication of acceptable cleanup levels for petroleum hydrocarbons compounds at service station sites to be reused for sensitive land-uses. DECC has advised that these guidelines should also be used for less sensitive land-uses. For semi-volatile petroleum hydrocarbons (C_{16} – C_{35} and >C_{35}) investigation levels are provided in the Auditor Guidelines, however, these are based on the NEPM health-based criteria, which require the laboratory analysis to unequivocally differentiate between aromatic and aliphatic compounds. The NSW EPA service station guidelines will be adopted in the first instance as soil investigation levels to assess TPH concentrations. If potentially unacceptable TPH impacts are identified in soil, then aromatic/aliphatic criteria from the Auditor Guidelines may be adopted to assess the speciation of TPH.

The Auditor Guidelines states that there are currently no national or NSW DECC endorsed guidelines relating to human health or environmental investigation of material containing asbestos on sites. Site Auditors must exercise their judgement when assessing if a site is suitable for a specific use in the light of evidence that asbestos may be a chemical of concern. NSW Health will provide advice to auditors on a case be case basis where appropriate. Enhealth (2005) '*Guidelines for Asbestos in the Non-*

Occupational Environment', provides some guidance on assessing and managing asbestos in soil although does not provide a threshold concentration or investigation level for asbestos. For this Site, Coffey propose to adopt a conservative investigation level for asbestos of 'no detectable asbestos' in soil samples because soil may be moved during the redevelopment process. A less conservative validation target may be defined (eg. no asbestos within 2m of the surface) during remediation and development of the Site once final bulk earthworks details are known, but given the preliminary level of planning for development of the Site, the conservative approach adopted by Coffey is considered justifiable.

The US EPA Region 9 Preliminary Remediation Goals (USEPA, 2004) (Pacific Southwest) for industrial land use will be used as initial screening levels for volatile organic compounds (VOCs) that do not have soil investigation levels defined by the above references. The exposure scenarios used to derive these guidelines are similar to the NEPM exposure scenario.

It is noted that the US EPA Region 9 Preliminary Remediation Goals are not approved guidelines under the NSW Contaminated Land Management Act. They are used in this assessment for screening purposes only. Should any VOCs exceeding the US EPA Region 9 Preliminary Remediation Goals be reported, this issue will be addressed in conjunction with the NSW DECC accredited Site Auditor.

The soil investigation levels adopted for this Stage 2 ESA are presented in **Table 4**.

Table 4 - Soil Investigation Levels

Chemical of Concern	**Soil Investigation Level (mg/kg)**			
	Residential	Phytotoxicity	Open Space	Comm/Ind
TPH				
TPH/TRH C6-C9	65[2]		65[2]	65[2]
TPH/TRH C10-C36	1000[2]		1000[2]	1000[2]
BTEX				
Benzene	1[2]		1[2]	1[2]
Toluene	1.4[2]		1.4[2]	130[2]
Ethylbenzene	3.1[2]		3.1[2]	50[2]
Total Xylenes	14[2]		14[2]	25[2]
VOCs, including Methane	By Agreement with Site Auditor, if VOCs identified			

Chemical of Concern	**Soil Investigation Level (mg/kg)**			
PAH				
Naphthalene	56[3]		56[3]	190[3]
Benzo(a)pyrene	1[1]		2[1]	5[1]
Total PAHs	20[1]		40[1]	100[1]
Total Phenols	8,500[1]		17,000[1]	42,500[1]
OCP/PCB				
Aldrin & Dieldrin	10[1]		20[1]	50[1]
DDD+DDT+DDE	200[1]		400[1]	1,000[1]
Heptachlor	10[1]		20[1]	50[1]
Chlordane	50[1]		100[1]	250[1]
Total PCB	10[1]		20[1]	50[1]
Cyanide (free)	250[1]		500[1]	1,250[1]
Asbestos	None detected		None detected	None detected
Sulphate		2,000[4]		
Heavy Metals				
Arsenic	100[1]	20[4]	200[1]	500[1]
Cadmium	20[1]	3[4]	40[1]	100[1]
Total Chromium[5]	120,000[1]	400[4]	240,000[1]	600,000[1]
Copper	1,000[1]	100[4]	2,000[1]	5,000[1]
Lead	300[1]	600[4]	600[1]	1,500[1]
Mercury	15[1]	1[4]	30[1]	75[1]

Chemical of Concern	Soil Investigation Level (mg/kg)			
Nickel	600[1]	60[4]	600[1]	3,000[1]
Zinc	7,000[1]	200[4]	14,000[1]	35,000[1]

1. NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme, Columns 1-4
2. NSW EPA (1994) Guidelines for Assessing Service Station Sites, Table 3
3. USEPA (2004) Region 9 Preliminary Remediation Goals
4. NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme, Columns 5
5. Total chromium represented by Chromium III Guideline

5.3 Groundwater Investigation Levels

For assessing groundwater quality, it is necessary to assess the beneficial uses of groundwater down-gradient of the Site being assessed. It is considered likely that groundwater from the investigation area would most likely discharge to Woongarrah Creek, approximately 3km to the north-east and to Porters Creek, approximately 5km to the south-west. The Stage 1 ESA identified three registered groundwater bores within a 3km radius of the investigation area. Two of the registered bores are located 2.5-3km to the south-east and are for agricultural purposes. The third bore is located approximately 400m to the east and is for domestic use. Groundwater in this bore was recorded at a depth of 18-23m.

It is typical to assess groundwater to those potential beneficial end uses of receiving waters. Based on these adjacent uses groundwater criteria should assess:

- Protection of aquatic freshwater ecosystems;
- Drinking water;
- Plant irrigation; and
- Stock irrigation.

The lower of the trigger values for aquatic ecosystem, drinking water, irrigation and stock water are adopted for groundwater investigation levels (bolded) in **Table 5** below.

5.3.1 Ecosystem Trigger Values

ANZECC (2000) advocates a site-specific approach to developing guideline trigger values for ecosystems based on such factors as local biological affects data, the current level of disturbance of the ecosystem etc. The guidelines present ‘low risk guidelines trigger values’ which are defined as concentrations of key performance parameters below which there is a low risk that adverse biological effects will occur. It is important to note that these are not threshold values at which an adverse environmental effect would be observed if exceeded. Rather, if the trigger values are exceeded, then further action is required which may include either further site-specific investigations to assess whether or not there is an actual problem or management / remedial action.

Low risk trigger values are provided for the protection of 80-99% of species in freshwater water (presented in Table 3.4.1 of the guidelines), with the trigger value depending on the ‘health’ of the receiving waters. It is considered that the freshwater water trigger values are applicable for investigating chemical concentrations in groundwater at the investigation area.

It is understood that the DECCs policy is that the trigger values for the protection of 95% of aquatic ecosystems should be used except where contaminants are potentially bioaccumulative in which case the trigger values for protection of 99% of species should be used. Therefore, we have selected trigger values for protection of 95% of freshwater water species for the majority of contaminants, and 99% of freshwater water species for bioaccumulative contaminants for initial comparison purposes.

ANZECC (2000) states that there is currently insufficient data to derive high reliability trigger values for various contaminants. For these contaminants, low or medium reliability trigger values have been adopted.

ANZECC (2000) state that there is currently insufficient data to derive a high reliability and a low reliability trigger value of 7µg/L is provided for TPH. The DECC Guidelines for Assessment and Management of Groundwater Contamination, Section 2.2.2, state that the Limit of Reporting (LOR) may be used as a default investigation level where no published trigger value is available, or it is impractical to apply the published trigger value due to limitations of currently available analytical methods. The latter condition applies to TPH, and thus, the LOR value(s) has been adopted as the investigation level for TPH.

5.3.2 Drinking Water

NHMRC updated the Australian Drinking Water Guidelines in 2004. These provide a risk based framework approach to management of drinking water. The guideline values provided are not absolute values but are starting points from which using the framework local/regional drinking water standards can be derived. The guidelines provide standards to minimise health affects of consumers and reduce aesthetic nuisance.

As the investigation is not intended to assess the suitability of the groundwater beneath the investigation area for drinking in an untreated state, the use of the less stringent ‘health’ guidelines is considered appropriate.

5.3.3 Irrigation and Stock Water

ANZECC (2000) provides water quality guidelines for primary industries, including irrigation uses and stock watering. As irrigation and stock water is sourced from both surface water and groundwater, the irrigation and stock water guidelines are applicable to both sources.

Irrigation guidelines for heavy metals use trigger values based on short (20 year) or long term uses (100year). As the area surrounding the proposed WTC will likely be progressively rezoned from agricultural to domestic and commercial uses, short term trigger values would be suitable for the investigation. In order to be conservative, Coffey have adopted long term irrigation water criteria for groundwater beneath the investigation area.

Stock watering guidelines are available for heavy metals. Additional compounds such as organic and pesticide contaminants are not available, and the guidelines for drinking water for humans are applicable in the first instance.

Table 5 - Groundwater Investigation Levels

Contaminant	Drinking Water (health values) (ug/L)	Trigger values for protection of 95% of freshwater water species (ug/L)	Long Term Trigger Values for Irrigation (ug/L)	Livestock (ug/L)
pH	4-11[9]	**6.5-8.0[5]**	6.0-8.5[7]	4-9[13]
Electrical Conductivity (mS/cm)	-	-	1.38[14]	3
TPH/TRH	-	**Limit of Reporting[10]**	-	-
BTEX	-		-	
Benzene	**1[9]**	950[1]	-	-
Toluene	800[9]	**180[2]**	-	-
Ethylbenzene	300[9]	**80[2]**	-	-
o-Xylene		**350[1]**	-	-
p-Xylene	600[9]	**275[1,2]**	-	-
PAH				
Benzo(a)pyrene	**0.01[9]**	0.1[4]	-	-
Anthracene		**0.01[4]**	-	-
Naphthalene		**16[1]**	-	-
Phenanthrene		**0.6[4]**	-	-
Fluoranthene		**1[4]**	-	-
Total Phenols		**320[1]**	-	-
VOCs	Trigger values to be provided for those compounds recorded during analyses		-	-

Contaminant	Drinking Water (health values) (ug/L)	Trigger values for protection of 95% of freshwater water species (ug/L)	Long Term Trigger Values for Irrigation (ug/L)	Livestock (ug/L)
SVOC	Trigger values to be provided for those compounds recorded during analyses		-	-
Heavy Metals				
Arsenic III	**7**[9]	24[1]	100[7]	500[12]
Cadmium	2[9]	**0.2**[1,5]	10[7]	10[12]
Chromium[11]	50[9]	**3.3**[2,5]	100[7]	1000[12]
Copper	2000[9]	**1.4**[1,6]	200[7]	400[12]
Lead	10[9]	**3.4**[1,6]	2000[7]	100[12]
Mercury	1[9]	**0.6**[4]	2[7]	2[12]
Nickel	20[9]	**11**[1,6]	200[7]	1000[12]
Zinc	3000[9]	**8**[1,6]	2000[7]	20000[12]

1. *ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Freshwater Water Quality, Table 3.4.1*
2. *ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Freshwater Water Quality, low reliability values*
3. *ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Freshwater Water Quality, bioaccumulative low reliability values*
4. *ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Freshwater Water Quality, bioaccumulative 99% reliability values*
5. *Default trigger values for south-east Australia lowland rivers. To be used until local data obtained.*
6. *Hardness dependant*
7. *ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Freshwater Water Quality, Table 4.2.10-Irrigation up to 100years*
8. *NSW EPA (1994) Guidelines for Assessing Service Station Sites*
9. *NHMRC (2004) Australian Drinking Water Guidelines*
10. *NSW DECC (2007) Guidelines for Assessment and Management of Groundwater Contamination, Section 2.2.2*
11. *Based on trigger values for Chromium III*
12. *ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Freshwater Water Quality, Table 4.3.2, low risk stock trigger values*
13. *ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Freshwater Water Quality, General water uses, Section 4.2.10.1*
14. *ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Freshwater Water Quality, Table 4.2.4*

5.4 Landfill Gas Investigation Levels

Landfill gas investigation levels were not established in the SAQP as the procedure and type of gases to be investigated were not finalised at that point in the investigation process. As methane typically forms up to 60% of landfill gases, it was subsequently agreed with the NSW EPA accredited Auditor for the investigation that methane only would be assessed during the Stage 2 ESA as an indicator of the generation of landfill gases. Further assessment of potential generation of volatile gases would be dependent upon the results of the first pass landfill monitoring, soil results and groundwater analytical results. As the methane meter also measured for this gas, Coffey also included an assessment of the presence of hydrogen sulfide (H_2S) in the landfill gas stream. The presence of volatile gases was also assessed by screening gas samples with a PID calibrated to isobutylene.

The methane acceptance criterion was derived from the NSW EPA Guidelines for Solid Waste Landfills (NSW EPA 1996). In accordance with Appendix A (Procedure 15) of the guideline the investigation level for methane in surface (1m above ground level) and subsurface monitoring points should be less than 1.25% v/v. No NIOSH exposure limits are known, though inhalation of very high concentrations (>500,000ppm) may cause injury or death. Methane is an asphyxiant, therefore oxygen concentrations are measured rather than methane. Methane is odourless and colourless, and is explosive between 5%-15%.

No known NSW EPA published guidelines for H_2S are available. NIOSH guidelines for H_2S are Recommended Exposure Limit of 10ppm in 10minutes (TWA 10ppm, and STEL 15ppm), and that H_2S is Immediately Dangerous to Life or Health at concentrations in the order of 100ppm. The OSHA workplace Permissible Exposure Limit of H_2S is 20ppm. H_2S is explosive at concentrations between 4%-44%.

No known published guidelines are available to assess the significance of volatile concentrations with a PID. The NOHSC TWA for benzene is 5ppm. Typically an ambient concentration of general volatile contaminants recorded by a PID in air of 10ppm is used as an acceptance criterion for assessing health and safety of workers at a contaminated site.

A methane concentration of 1.25%v/v, H_2S concentration of 10ppm and PID concentrations of 10ppm were adopted as investigation criteria for landfill gas during the investigation.

6 SAMPLING AND ANALYSIS PLAN & METHODOLOGY

The following sections describe the ‘Define the Study Boundaries’ and ‘Optimise the Design for Obtaining Data’ as identified in the DQO process of **Table 1**.

6.1.1 Data Required to Meet Objectives of the Stage 2 ESA

The input data required to allow an assessment of the suitability of the Site for the proposed landuses include:

- A review of the results of the previous assessment by Douglas Partners;
- Field investigations and observations to be made by Coffey Geotechnics field staff;
- Analytical results of the soil samples to be collected by Coffey Geotechnics field staff;
- Assessment of analytical results against the investigation levels presented in **Table 4** and **Table 5**; and
- Review and compilation of field and laboratory results.

Based on the previous steps 1 to 6 of the DQO process, the field and laboratory programs have been designed as follows.

6.1.2 Sampling and Analysis Scope and Rationale

The lateral study boundaries are defined by the investigation area shown on **Figures 3, 4 and 5**.

The vertical study boundary is defined as being at 0.5m into natural soils (through the extent of fill if present). If groundwater is encountered, the vertical study boundary where groundwater is to be sampled would be extended to 2m below the watertable.

The proposed fieldwork is based on a mixture of broad grid sampling and targeted sampling using information derived from:

- The investigation areas of the defined AEC's as recommended in the Stage 1 ESA by Douglas Partners;
- Our current level of understanding of the Site from previous investigations;
- Experience at similar sites; and
- Published guidelines and regional geological and hydrogeological information.

Table 6 outlines the sampling strategy undertaken for the investigation. The number of sampling locations for the identified AEC's was generally based on the suggested minimum number of sampling locations based on the NSW EPA (1995) *Sampling Design Guidelines* as identified in Table 15 of the Douglas Partners assessment. To supplement these, broad composite and targeted stockpile or gully sampling was undertaken to confirm that locations outside the AEC's were generally not impacted.

Table 6 also provides a comparison between the proposed investigation strategy and the works completed for implementation of that strategy. Coffey generally met or exceeded the proposed investigation strategy during the ESA. Differences between proposed and undertaken included:

- As agreed by the Auditor, a number of test-pit locations in the forested portions of the investigation area were replaced by hand auger borings. Given that the hand augers were drilled mainly into areas of the site containing fill and penetrated the underlying residual profile (as required by the SAQP), the change from test pits to hand augers is not expected to have unreasonably modified the results of the ESA;
- Groundwater was not encountered in as many locations as intended for sampling during the tendering process, which resulted in a reduced number of monitoring wells being installed (9 instead of 12). The number of monitoring wells was increased from six proposed to eight installed in the landfill area. Overall, groundwater in surface alluvial/residual soils is less significant across the investigation area than anticipated, which is a positive outcome from the ESA. The groundwater assessment was increased in the former landfill portion of the investigation area, and resulted in a better understanding of the hydrogeological conditions than required by the SAQP;
- Fewer stockpiles were encountered in the nursery area than were envisaged during the tendering process. Additional stockpiles were sampled in the former quarry/landfill portions of the investigation area. Again, the lack of stockpiles in the former nursery area is a positive outcome for the ESA, meaning that a lower risk of imported filling is present than envisaged in the SAQP. Numerous stockpiles were encountered along access tracks for the former quarry/landfill and more of these were sampled than required as a minimum in the SAQP, including analysis for Asbestos;
- Two additional background surface samples were collected and analysed for composite sample investigation criteria calculations. The SAQP required composite samples to be collected, but did

not clarify investigation criteria to be compared against. In order to prevent the recording of 'false positives', NSW EPA (1995) outlines adjustments to investigation criteria as a result of compositing. Therefore, though above the minimum requirements of the SAQP, Coffey collected and analysed additional 'background' samples to aid in the revision of the composite sample investigation criteria;

- Asbestos was not identified as a wide-spread COC during the tendering process. During fieldwork, surface fibro-cement fragments were observed by Coffey staff, and additional fragment samples were collected and analysed during the investigation, above the minimum requirements of the SAQP. In addition, asbestos analyses were undertaken in fill to assess for particulate asbestos to be present; and
- The ratio of boreholes/test pits and hand augers specified in the SAQP was modified during the ESA to suit site conditions, depth or presence of filling, access restrictions, and availability of the drilling/excavation equipment. Coffey considers that the overall objectives of the ESA were not limited by the ratio of investigation methods finally employed in the ESA as the total number of locations met the requirements of the SAQP, and where fill was encountered (except for HA8-HA11) it was fully intercepted and described.

The subsurface soil investigation locations are presented in **Figures 6 and 7,** and the surface soil investigation locations are presented in **Figures 8 and 9**. The water (surface and groundwater) investigation locations are presented in **Figure 10.**

The investigations were performed by a Coffey environmental scientist, who is trained in sampling at contaminated sites. The sampling was undertaken in general accordance with the standard operating procedures of Coffey Environments, including:

- Daily field sheets were used to record Site observations, calibration of equipment etc;
- Photographs of Site conditions were collected for future reference;
- Samples were collected using disposable nitrile gloves, changed between every sample collection;
- Each soil sample was divided into two sub-samples:
    - One of the sub-samples will be placed into a laboratory-supplied, acid-rinsed 250mL glass jar and placed in an ice-chilled cooler box as primary sample for analysis;
    - The second sample (not more than approximately 50g mass) will be placed in a ziplock bag and stored for transport to the laboratory for asbestos analysis (if required); and
- A GPS reading was recorded at sample location to map the location relative to Map Grid Australia (MGA) coordinates.

The soil, groundwater and landfill gas monitoring fieldwork was undertaken between12 September and 5 November 2007.

Table 6 – Sampling and Analysis Strategy

LOT	ACTIVITY	PROPOSED INVESTIGATION LOCATIONS	PROPOSED ANALYTICAL STRATEGY	UNDERTAKEN INVESTIGATION LOCATIONS	INVESTIGATION ID's	ANALYTICAL STRATEGY UNDERTAKEN
L521 DP594725	Nursery/filling	44 test pits	66 heavy metals (8) 44 OCP/OPP 20 Cyanide	44 test pits	ETP1-29, 54-68	71 heavy metals (8) 46 OCP/OPP 23 Cyanide 3 Asbestos
	Illegal Dumping	4 stockpile samples	4 heavy metals (8), OCP/PCB, TPH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate	1 fibro cement stockpile sample	Asbestos2	Asbestos
	Drainage Lines	4 dam water, 3 gully/sediment samples	Water: 4 heavy metals (8), OCP/OPP, TPH/PAH (ultratrace) Soil: 3 heavy metals (8), OCP/OPP, TPH/PAH	4 dam water, 3 gully/sediment samples	DW1-4 G1-3	Water: 4 heavy metals (8), OCP/OPP, PAH. 3 TRH Soil: 3 heavy metals (8), OCP/OPP, TRH/PAH
	Broad Impacts	10 composites of 3 surface samples each (30 locations)	10 heavy metals (8), OCP/OPP/PCB, PAH	10 composites of 3 surface samples each	Composite 1-10	10 heavy metals (8), OCP/OPP/PCB, PAH

LOT	ACTIVITY	PROPOSED INVESTIGATION LOCATIONS	PROPOSED ANALYTICAL STRATEGY	UNDERTAKEN INVESTIGATION LOCATIONS	INVESTIGATION ID's	ANALYTICAL STRATEGY UNDERTAKEN
L1 DP376264 & L54 DP7527	Landfill	10 hand augers 27 test pits 10 boreholes 6 groundwater monitoring wells	70 heavy metals (8) 47 VOC/SVOC 25 Asbestos 6 Groundwater: heavy metals (8)/VOC/SVOC 6 landfill gases: methane/TPH/BTEX/ Phenols	6 hand augers 30 test pits 12 boreholes 8 groundwater monitoring wells	HA8-13 ETP36-53, 73-74, 85-91, 107-110 EBH13, 16-22, 24-26 MW1, 3-9	76 heavy metals (8) 43 VOC/SVOC 29 Asbestos 6 Groundwater: heavy metals (8)/VOC/SVOC 7 landfill gases: methane
	Illegal Dumping	4 stockpile samples	4 heavy metals (8), OCP/PCB, TPH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate	4 stockpile samples	ST8-11	4 heavy metals (8), OCP/PCB, TRH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate
	Broad Impacts	3 composites of 3 surface samples each (9 locations)	3 heavy metals (8), OCP/OPP/PCB, PAH	3 composites of 3 surface samples each	Composite 11, 12 and 17	3 heavy metals (8), OCP/OPP/PCB, PAH

LOT	ACTIVITY	PROPOSED INVESTIGATION LOCATIONS	PROPOSED ANALYTICAL STRATEGY	UNDERTAKEN INVESTIGATION LOCATIONS	INVESTIGATION ID's	ANALYTICAL STRATEGY UNDERTAKEN
L521 DP594725, L1 DP376264, L54 DP7527 & L55 DP7527	Quarry	34 test pits 20 boreholes 6 monitoring wells	81 heavy metals (8) 54 TPH/BTEX 25 PAH/Total Phenols 6 Groundwater: heavy metals (8)/TPH/BTEX, PAH (low level)/Total Phenols 6 landfill gases: methane/TPH/BTEX/ Phenols	11 test pits 13 boreholes 29 hand augers 1 monitoring wells	ETP30-35, 69-72, 111 EBH1-12, 14-15, 23 HA1-7, 14-35 MW2	75 heavy metals (8) 53 TRH/BTEX 25 PAH/Total Phenols 7 Asbestos 1 Groundwater: heavy metals (8)/TRH/BTEX, PAH (low level)/Total Phenols
	Illegal Dumping	3 stockpile samples	3 heavy metals (8), OCP/PCB, TPH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate	3 stockpile samples	ST5-7, Asbestos1, SS97A&B	3 heavy metals (8), OCP/PCB, TRH/BTEX, PAH/Total Phenol, Cyanide, Sulfate, 6 Asbestos
	Access Tracks	1 surface samples	1 heavy metals (8), TPH, PAH, OCP/PCB, Asbestos	1 surface samples	SS28	1 heavy metals (8), TRH, PAH, OCP/PCB, Asbestos

LOT	ACTIVITY	PROPOSED INVESTIGATION LOCATIONS	PROPOSED ANALYTICAL STRATEGY	UNDERTAKEN INVESTIGATION LOCATIONS	INVESTIGATION ID's	ANALYTICAL STRATEGY UNDERTAKEN
L54&55 DP7527	Illegal Dumping	0 stockpile samples		4 stockpile samples	ST1-4	4 heavy metals (8), OCP/PCB, TRH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate
	Drainage Lines	3 gully samples	3 heavy metals (8), OCP/OPP, TPH/PAH	3 gully samples	G4-G6	3 heavy metals (8), OCP/OPP, TRH/PAH
	Access Tracks	3 surface samples	3 heavy metals (8), TPH, PAH, OCP/PCB, Asbestos	3 surface samples	SS25-27	3 heavy metals (8), TRH, PAH, OCP/PCB, Asbestos
	Background	0 surface samples	nil	2 surface samples	SS1, 17	1 heavy metals (8), OCP/OPP/PCB, PAH
	Broad Impacts	4 composites of 3 samples each (12 locations)	4 heavy metals (8), OCP/OPP/PCB, PAH	4 composites of 3 samples each	Composite 13-16	4 heavy metals (8), OCP/OPP/PCB, PAH

LOT	ACTIVITY	PROPOSED INVESTIGATION LOCATIONS	PROPOSED ANALYTICAL STRATEGY	UNDERTAKEN INVESTIGATION LOCATIONS	INVESTIGATION ID's	ANALYTICAL STRATEGY UNDERTAKEN
L51 DP561032	Rural residential and market garden	10 hand augers 8 test pits	27 heavy metals (8) 10 OCP/OPP/PCB 9 TPH/BTEX/PAH/Total Phenols 7 Cyanide/Asbestos/Sulfate	18 test pits	ETP75-84, 89, 93-97, 105-106	27 heavy metals (8) 10 OCP/OPP/PCB 8 TRH/BTEX/PAH/Total Phenols 8 Cyanide/Asbestos/Sulfate
	Illegal Dumping	3 stockpile samples	3 heavy metals (8), OCP/PCB, TPH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate	4 stockpile samples	ST12-14, SS92	3 heavy metals (8), OCP/PCB, TRH/BTEX, PAH/Total Phenol, Cyanide, Sulfate. 4 Asbestos
	Drainage Lines	1 gully sample	1 heavy metals (8), OCP/OPP, TPH/PAH	1 gully sample	G7	1 heavy metals (8), OCP/OPP, TRH/PAH
	Broad Impacts	3 composites of 3 samples each (9 locations)	3 heavy metals (8), OCP/OPP/PCB, PAH	3 composites of 3 samples each	Composite 28-30	3 heavy metals (8), OCP/OPP/PCB, PAH

LOT	ACTIVITY	PROPOSED INVESTIGATION LOCATIONS	PROPOSED ANALYTICAL STRATEGY	UNDERTAKEN INVESTIGATION LOCATIONS	INVESTIGATION ID's	ANALYTICAL STRATEGY UNDERTAKEN
L52 DP561032	Rural residential including surface filling (0.18ha)	5 hand augers 2 test pits	11 heavy metals (8) 5 OCP/OPP 4 TPH/BTEX/PAH/ Phenols 3 Cyanide/Asbestos/Sulfate	7 test pits	ETP98-104	11 heavy metals (8) 6 OCP/OPP 4 TRH/BTEX/PAH/ Phenols 3 Cyanide/Asbestos/ Sulfate
	Illegal Dumping	3 stockpile samples	3 heavy metals (8), OCP/PCB, TPH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate	3 stockpile samples	ST15-17	3 heavy metals (8), OCP/PCB, TRH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate
	Access Tracks	2 surface samples	2 heavy metals (8), TPH/BTEX, PAH, OCP/PCB, Asbestos	2 surface samples	T1-2	2 heavy metals (8), TRH/BTEX, PAH, OCP/PCB, Asbestos
	Drainage Lines	1 gully sample	1 heavy metals (8), OCP/OPP, TPH/PAH	1 gully sample	G8	1 heavy metals (8), OCP/OPP, TRH/PAH
	Broad Impacts	3 composites of 3 samples each (9 locations)	3 heavy metals (8), OCP/OPP/PCB, PAH	3 composites of 3 samples each	Composite 18-20	3 heavy metals (8), OCP/OPP/PCB, PAH

LOT	ACTIVITY	PROPOSED INVESTIGATION LOCATIONS	PROPOSED ANALYTICAL STRATEGY	UNDERTAKEN INVESTIGATION LOCATIONS	INVESTIGATION ID's	ANALYTICAL STRATEGY UNDERTAKEN
L1 DP375712 & L1 DP371647	Access Tracks	4 surface samples	4 heavy metals (8), TPH/BTEX, PAH, OCP/PCB, Asbestos	4 surface samples	SS93-96	4 heavy metals (8), TRH/BTEX, PAH, OCP/PCB, Asbestos
L4 DP7738	Illegal Dumping	2 stockpile samples	2 heavy metals (8), OCP/PCB, TPH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate	2 stockpile samples	ST18-19	2 heavy metals (8), OCP/PCB, TRH/BTEX, PAH/Total Phenol, Cyanide, Asbestos, Sulfate
	Background	0 surface samples	nil	1 surface sample	SS81	1 heavy metals (8), OCP/OPP/PCB, PAH
	Drainage Lines	1 gully sample	1 heavy metals (8), OCP/OPP, TPH/PAH	1 gully sample	G9	1 heavy metals (8), OCP/OPP, TRH/PAH
	Broad Impacts	6 composites of 3 samples each (18 locations)	6 heavy metals (8), OCP/OPP/PCB, PAH	6 composites of 3 samples each	Composite 21-26	6 heavy metals (8), OCP/OPP/PCB, PAH

6.1.3 Surface Soil Investigation

Surface (composite, gully and track) samples were collected after firstly scraping back the vegetation layer. Samples were generally collected from the 0.0 to 0.05m depth range of the surface soil. Generally samples were collected from the groundsurface using a hand trowel, which was decontaminated between every sample collection.

Stockpile samples were collected at random depths within stockpiles depending on their composition. In some instances surface samples (eg. Asbestos) were only able to be collected using hand techniques, and in other instances a shovel was able to be used to dig into the stockpile itself. Field rinsate blanks were collected during the days of sampling where surface samples were collected.

Composite samples were combined in the primary laboratory from three discrete surface samples.

Table 6 presents the list of surface soil samples collected.

6.1.4 Subsurface Soil Investigation

The subsurface investigation program included hand auger, truck mounted drilling rig, mini-excavator and 20t excavator methods of digging into the groundsurface depending on site conditions and access restrictions. **Table 6** presents the list of subsurface investigations and their locations. Copies of borehole and test pit logs are included in **Appendix C** and **Appendix D** respectively.

- Drilling was undertaken using a truck mounted 4WD drilling rig equipped with solid flight augers. Samples were collected from a decontaminated Standard Penetration Test (SPT) sampler in augered boreholes, and from a decontaminated hand-auger in hand drilled boreholes. Samples were collected directly from an undisturbed portion of soil from the machine bucket in test pits (for OH&S reasons);
- Investigations were extended through fill (if present) and 0.5m into natural soils or prior refusal. If groundwater was encountered, selected boreholes were converted into monitoring wells after extending 2m below the groundwater surface;
- Each soil sample (except for composite samples) was collected into a laboratory supplied glass jar and a ziplock bag fur further PID screening;
- Where duplicate and triplicate samples were required, samples were split into laboratory supplied 125ml glass jars to enable collection of samples from a similar depth range;
- Soil samples were screened with a calibrated Photoionisation Detector (PID) to provide field indications of volatile concentrations in the sample. Copies of the PID field sheets are included in **Appendix E**;
- Based on the results of PID screening, field observations (odour, colour, inclusions etc), soil samples were selected for analysis at an independent laboratory;
- Soil cuttings were placed back into test pits or boreholes and compacted where possible using the equipment available. Excess cuttings were mounded on the surface over the location; and
- Selected environmental soil and groundwater samples were dispatched to the SGS Australia laboratory at Alexandria for NATA accredited laboratory analyses. The laboratory analyses undertaken are outlined in **Table 6**.

6.1.5 Surface Water Sampling

Surface water samples were collected from dams directly into laboratory supplied containers fitted onto an extendable rod. Where the water column depth permitted, samples were collected to minimise sediment disturbance. All samples for heavy metals were filtered in the field prior to placement into preserved bottles.

6.1.6 Groundwater Sampling

Monitoring wells were constructed with 50mm uPVC to standard environmental specifications for groundwater wells. Screen lengths of a minimum 3m were installed, with the top of screen approximately 1m above the intercepted water level. All well materials contained screw threaded joints. A sand filter pack of 2mm-5mm graded sand was placed around the screen and extend approximately 0.5m above the tops of the screen. The filter pack was sealed with a wetted bentonite layer, and the remainder of the annulus backfilled with borehole cuttings. The well casing was sealed by a torque cap, and the wells finished with a lockable galvanised iron monument approximately 1m above ground level. Monitoring wells were not constructed specifically to the requirements of NSW EPA **(**1996) Benchmark Technique No.15 for landfill gas monitoring, in that a graded sand filter pack was used instead of pea gravel around the screened section of the groundwater monitoring wells. This difference in construction of the groundwater monitoring wells is not expected to impair the performance of these wells for landfill gas monitoring because the relative permeabilities of graded filter sand and pea gravel for gas flow are similar.

Monitoring wells were developed a minimum three days following installation to remove as much sediment from the filter pack and smeared up the borehole annulus. Development included surging with a loaded bailer and removal of turbid water. Development continued until the wells bailed dry, at least three well volumes were removed, or the water became clear.

All wells were surveyed to Australian Height Datum (AHD) by a registered surveyor to enable groundwater flow directions to be ascertained;

Prior to groundwater sampling Phase Separated Hydrocarbons (PAH) and Standing Water Levels (SWL) were recorded on the 25 of September 2007 during well development and later on 3 October. A third round of groundwater level monitoring was undertaken on 5 November after landfill gas monitoring. A summary of the monitoring well construction details and recorded water levels are presented in **Table 7** below. Copies of the monitoring well construction log are included in **Appendix C**. Groundwater field sheets are included in **Appendix F**.

Table 7 – Summary of Well Construction

Well ID	**BOC (mbgs)#**	**Screened Interval (mbgs)**	**Elevation of TOC (mAHD)**	**Water Depth (mBTOC)**			**Water Level (mAHD)**		
				25/9	3/10	5/11	25/9	3/10	5/11
MW1	4.7	0.4-3.4	51.02	2.260	3.180	3.665	48.76	47.84	47.36
MW2	3	0.5-3.0	36.72	Dry	Dry	Dry	-	-	-

Well ID	BOC (mbgs)#	Screened Interval (mbgs)	Elevation of TOC (mAHD)	Water Depth (mBTOC)			Water Level (mAHD)		
MW3	2.9	0.5-2.9	42.91	Dry	Dry	Dry	-	-	-
MW4	4.5	1.0-4.4	54.33	5.140	4.570	Dry	49.19	49.76	-
MW5	2.79	0.5-2.8	54.15	3.010	Moist	Moist	51.14	49.63	-
MW6	4.5	1.0-4.5	54.88	Dry	Dry	Dry	-	-	-
MW7	4.5	1.0-4.4	54.07	??	4.860	Dry	-	49.21	-
MW8	4.5	1.5-4.5	54.66	5.190	Dry	Dry	49.47	-	-
MW9	5.5	1.0-5.3	53.43	3.480	3.390	3.810	49.95	50.04	49.62

BOC – Bottom of Casing (i.e. well depth)   TOC – Top of Casing

bgs – Below Ground Surface   AHD – Australian Height Datum

Top of casing of the monitoring wells are in the order of 0.6-0.7m above ground level

A round of groundwater monitoring was undertaken on the 3 October 2007. All monitoring wells containing groundwater were purged prior to sampling using low flow techniques and a peristaltic pump. Purging continued until at least three well volumes were removed, the well purged dry, or water characteristics stabilised. Purge water was disposed onsite adjacent to the source monitoring well.

Upon 80% recovery of groundwater levels, sampling were then collected using low flow techniques into laboratory supplied sample containers appropriate for the analyses, including vials filled to zero headspace for BTEX and VOCs. Metals were field filtered to 45µm.

Groundwater samples were placed into a chilled cooler and transported to the primary laboratory under chain of custody conditions.

Five monitoring wells which contained groundwater (MW1, MW4, MW5, MW7 and MW9) were sampled, and two surface water samples were collected directly into laboratory bottles from a gully or dam adjacent to two dry monitoring wells (MW2 and MW3).

6.1.7 Landfill Gas

Landfill gas sampling was undertaken generally in accordance with the 'Standard Guide for Soil Gas Monitoring in the Vadose Zone' (ASTM D5314-92). The sampling methodology was a whole-air active pumping method. The monitoring process included:

- Fitting of a landfill gas collection torque cap to each monitoring well at least a week prior to gas monitoring;

- Recording background concentrations of methane (CH_4), Methane Lower Explosive Limit (LEL), Carbon Dioxide and Monoxide (CO_2 and CO), Hydrogen Sulfide (H_2S), and Oxygen (O_2);
- Attaching a calibrated landfill gas analyser (GA2000) to the torque cap coupling;
- Extraction of trapped air from the monitoring well through the analyser by means of the inbuilt pump (250cc/min);
- Recording first pull landfill gas readings and regular readings until CH_4 concentrations stabilised or reduced to zero;
- Connecting a calibrated PID and recording concentrations of volatiles in the monitoring well.

Directly after installation, the air within the monitoring wells (with 100% porosity) will have no to minimal methane concentrations. Due to concentration differential, methane gases will migrate from the surrounding soil profile into the monitoring well void until pressures and concentrations stabilise. As methane is lighter than air, the gas will partition by weight at the top of the well column, directly below the torque cap. By measuring the first pull methane readings a maximum ‘collected’ methane concentration should be read. With further air purging of more than one well volume, fresh gases from the adjacent soil profile will be drawn into the well providing an indication of the available methane for migration. Given that active pumping is occurring from an open void, these later readings are not indicative of the rate that methane would migrate through the soil profile.

Landfill gases were recorded from all monitoring wells located within the former landfill (MW1, MW3-MW9). Copies of the landfill gas field monitoring sheets are included in **Appendix G**.

6.1.8 Laboratory Analyses

Soil and groundwater samples were sent to the primary laboratory under Chain-Of-Custody (COC) conditions. Due to the number of investigation locations and samples collected, multiple batches of samples were sent to the primary laboratory for analysis. **Table 8** below lists the primary and secondary laboratory batches.

Table 8 – List of Laboratory Batches

Laboratory	Sample Date Range	Batch	Medium
SGS	12/9-14/9	55276	Soil
SGS	12/9-14/9	55276A	Waters
SGS	17/9-18/9	55332	Soil
SGS	17/9-18/9	55332A	Waters
SGS	19/9-19/9	55334	Soil
SGS	19/9-19/9	55334A	Waters
SGS	20/9-20/9	55397	Soil

Laboratory	Sample Date Range	Batch	Medium
SGS	20/9-20/9	55397A	Waters
SGS	20/9-21/9	55398	Soil
SGS	20/9-21/9	55398A	Waters
SGS	24/9-25/9	55456	Soil
SGS	24/9-25/9	55456A	Waters
SGS	27/9-28/9	55564	Soil
SGS	27/9-28/9	55564A	Waters
SGS	3/10-4/10	55634	Soil
SGS	3/10-4/10	55634A	Waters
MGT	12/9-14/9	214826	Soil
MGT	18/9-19/9	214916	Soil
MGT	20/9-20/9	215112	Soil
MGT	24/9-25/9	215313	Soil
MGT	28/9-28/9	215611	Soil
MGT	27/9-27/9	215612	Soil
MGT	3/10-4/10	215698	Water

6.2 Quality Assurance and Quality Control

The following sections describe the ‘Specify Limits on Decision Errors’ as identified in the DQO process of **Table 1**.

6.2.1 Field Quality Control

Environmental sampling activities were based on procedures and protocols outlined in Coffey Environments Standard Operating Procedures (SOP’s), which is based on industry accepted standard practice.

The drilling augers were decontaminated between sampling locations by physically removing soil material then washing with 'decon 90' detergent and rinsing with tap water. Hand augers were decontaminated between the drilling of each borehole by a similar process.

A clean pair of disposable gloves was used when handling each soil and groundwater sample.

Separate bailer chord, disposable bailers and filters were used for each monitoring well when purging, and separate disposable tubing used when low flow sampling.

The following quality control samples were collected in the field:

- Intra-laboratory duplicates were collected at a minimum rate of 5% of samples collected;
- Inter-laboratory duplicates were collected at a minimum rate of 5% of samples collected;
- A wash blank generally for every day that non dedicated or multi-use sampling equipment was utilised; and
- A trip spike and trip blank sample were generally included with samples during transport including BTEX and/or VOCs in the analysis and analysed per batch.

Selection of samples for analyses were based on the AECs and COC's previously identified, and observations of the investigation area obtained during the current investigation.

Primary, duplicate and quality control samples collected were forwarded to the SGS laboratory for the analyses required. Triplicate samples were collected and forwarded to the MGST laboratory for the analyses required.

Table 9 lists the primary and corresponding duplicate soil analyses, **Table 10** lists the primary and corresponding triplicate soil analyses, and **Table 11** lists the primary and duplicate/triplicate water analyses undertaken.

Table 9 - Summary of Field Duplicate Soil Samples Analysed

Primary Sample	Duplicate Sample	Laboratory Batch Reference
ETP90 0.0-0.3	DUP3	214826
EBH6 0.0-0.2	DUP5	214826
EBH14 0.0-0.1	DUP9	214826
ETP1 0.0-0.1	DUP14	214916
ETP18 0.0-0.1	DUP19	214916
ETP24 0.0-0.1	DUP21	214916
ETP31 0.0-0.1	DUP25	214916

Primary Sample	Duplicate Sample	Laboratory Batch Reference
ETP40 0.0-0.1	DUP32	215112
ETP47 0.4-0.5	DUP35	215112
ETP50 0.0-0.1	DUP36	215112
G8	DUP48	215313
ETP73 0.0-0.1	DUP51	215313
ETP94 0.0-0.1	DUP54	215313
HA16 0.4-0.5	DUP60	215611
HA11 0.0-0.1	DUP57	215612
HA30 0.4-0.5	DUP63	215698

Table 10 - Summary of Field Triplicate Soil Samples Analysed

Primary Sample	Duplicate Sample	Laboratory Batch Reference
ETP88 0.0-0.3	DUP1	55276
EBH4 0.0-0.2	DUP6	55276
EBH9 0.1-0.3	DUP7	55276
EBH13 4.0-4.2	DUP8	55276
ETP17 0.0-0.1	DUP19	55332
Composite1	COMPDUP1	55332
ETP21 0.0-0.1	DUP20	55334
Composite26	Composite27	55397
ETP38 0.0-0.1	DUP31	55397

Primary Sample	Duplicate Sample	Laboratory Batch Reference
G1	DUP46	55456
ST7	DUP47	55456
HA1 0.0-0.1	DUP49	55456
ETP83 0.0-0.1	DUP53	55456
ETP102 0.0-0.1	DUP55	55456
HA7 0.0-0.1	DUP56	55564
HA16 0.0-0.1	DUP59	55564
HA25 0.0-0.1	DUP61	55564
HA26 0.0-0.1	DUP62	55634
HA35 0.0-0.1	DUP64	55634

Table 11 - Summary of Field Duplicate and Triplicate Groundwater Samples

Primary Sample	Duplicate Sample	Sample Type	Laboratory Batch Reference
MW1	MWQC2	Duplicate	215698
MW1	MWQC1	Triplicate	55634A

Table 12 below lists all trip spike and blanks included with batches to the primary laboratory. **Table 13** lists the wash blanks collected and analysed. Trip spikes and blanks were analysed for BTEX, and Wash Blanks for TRH/BTEX and heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ni and Zn).

Table 12 - Summary of Trip Blanks and Trip Spikes

Laboratory Batch	Trip Spike/Blank ID
55276A	Trip Blank
55332A	Trip Blank

Laboratory Batch	Trip Spike/Blank ID
55398A	Trip Blank
55456A	Trip Blank
55564A	Trip Blank
55634A	Trip Blank
55276A	Trip Spike
55332A	Trip Spike
55398A	Trip Spike
55456A	Trip Spike
55564A	Trip Spike
55634A	Trip Spike

Table 13 - Summary of Wash Blanks

Laboratory Batch	Wash Blank ID	Date Represented
55276A	WB-1	12/9
55276A	WB-2	14/9
55332A	WB-3	17/9
55332A	WB-4	18/9
55334A	WB-5	19/9
55397A	WB-6	20/9
55398A	WB-7	21/9
55456A	WB-8	24/9
55564A	Wash Blank Master	Comparison sample of wash blank water

Laboratory Batch	Wash Blank ID	Date Represented
55564A	WB-9	27/9
55564A	WB-10	28/9
55634A	WB-11	4/10

6.2.2 Laboratory Quality Control

Laboratory Quality Control included the following:

- The laboratory analysis of samples was undertaken to NATA accredited testing methodologies. The list of testing method references for the primary laboratory are presented in **Table 14**; and
- The laboratory tested reagent blanks, laboratory control samples (LCS), matrix spikes and surrogates spikes, and laboratory duplicates to assess laboratory quality control.

Table 14 - Summary of Analytical Method References

Analysis	Medium	SGS
TPH/TRH	Soil	USEPA 3550/8000
BTEX	Soil	USEPA 5021/5030
PAH	Soil	USEPA 3550/8270/830
OCP/PCB	Soil	USEPA 3550/8140/8081
VOC	Soil	USEPA 8260
Metals	Soil	USEPA 2455/200.8/3050, APHA 3500
Mercury	Soil	USEPA 2455/200.8/3050, APHA 3500
Cyanide - Total	Soil	APHA 4500-CN
Asbestos	Soil	NATA Guidelines 1991
TPH/TRH	Water	USEPA 3510/3520/8000
BTEX	Water	USEPA 5021/5030
PAH	Water	USEPA 3510/3520/8270

Analysis	Medium	SGS
VOC	Water	USEPA 8260
Metals	Water	USEPA 6020
Mercury	Water	
Chromium VI	Water	USEPA 3500-Cr
Cyanide	Water	APHA 4500-CN
pH	Water	APHA4500-H
EC	Water	APHA 2510
Hardness	Water	APHA 2340
Compositing	Soil	In-House

7 RESULTS

7.1 Surface and Subsurface Soil Conditions

Borehole and test pit logs are presented in **Appendix C** and **Appendix D**. Surface and subsurface conditions across the investigation area typically corresponded to previous landuses, that is:

- Typically undisturbed soil profiles were encountered in the forested Lot 55 DP7527and Lot 4 DP7738 (eg HA21), northern forested margins of Lot 1 DP376264 and Lot 54 DP7527 (eg HA3 and ETP30), southern forested edge of Lot 1 DP376264 (eg HA14), and open paddock on Lot 521 DP594725 (eg EBH8). These included silty sand topsoils underlain by residual sandy clays and shallow bedrock;
- Bedrock, if encountered, in these areas was typically fine sandstone, though claystone was encountered beneath residual clays in the north-western portion of Lot 521 DP594725 (EBH6);
- Partially disturbed soil profiles were encountered in the former rural residential areas of Lot 51 and Lot 52 DP561032. These included:
    - Localised filling from previous greenhouse cut/fill pads in the vicinity of ETP80;
    - Scatterings of surface and shallow subsurface agricultural wastes including plastic seed trays, geotextile, wood and plastic piping in the vicinity of ETP81 and 95; and
    - Previous foundations and disturbed soils associated with residential use in the vicinity of ETP89 (subsurface drain), and ETP104 (concrete pad).

- Partially disturbed soil profiles were encountered in the former nursery area of Lot 521 DP594725. These included:
  - o Localised filling from previous greenhouse cut/fill pads in the vicinity of ETP8, ETP15, ETP18 and ETP24. This fill was typically up to 0.5m in thickness and consisted of brown to black imported gravels;
  - o Localised filling in the vicinity of the former dwelling cut/fill pad at EBH10;
  - o Scatterings of surface agricultural wastes including plastic seed trays, geotextile, wood and plastic piping in the vicinity of ETP8, ETP15, ETP18 and ETP29;
  - o Concrete pads and remaining structures of the former nursery in the vicinity of ETP29 to EBH10.
- Disturbed and partially cut/filled tracks across all lots on the investigation area associated with illegal dumping of wastes;
- Significant filling associated with the former quarry void/landfill, underlain by either residual clays or sandstone bedrock. Fill was identified from the surface to depths ranging between 0.3m (ETP47) to 5.5m (EBH26) depth. The fill was typically thicker in the north-eastern portion of the former landfill around the likely former alignment of the drainage line. At portions the fill was irregular in profile with interpreted likely steep former cut sandstone faces and pillars of sandstone that had been left behind during quarrying operations (eg ETP45 and ETP73 with fill at 0.5m-0.9m thickness, dropping away to 3m thickness of fill at EBH24 and ETP74). The fill of the former landfill was observed to extend north-east from Lot 1 DP376264 across onto Lot 521 DP594725 of the former nursery (eg HA8/9 and ETP6/8).

  The base of the landfill was identified by a change to either bedrock or residual type clays. Given the presence of fill and water, the identification of the substrate as clay may be conservative, and extremely weathered bedrock may have been encountered. There is also the possibility that local fill was placed back in the quarry pit prior to filling.

  The fill typically consisted of 1-2m of sand dominated soils (brown, gravelly to silty) (eg EBH26), underlain by various clay and/or sand dominated soils (brown, grey) (eg EBH22). Anthropogenic inclusions were generally observed in the underlying clayey fill and included wood (cut and natural), concrete kerbing and piping, bitumen, geotextile and plastic sheeting derived from roadworks, but in parts also included car bodies (eg ETP 85), and demolition rubble including fibro cement pieces (eg ETP90).

  Hydrocarbon odours were typically not recorded in the fill, though oily odours were recorded in ETP85 associated with a car body, ETP86, ETP90 and ETP91. A slight rotten egg odour was observed in the base of fill in ETP107.

The location of inferred filling across the investigation area is presented on **Figure 11** and **Figure 12**. Inferred sections across the former landfill are presented in **Figure 13** and **Figure 14**.

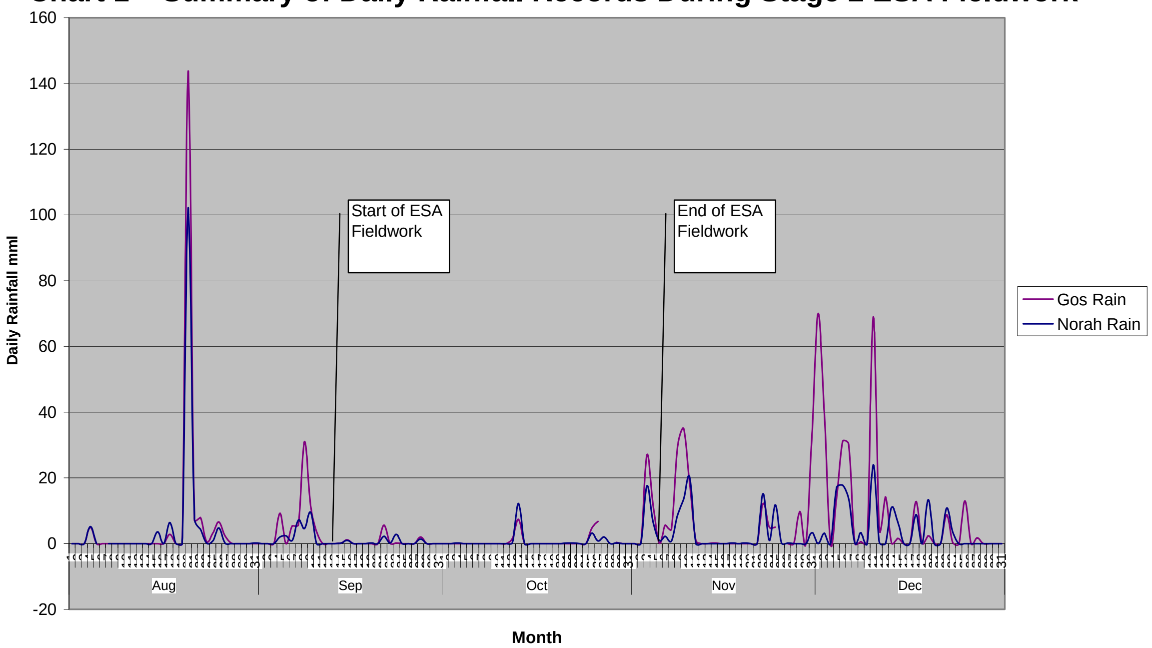
7.2 Groundwater Characterisation

Groundwater was not encountered in topsoils or residual clays during the investigation. Groundwater inflows were recorded in some of the test pits and boreholes undertaken within the former landfill, typically within voids (car bodies, tyres, plastic bottles etc), perched on-top of clayey fill lenses or at the base of fill on-top of residual/bedrock. Groundwater inflows were encountered in EBH13 at 1.2m, EBH26 at 3.2m, ETP85 at 1.5m, ETP86 at 0.4m, ETP87 at 1.4m, ETP90 at 2.5m, ETP88 at 2.0m, and ETP107 at 1.4m in fill, and EBH24 at 2.6m, ETP36 at 1.8m, ETP75 at 0.8m and ETP91 at 4.0m depth in top of residual/bedrock. Monitoring wells were installed to gain a vertical and horizontal spread of groundwater quality data across the former landfill. Except for MW1, monitoring wells were screened across the fill profile including base of fill to capture any baseflow groundwater. MW1 was installed across the majority of the fill profile at that location, but finished about 1.5m above the base of fill. As MW1 consistently recorded groundwater levels throughout the investigation, this monitoring well is also considered to have intercepted any baseflow groundwater in the fill.

Groundwater levels were recorded at between 2.5m and 5m in the first round of groundwater monitoring, being deepest at MW1 (close to drainage line). Groundwater levels did not stabilise in the monitoring wells installed across the landfill, and continued to fall over the three dates recorded. The majority of monitoring wells dried up by the third and final round of monitoring. The monitoring wells were installed after a period of rainfall, and a surface spring was observed at the base of slope between EBH13/MW1 and ETP43, with water draining slowly into the adjacent gully, into the dam adjacent to EBH15/MW3 and downstream past EBH14/MW2 and offsite. By the final round of groundwater monitoring the gully had dried up. It is surmised that the groundwater intersected in the monitoring wells represented perched water migrating down through the former landfill to the drainage line or the base of the landfill.

Chart 1 (below) presents a summary of rainfall patterns for the nearest two weather stations on the Central Coast, Norah Head and Gosford (Narara). The data indicates that a large rainfall event occurred in August, followed by a period of mainly nil to low rainfall in September through October. A period of rainfall activity returned in late November after fieldwork completed.

Chart 1 – Summary of Daily Rainfall Records During Stage 2 ESA Fieldwork



Based on this data and the inferred geological sections, the former quarry was cut into the sides of a drainage valley in a series of steps. No significant 'bowls' were encountered to hold groundwater, and the hydrogeological model for the former landfill is of temporary groundwater vertical and horizontal migration through the more hydraulically conductive fill from the upper valley sides by percolation through the fill after rainfall, draining down towards the spring at the base of fill in the drainage channel (intersected by MW1). The former quarry floor is assumed to mainly act as a permeability barrier to vertical groundwater flow, though some slow ‘leakage’ from the intermittent groundwater in fill into the underlying bedrock is expected to be occurring and needs to be further assessed.

The inferred groundwater surface contours based on the monitoring round of 3 October (see **Table 7**) are presented in **Figure 15**. The contours show that the inferred flow direction was relatively flat and irregular on the upper, level southern portion of the former landfill and down to the north-east in the lower irregular portion close to the drainage line.

Given the layout of the investigation area, no ‘background’ or upstream monitoring wells were able to be installed. **Table 15** presents a summary of the groundwater field parameters recorded on 3 October. Groundwater field sheets are included in **Appendix F**. The readings showed that:

- Groundwater pH was moderately acidic at 5.3pH Units compared to that of surface water at 6.15pH Units. These pH levels are less than the trigger levels for lowland rivers and long term irrigation values, but within the acceptable range for drinking water and livestock watering;
- Groundwater was slightly more conductive than surface water with an Electrical Conductivity (EC) of 0.4mS/cm compared to 0.210mS/cm. Overall groundwater and surface water were only marginally saline to fresh, with a conductivity an order of magnitude less than the long term irrigation and livestock watering trigger values;
- Groundwater was only slightly oxygenated with a Dissolved Oxygen (DO) at 2.5mg/L, compared to surface waters at 6mg/L; and
- Temperature of surface and groundwater’s were similar, and groundwater was highly turbid related to poor well development.

Table 15 - Indicative Groundwater Field Parameters (3/10/07)

Monitoring Well	**pH (pH Units)**	**E.C. (mS/cm)**	**Turbidity (NTU)**	**D.O. (mg/L)**	**Temp (°C)**
MW1	5.30	0.307	>999	2.29	24.0
MW2 (gully water)	6.15	0.214	26	6.12	25.3
MW3 (dam water)	6.27	0.215	42	6.08	25.9
MW4	5.10	0.298	>999	2.47	26.0
MW5	5.19	0.409	>999	2.70	24.5
MW6	-	-	-	-	-
MW7	5.32	0.416	>999	2.81	25.1
MW8	-	-	-	-	-

Monitoring Well	pH (pH Units)	E.C. (mS/cm)	Turbidity (NTU)	D.O. (mg/L)	Temp (°C)
MW9	5.14	0.301	>999	2.07	24.5

7.3 PID Results

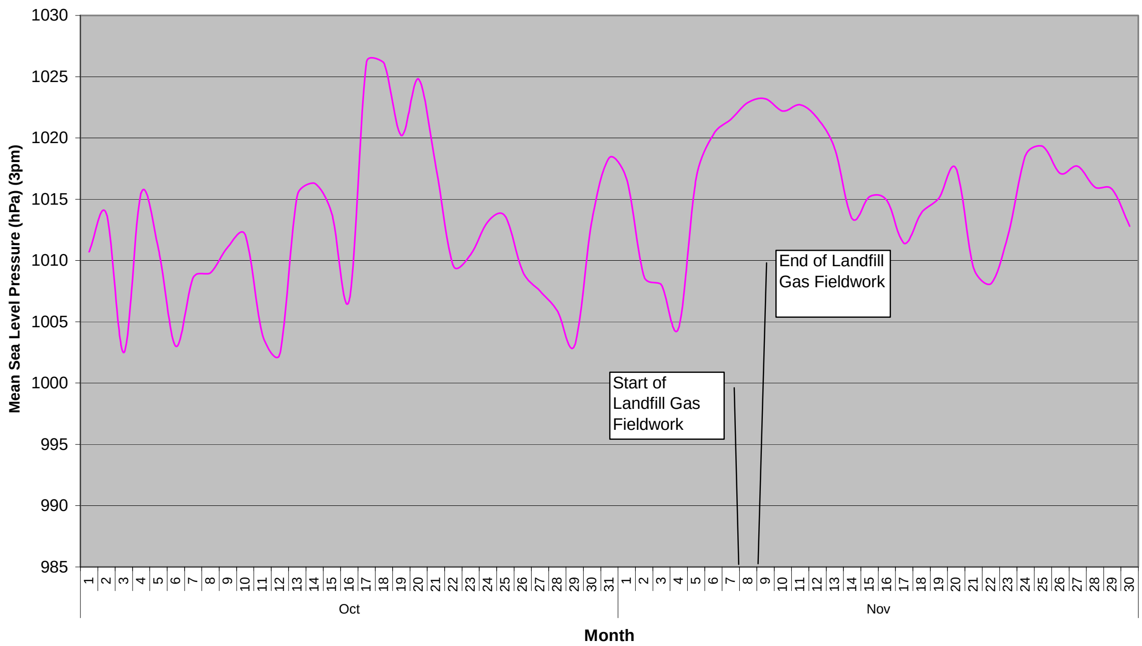
Soil samples were screened with a PID, the results of which are presented in **Appendix E**. Based on previous experience and dependent on the volatility of the hydrocarbon fraction, readings of 0ppm to 10pmm were considered to represent low to background conditions, 10ppm to 50ppm the potential for moderate hydrocarbon concentrations and greater than 50ppm to represent moderate to high hydrocarbon concentrations.

In summary no to background readings were recorded in the majority of the samples collected, attributed to the lack of hydrocarbon impacts across the majority of the investigation area. Low readings were recorded within the landfill area in ETP8, ETP86 and ETP87 only at less than 11ppm.

7.4 Landfill Gas Results

Landfill gas field sheets are included in **Appendix G**. **Table 16** below summarises the landfill gas results. As indicated in Chart 2, Landfill gas monitoring was undertaken at the end of a pressure increasing cycle. Coffey expects that the effect of increasing barometric pressure on gas accumulation in the monitoring wells was small given the buoyancy of methane and that the wells were screened deeper than 0.5m below the surface of the former landfill.

Chart 2 – Summary of Pressure Patterns (Norah Head) During Stage 2 ESA Fieldwork



The results indicate that H_2S was not detected or detected at low concentrations in monitoring wells, and concentrations of volatile gases were also low. Methane concentrations were variable with low to background readings recorded in MW3, MW6 and MW9, moderate concentrations in MW1, and concentrations greater than the NSW EPA Guideline in MW4, MW5, MW7 and MW8. Hydrogen sulfide was generally not associated with methane concentrations.

Table 16 - Indicative Landfill Gas Results (5/11/07)

Monitoring Well	**CH_4 (%)***	**H_2S (ppm)***	**PID (ppm)**
Adopted Investigation Level	**1.25**	**10**	**10**
MW1	0.7	1	0.2
MW3	0.0	1	0.3
MW4	**24.3**	0	0.0
MW5	**2.2**	1	0.0
MW6	0.1	1	0.7
MW7	**>1.25**	1	0.6
MW8	**9.9**	0	0.5
MW9	0.3	0	1.7
* = first flush maximum concentrations			

Methane is a known asphyxiant and is explosive. Inhalation of methane only at very high concentrations is a health concern. Given the concentrations of methane recorded, an explosion risk (5%-15%) was present in gases extracted from some of the monitoring wells, and confined space entry asphyxiation risks were indicated. Thus, the current condition of the landfill may present a risk of explosion due to accumulation of methane in subsurface vaults or basements. Inhalation risks for methane were low in ambient air because of the preference for methane to disperse rather than accumulate.

Hydrogen sulfide is not expected to be an explosion, or inhalation risk at the concentrations encountered. Hydrogen sulfide is typically not considered an asphyxiant at concentrations less than 15ppm because of the low odour threshold of this gas.

Insufficient data is available on concentrations of methane and hydrogen sulfide at the surface of the former landfill to assess landfill gas risks to existing or proposed site users.

7.5 Comparison of Soil Laboratory Results with Investigation Levels

Laboratory reports are included in electronic format in **Appendix H**, soil analytical results are summarised in the attached **Tables LR1-LR9**. The tables were compiled in the ESDAT database, with standard shadings for non-detects and exceedances. A cover page to the tables explains the formatting. As laboratory reports are presented in electronic format a list of all samples analysed and the corresponding batch is included in **Appendix H**.

The soil exceedances are highlighted in **Figure 16** and **Figure 17**. Coffey have adopted a 'lowest common denominator' approach to comparing analytical results to investigation levels as the investigation area is proposed to be redeveloped for a variety of landuses from public recreation through to commercial/industrial, and the plan of the redevelopment has not been finalised. With this approach, Coffey have adopted the lowest investigation level for any analyte as the level to compare against the analytical results. If the concentration of that analyte is very high, Coffey have commented on additional guidelines that the analyte exceeds.

7.5.1 L521 DP594725-Former Nursery

Comparison of the laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of heavy metals were recorded below the adjusted EIL investigation levels in the composite soil samples analysed;
- Concentrations of OCP, OPP, PCB and PAH were all recorded less than the laboratory practical detection limits (PQL) in the composite samples analysed;
- Concentrations of zinc exceeded the EIL at ETP5 0.0-0.1 in a discrete soil sample. All other concentrations of heavy metals in test pit, borehole and surface samples were either less than the laboratory PQL or less than the EIL guidelines;
- Low concentrations of TRH C15-C36 and PAH were recorded in one gully sample (G3) above the laboratory PQL but less than the investigation level. The remaining two gully samples recorded concentrations of TRH and PAH below the laboratory PQL;
- Low concentrations of OCP (chlordane and heptachlor) were recorded in one sample (ETP8 0.0-0.1) close to the PQL and well below the investigation levels. Concentrations of the OCP and OPP at the remaining samples were recorded below the laboratory PQL;
- Concentrations of total cyanide were not detected above the laboratory PQL in the samples analysed; and
- Asbestos in soil and one fragment sample (Asbestos 2) submitted for analyses recorded no detections of fibrous or bonded asbestos.

7.5.2 L521 DP594725, L1 DP376264, L54 DP7527 & L55 DP7527-Former Quarry

Comparison of the laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of arsenic exceeded the EIL in EBH3 0.1-0.3, concentrations of lead exceeded the EIL at HA21 0.0-0.1, HA23 0.0-0.1 and HA24 0.0-0.1. The lead concentration in HA23 marginally exceeded the HIL A investigation level. All other concentrations of heavy metals in test pit, borehole, track, gully, and stockpile samples were either less than the laboratory PQLs or less than the EIL guidelines;

- Low concentrations of TRH C15-C36, less than the investigation level, were recorded in EBH3 0.1-0.3, EBH11 0.0-0.1, ETP31 0.0-0.1, ETP31 0.0-0.1, HA1 0.0-0.1, HA2 0.0-0.1, HA3 0.0-0.1, HA4 0.0-0.1, HA5 0.0-0.1, HA14 0.0-0.1, HA27 0.0-0.1, HA30-HA35 0.0-0.1, the surface samples SS26-28, and stockpile ST6. The remaining soil samples recorded concentrations of TRH below the laboratory PQL;
- Concentrations of BTEX, OCP, PCB were recorded less than the laboratory PQLs in all samples analysed;
- Low concentrations of Total Phenols were recorded in samples EBH7 0.0-0.2, ETP31 0.0-0.1, ETP71 0.0-0.1 and HA2 0.0-0.1 close to the PQL and well below the investigation levels. Concentrations of Total Phenols in the remaining samples were recorded below the laboratory PQL;
- Low concentrations of Total PAH and/or Benzo(a)Pyrene (BaP) were recorded in samples EBH10 0.0-0.2, ETP31 0.0-0.1, HA15 0.0-0.1, HA26 0.0-0.1, HA29 0.0-0.1, HA31 0.0-0.1, SS26-28 and ST6 close to the PQL and well below the investigation levels. Concentrations of PAHs in the remaining samples were recorded below the laboratory PQLs;
- Concentrations of total cyanide were not detected above the laboratory PQL in the three stockpile samples analysed;
- Concentrations of sulfate were recorded at or close to the laboratory PQL in the three stockpile samples analysed; and
- Asbestos in soil was recorded in HA33 0.0-0.1 and HA35 0.0-0.1, and asbestos in fragments was recorded in the adjacent surface sample Asbestos 1. Asbestos in soil was not recorded in the remaining 14 samples analysed.

7.5.3 L1 DP376264 & L54 DP7527-Former Landfill

Comparison of the laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of heavy metals were recorded below the adjusted EIL investigation levels in the composite soil samples analysed;
- Concentrations of OCP, OPP, PCB and PAH were all recorded less than the laboratory practical detection limits (PQL) in the composite samples analysed;
- Concentrations of zinc exceeded the EIL at ETP88 2.5-2.8. The concentration was well below the HIL A investigation level. All other concentrations of heavy metals in test pit, borehole and stockpile samples were either less than the laboratory PQLs or less than the EIL guidelines;
- Low concentrations of TRH C15-C36 were recorded in three of the four stockpile samples analysed (ST8, ST10-11);
- Low concentrations of Total Phenols were recorded in one of the four stockpile samples analysed (ST10);
- Concentrations of BTEX, VOC, OCP, OPP and PCB were recorded less than the laboratory PQLs in all samples analysed;
- Concentrations of BaP were recorded at or greater than the HIL A investigation level in ETP74 1.9-2.0 and HA12 0.0-0.1. Low concentrations of Total PAH and/or BaP less than the HIL A investigation levels were recorded in approximately half the samples analysed, including EBH13 0.5-

0.6, EBH16 0.5-0.95, EBH18 3.0-3.45, EBH22 0.0-0.1, ETP40 0.9-1.0, ETP43 0.9-1.0, ETP46 0.0-0.1, ETP48 0.0-0.1, ETP51 0.0-0.1, ETP52 0.4-0.5, ETP90 2.5-2.8, and ST8 and ST11. Concentrations of PAHs in the remaining samples were recorded below the laboratory PQLs;

- Concentrations of total cyanide were not detected above the laboratory PQL in the four stockpile samples analysed;
- Concentrations of sulfate were recorded less than the EIL investigation level in four stockpile samples analysed; and
- Asbestos in soil was recorded in one of 27 soil samples analysed (ST8), and asbestos in fragments was recorded in all four samples analysed (ETP86 2.0-2.3, ETP88 2.5-2.8, ETP90 2.5-2.8, ETP108 0.0-0.1.

7.5.4 Lot 54 and L55 DP7527-Eastern Forested Area

Comparison of the laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of Arsenic in Composite 13 were recorded marginally greater than the adjusted EIL investigation level. Concentrations of heavy metals were recorded below the adjusted HIL A (residential) investigation levels in all the composite soil samples analysed;
- Concentrations of OCP, OPP, PCB and PAH were all recorded less than the laboratory practical detection limits (PQL) in the composite samples analysed;
- Concentrations of heavy metals in stockpile and track samples were either less than the laboratory PQLs or less than the EIL guidelines;
- Low concentrations of TRH C15-C36 were recorded in three of the seven samples analysed (SS26, SS27 and ST3);
- Low concentrations of Total Phenols at the PQL were recorded in one of the four stockpile samples analysed (ST2);
- Concentrations of BTEX, OCP and PCB were recorded less than the laboratory PQLs in all samples analysed;
- Low concentrations of Total PAH and/or BaP less than the HIL A investigation levels were recorded in approximately half the samples analysed, including SS26, SS27, ST2 and ST3. Concentrations of PAHs in the remaining samples were recorded below the laboratory PQLs;
- Concentrations of total cyanide were not recorded above the laboratory PQL in the four stockpile samples analysed;
- Concentrations of sulfate were recorded at the PQL or less than the EIL investigation level in the four stockpile samples analysed; and
- Asbestos in soil was not recorded in the seven samples analysed.

7.5.5 L4 DP7738 Southern Forested Area

Comparison of the laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of heavy metals were recorded below the adjusted EIL investigation levels in all the composite soil samples analysed;
- Concentrations of OCP, OPP, PCB and PAH were all recorded less than the laboratory practical detection limits (PQL) in the composite samples analysed;
- Concentrations of heavy metals in stockpile and gully samples were either less than the laboratory PQLs or less than the EIL guidelines;
- Concentrations of TRH, BTEX, PAH, Total Phenols, OCP, OPP, PCB and total cyanide were recorded less than the laboratory PQLs in all samples analysed;
- Concentrations of sulfate were recorded less than the EIL investigation level in the two stockpile samples analysed; and
- Asbestos in soil was not recorded in the two stockpile samples analysed.

7.5.6 L51 DP561032-Former Rural-Residential

Comparison of the laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of heavy metals were recorded below the adjusted EIL investigation levels in all the composite soil samples analysed;
- Concentrations of OCP, OPP, PCB and PAH were all recorded less than the laboratory practical detection limits (PQL) in the composite samples analysed;
- Concentrations of zinc in ETP75 0.5-0.6, and arsenic in ETP93 0.4-0.5 were recorded greater than the EIL investigation levels. Concentrations of heavy metals in the remaining discrete surface samples were recorded less than the laboratory PQLs or less than the EIL investigation levels;
- Low concentrations of TRH C15-C36 were recorded in three of the twelve samples analysed (ETP94 0.0-0.1, G7 and ST12);
- Low concentrations of OCP were recorded in ETP89 0.0-0.1 at concentrations well below the HIL A investigation levels. Concentrations of OCP in the remaining discrete soil samples analysed were less than the laboratory PQL;
- Low concentrations of Total Phenols at or close to the laboratory PQL were recorded in five of the eleven soil samples analysed. All concentrations were well below the HIL A investigation levels;
- Low concentrations of Total PAH and/or BaP were BaP less than the HIL A investigation levels were recorded in ETP94 0.0-0.1. Concentrations of PAHs in the remaining samples were recorded below the laboratory PQLs;
- Concentrations of BTEX, OPP, PCB and total cyanide were recorded less than the laboratory PQLs in all samples analysed;
- Concentrations of sulfate were recorded less than the EIL investigation level in the discrete soil samples analysed; and
- Asbestos was not detected in the eleven soil samples submitted, though synthetic man-made fibres were detected in soil in ETP94 0.0-0.1. Bonded asbestos was detected in the single fibrous-cement guttering sample submitted for analysis (SS92).

7.5.7 L52 DP561032-Former Rural-Residential

Comparison of the laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of heavy metals were recorded below the adjusted EIL investigation levels in all the composite soil samples analysed;
- Concentrations of OCP, OPP, PCB and PAH were all recorded less than the laboratory practical detection limits (PQL) in the composite samples analysed;
- Concentrations of zinc in ETP100 0.0-0.1 were recorded marginally greater than the EIL investigation levels. Concentrations of heavy metals in the remaining discrete surface samples were recorded less than the laboratory PQLs or less than the EIL investigation levels;
- Low concentrations of Total Phenols at or close to the laboratory PQL were recorded in three of the seven soil samples analysed. All concentrations were well below the HIL A investigation levels;
- Low concentrations of Total PAH and/or BaP were BaP less than the HIL A investigation levels were recorded in ETP100 0.0-0.1, and ETP101 0.0-0.1. Concentrations of PAHs in the remaining samples were recorded below the laboratory PQLs;
- Concentrations of TRH, BTEX, OCP, OPP, PCB and total cyanide were recorded less than the laboratory PQLs in all samples analysed;
- Low concentrations of sulfate were recorded less than the EIL investigation level in the six discrete soil samples analysed; and
- Asbestos was detected two of the eight soil samples submitted (stockpiles ST16 and ST17).

7.5.8 L1 DP375712 & L1 DP371647-Access Track

Comparison of the laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of heavy metals in the discrete surface samples were recorded less than the laboratory PQLs or less than the EIL investigation levels;
- Concentrations of TRH, BTEX, PAH, OCP and PCB were recorded less than the laboratory PQLs in all samples analysed; and
- Asbestos was not detected in the four soil samples submitted.

7.6 Comparison of Water Analytical Results with Investigation Levels

Laboratory reports are included in electronic format in **Appendix H**, water analytical results are summarised in the attached **Table LR10**. The tables were compiled in the ESDAT database, with standard shadings for non-detects and exceedances. A cover page to the tables explains the formatting. As laboratory reports are presented in electronic format a list of all samples analysed and the corresponding batch is included in **Appendix H**.

The water exceedances are highlighted in **Figure 18**.

7.6.1 Surface Water

Comparison of the surface water laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of copper and/or zinc marginally exceeded the ANZECC Protection of Aquatic Ecosystem 95% (ANZECC 95%) investigation levels in samples from Dam 1, 2, 3 and 4.
- Concentrations of total chromium marginally exceeded the ANZECC 95% investigation levels in the gully water and dam water from adjacent to MW2 and MW3 respectively;
- Concentrations of the remaining heavy metals were recorded either less than the laboratory PQLs or less than the investigation levels;
- Concentrations of OCP, OPP and PAH were recorded less than the laboratory PQLs in all dam water samples analysed. The PQL for azinophos methyl and parathion were greater than the investigation level;
- Concentrations of total phenols, BTEX and PCB were recorded less than the laboratory PQLs in all dam and gully water samples from adjacent to monitoring wells analysed.
- Low concentrations of TRH (1775ug/L) greater than the laboratory PQL were recorded in the sample from Dam 2. The adopted investigation level for TRH is the laboratory PQL.

7.6.2 Groundwater

Comparison of the groundwater laboratory results to the adopted Investigation Levels are summarised as follows:

- Concentrations of chromium, copper and/or zinc exceeded the ANZECC 95% investigation levels in all samples from monitoring wells. Concentrations of the remaining heavy metals were recorded either less than the laboratory PQLs or less than the investigation levels;
- Concentrations of PCB congeners were recorded all less than the laboratory PQLs;
- Low concentrations of TRH (1329-3420ug/L) greater than the laboratory PQL were recorded in the samples from MW5, MW7 and MW9. The adopted investigation level for TRH is the laboratory PQL;
- Concentrations of PAH were recorded greater than the laboratory PQLs in samples from all monitoring wells (MW1, MW4, MW5, MW7 and MW9). Concentrations of Anthracene were recorded at the ANZECC 99% investigation level of 0.01ug/L. The laboratory PQL in the sample from MW7 was raised due to matrix interference or insufficient sample volumes, resulting in PQLs for Anthracene and BaP greater than the investigation levels;
- Concentrations of OCP and OPP were recorded less than the laboratory PQLs in all samples analysed. The laboratory PQLs for azinophos methyl, lindane, DDT, chlorpyrifos, diazinon and parathion were greater than the investigation levels; and
- Low concentrations of dichlorodifluoromethane were recorded in samples from monitoring wells MW4, MW5, MW7 and MW9. No Low concentrations of chloromethane were recorded in the sample from monitoring well MW9. Both concentrations were orders of magnitude less than the investigation levels. The laboratory PQLs for dichloromethane, hexachlorobutadiene and vinyl chloride were greater than the investigation levels.

7.7 Data Quality Check

In accordance with Appendix V of the NSW DEC (2006) Guidelines, the quality of the field and laboratory data that has been collected during this investigation has been compared to the DQO's for the project that were outlined in the SAQP.

Laboratory data was entered into the ESDAT proprietary software using the ESDAT format of laboratory results supplied by the primary and secondary laboratory. Every sample is labelled with a unique identifier in the laboratory information management system (LIMS), and ESDAT organises the imported data into a database so that relevant statistical summaries of quality assurance exceedances and guideline exceedances can be obtained. The ESDAT output summary of quality assurance issues is included in **Appendix I**. The data quality check is outlined in **Table 17** below. In summary, the field and laboratory QA/QC indicated that some data quality exceedances were recorded, resulting in a reduced data completeness, data precision and data accuracy. Specifically, issues identified during the data quality check review indicated that:

- The majority but not all test pits and hand augers were able to be excavated/drilled through the complete fill profile. In most of the cases, this was due to the thickness of fill exceeding the limits of the excavation equipment onsite;
- The laboratory PQL for some OPP, PAH and VOC were greater than the available investigation levels. Low level PQL's were requested of the laboratory, but as high reliability data was not always available, low reliability trigger values were adopted, with levels below that the laboratory could achieve within the standard low level analysis suites;
- Holding time exceedances were recorded for soil and water samples extracted between 7-14 days after sampling (not less than 7 days as preferred);
- High RPDs between primary and intra-lab and inter-lab duplicate samples were recorded for heavy metals. Heavy metal concentrations were generally low, and in some cases these high RPDs were related to variability at concentrations close to the laboratory PQL. Variability of heavy metals related to matrix inhomogeneity was also identified as a factor; and
- The majority of wash blank samples recorded concentrations of copper, nickel and zinc. The wash blank master sample (check sample of rinsate water) also recorded concentrations of copper and zinc, which are common contaminants in water.

Overall, given the scope of the ESA and the number of samples collected and analysed, the field and laboratory QA/QC meet the DQO requirements of data completeness, comparability, representativeness, precision and accuracy. Therefore the analytical results are expected to reliably represent the concentrations of the analytes in the field and meaningful observations and conclusions can be drawn from the analytical dataset. It is recommended that during further sampling, if heavy metals are of particular concern then the analytical regime should be increased to compensate for data variability observed in the current data set

Table 17 - Data Quality Indicators

Objective	Met DQO	Field	Laboratory
Data Completeness	Yes	The total number of boreholes and test pits were completed as per the scope of works, though the proportion of boreholes, hand augers and test pits were modified to suit the site conditions. Due to a lack of stockpiles, the number of stockpiles sampled in the former nursery area was less than required by the SAQP, though to compensate, additional stockpiles were sampled in the quarry/landfill area. Samples were generally collected at the appropriate depth ranges All fieldwork was undertaken by a trained Coffey Environmental Scientist using consistent methods as per the Coffey operating procedures. All fieldwork data was collected on standard forms as attached in the report. Not all test pits were able to be excavated though the fill in the landfill due to thickness of fill or collapsing conditions. Given the number of boreholes and test pits undertaken in the landfill, and the generally low concentrations of contaminants at those depths, the missing data is not considered significant enough to warrant further investigations at this stage. The PQL for azinophos methyl, parathion,	All critical analyses were generally undertaken by the laboratory in accordance with the SAQP. Additional asbestos analyses were requested and undertaken. ESDAT identified 817 minor holding time exceedances relating to dates of extraction between 7-14 mainly related to BTEX, VOC and SVOC compound analyses within water samples (Trip Blanks, Wash Blanks, groundwater and dam samples) in batches 55276A, 55332A, 55398A, 55456A and 55634A; but also including soil SVOC Exceedances in batches SE06270, SE06835, cyanide and sulfate exceedances in batches 55332, 55334 and 55456. These are not considered significant as all samples were extracted by 14 days from sampling. ESDAT also identified 4 major holding time exceedances in batch 55456B related to reanalysis of four samples for mercury (ETP105 0-0.1, 0.4-0.5 and ETP106 0-0.1, 0.4-0.5). The extraction date was 63 days following sampling. This batch was a reanalysis undertaken by Coffey to assess a possible heavy metal impacts in the southern portion of the investigation. . Mercury was not recorded exceeding the investigation criteria across the investigation area, so this holding time exceedance wis not considered significant.

Objective	Met DQO	Field	Laboratory
		anthracene, BaP, dichloromethane, hexachlorobutadiene and vinyl chloride in groundwater were greater than the adopted investigation levels in some wells due to insufficient sample volumes to enable concentration in the laboratory. OCP and OPP were not recorded in the groundwater in adjacent wells and remaining OCP/OPP analytes. Anthracene and VOC were recorded in adjacent monitoring wells. Further analyses could be undertaken though recovery of monitoring wells may be required after a period of rainfall.	
Data Comparability	Yes	Soil fieldwork was undertaken in an uninterrupted block of time using standard methodologies and with the same staff member supervising the work. Soil fieldwork was undertaken after a period of rainfall, though the investigation period was dry. Groundwater in the monitoring wells fluctuated due to the nature of the aquifer under investigation, though gauging of water levels was undertaken over a short enough time span to be practically unaffected by these changes.	The same primary and secondary laboratory were used during the Stage 2 ESA. PQL's were generally acceptable, and low level PQL's in groundwater were undertaken. Due to limited volumes of groundwater, some PQL's could not be met for some organic analyses. Specifically the laboratory PQL exceeded investigation criteria: -Azinophos methyl (an OCP) in all water samples. As OCP were not recorded in any water samples this is not considered significant; -Chloripyrifos and diazinon (OPP) in MW7, and parathion in all water samples. As OPP were not recorded in any water samples this is not considered significant; - Anthracene and BaP (PAH) in MW7. Anthracene was recorded at the PQL and investigation criteria in the adjacent MW5, so Anthracene may

Objective	Met DQO	Field	Laboratory
			also be present in MW7; -Dichloromethane in all water samples and hexachlorobutadiene / vinyl chloride in MW1 and MW7. These compounds were not recorded in the remaining water samples.
Data Representative ness	Yes	The Stage 2 ESA incorporated multiple sampling points using multiple sampling techniques (boreholes, test pits, hand augers, monitoring wells, landfill gas).	The laboratory program generally included all analyses as per the SAQP, and additional asbestos analyses were undertaken as this was identified in the field as a COC that was not highlighted in the Stage 1 ESA. Additional asbestos analyses are required to fully characterise the investigation area for asbestos.
Data Precision	Yes	Fieldwork was undertaken by a trained Coffey environmental scientist using consistent methods as per the Coffey operating procedures.	The SAQP required that field intra-lab and inter-lab duplicates be analysed at 1in20 primary. Soil field intra-laboratory duplicates for the major COC's were analysed rate of 1in10 for TRH/BTEX, 1 in 13 for metals, 1 in 25 for PAH, and 1 in 19 for OCP. Less soil field duplicates were analysed for minor COC's. Based on this the field intra-lab duplicates were analysed in accordance with the SAQP for TRH/BTEX, metals and OCP (volatile, semi-volatile and non volatile compounds), but slightly less than required were analysed for PAH. Given the number of analyses undertaken in total for the project (242), and that for TRH/BTEX and heavy metals almost double the number of intra-lab duplicates were analysed this is considered satisfactory. Soil field inter-laboratory duplicates for the major COC's were analysed rate of 1in20 for TRH/BTEX, 1in14 for metals, 1in50 for PAH, and 1in 43 for OCP. Less soil field duplicates were analysed for minor COC's. Based on this the field inter-lab duplicates were analysed in accordance with the SAQP for TRH/BTEX and metals (Volatile and non volatile compounds), and less than required for OCP and PAH. Given the number of analyses undertaken in total for the project, and that for TRH/BTEX and heavy metals the number of intra-lab duplicates were analysed in accordance

Objective	Met DQO	Field	Laboratory
			with the SAQP, this is considered satisfactory. Relative Percentage Differences (RPD) of heavy metal results exceeding the nominated 50% were recorded in 11 of the 19 intra-laboratory duplicates analysed (samples EBH4 0.0-0.2, EBH13 4.0-4.2, ETP17 0.0-0.1, Composite 1, ETP21 0.0-0.1, ETP38 0.0-0.1, ETP102 0.0-0.1, HA16 0.0-0.1, HA25 0.0-0.1, HA7 0.0-0.1, HA35 0.0-0.1). An RPD of sulfate exceeding 50% was also recorded in ST7. All organic analyses recorded acceptable RPD in intra-lab duplicates. These results show that heavy metals in surface soils are variable, likely related to inhomogeneity in fill. RPDs of heavy metal results exceeding the nominated 50% in 12 of the 16 inter-lab duplicate samples analysed (samples ETP94 0.0-0.1, HA16 0.0-0.1, HA11 0.0-0.1, HA30 0.4-0.5, ETP90 0.0-0.3, EBH6 0.0-0.2, ETP1 0.0-0.1, ETP17 0.0-0.1, ETP24 0.0-0.1, ETP31 0.0-0.1, ETP47 0.4-0.5and ETP50 0.0-0.1). RPD of TRH analyses also exceed the nominated 50% in soil from ETP31 0.0-0.1. As the laboratories employ slightly different heavy metal analysis methodologies (though NATA accredited), the results may indicate data precision errors; though the error is expected to be low as the intra-lab and inter-lab duplicate results were generally variable. Therefore these results show that heavy metals in surface soils are variable, likely related to inhomogeneity in fill. As heavy metals were generally low in concentration the variability in results is not considered significant for the purpose of assessing the contamination status of the site. An alternative method of collection of duplicates may need to be adopted for any future investigation; for example, collection of large volumes, mixing and splitting in the field, or or collecting duplicates from a horizontally adjacent soil layers, or more than the minimum required heavy metal analyses should be undertaken to increase the statistical confidence of the heavy metal dataset. The intra-laboratory and inter-laboratory duplicate samples of MW1 both

Objective	Met DQO	Field	Laboratory
			recorded no concentrations of chloromethane above the PQL's, though the primary sample recorded a concentration greater than the laboratory PQL. Further sampling of groundwater may be required to confirm the significance of VOC concentrations in groundwater. Laboratory duplicates with RPDs of heavy metal results greater than 50% (77%-189%) were reported in MGT batches 215313 (DUP48), 215611 (DUP60), 215612 (DUP57), 214826 (DUP3) 214916 (DUP14), and 215112 (DUP32). Laboratory duplicates with RPDs of heavy metal results greater than 50% (51%-140%) were recorded in SGS batch 55332 (EBH20 0.5-0.95), 55334 (ETP22 0.0-0.1), and 55634 (HA31 0.0-0.1). Generally low and variable heavy metal concentrations were recorded in the primary and field duplicate samples, and these high RPDs in the laboratory duplicates generally reflect concentrations within 10 times the laboratory PQL or variability in sample matrices. Laboratory duplicates with RPDs of PAH or TRH greater than 50% (52%-189%) were recorded for MGT batch 214826 (DUP5), and 214916 (DUP25) and in SGS batch 55456 (ST8). The variations in concentrations in laboratory duplicates may indicate some heterogeneity of heavy metals, TRH and PAH in the matrix. This is not uncommon for these analytes, as the analytes may be inhomogeneously bound to clay particles. A trip spike was submitted with five of the laboratory batches and analysed for BTEX. All trip spike results were recorded between 84% and 113%, within acceptable recoveries. Due to a chain of custody error, one trip spike sample, for batch 55398, was not analysed. Given the large number of samples collected and analysed and the low concentrations reported, the RPD exceedances are not considered significant. The field and laboratory methods resulted in a reasonably precise dataset. Some variability in heavy metal concentrations were observed and if heavy metals are a significant COC in future ESA, the

Objective	Met DQO	Field	Laboratory
			sampling and analysis strategy should take into account this expected variability.
Data Accuracy	Yes	All fieldwork was undertaken by a trained Coffey Environmental Scientist using consistent methods as per the Coffey operating procedures.	11 wash blanks were submitted for analysis plus one check sample (wash blank master) of the wash blank water. The wash blanks were analysed for the main COCs in the batch submitted; as a minimum BTEX, and generally TRH, BTEX and heavy metals. The check sample showed that the wash blank water contained reportable (but low) concentrations of copper and zinc, and concentrations less than the laboratory PQLs for TRH and BTEX. The wash blank results for the 11 field collected samples recorded heavy metal concentrations of mainly copper, nickel and zinc in nearly every sample, but also cadmium and chromium in one sample each. Concentrations of TRH and BTEX were all recorded less than the laboratory PQLs. As heavy metals were recorded at only very low concentrations across the investigation area, and given the presence of heavy metals in the wash blank master water, the results appear to indicate spiking of the wash blank samples by the wash blank water used and not any deficiency in equipment decontamination. Therefore the hand auger, SPT and trowel decontamination techniques are considered appropriate. A trip blank was submitted with five of the laboratory batches and analysed for BTEX. No BTEX contaminants were reported by the laboratory for any trip blank samples. Due to a chain of custody error, one trip blank sample, for batch 55398, was not analysed. No contamination of method blanks were reported by SGS or MGT. Surrogate spikes were undertaken by the laboratories. Low surrogate spike recoveries (43%-53%) were recorded by the primary lab on PAH analyses for samples DW1-DW3 and MW5, and by the secondary lab (51%-56%) for Phenol, BTEX and OCP recoveries on three inter-

Objective	Met DQO	Field	Laboratory
			laboratory samples DUP14, DUP25 and DUP54. Matrix spikes were undertaken by both laboratories within the appropriate ratio of 1in20 samples. A low matrix spike recovery (57%) was recorded by the primary laboratory for BaP in batch 55398. Laboratory Control Samples (LCS) were analysed in every batch by the laboratories. Low recoveries were reported for PAH and OPP (36%-57%) in batch 55634. The remaining LCS results reported acceptable recoveries. Certified reference materials were used during analyses in all batches. Given the number of analyses undertaken, the amount of quality assurance performed by the laboratories, and that PAH were reported in water samples in batch 55634A, the laboratory reports are considered to be reasonably accurate.

8 DISCUSSION

8.1 Former Nursery

In total 44 test pits were excavated, 10 soil composites, three gully sediment, one stockpile, and four dam water samples were collected across the former nursery.

The surface of the former nursery was observed to be heavily modified by cutting down the natural west facing slope. Pads for the former buildings were still present as well as frames for the former dwelling and office, and the surface was littered with nursery packaging and operational wastes (piping, plastics etc). No hazardous building materials surveys were undertaken of the buildings on the area, though only one stockpile of potential asbestos containing materials was observed during the investigation. Additional investigations for asbestos in soil may be required to characterise this material in the vicinity of these structures.

Approximately 0.2m of roadbase gravel fill was observed across the cut pads underlain by residual clays or sandstone bedrock.

Analytical results indicated that concentrations of cyanide, OCP and OPP were generally not detected across the former nursery. One sample from ETP8 record very low concentrations of OCP adjacent to one of the former nursery sheds. It is possible that spillage of stored or applied pesticides occurred in that area. As only one investigation was undertaken adjacent to this building additional higher concentration OCP impacts may be present.

Zinc was recorded at concentrations exceeding the EIL guideline at ETP5. The results show that runoff from building materials adjacent to the former dwellings and sheds are likely to have resulted in surface heavy metal impacts, but the concentrations are typically below EIL and HILA (residential) guidelines.

Low heavy metal (copper and zinc) impacts were recorded in all the dams, and low TRH concentrations were recorded in water from Dam 2 (see **Figure 10**). The heavy metal concentrations are likely to be a combination of natural background levels as well as impacts derived from surface water runoff from the upslope former nursery, quarry and landfill. It is uncertain the cause of the TRH impacts in Dam 2, but may be the result of illegal dumping of rubbish in the dam, leaking of an old pump, or just surface water run-on. The TRH impacts in water may be contributing to TRH run-off during periods of heavy rainfall and overflow, and TRH concentrations in sediment may also be present. Additional water sampling should be undertaken to confirm the TRH concentrations and soil/sediment analyses undertaken to assess concentrations of TRH in upslope or spillway soils.

Given the previous landuse as a nursery, expect for potential asbestos and OCP impacts identified in the current investigation the former nursery area had less recordable contamination issues than expected.

8.2 Former Quarry

In total 11 test pits were excavated, 13 boreholes and 28 hand augers drilled, three gully sediment samples collected, one surface track, and four stockpile samples collected. One monitoring well was installed and sampled.

The former quarry spreads across four properties in the investigation area and excludes the quarry void which is discussed in the 'former landfill' section and portion of overlapping former nursery. The Phase

1 ESA roughly defined the former quarry as the extents of land clearing and ground disturbance associated with the excavation of soil and bedrock from the ridgetop. Aerial photographs show that the extent of former disturbance stretched from the north-western corner of the investigation area on Lot 521 down to the central eastern portion at the eastern boundary of Lot 55. The aerial photographs are at a scale and resolution that it is difficult to assess the extents of the quarry void, the reason and use for the additional disturbed areas and if buildings were present.

Due to regrowth of forest it is difficult to see the former extents of clearing and ground disturbance, but occasional stockpiles of sandstone, less thick forest and topographical changes do give an indication of the presence of this disturbed area. The margins of the former landfill are especially disturbed and the boundary between the 'former landfill' and 'quarry' are arbitary. Of note and as indicated on **Figure 4** an area of ground disturbance was noted either side of the main access track on Lot 1, Lot 54 and Lot 55, and the area of disturbance and historical rubbish wastes on the north-eastern edge of the former landfill around EBH15.

8.2.1 Filling

Filling of introduced wastes were generally not recorded across the former quarry, and filling with local material (unless a stratigraphy inversion or break is recorded) was difficult to observe given that material excavated from onsite may have been pushed out around the quarry. Historical stockpiled waste though was observed along the southern margin of the main access track into the north-eastern portion of the former quarry and included quarry waste sandstone, roadworks waste (bitumen, concrete and gravel) but also occasional more recent dumped domestic or demolition waste.

Analytical results indicated that fill and stockpiled material that was sampled did not contain asbestos and other inorganic or organic contaminants at concentrations greater than the EIL and HILA. Given geotechnical and aesthetic issues, the majority of stockpiled material would likely be suitable to remain onsite.

Concentrations of Lead greater than the HILA (residential) guidelines were recorded on the surface at three test pits down the eastern flank of the former quarry extents (Lot 55). This area is proposed to be redeveloped for a mixture of open space, environmental conservation and residential. One location recorded a concentration of lead marginally greater than the HILE (open space) guideline, but given the number of data points it is likely with 95% confidence the average lead concentrations would be less than the HILE and/or HILA guidelines. Once the final development layout is known some additional investigations of surface lead concentrations may be required.

Arsenic was recorded at concentrations exceeding the EIL guideline at EBH3. The results show that either impacted fill was used as pavement subbase or runoff from building materials or nursery activities prior to placement of the bitumen surface may have resulted in heavy metal impacts along the roadway drainage swale and surface. Concentrations would be expected to be typically below EIL and HIL guidelines. Once the final road and lot design for this area is known, further investigations or remediation of the existing nursery entrance road may be necessary.

Asbestos in fibres was identified in dumped rubbish on the surface of the former quarry adjacent to the access track that leads south from the landfill onto Lots 51 & 52 (Asbestos1). Asbestos in soil was also detected on the surface of the former quarry adjacent to this area at HA35 and HA33. The extents of the surface impacts of asbestos in soil were not delineated during the investigation.

8.2.2 Groundwater

Groundwater was not encountered in residual soils across the former quarry and groundwater would be expected within bedrock at depth. Surface water runoff down from the former landfill through the drainage alignment of Lot 54 and Lot 55 was observed. As low TRH, VOC and heavy metal concentrations were recorded in the groundwater in the landfill it is expected that these may be moving downslope through surface expression at the base of the former landfill into the drainage alignment. No TRH impacts were recorded in these surface waters and heavy metal concentrations of chromium were at similar levels to groundwater in the landfill. Lower concentrations of copper and zinc were recorded though in the surface waters. VOC analyses were not undertaken in drainage waters. Given that the former landfill straddles the ridgetop background groundwater or surface water analyses were not able to be collected, though overall the concentrations of heavy metals in the drainage waters were not high indicating that the landfill is unlikely to be contributing grossly contaminated water to the drainage alignment.

8.3 Landfill

In total 46 test pits, boreholes and hand augers were excavated or drilled across the former landfill. Four samples were also collected of stockpiled material. Eight monitoring wells were installed, groundwater samples collected and a round of landfill gas monitoring undertaken.

8.3.1 Filling

Fill was encountered to various depths across the former landfill, typically greater than 2.5m deep. The deepest record area of fill was in the northern portion of the former landfill adjacent to the drainage alignment (BH13) at 4.5m. The edge of filling was generally pronounced, controlled by the walls of the former quarry pit. Some placement of fill over the top of the quarry pit margins was observed in the southern edge of the former landfill (ETP108), down the former access track to the east (ETP49) and around the drainage alignment (ETP43). The fill was observed to contain two main layers, an upper brown sandy layer (topsoil like), and a deeper more variable series of layers including grey clays and sands.

Various waste materials were recorded in the fill, though overall waste inclusions likely accounted for less than 30% of the total fill volume. Green waste (tree trunks) was the main observed component of waste in the fill, and some portions also contained road wastes such as concrete kerbing and piping, plastic piping, bitumen and geotextile, and various demolition or domestic wastes such as fibro cement sheeting (ETP90), and car bodies (ETP85). Hydrocarbon odours were recorded in the fill adjacent to ETP85.

It is supposed that the surface topsoil layer was placed as a cap to the landfill to allow revegetation and separation from the deeper fill containing waste materials.

The analytical results confirmed that asbestos in fragments was recorded in the fill across the former landfill, with detections in all four fragment samples analysed. Asbestos was recorded at the surface and greater than 2m depth. Asbestos was not recorded in the sandy surface capping layer itself , supporting the hypothesis that filling of the landfill occurred in two stages, a deeper more impacted clay and sandy fill below 1-2m depth, and a less impacted surface sandy cap. Some zinc and BaP contamination was also recorded at depth, but zinc levels were less than human health guidelines for all landuses and BaP concentrations were less than 2.5 times the human health based guidelines for residential landuse, so the average concentrations across the entire former landfill would likely be less than proposed open space use guidelines (with 95% Confidence) given statistical analysis.

The subsurface investigations and analyses have highlighted that asbestos is a contaminant of concern within the former landfill that was not fully identified in the Phase 1 ESA. Only limited analyses were undertaken for asbestos during the current investigation, so it is not possible to yet fully characterise the former landfill for asbestos.

8.3.2 Groundwater

The groundwater investigation indicated that groundwater is intermittent across the former landfill, likely migrating by infiltration down through the sandy portions and lenses of fill and forming an intermittent aquifer at the base of fill migrating down to the drainage alignment in the north-eastern portion of the landfill. Except for in the vicinity of the drainage channel, no permanent groundwater aquifer was identified in the fill during the ESA. The intermittent groundwater flow direction was recorded to be flowing down to the north-east, though given falling levels in the monitoring wells the groundwater surface is expected to be erratic. Other pathways of groundwater migration may also be occurring including down through the fractured sandstone bedrock floor/walls or out through the fill/residual soil/bedrock contact. Recharge from the walls of the former landfill is also possible and was beyond the scope of the investigation to assess. Further investigations into the bedrock aquifer downslope of the former landfill may be prudent to assess if migration into the bedrock is occurring.

Widespread concentrations of heavy metals (chromium, copper and zinc) were recorded in groundwater and downstream surface waters at concentrations greater than the ANZECC 95% protection of Aquatic Ecosystem Guidelines. Typically the concentrations were only marginally over the guidelines. Concentrations of TRH <3500ug/L and low concentrations of VOC (dichlorodifluoromethane and chloromethane) were recorded in groundwater across the landfill, in the area around the test pit where the car body was observed (ETP85) and in the portion of the landfill along the drainage alignment. Dichlorodifluoromethane was previously a refrigerant, so a potential source could be the air conditioning unit in the car body or additional dumped whitegoods or vehicles. Very low concentrations of PAH (anthracene) at the guideline were also recorded in groundwater in one monitoring well. These concentrations are all low to moderate and indicate some low grade point or diffuse sources in the fill.

Where trigger values were available groundwater quality appeared to be suitable for livestock watering and long term irrigation.

8.3.3 Landfill Gas

Methane was recorded to be collecting in air space above the groundwater level in the monitoring wells at concentrations greater than NSW EPA Guideline in MW4, MW5, MW7 and MW8 located in the upper flat southern portion of the former landfill. Hydrogen sulfide was generally not associated with methane concentrations. No monitoring wells were installed in the north-western portion of the former landfill.

Given the concentrations of methane recorded, an explosion risk was present in gases extracted from some of the monitoring wells, and confined space entry asphyxiation risks were present by replacement or dilution of oxygen. Inhalation risks for methane were low.

Hydrogen sulfide is not expected to be an explosion, or inhalation risk at the concentrations encountered. Hydrogen sulfide is typically not considered an asphyxiant.

It is understood that an aquatic centre may be built over that portion of the former landfill, therefore an assessment of methane generation in that area may be required to further assess the risks associated with build-up beneath slabs. Insufficient data is available on concentrations of methane and hydrogen sulfide at the surface of the former landfill to assess landfill gas risks to existing or proposed site users, and further monitoring and management measures for landfill gases being generated in the upper southern portion of the landfill are required.

8.3.4 Dumping of Rubbish

The investigations revealed that dumping of rubbish has occurred alongside the track that provides entry to the north-eastern corner of the landfill, with occasional additional stockpiles throughout the surface of the landfill. Rubbish consists of various domestic and building wastes with only small quantities of fibro cement sheeting observed. In total approximately an area of 100m by 100m was observed to contain stockpiles of surface rubbish in that area. No asbestos was detected in the stockpiles and concentrations of other inorganic and organic contaminants were less than the onsite EIL and HIL guidelines. Given that the materials are geotechnically unsound and aesthetically unpleasing all stockpiled wastes will need to be collected and either managed onsite or disposed offsite. Waste classification of any materials requiring offsite disposal will be required.

8.4 Eastern Forested Area

Beyond the limits of the former quarry, Lots 54 & 55 contain relatively undisturbed bushland, intersected by the main access track into the former quarry and landfill. In total three track surface, two surface ‘background’, four stockpile, and four composite soil samples were collected this eastern forested area.

The area straddles previously undisturbed or minimally disturbed areas north of the main access on Lot 54 and Lot 55 (and to a lesser extent Lot 1), and east of the main access track on Lot 55. The area is mainly disturbed along the access track and its margins with dumping of stockpiles having occurred over a long period of time, including former quarry wastes and illegally dumped domestic/demolition wastes. The extent of placement of stockpiles is estimated on **Figure 4**.

Analytical results indicated that no asbestos or other inorganic or organic contaminants were present at concentrations greater than the EIL or HILA (residential) guidelines on the track surface or adjacent sampled stockpiles. The presence of additional unidentified stockpiled material in this area cannot be precluded, including the presence of asbestos containing materials.

The concentration of arsenic in Composite 13 exceeded the adjusted EIL but was less than the adjusted HILA (residential) guideline. As composite concentrations are typically not able to be compared to EILs (an average concentration should not be compared to a stationary receptor such as the roots of a plant), the concentration of arsenic is not considered to warrant further investigations.

8.5 Southern Forested Area

Lot 4 is vegetated almost entirely by a casuarina forest on a relatively undisturbed south facing slope.

A dirt access track runs up along the eastern boundary between Lot 4 and Lot 51. Dumping on rubbish was observed on the cleared Lot 51 side of the access track though no significant dumping of rubbish was recorded on the Lot 4 side of the access track as the vegetation is thick and runs up to the boundary.

In total six composite, two stockpile and one gully sample was collected across Lot 4. Analytical results indicated that concentrations of COC's were less than EIL and HILA (residential) guidelines.

8.6 Former Rural-Residential

Lots 51 and 52 contained revegetated forested northern margins and more disturbed southern portions. A dam is present in the northern portion of Lot 51, remnants of footings and concrete slabs of former dwellings are present in the southern portions, and a slightly disturbed area of cut benches is present between the dam and former dwellings on Lot 51. This disturbed area contained remnant poly piping, seedling trays and minor filling to 0.8m depth (ETP81).

Illegal dumping of rubbish was observed to be actively occurring alongside the track on Lot 51 (western edge), extending in the northern part onto Lot 52, and eastern edge of Lot 52. This included fibro cement sheeting and guttering. The approximate extents of dumping are highlighted on **Figure 5**.

In total eighteen test pits were excavated across Lot 51 and seven test pits across Lot 52. Five stockpile and one gully sample were collected across Lot 51 and two stockpile, one gully and two track samples were collected across Lot 52.

The analytical results indicated that concentrations of zinc and arsenic were recorded at 0.4m depth in two separate test pits (ETP75 and ETP93 respectively), and at the surface in one test pit (ETP100) at concentrations greater than EIL but less than HILA (residential) guidelines. These were associated with filling adjacent to the dam wall construction (ETP97) and former buildings (ETP93 and ETP100). As this portion of the investigation area is proposed to be developed for residential landuse, depending on the final development plan additional investigations or remediation of the arsenic and zinc impacts may be required. Asbestos in fibro cement guttering was recorded in one stockpile adjacent to the dam on Lot 51 (SS92) and two stockpiles on Lot 52 (ST16 and ST17). It is unknown if asbestos is present in soil in these areas and additional investigations for the presence of asbestos in the surface would be required.

8.7 Eastern Track

A dirt track runs up along the south-eastern boundary along Lot 1 DP375712 and Lot 1 371647. The track provides access for a residential dwelling further east and service access to the adjacent school. No filling or rubbish stockpiles were observed on the track, though the track is being used to dump rubbish on the eastern margin of Lot 52. Four surface samples were collected along the track. The analytical results showed that concentrations of the COCs analysed were less than the EIL and HILA (residential) guidelines.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

A Stage 2 ESA has been undertaken across the investigation area including a combination of boreholes, test pits, hand augers, installation of monitoring wells, and landfill gas monitoring. The investigation has resulted in a snapshot of the general conditions of the investigation area and highlighted some AEC's and COCs that may require additional investigations in order to characterise the investigation area.

Overall the investigation area recorded low concentrations of the COCs investigated, generally at levels such that all proposed Warnervale Town Centre landuses should be suitable with only minimal additional investigations or remediation given the size of the area investigated and the previous landuses undertaken. Groundwater contamination in the former landfill was recorded and needs to be managed in the future Asbestos impacts were recorded across the investigation area within filling in the landfill, stockpiled wastes and on the surface of adjacent soils. The asbestos investigation was limited and asbestos remains a COC that has not been fully assessed across the investigation area. Minor heavy metal impacts were identified across the site generally adjacent to former structures or runoff from these. Given statistical analysis most of these impacts would be reassessed as suitable for the proposed landuses with 95% confidence, but in areas of proposed residential or conservation use arsenic and zinc impacts in Lots 51 & 52, and lead impacts in Lot 55 may require further assessment or remediation.

In its current condition the investigation area is not suitable for the proposed landuses without further investigations.

9.2 Recommendations

The further investigations that Coffey recommend are presented in **Table 18** below.

Table 18 – Recommended Further Investigations

Property/Landuse	Recommendation
All properties/landuses	During fieldwork of the Stage 2 it was observed that multiples points of access to the site were available, and illegal dumping of rubbish, including fibro cement sheeting is ongoing. Coffey recommend that the entire investigation area is secured to prevent further dumping and contamination of the surface of the area. Given the limited asbestos analyses undertaken to date, a conclusion on the extent of asbestos impacts associated with dumping of rubbish and burial in the landfill is not possible. Further investigations for asbestos across the investigation area are required. Once the proposed landuse and built environment over the investigation area is known, a Remedial Action Plan (RAP) or RAPs be prepared to explore the appropriate remedial options for the identified dumped rubbish, subsurface impacts within the landfill, and surface impacts in the former nursery and rural-residential areas. These options may include preparation

Property/Landuse	Recommendation
	of a Site Management Plan (SMP) to manage ongoing contamination risks (such as buried asbestos in the landfill).
Former Nursery – Lot 521	Additional analyses for asbestos are undertaken across the surface of the former nursery and adjacent to buildings once demolished. Additional investigations for OCP impacts are undertaken in the vicinity of ETP8. Additional water sampling be undertaken to confirm TRH concentrations in Dam2 (former nursery), and soil/sediment analyses undertaken to assess concentrations of TRH in upslope or spillway soils.
Former Quarry – Lot 521, Lot 1, Lot 54 and Lot 55	Additional analyses for asbestos are undertaken across the surface of the former quarry beyond the limits of HA35-HA33, and in stockpiles along the access track and landfill margin. Further investigations into the bedrock aquifer downslope of the former landfill are undertaken to assess if migration of contaminants into the bedrock is occurring.
Former Landfill - Lot 1, Lot 54 and Lot 55	Additional analyses for asbestos are undertaken across the surface of the former landfill, within stockpiled waste materials and on the surface adjacent to dumped stockpiles. Additional monitoring wells are installed to the base of fill in the north-western portion of the former landfill to assess for presence of groundwater and methane. Once the proposed landuse and built environment over the former landfill is known additional investigations are undertaken to assess the extent of landfill gas generation adjacent to the built structures and across the surface of the landfill in general. A plan of management may be required to be prepared to manage methane which may include recommendations for capping and methane collection systems.
Eastern Forested Area – Lot 54 and Lot 55	Additional analyses for asbestos are undertaken across the surface adjacent to the stockpiles on the main access track margins.
Southern Forested Area – Lot 4	Additional analyses for asbestos are undertaken across the surface adjacent to the stockpiles on the access track margins. Further investigations into the bedrock aquifer downslope of the former landfill are undertaken to assess if migration of contaminants into the bedrock is occurring.
Former Rural Residential	Additional analyses for asbestos are undertaken adjacent to stockpiles on

Property/Landuse	Recommendation
- Lot 51 and Lot 52	Lot 51 and Lot 52.
Track – Lot1 DP375712 and Lot 1 DP371647	Additional analyses for asbestos are undertaken adjacent to stockpiles on the margin of the access track.

10 LIMITATIONS

The findings within this report are the result of discreet/specific sampling methodologies used in accordance with normal practices and standards. To the best of our knowledge they represent a reasonable interpretation of the general conditions of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

It is the nature of contaminated site investigations that the degree of variability in site conditions cannot be known completely and no sampling and analysis program can eliminate all uncertainty concerning the condition of the site. Professional judgement must be exercised in the collection and interpretation of the data.

The investigations undertaken were preliminary only and the possibility that other, as yet unidentified, contamination is present at the site cannot be precluded.

In conducting this review and preparing the report, current guidelines for assessment and management of contaminated land were followed. This work has been conducted in good faith in accordance with Coffey's understanding of WSCs' brief and general accepted practice for environmental consulting.

This report did not cover waste classification of soils for offsite disposal. If soils are to be disposed of offsite they first need to be classified in accordance with the NSW DEC Environmental Guidelines: Assessment, Classification &Management of Liquid and Non-liquid Wastes (2004).

Information within the report including borehole logs should not be used for geotechnical investigation purposes.

11 REFERENCES

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Important information about your **Coffey** Environmental Site Assessment

Uncertainties as to what lies below the ground on potentially contaminated sites can lead to remediation costs blow outs, reduction in the value of the land and to delays in the redevelopment of land. These uncertainties are an inherent part of dealing with land contamination. The following notes have been prepared by Coffey to help you interpret and understand the limitations of your environmental site assessment report.

Your report has been written for a specific purpose

Your report has been developed on the basis of a specific purpose as understood by Coffey and applies only to the site or area investigated. For example, the purpose of your report may be:

- To assess the environmental effects of an on-going operation.
- To provide due diligence on behalf of a property vendor.
- To provide due diligence on behalf of a property purchaser.
- To provide information related to redevelopment of the site due to a proposed change in use, for example, industrial use to a residential use.
- To assess the existing baseline environmental, and sometimes geological and hydrological conditions or constraints of a site prior to an activity which may alter the sites environmental, geological or hydrological condition.

For each purpose, a specific approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible, quantify risks that both recognised and unrecognised contamination pose to the proposed activity. Such risks may be both financial (for example, clean up costs or limitations to the site use) and physical (for example, potential health risks to users of the site or the general public).

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man and may change with time. For example, groundwater levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of the subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project and/or on the property.

Interpretation of factual data

Environmental site assessments identify actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from indirect field measurements and sometimes other reports on the site are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how well qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, parties involved with land acquisition, management and/or redevelopment should retain the services of Coffey through the development and use of the site to identify variances, conduct additional tests if required, and recommend solutions to unexpected conditions or other problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered with redevelopment or on-going use of the site. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

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Important information about your **Coffey** Environmental Site Assessment

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. In particular, a due diligence report for a property vendor may not be suitable for satisfying the needs of a purchaser. Your report should not be applied for any purpose other than that originally specified at the time the report was issued.

Interpretation by other professionals

Costly problems can occur when other professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other professionals who are affected by the report. Have Coffey explain the report implications to professionals affected by them and then review plans and specifications produced to see how they have incorporated the report findings.

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, laboratory data, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel), field testing and laboratory evaluation of field samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

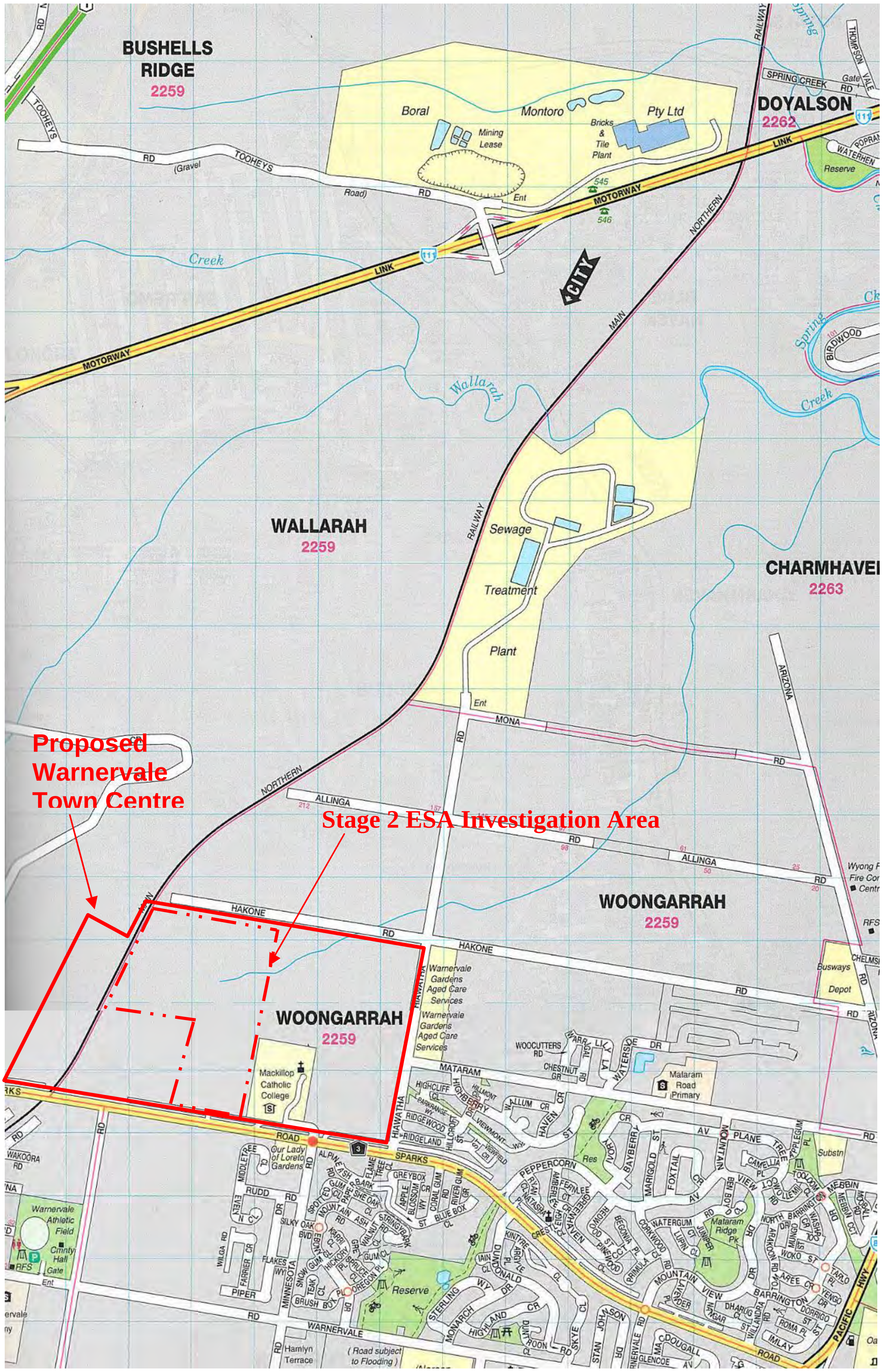
Contact Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to land development and land use. It is common that not all approaches will be necessarily dealt with in your environmental site assessment report due to concepts proposed at that time. As a project progresses through planning and design toward construction and/or maintenance, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Environmental reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than other design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

Figures



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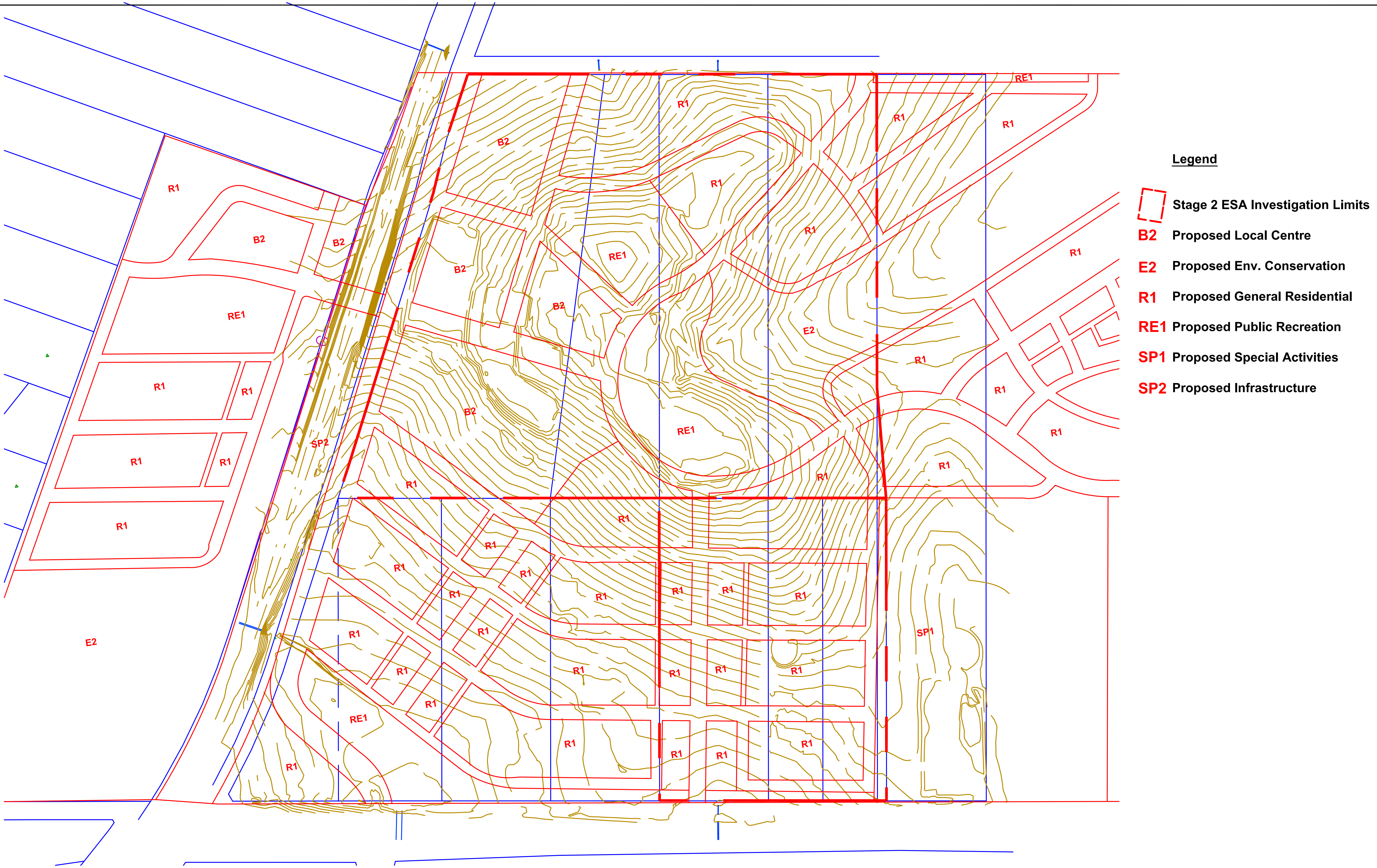
approved	MD	coffey geotechnics SPECIALISTS MANAGING THE EARTH	project:	Proposed Warnervale Town Centre, Sparks Road, Woongarrah, NSW Stage 2 Environmental Site Assessment
date	3/3/08			
scale	1:18000		title:	Site Location
original size	A4		project no: **GEOTKARI02021AA**	figure no: **Figure 1**



Source: Bannister & Hunter Pty Ltd. ref 55477-01G, November 2004

revision	description	drawn	approved	date

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Horizontal Scale (metres)

drawn	SD
approved	MD
date	31/3/07
scale	1:4000
original size	A3

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SPECIALISTS MANAGING THE EARTH

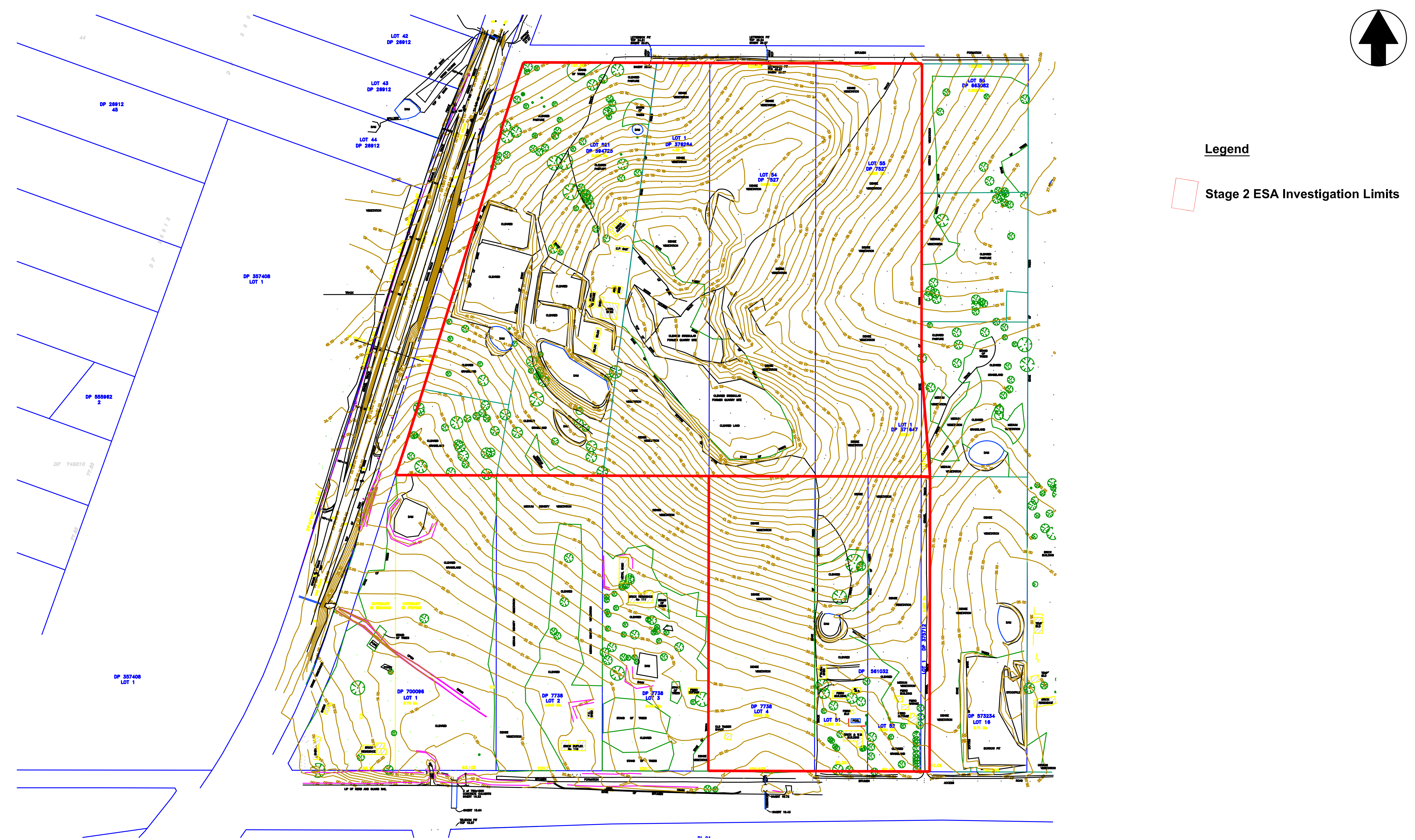
client: **Wyong Shire Council**

project: **Proposed Warnervale Town Centre, Sparks Road, Woongarrah, NSW**
Stage 2 Environmental Site Assessment

title: **Proposed Landuse**

project no: **GEOTKARI02021AA**

drawing no:/figure no: **Figure 2**



Source: Bannister & Hunter Pty Ltd. ref 55477-01G, November 2004

revision	description	drawn	approved	date

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Horizontal Scale (metres)

drawn	SD
approved	MD
date	31/03/08
scale	1:4000
original size	A3

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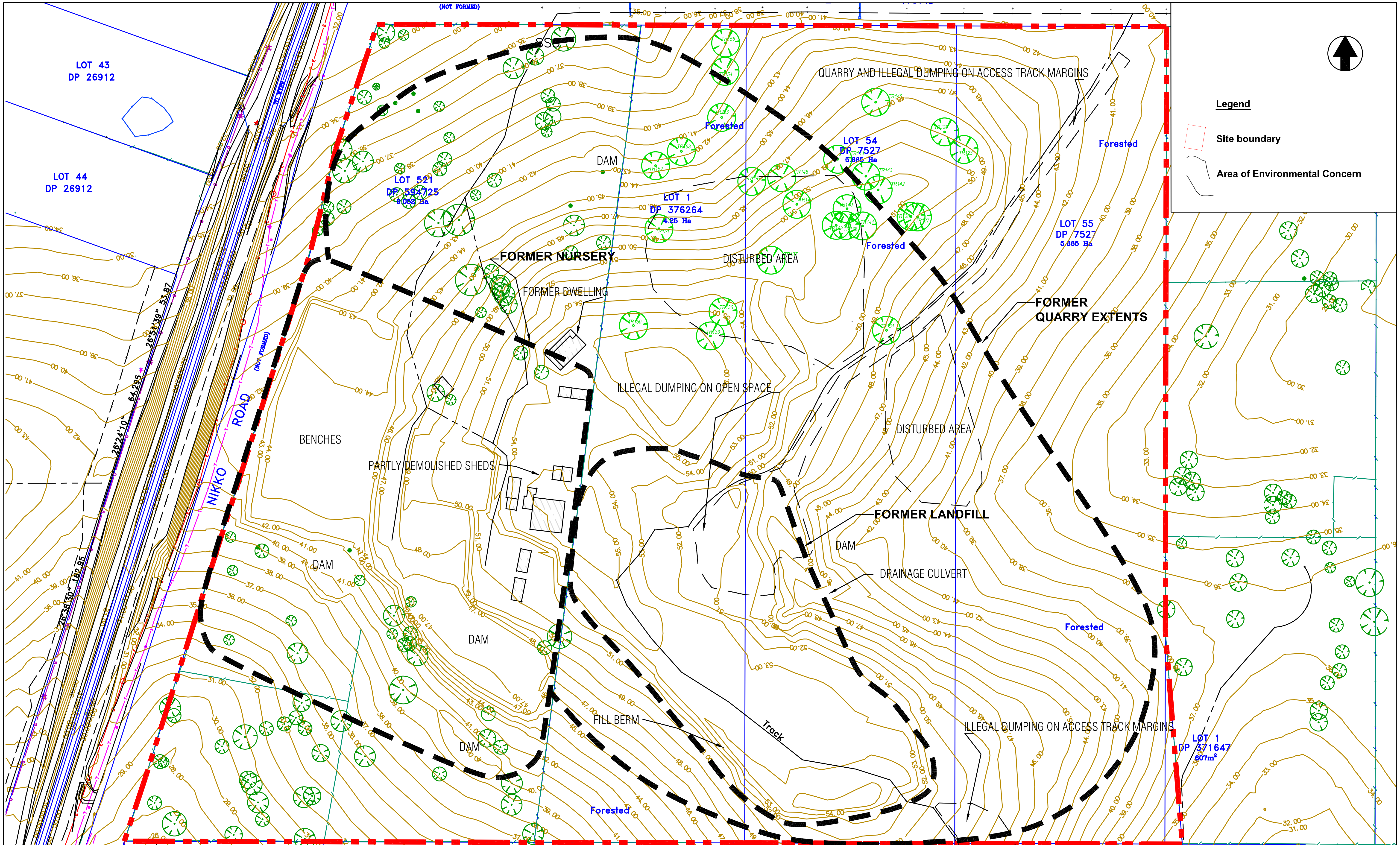
SPECIALISTS MANAGING THE EARTH

client:	Wyong Shire Council
project:	Proposed Warnervale Town Centre, Sparks Road, Woongarrah, NSW Stage 2 Environmental Site Assessment
title:	Existing Investigation Area Layout
project no: GEOTKARI02021AA	drawing no:/figure no: Figure 3



Source: Bannister & Hunter Pty Ltd (Ref 55477-01G, November 2004) & Douglas Partners Pty Ltd (Ref 4118A DWG 1A&1B, 1/3/06)

revision	description	drawn	approved	date

Scale (metres): 20 0 100

drawn	SD/SW
approved	MD
date	31/03/08
scale	1:2000
original size	A3

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SPECIALISTS MANAGING THE EARTH

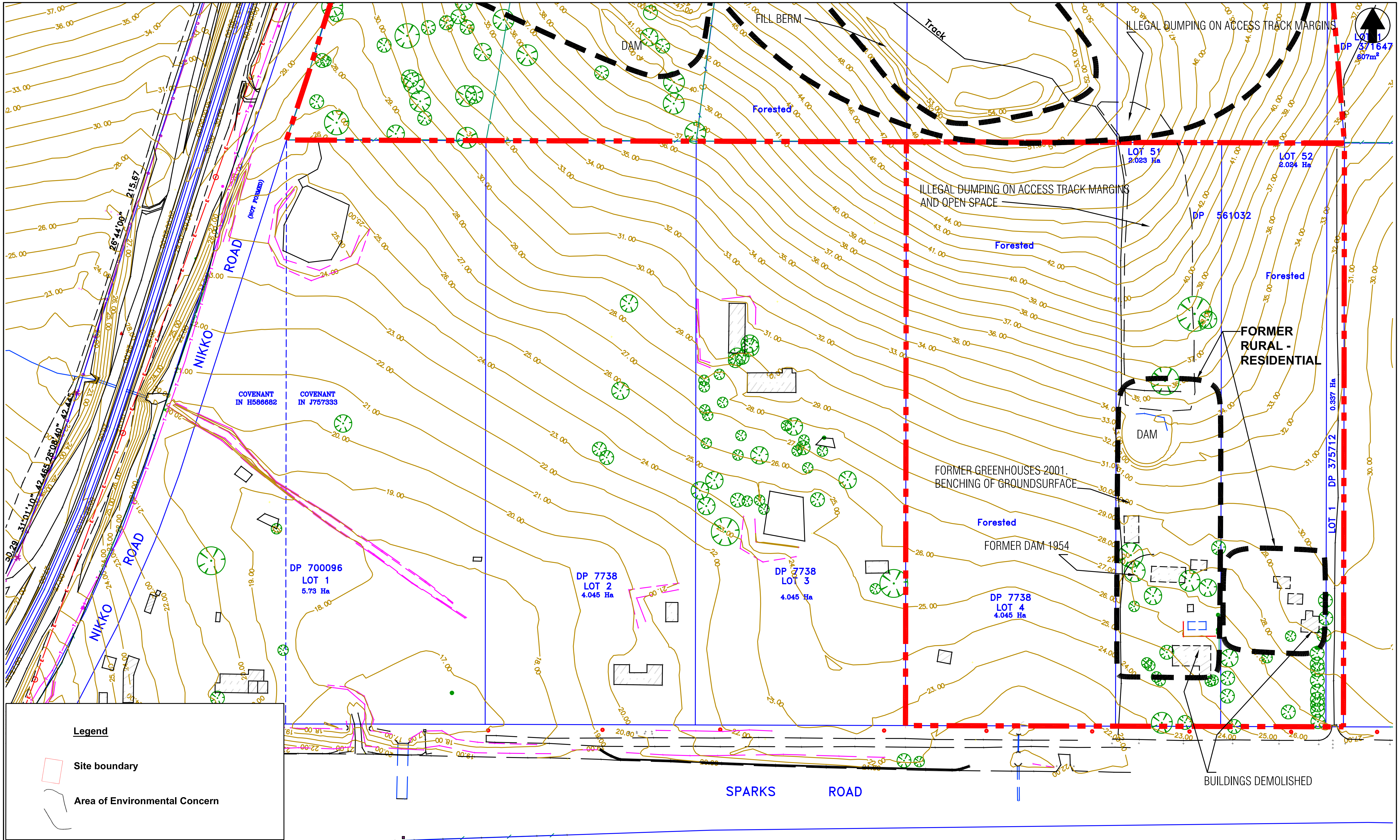
client: Wyong Shire Council

project: Proposed Warnervale Town Centre, Sparks Road, Woongarrah, NSW
Stage 2 Environmental Site Assessment

title: Identified Areas of Environmental Concern Northern Lots

project no: GEOTKARI02021AA

figure no: Figure 4



Source: Bannister & Hunter Pty Ltd (Ref 55477-01G, November 2004) & Douglas Partners Pty Ltd (Ref 4118A DWG1A&1B, 1/3/06)

revision	description	drawn	approved	date

Scale (metres): 20 0 100

drawn	SD/SW
approved	MD
date	31/03/08
scale	1:2000
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

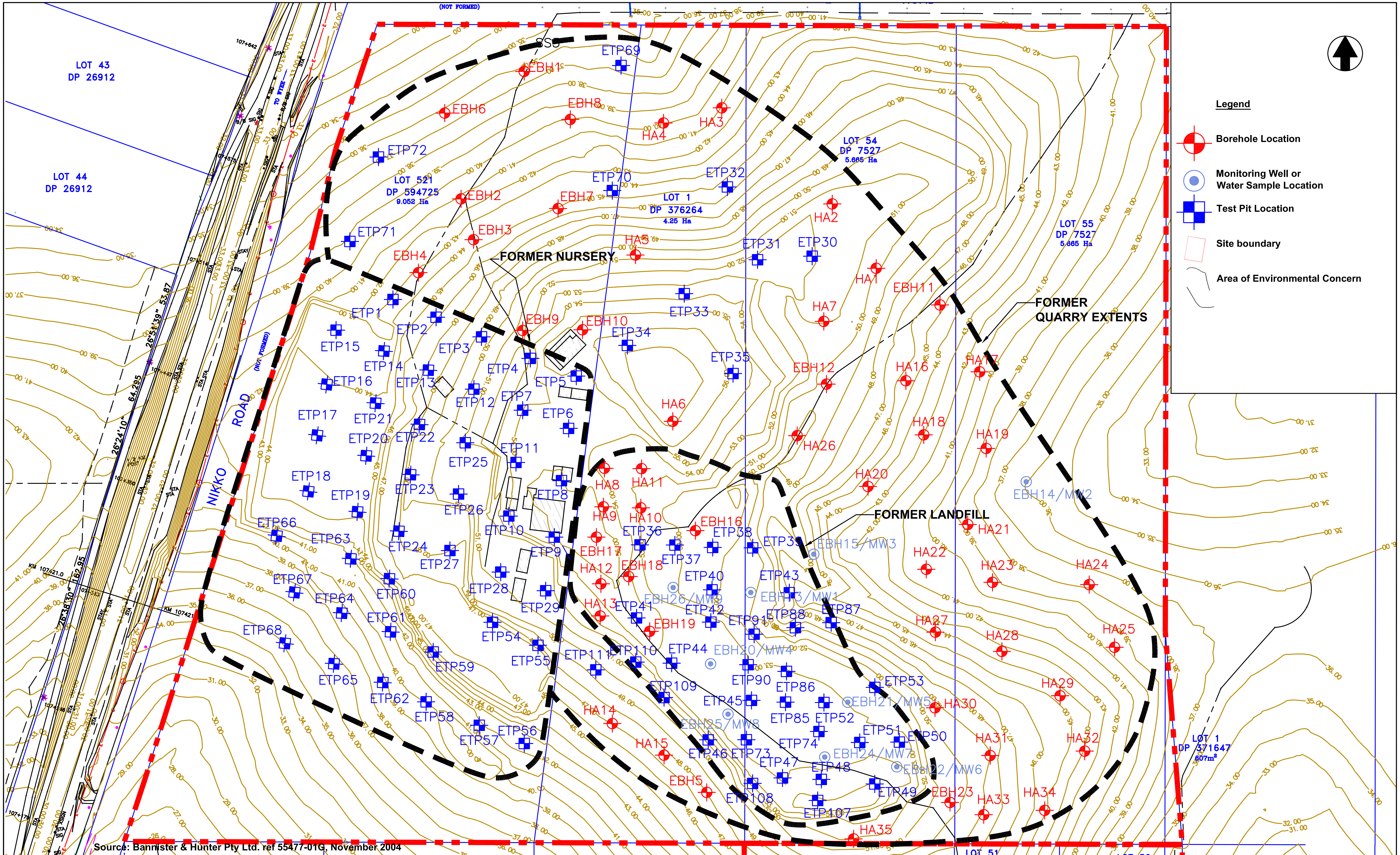
client: **Wyong Shire Council**

project: **Proposed Warnervale Town Centre, Sparks Road, Woongarrah, NSW**
Stage 2 Environmental Site Assessment

title: **Identified Areas of Environmental Concern Southern Lots**

project no: **GEOTKARI02021AA**

figure no: **Figure 5**



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Scale (metres): 20 0 100

drawn	SD/SW
approved	MD
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original size	A3

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SPECIALISTS MANAGING THE EARTH

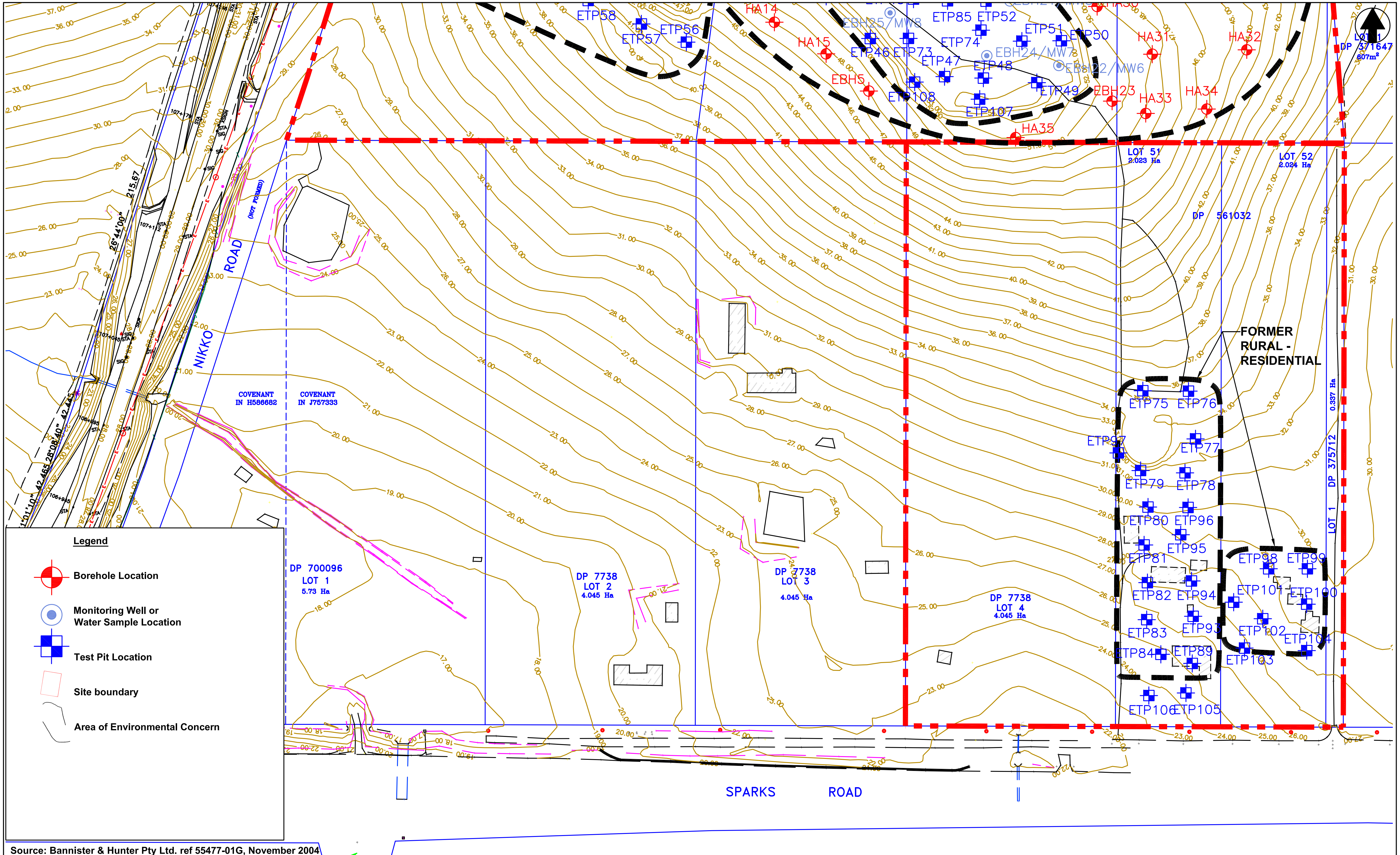
client: Wyong Shire Council

project: Proposed Warnervale Town Centre, Sparks Road, Woongarrah, NSW
Stage 2 Environmental Site Assessment

title: Subsurface Soil Investigation Locations
Northern Lots

project no: GEOTKARI02021AA

figure no: Figure 6



revision	description	drawn	approved	date

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original size	A3

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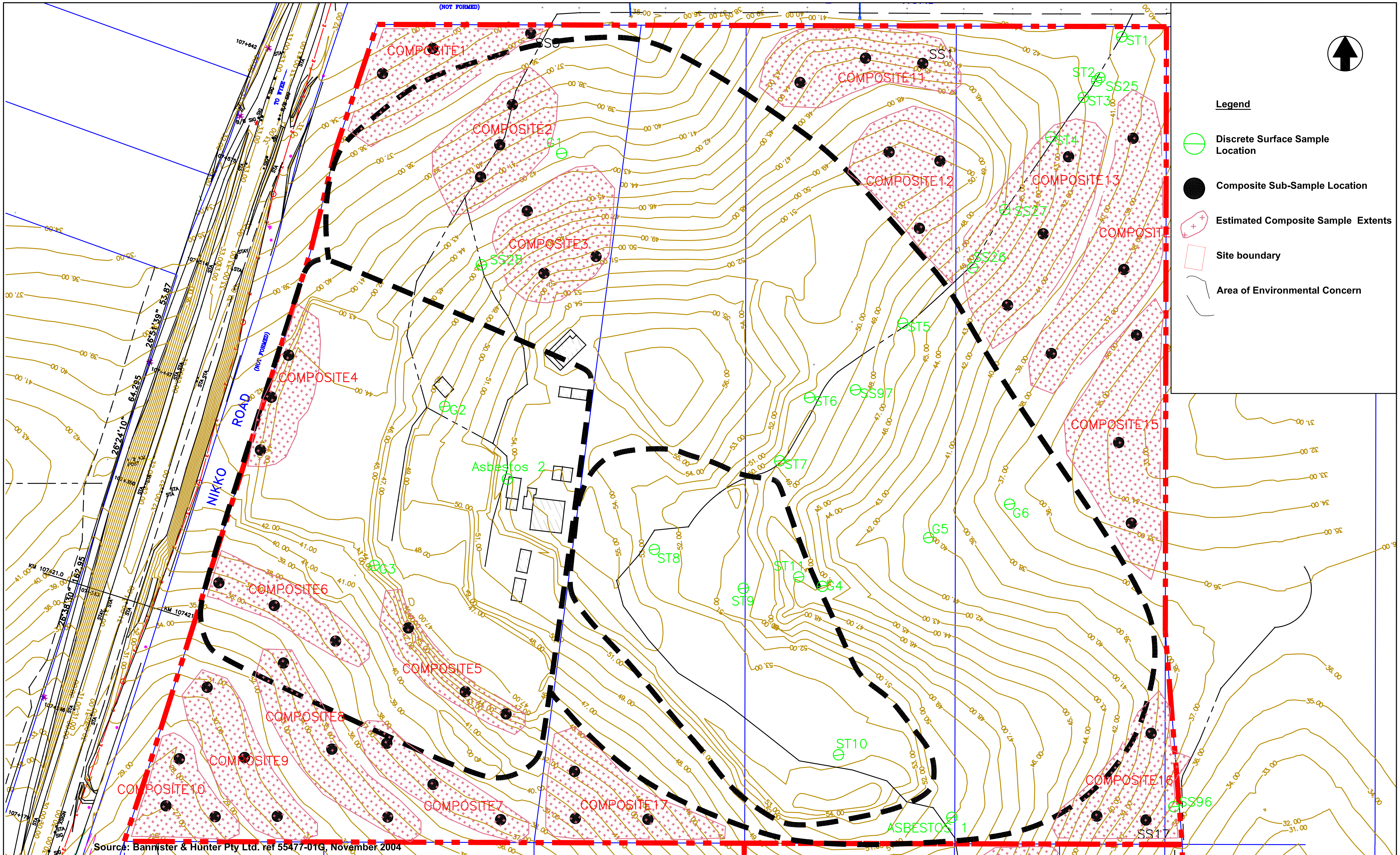
SPECIALISTS MANAGING THE EARTH

client:	Wyong Shire Council
project:	Proposed Warnervale Town Centre, Sparks Road, Woongarrah, NSW Stage 2 Environmental Site Assessment
title:	Subsurface Soil Investigation Locations Southern Lots
project no:	GEOTKARI02021AA
figure no:	Figure 7



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Scale (metres)

drawn	SD/SW
approved	MD
date	31/03/08
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original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: **Wyong Shire Council**

project: **Proposed Warnervale Town Centre, Sparks Road, Woongarrah, NSW
Stage 2 Environmental Site Assessment**

title: **Surface Soil Investigation Locations
Northern Lots**

project no: **GEOTKARI02021AA**

figure no: **Figure 8**