Wallarah 2
COAL PROJECT

Wallarah 2 Coal Project

Environmental Impact Statement

April 2013

Appendix X

Soils and Land Capability Impact Assessment

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ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

REPORT NO. 612017_V7

SOILS AND LAND CAPABILITY IMPACT ASSESSMENT, WALLARAH 2 COAL PROJECT

ENVIRONMENTAL EARTH SCIENCES NSW
HANSEN BAILEY (SINGLETON)
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EXECUTIVE SUMMARY

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1 INTRODUCTION

This report presents the findings of a desktop soils and land capability impact assessment for the Wallarah 2 Coal Project (the Project). The purpose of the study is to present a relevant assessment of soil distribution and potential impacts to soil capability within the Project Boundary as a result of the Project.

2 PROJECT OVERVIEW

The Wyong Areas Coal Joint Venture (WACJV) seeks a Development Consent under Division 4.1 in Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the Wallarah 2 Coal Project (the Project). This Soil and Land Capability Impact Assessment supports 'The Wallarah 2 Coal Project Environmental Impact Statement' (Wallarah 2 EIS) prepared by Hansen Bailey Environmental Consultants to support the application.

This Soil and Land Capability Impact Assessment has been prepared in accordance with the Director-General's Environmental Assessment Requirements (DGRs) for the Project issued 12 January 2012 in accordance with the requirements in Part 2 in Schedule 2 to the *Environmental Planning & Assessment Regulation 2000* (EP&A Regs).

Development Consent is sought to mine coal within the Extraction Area for a period of 28 years. The majority of this resource lies beneath the Wyong State Forest and surrounding ranges (including the Jilliby State Conservation Area (SCA)) while a proportion, to be extracted first, lies beneath a section of the Dooralong Valley and the Hue Hue area. The location of the Project is shown on Figure 1.

Key features of the Project include:

- the construction and operation of an underground mining operation extracting up to 5.0 Mtpa of export quality thermal coal by longwall methods at a depth of between 350 m and 690 m below the surface within the underground Extraction Area;
- mining and related activities will occur 24 hours a day 7 days a week for a Project period of 28 years;
- Tooheys Road Site surface facilities on company owned and third party land (subject to a mining lease) between the Motorway Link Road and the F3 Freeway which will include (at least) a rail loop and spur, stockpiles, water and gas management facilities, workshop and offices;
- Buttonderry Site Surface Facilities on company owned land at Hue Hue Road between Sparks Road and the Wyong Shire Council's (WSC) Buttonderry Waste Management Facility. This facility will include (at least) the main personnel access to the mine, main ventilation facilities, offices and employee amenities;
- an inclined tunnel (or "drift") constructed from the coal seam beneath the Buttonderry Site to the surface at the Tooheys Road Site;
- construction and use of various mining related infrastructure including water management structures, water treatment plant (reverse osmosis or similar), generator, second air intake ventilation shaft, boreholes, communications, water discharge point,

powerlines, and easements to facilitate connection to the WSC (after July 2013, the Central Coast Water Corporation) water supply and sewerage system;

- capture of methane for treatment initially involving flaring as practicable for greenhouse emission management and ultimately for beneficial use of methane such as electricity generation at the Tooheys Road Site;
- transport of coal by rail to either the Newcastle port for export or to domestic power stations;
- a workforce of approximately 300 full-time company employees (plus an additional 30 contractors); and
- rehabilitation and closure of the site at cessation of mining operations.

2.1 Rehabilitation and closure

The final rehabilitation works for the Project will be documented in a Closure Management Plan to be approved by DP&I within five years of closure and may include:

- Tooheys Road Site will be left relatively intact for resale for industrial landuse. However, relevant remediation and rehabilitation may include:
    - sealing of the drift portal entry;
    - removal of carbonaceous material;
    - removal of the water treatment plant if a future industrial user has not identified it as an asset;
    - removal of conveyors and other coal handling equipment; and
    - removal of the gas management facility if it is not identified as an asset by a future industrial user.
- Buttonderry Site will be fully rehabilitated and revegetated to provide additional conservation areas, unless developed for a relevant industrial use. Rehabilitation works may include:
    - filling and capping of ventilation, employee / materials access shafts and ballast borehole consistent with contemporary Division of Resources and Energy (DRE) Guidelines;
    - removal of all buildings and equipment / infrastructure and;
    - all contaminated hardstand areas remediated and removed
    - .
- Western Ventilation Shaft will be fully rehabilitated and include:
    - filling and sealing of the shaft; and
    - removal of all surface infrastructure.

A number of natural and man-made features have been identified with relation to subsidence impacts during and after completion of the Project. These features include groundwater, surface water, houses and structures, public infrastructure and soils. A summary of the impacts and associated risks identified by Mine Subsidence Engineering Consultants (MSEC) (2012) for physiological components within the Project Boundary (i.e. excluding man-made structures and infrastructure) is as follows:

- based on groundwater modelling it is considered highly unlikely that mining induced fracturing will adversely affect streams and alluvial aquifers;
- the coal seams are very deep and overburden comprises strong, relatively unfractured rock with no significant aquifers. Therefore it is expected that loss of surface flow or groundwater through fractures is considered extremely unlikely;
- the impact on soils is expected to relate directly to the type of material being impacted and will be through physical impacts. It is not anticipated that the chemical composition will be altered. Potential physical effects as a result of subsidence within the Project Boundary has been listed by MSEC as follows:
  - surface cracking of hardsetting soil surfaces;
  - potential erosion of cracked surfaces;
  - potential for extending existing pooling of water in subsided landscapes; and
  - potential for increased risk of slope failure (such as slumping) on steep slopes.

Based upon the MSEC report, issues relating to mine subsidence interacting with the physiological aspects of the Project Boundary are anticipated to be rehabilitated as follows:

- filling of cracks;
- revegetation; and
- erosion control.

Evidence of subsidence and its impacts on the ground surface will be monitored through regular inspections, ongoing subsidence data collection and recording and reporting of monitoring results.

3 ASSESSMENT OBJECTIVES

The primary objective of this assessment is to provide a soils and land capability assessment report to support the Wallarah EIS for the Project to meet the DGRs (discussed in Section 5.0).

Components of this soils assessment report include:

- mapping of soil types across the study area;
- assessment of pre and post mining land capability and classes;
- assessment of pre and post mining agricultural suitability;
- assessment of available topsoil resource for post mining rehabilitation for infrastructure areas, management and mitigation measures; and
- distribution of acid sulfate soils and potential acid sulfate soils within the Project Boundary.

4 SCOPE OF WORKS

The scope of works for this assessment has been split into the following sub-sections.

4.1 Desktop assessment

The purpose of the desktop assessment was to construct a baseline conceptual site model of the soil and landscape characteristics within the Project Boundary (for further refinement during the field studies). Additionally, a preliminary plan for selection of sample locations during the intrusive investigations was prepared. The scope of works comprised the review of:

- available past land suitability, geological and ecological assessment reports made available to Environmental Earth Sciences;
- available topographic, geological, soil, vegetation, salinity, acid sulfate soils, landuse and capability maps;
- climatic and (where applicable) demographic data within the Project Boundary and surrounds for the purpose of assessing land capability and agricultural suitability;
- online databases including the NSW Natural Resource Atlas and Australian Soil Resource Information System (ASRIS), online bore licences and other sources;
- NSW Soil and Land Information System (SALIS) soil technical reports presenting logged soil profiles within the Project Boundary. Twenty such profiles were identified during the on-line search (see Figure 3 for the location of the 20 SALIS profiles); and
- the latest aerial photographs of the Project Boundary area including a detailed landform survey.

This information allowed us to prepare a preliminary model of soil generation and distribution across the Project Boundary and informed the limited site walkover and reporting components of the scope of works.

4.2 Limited site walkover

In order to ground-truth and complement the desktop component of the scope of works, Environmental Earth Sciences NSW conducted a limited walkover of the Project Boundary. The walkover occurred on 26 March 2012 and was predominantly limited to the Tooheys Road Site and Buttonderry Site (Figure 2) and all available public access roads and public lands.

The potential for soil and landscape disturbance at surface facility sites are greater than in other areas. Consequently, higher risk areas within the Project Boundary were targeted during the walkover.

Where accessible open cuts along roadways and along erosional features were inspected in order to get an understanding of sub-surface soil conditions within the Project Boundary. A total of four locations were identified. These were named based on their geographic location and included West Shaft, Buttonderry, Tooheys Dam (located at the Tooheys Road Site) and Sparks Road. These locations are presented in Figure 3. No intrusive works, sampling or laboratory analyses were carried out during the implementation of this scope of works.

4.3 Reporting

Environmental Earth Sciences NSW prepared this letter report on the soils assessment findings which (in lieu of intrusive investigations and laboratory analysis) provides preliminary information on all of the points noted in Section 3.0.

4.4 Figure preparation

In the preparation of the letter report, Environmental Earth Sciences NSW constructed a Geographic Information System (GIS) database based predominantly on the desktop assessment with some ground-truthing from the walkover of the Project Boundary. Output from this database have been presented as figures alongside this report detailing the inferred extent of soil types and capability and suitability classes within the Project Boundary.

5 POLICIES, GUIDELINES AND PLANS

Environmental Earth Sciences NSW refers to a number of relevant documents as part of the preparation of the impact assessment, including:

- *Wallarah 2 Coal Project EIS – Director Generals Requirements and Responsibilities* (3 February 2012);
- *The Australian Soil Classification* (Isbell, 1996);
- *Systems used to Classify Rural Lands in New South Wales* (Cunningham, et.al., 1988);
- The *Agricultural Land Classification* (NSW Agriculture, 2002);
- *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas* (Elliot and Veness, 1981);
- *Guidelines for Surveying Soil and Land Resources (Second Edition)* (McKenzie, et. al., 2008); and
- *Australian Soil and Land Survey: Field Handbook (Third Edition)* (The National Committee on Soil and Terrain, 2010).

Based upon the Director Generals Requirements and Responsibilities document, the DGRs relevant to this Project include a detailed assessment of the potential impacts of the Project upon:

- soils and land capability;
- landforms and topography, including cliffs, rock formations, steep slopes, etc;
- impacts to agricultural resources and/or enterprises in the local area including:
  - any change in land use arising from requirements for biodiversity offsets;
  - a detailed description of the measures that would be implemented to avoid and/or minimise the potential impacts of the Project on agricultural resources and/or enterprises; and
  - justification for any significant long term changes to agricultural resources, particularly if highly productive agricultural resources (e.g. alluvial lands) are proposed to be affected by the Project.

The DGRs also include comments from state and local regulatory authorities, however these have not been included in this list.

In order to classify and determine soil profiles within the Project Boundary, Environmental Earth Sciences NSW used *The Australian Soil Classification* (Isbell, 1996).

The *Systems used to Classify Rural Lands in New South Wales* (Cunningham, et.al., 1988) was employed to assist in determination of land capability across the Project Boundary. This is the guideline approved by the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) (former NSW Land and Property Management Authority). The *Agricultural Land Classification* (2002) was also employed for this purpose.

Recommendations for selective topsoil and subsoil management have been developed based on the *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas* (Elliot and Veness, 1981). The assessment provides guidance for determining which soils throughout the Project Boundary are suitable for conserving and utilising in the Project rehabilitation program. The approach presented in the assessment remains the benchmark for this purpose in the Australian mining industry.

The field component of the works was carried out with reference to the *Australian Soil and Land Survey: Field Handbook* (The National Committee on Soil and Terrain, 2010).

6 PROJECT BOUNDARY

Based upon the information provided, the overall area of the Project Boundary is 4,558 hectares with 3,730 hectares comprising the Extraction Area and 165 hectares being set aside for Infrastructure Boundary (see Figure 2).

Based upon the *Dooralong 1:25,000 Topographic and Orthophoto Map (9131-1S)*, the Project Boundary covers a number of topographical landscapes. This includes hills and relatively steep valleys in the west and centre of the Project Boundary and flat to slightly hilly terrain in the east.

A number of waterways flow through the Project Boundary. The main waterways include Jilliby Jilliby Creek, Myrtle Creek and Wallarah Creek. Part of the southern extent of the Project Boundary is bounded by the Wyong River. All of these waterways drain into Tuggerah Lake to the east. A number of smaller creeks and ephemeral streams also run through the Project Boundary.

According to the *1:100,000 Gosford – Lake Macquarie Soil Landscape Series Sheet* (9131-9231) the Project Boundary comprises a complex series of erosional, colluvial, residual and alluvial soil landscape types. These soil types have developed as a function of the underlying geology and the local topography, with a dominance of the alluvial Wyong landscape grouping along Wallarah Creek and other waterways in the east of the Project Boundary and the alluvial Yarramalong landscape along Jilliby Jilliby Creek and Myrtle Creek in the Project Boundary's west. The erosional Gorokan landscape group is the dominant landscape group in non-alluvial areas in the east while in the west a complex series of erosional, colluvial and residual landscapes are present in areas not influenced by alluvial processes. The dominant soil group in the west is the colluvial Watagan landscape grouping.

Soil characteristics of the individual soil landscapes identified in the Project Boundary are as follows:

- Woodburys Ridge (Residual Landscape): deep (>150cm) red podzolic soils with some soloths in poorly drained areas on claystone bedrock; shallow to moderately deep (50-150cm) yellow podzolic soils on sandstone bedrock;
- Erina (Erosional Landscape): moderately deep to deep (100->200cm) yellow podzolic soils on fine-grained bedrock with yellow podzolic soils in poorly drained areas; moderately deep to deep (50->150cm) yellow podzolic soils and yellow earths on coarse-grained parent material with yellow earths on footslopes and deep (>300cm) structured loams and yellow earths along drainage lines;
- Gorokan (Erosional Landscape): moderately deep (50-150cm) soloths and yellow podzolic soils on ridges and crests; soloths, yellow podzolic soils and grey-brown podzolic soils on slopes with gleyed podzolic soils along drainage lines;
- Mandalong (Colluvial Landscape): moderately deep to deep (100->150cm) red podzolic soils, brown podzolic soils, yellow podzolic soils on claystones; shallow to moderately deep (<50-150cm) yellow podzolic soils on sandstones; clays or rock outcrop along drainage lines;
- Watagan (Colluvial Landscape): very complex: includes shallow (<50cm) lithosols/siliceous sands and yellow earths on coarse sandstones, shallow to deep (<50 to >150cm) yellow podzolic soils and some red podzolic soils on fine-grained bedrock; deep (>150cm) sandstone colluvial deposits of no suitable group, yellow earths, yellow podzolic soils and siliceous sands and alluvial soils along drainage lines;
- Wyong (Alluvial Landscape): deep (>200cm) yellow podzolic soils, brown podzolic soils, soloths with some humus podzols around lake edges; and
- Yarramalong (Alluvial Landscape): deep (>200cm) alluvial soils and siliceous sands in upper reaches; deep (>150cm) alluvial soils and red earths along levee banks; deep (>200cm) yellow podzolic soils and brown podzolic soils along the backplain; deep (>200cm) alluvial soils and yellow earths on terraces.

A discussion of how these soil landscapes relate to the soil types identified is presented in Section 9.0 and Figure 5 of this report.

Based upon the *1:100,000 Provisional Gosford – Lake Macquarie Geological Series Sheet (9131 - 9231)*, the Project Boundary is underlain by a varied sedimentary geology which was deposited during the early to mid-Triassic geological period.

The majority of the geology in the east of the Project Boundary comprises early Triassic Tuggerah Formation (red, green and grey shale and quartz-lithic sandstone). This is generally the dominant underlying geology in the lower areas of the Project Boundary and is overlain in the west of the by younger sedimentary sequences. These sequences include the early Triassic Patonga Claystone (red, green and grey shale and quartz-lithic sandstone) which is overlain by the Terrigal Formation (interbedded laminite, shale and quartz to lithic sandstone with minor red claystone).

7 ACID SULFATE SOILS

In conducting an assessment for the possible presence of acid sulfate soils (ASS) and potential acid sulfate soils (PASS) within the Project Boundary, Environmental Earth Sciences NSW reviewed the following sources:

- the CSIRO *Australian Soil Resource Information System*;
- the *Wyong Acid Sulfate Soil Risk Map (Ed. 2)*; and
- the *NSW Natural Resource Atlas*.

Figure 4 presents a preliminary plan of the distribution of ASS and PASS across the Project Boundary based on these sources. The review indicates that ASS and PASS have a potential to occur in the south of the Project Boundary along the lower reaches of Jilliby Jilliby Creek and Little Jilliby Creek and also along the unnamed waterway adjacent the western boundary of the Buttonderry Site.

The desktop information coupled with our understanding of the elevation these areas of the Project Boundary (being greater than 4 m above sea level), indicates that these sections have a low probability of being underlain by ASS or PASS. It should also be noted that none of the areas of delineated surface infrastructure are located within these low probability areas and are generally unlikely to be impacted by ASS or PASS. However, any activities in sections of the Project Boundary within or close to these areas (for example the construction and final rehabilitation of the Buttonderry Site which is within 800 metres of an area where there is a potential for ASS and PASS to be present) should take into account the potential presence of ASS and PASS and ensure that where identified, such soils are appropriately assessed and managed.

8 SOIL SURVEY METHODOLOGY

The soil survey methodology outlines the activities undertaken to classify and analyse the main soil types located within the Project Boundary.

8.1 Background information

Before conducting the field assessment, an initial understanding of the different types of soil and landscapes across the Project Boundary was developed. This was prepared through a review of available aerial photographs and geological, soil and topographic maps of the Project Boundary and surrounds.

The aerial photographs and topographic maps were reviewed for the purpose of delineating landscape features and geomorphic processes within the Project Boundary. These were then correlated with soil and geological maps to gain an understanding of the relationships between geology and physical and biological processes, which may contribute to the formation of soil types within the Project Boundary.

Cadastral data and GIS presenting geological, vegetation, hydrological and hydrogeological data was also reviewed.

8.2 Assessment of soil profiles

Information relating to soil profiles at specific locations within the Project Boundary was collected from two separate sources:

- records of 20 soil profiles collected as part of the NSW Soil and Land Information System (SALIS) from the NSW Natural Resource Atlas; and
- four soil profiles were recorded as part of the field survey component of the works. These included opportunistic profiles from each of the surface infrastructure sites (titled Western Ventilation Shaft, Buttonderry Site and Tooheys Dam) as well as one off-site location (titled Sparks Road). Each of these locations were logged in accordance with the information requirements discussed in Section 8.3.

Soil profile locations were selected in a targeted manner with one undertaken in each of the Buttonderry Site, Tooheys Road Site (which was collected from the wall of a dam at Tooheys Road which was thus entitled “Tooheys Dam”) and the Western Ventilation Shaft as well as one outside the Project Boundary along Sparks Road. These locations were logged in an opportunistic manner from cuts and exposures identified during the field survey. A total of four (including one which lay outside the Project Boundary) were logged. Each location was then used to confirm, discount or further refine existing records.

Activities conducted during the field survey included:

- opportunistic logging of exposed soil profiles at three locations within the Project Boundary and one location outside;
- assessment of surface observation sites;
- assessment of landform extent and variability;
- assessment of geomorphologic units and landscape connectivity across the Project Boundary;
- refinement of soil units classifications across the Project Boundary;
- assessment of erosion features and indications of soil movement (e.g. slumping);
- search for salinity indicators across the Project Boundary (e.g. dead vegetation, salinity resistant vegetation, scalding, salt crusts, etc); and
- logging of four soil profiles.

The four soil profile locations along with the 20 SALIS soil profiles identified during the desktop assessment are presented in Figure 3.

The four opportunistic soil profile locations ranged in depth from 0.3 m to 4.0 metres below ground level. Soil profiles were generally distinguished based on variations in structure, texture and colour. Soil colours were assessed in accordance with the *Munsell Soil Colour Charts* (Macbeth, 1975).

Soil profiles were described for all soil sample locations using the parameters outlined in Table 1.

TABLE 1 SOIL PROFILE DESCRIPTION PARAMETERS

Descriptor	Application
Horizon depth	Weathering characteristics, soil development
Field colour	Permeability, susceptibility to dispersion / erosion
Field texture grade	Erodibility, hydraulic conductivity, moisture retention, root penetration
Boundary distinctness and shape	Erosional / depositional status, textual grade, soil age
Consistence force	Structural stability, dispersion, pedality formation
Structure pedality grade and ped size	Soil structure, root penetration, permeability, aeration, assessment of sodicity
Gravel and cobble inclusion, composition, size	Water holding capacity, weathering status, erosional / depositional character
Roots – amount and size	Effective rooting depth, presence and prevalence of roots in the A and B horizons and vegetative stability
Bioturbation	Biological mixing depth (where discernible)

Opportunistic field observations of existing exposed profiles and landscape features were also conducted to confirm soil units and boundaries between different soil types. This was generally conducted across the Project Boundary as well as at a single location outside the Project Boundary (named Sparks Road). These locations were further supplemented by the SALIS locations extracted from the NSW Natural Resource Atlas.

Where sufficient information was present within the logs of individual available soil profiles the landscape for which those soil profiles were representative were assessed according to a procedure devised by Elliot and Veness (1981) for the recognition of suitable topdressing materials. This procedure assesses soils based on grading, texture, structure, consistency, mottling and root presence.

8.3 Soil classification

The applicable technical standard adopted to classify soil types identified across the Project Boundary is the Australian Soil Classification (ASC) system (Isbell, 1996). The standard is routinely used as the soil classification system in Australia and formed the key descriptor throughout this assessment. In addition to the ASC system, soil types were also identified by a ‘common name’ for discussion in the assessment.

Soil types can be named based on their characteristics and attributes as follows:

- number of horizons (soil layers) in the profile;
- colour of various horizons with special emphasis on the surface horizons;
- texture, texture contrast and structure;
- relative arrangement and geochemistry;
- geological origin of the soil material (i.e. alluvial, colluvial, residual, etc); and
- thickness of the horizons.

This system was applied to the four logs recorded during the limited walkover on the Project Boundary as well as the 20 soil logs retrieved from the NSW Soil and Land Information System.

9 SOIL SURVEY RESULTS

This section provides an overview of each soil type identified within the Project Boundary, its characteristics and distribution (Table 2). Figure 5 illustrates the spatial distribution of all soil types within the Project Boundary.

TABLE 2 SOIL TYPES

Soil Type	ASC Soil Name	Project Boundary		Infrastructure Boundary	
		Area (ha)	Area (%)	Area (ha)	Area (%)
DE	Dermosol	117	2.6	0	0.0
KA	Kandosol	485	10.6	18	17.4
KU	Kurosol	2,836	62.2	85	82.5
SO	Sodosol	860	18.9	0	0.1
TE	Tenosol	262	5.7	0	0.0
		4,560	**100.0**	**103**	**100.0**

Based upon the detailed desktop study and the site walkover it is considered that the different soil types are distributed as follows:

- Dermosols are inferred to be located within and close to the main channels of Jilliby Jilliby and the lower reaches of Little Jilliby Jilliby Creek. They correspond with the alluvial Yarramalong soil landscape grouping according to the *1:100,000 Gosford – Lake Macquarie Soil Landscape Series Sheet*;
- Sodosols are inferred to be located on the remaining alluvial landscapes of the lower reaches of Jilliby Jilliby Creek, Little Jilliby Jilliby Creek and Myrtle Creek as well as the unnamed waterway to the immediate west of the Buttonderry Site. They correspond with the Yarramalong and Wyong soil landscape according to the *1:100,000 Gosford – Lake Macquarie Soil Landscape Series Sheet*;
- Kandosols are inferred to be located on the lower slopes adjacent to alluvial landscapes as well as in the mid to upper reaches of waterways within the study area. They correspond with the residual Woodburys Ridge soil landscape and erosional Erina and Gorokan soil landscapes according to the *1:100,000 Gosford – Lake Macquarie Soil Landscape Series Sheet*;
- Tenosols are inferred to be located in the upper reaches of some waterways as well as along the ridges of more elevated areas within the Project Boundary. They correspond with parts of the alluvial Yarramalong soil landscape as well as parts of the colluvial Mandalong and Watagan soil landscapes according to the *1:100,000 Gosford – Lake Macquarie Soil Landscape Series Sheet*; and
- Kurosols are the most prevalent soil type within the Project Boundary. They are situated in the crests and upper and mid-slopes of the west and centre as well as across the majority of the east of the Project Boundary. They are also present in the upper reaches of some waterways flowing through the Project Boundary. This soil type stretches across a number of seemingly different soil landscapes which are predominantly of colluvial and residual origin according to the *1:100,000 Gosford – Lake Macquarie Soil Landscape Series Sheet*.

9.1 Dermosols

Dermosols are represented at one soil profile location within the Project Boundary (location 10). At this location, this soil type has an acidic soil reaction (pH) range and predominantly moderate to strong pedality. In general, this soil type possesses a structured B2 horizon but lacks a strong texture contrast between the A and B horizons.

The results of this assessment indicate that Dermosols are located within close proximity to the perennial drainage lines located in low-lying areas within the floodplain, making up the smallest percentage of soil types within the Project Boundary. No Dermosols were identified within the Infrastructure Boundary.

9.2 Kandosols

Kandosols are the third most widespread soil type within the Project Boundary, second-most within the Infrastructure Boundary areas (Western Ventilation Shaft and Tooheys Road sites) and have been identified at five locations (locations 4, 6, 8, 9 and Tooheys Road Site). The Kandosol soil type is acidic in nature, lacks strong texture contrast and has massive or weakly structured B horizons.

The results of this assessment indicate that this soil type is generally situated on lower slopes and at the edge of floodplains. Surface erosional features, including gully and rill formations, and slumping can be encountered in the general vicinity. This was confirmed during the limited site walkover when channel incision was identified along sections of Wallarah Creek within the Tooheys Road Site.

9.3 Kurosols

Kurosols are the most widespread soil type within the Project and Infrastructure Boundary and have been identified at 13 locations (locations 1, 2, 3, 5, 7, 13, 15, 16, 17, 18, Western Ventilation Shaft, Sparks Road and Buttonderry Site (Figure 3)). The Kurosol soil type has a strong texture contrast between the A and B horizons and strongly acidic B horizons. While the acidic subsoils mostly do not disperse, the A horizon is moderate to highly erodible.

The results of this assessment indicate that this soil type is widespread across the Project Boundary, particularly situated within residual and colluvial landscapes on hill crests, ridges and slopes where surface erosional features have been encountered. During the limited site walkover heavy rutting of dirt tracks on the Buttonderry Site and along the access road to Western Ventilation Shaft was noted. These areas of erosion of the roadway were within landscapes identified as Kurosols and indicate that this soil type has the potential to be dispersive.

9.4 Sodosols

Sodosols are the second-most widespread soil type across the Project Boundary, although the soil type is not widely represented across the Infrastructure Boundary. Sodosols have been identified at four locations (locations 11, 12, 19 and 20). At these locations the soil type has moderate to strong texture contrasts between A and B horizons. In general the B horizon is strongly sodic.

The results of this assessment indicate that this soil type is situated on lower slopes and floodplains bordering drainage lines. This soil type has largely been generated from a combination of alluvial and part-colluvial deposits across the Project Boundary.

9.5 Tenosols

Tenosols were identified over a small portion of the Project Boundary represented by one profile location (location 14). At this location the A horizon is weakly structured, and in general Tenosols predominantly comprises a weak pedologic organisation, particularly in the B horizon, and a sandy composition greater than that of other soils within the Project Boundary.

This soil type is generally situated in residual terrain and in the upper catchment of secondary watercourses. Surface erosional features, including channel incision and gully and rill formations, can be encountered in the general vicinity. No Tenosols were identified within the infrastructure footprint areas.

10 LAND CAPABILITY ASSESSMENT

This section describes and assesses the agricultural suitability and regional rural land capability within the Project Boundary.

10.1 Land capability

10.1.1 Methodology

The land capability assessment was conducted in accordance with the NSW Soil Conservation Service rural land capability assessment system, S*ystems Used to Classify Rural Lands in New South Wales* (Cunningham et.al., 1988). The system consists of eight classes, which classify land generally based on soil erosion, stability hazard and decreasing versatility of use. The classes are categorised for their suitability to the following land uses:

- land suitability for cultivation;
- land suitability for grazing; and
- land suitability for rural production.

Capability classifications present a set of limitations regarding the ongoing use of the land. This is a result of the interaction between land use and the specific chemical, physical and biological characteristics of the landscape.

The land capability assessment system method factors in parameters such as climate, geomorphology, soil type and chemistry, geology and topography along with the effects of past land use. The classification does not necessarily reflect the existing land use rather it indicates the potential of the land to support the three land use types mentioned above.

A description of the land capability classes is presented in Table 3.

TABLE 3 LAND CAPABILITY CLASSES

Land Class	Land Suitability	Land Definition
Land capable of being regularly cultivated		
Class I	Regular cultivation	No erosion control requirements
Class II	Regular cultivation	Simple requirements such as crop rotation and minor strategic works
Class III	Regular cultivation	Intensive soil conservation measures required such as contour banks and waterways
Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation		
Class IV	Grazing, occasional cultivation	Simple practices such as stock control and fertiliser application
Class V	Grazing, occasional cultivation	Intensive soil conservation measures required such as contour ripping and banks
Land not capable of being cultivated but suitable for grazing		
Class VI	Grazing only	Managed to ensure ground cover is maintained
Other lands		
Class VII	Unsuitable for rural production	Green timber maintained to control erosion
Class VIII	Unsuitable for rural production	Should not be cleared, logged or grazed
Land unsuitable for rural production		
U	Urban areas	Unsuitable for rural production
SF	State Forests	Unsuitable for rural production
M	Mining and quarrying areas	Unsuitable for rural production

Note:
1. Source: Soil Conservation Service of NSW (1986)

10.1.2 Results

The pre-mining and post-mining rural land capability classification of the Project Boundary has been assessed in accordance with NSW Soil Conservation Service guidance (Figures 6 and 7). A comparison of the pre and post-mining rural land capability classification is provided in Table 4.

TABLE 4 COMPARISON OF PRE AND POST-MINING RURAL LAND CAPABILITY CLASSES

Land Class	Pre-mining				Post-mining			
	Infrastructure Area		Remaining Area		Infrastructure Area		Remaining Area	
	ha	%	ha	%	ha	%	ha	%
Class I	0	0.0	0	0.0	0	0.0	0	0.0
Class II	0	0.0	0	0.0	0	0.0	0	0.0
Class III	18	17.5	1,025	23.0	0	0.0	31	0.7
Class IV	0	0.0	0	0.0	0	0.0	993	22.3
Class V	0	0.0	0	0.0	0	0.0	0	0.0
Class VI	82	79.6	1,173	26.3	11	10.7	1,173	26.3
Class VII	3	2.9	2,259	50.7	3	2.9	2,260	50.7
Class VIII	0	0.0	0	0.0	0	0.0	0	0.0
Class M	0	0.0	0	0.0	89	86.4	0	0.0
Total	**103**	**100.0**	**4,457**	**100.0**	**103**	**100.0**	**4,457**	**100.0**

Note

Post mining area for assessment of capability class is less than pre-mining because Tooheys Road Site Area (79 ha) has been excluded from the assessment area because it is understood that the infrastructure on Tooheys Road is to be retained and the land is not to be rehabilitated following closure.

10.1.3 Pre-mining

This section presents a breakdown of the distribution of different pre-mining rural land capability classes across the Project Area. The identification of classes has been based on the results of the limited site walkover as well as the desktop assessment.

Class I Land

Based upon the survey of land capability, which was conducted in accordance with Cunningham et.al., (1988) *Systems Used to Classify Rural Lands in New South Wales*, there are no zones of Class I land within the Project Boundary.

Class II Land

Based upon the survey of land capability, which was conducted in accordance with Cunningham et.al., (1988) *Systems Used to Classify Rural Lands in New South Wales*, there are no zones of Class II land within the Project Boundary. Class 2 land comprises Land capable of being regularly cultivated and requiring soil conservation practices such as strip cropping, conservation tillage and adequate crop rotations.

Class III Land

Class III land present in the Project Boundary consists of inferred Sodosols and Dermosols on the alluvial floodplains in the centre and south west of the Project Boundary. Class III land is capable of being regularly cultivated however structural soil conservation works such as diversion banks, graded banks and waterways as well as strip cropping, conservation tillage and adequate crop rotations is recommended. Class III lands are generally located on the floodplains of the lower reaches of the waterways within the Project Boundary. These areas are not considered to be Class I and Class II because of the presence of potentially dispersive soils (on account of inferred sodicity).

Class IV Land

Based upon the survey of land capability, which was conducted in accordance with Cunningham et.al., (1988) *Systems Used to Classify Rural Lands in New South Wales*, there are no zones of Class IV land within the Project Boundary.

Class V Land

Based upon the survey of land capability, which was conducted in accordance with Cunningham et.al., (1988) *Systems Used to Classify Rural Lands in New South Wales*, there are no zones of Class V land within the Project Boundary.

Class VI Land

Class VI land present in the study area Project Boundary consists of all inferred Kandosols and the majority of inferred Kurosols in the centre and east of the Project Boundary. Class VI land is only suited to livestock grazing and is the lowest quality of grazing land. In these areas, structural soil conservation works are required to ensure maintenance of ground cover. Soils are generally constrained by slope, shallow topsoil (i.e. less than 0.1m) and acidity as well as potential for dispersion of the A Horizon.

Class VII Land

Class VII land present in the Project Boundary consists of soil types across the steep terrain comprising Kurosols and Tenosols in the centre of the Project Boundary and the Kurosols and Tenosols in the west of the Project Boundary. It is generally associated with moderate to steep often vegetated slopes. Class VII land is considered unsuitable for cultivation and grazing and is often best protected with green timber to minimise erosion risk. Land is generally classed as VII because of its slope, general terrain, existing soil erosion and heavy native vegetation coverage.

Class VIII Land
Based upon the survey of land capability, which was conducted in accordance with Cunningham et.al., (1988) *Systems Used to Classify Rural Lands in New South Wales*, there are no zones of Class VIII land within the Project Boundary.

10.1.4 Post-mining

Direct impacts to the land as a result of the Project will be within the Infrastructure Area. Areas outside this Infrastructure Area are expected to remain the same as the pre-mining class, apart from land situated within the low lying slopes and floodplain which are the landscapes most suited to agricultural landuse. Because of the sensitivity of this landuse as well as the inferred dispersive nature of the underlying soils, the agricultural suitability of these landscape components are most likely to be readily affected by indirect impacts of the mine such as subsidence and increased flooding risk.

Upon completion of mining works, the Tooheys Road Site will remain earmarked for industrial use. Site buildings are expected to be removed and the portal will be sealed. The dams will also possibly be removed (though the rail is expected to stay). The Site will not be rehabilitated post-mining to a pre-mining land condition as it is more suitable for industrial development in accordance with the site zoning. It is considered as Class M and therefore unsuitable for rural production. Therefore this area has not been included in our calculation of land requiring topdressing following the completion of activities.

The majority of land within the remaining post-mining Disturbance Area will be covered in low to moderate quality topdressing. These factors should result in a land capability class of VII at the Buttonderry Site and Western Ventilation Shaft locations. Based upon this classification, it is considered that consistent with pre-mining, the rehabilitated land post mining will be unsuitable for livestock grazing at these locations, and would be best utilised as industrial land use or otherwise protected with green timber to minimise erosion risk.

Land situated above the Extraction Area and located on the lower slopes and floodplain will, post-mining, result in a land capability class of IV due to the potential impacts to landform and localised hydrological conditions resulting from subsidence during operation and following closure. Based upon this classification, it is considered that the land would be suitable for livestock grazing with occasional cultivation. Land situated on the slopes will continue to have a land capability class of VI (lower-mid slopes) and VII (upper slopes and crests predominantly within the Wyong State Forest and Jilliby SCA.

10.2 Agricultural suitability

10.2.1 Methodology

The system of assessing agricultural land suitability (as presented in the NSW Agriculture 2002, *Agricultural Land Classification*) is an alternative classification system, which assesses land suitability against a specific type of agricultural production. The system consists of five classes, which have been designed to assess land on the basis of increasing suitability and potential for agricultural production. As well as assessing land capability, agricultural suitability considers industry specific factors that may influence potential production (i.e. the same piece of land may be classed differently depending upon the selected land use).

The agricultural suitability classes are described in Table 5. A description of agricultural suitability classification for the land within the Project Boundary is discussed in Section 10.2.3.

TABLE 5 AGRICULTURAL SUITABILITY CLASSES

Class	Description	Management Options
1	Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.	Arable land suitable for intensive cultivation where constraints to sustainable high levels of agricultural production are minor or absent.
2	Arable land suitable for regular cultivation for crops but not suited to continuous cultivation. It has a moderate to high suitability for agriculture but edaphic (soil factors) or environmental constraints reduce the overall level of production and may reduce the cropping phase to a rotation with sown pastures.	Arable land suitable for regular cultivation for crops but not suited to continuous cultivation
3	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture. The overall production level is moderate because of edaphic or environmental constraints. Erosion hazard, soil structural breakdown or other factors including climate may limit the capacity for cultivation and soil conservation or drainage works may be required.	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture.
4	Land suitable for grazing but not cultivation. Agriculture is based on native pastures or improved pastures based on minimum tillage techniques. Production may be seasonally high but the overall production level is low as a result of major environmental constraints.	Land suitable for grazing but not for cultivation. Agriculture is based on native or improved pastures established using minimum tillage.
5	Land unsuitable for agriculture or at best only light grazing. Agricultural production is low or zero as a result of severe constraints, including economic factors, which preclude land improvement.	Land unsuitable for agriculture or at best suited only to light grazing.

10.2.2 Results

The main soil properties and other landform characteristics considered significant for the agricultural land suitability assessment are topsoil texture, topsoil pH, soil profile depth, external and internal drainage, topsoil stoniness and slope as well as biological and physical factors such as bioturbation, elevation, aspect, rainfall and temperature. Human elements such as viability of regional infrastructure to support activities are also taken into account. A comparison of the pre and post-mining agricultural land suitability classification is provided in Table 6.

TABLE 6 COMPARISON OF PRE AND POST-MINING AGRICULTURAL LAND SUITABILITY CLASSES

Land Class	Pre-mining				Post-mining			
	Infrastructure Area		Remaining Area		Infrastructure Area		Remaining Area	
	ha	%	ha	%	ha	%	ha	%
Class 1	0	0.0	0	0.0	0	0.0	0	0.0
Class 2	0	0.0	0	0.0	0	0.0	0	0.0
Class 3	0	0.0	998	22.4	0	0.0	769	17.3
Class 4	84	81.6	371	8.3	0	0.0	509	11.4
Class 5	19	18.4	3,088	69.3	14	13.6	3,179	71.3
Class M	0	0	0	0.0	89	86.4	0	0.0
Total	**103**	**100.0**	**4,457**	**100.0**	**103**	**100.0**	**4,457**	**100.0**

Note

Post mining area for assessment of capability class is less than pre-mining because the Tooheys Road Site (79 ha) has been excluded from the assessment area.

10.2.3 Pre-mining

Class 1 land
Based upon the survey of agricultural land suitability, which was conducted in accordance with NSW Agriculture (2002) *Agricultural Land Classification (Agfact AC. 25)*, there are no zones of Class 1 Agricultural Land within the Project Boundary.

Class 2 land
Based upon the survey of agricultural land suitability, which was conducted in accordance with NSW Agriculture (2002) *Agricultural Land Classification (Agfact AC. 25)*, there are no zones of Class 2 Agricultural Land within the Project Boundary.

Class 3 land
Class 2 land within the Project Boundary is inferred to predominantly be situated on alluvial soils (believed to comprise Sodosols and Dermosols). This suitability class is suited more to grazing land or land well suited to pasture improvement. There is the potential for the land to be cultivated or cropped in rotation with sown pasture.

Class 4 land
Class 4 land within the Project Boundary is situated on soils inferred to predominantly comprise Kandosols (i.e. on lower slopes and in higher energy fluvial environments). This suitability class indicates that the land is only marginally suitable for grazing and not suitable for cultivation. Production may be seasonally high but the overall production level is low as a result of major environmental constraints.

Class 5 land
Class 5 land within the Project Boundary is situated predominately on the inferred Kurosols and Tenosols and is associated with land with more skeletal soils or on more hilly terrain where colluvial processes dominate. Agricultural production is low or zero as a result of severe constraints, including economic factors, which preclude land improvement.

10.2.4 Post-mining

Sections of the Tooheys Road Site which are to be developed will not be rehabilitated post-mining and has not been included within the post-mining land capability assessment. The areas within the remaining Infrastructure Boundary sites will continue post-mining to be classified as Class 4 and 5 land and only marginally suitable for livestock grazing.

The majority of the impacts to the agricultural suitability of the land as a result of the Project will be within the low lying slopes and floodplain areas of the Project Boundary. The extent of Class 3 land will reduce along the slopes, reducing the overall area of land suitable for regular cultivation. Based upon this assessment of agricultural land use suitability classes, rehabilitated land post mining will be most suitable for livestock grazing with minimal cultivation, which could be considered as a potential final land use goal for the Project Boundary.

11 SOIL MANAGEMENT

Section 11.1 provides an assessment of the suitability of soils across the Project Boundary for stripping and reuse for management of soil resource. Section 11.2 identifies measures for successful rehabilitation of the Project Boundary following completion of mining activities.

Topsoil stripping methodology
Determination of suitable soil to conserve for later use in mine closure rehabilitation has been conducted in accordance with Elliot and Veness (1981). The approach remains a benchmark for land resource assessment in the Australian mining industry (particularly in the Hunter Valley region). The approach involves the assessment of soils based on their physical and chemical parameters. The key parameters are presented in Table 7.

TABLE 7 TOPDRESSING SUITABILITY CRITERIA

Parameter	Desirable Criteria
Structure Grade	>30% peds
Coherence	Coherent (wet and dry)
Mottling	Absent
Macrostructure	>10cm
Force to Disrupt Peds	≤3 force
Texture	Finer than a fine sandy loam
Gravel and Sand Content	<60%
pH	4.5 to 8.4
Salinity	<1.5 dS/m
Sodic Limit	6 ESP

11.1 Topsoil stripping depths and volume

Limited laboratory soil analytical results from the SALIS soil profiles were compared with field and desktop observations to determine the depth of soil material suitable for recovery and reuse as topdressing material as part of the rehabilitation of the Infrastructure Boundary. Structural and textural properties of the subsoils, along with soil dispersivity and pH are considered the most significant limiting factors affecting the suitability of a soil for reuse.

11.2 Topsoil balance

The topsoil balance for this assessment is based upon the following assumptions:

- topsoil (i.e. the A horizon) will comprise of the topdressing material for rehabilitation works. ;
- a 10% handling loss for topdressing material; and
- topsoil will be applied on final landforms at depths stated in Table 9.

The final post-rehabilitation landform design for the Project has been used to calculate the area and volume of soil required to rehabilitate the Disturbance Area and thus determine the potential for topdressing deficit or surplus during rehabilitation.

TABLE 8 TOPSOIL BALANCE – DISTURBANCE AREA

Soil Type	Common Soil Name	Recommended Stripping Depth (m)	Disturbance Area (ha)	Volume (m^3)	Volume (10% loss) (m^3)
1	Kurosol	0.35	85.0	297,500	267,750
2	Sodosol	0.25	0.1	250	225
3	Kandosol	0.20	17.9	35,800	32,220
4	Tenosol	0.10	0.0	0	0
5	Dermosol	0.50	0.0	0	0
Total Disturbance Footprint			**103**		
Total Volume (m^3)				**333,550**	
Total Volume (10% Handling Loss Allowance) (m^3)				**300,195**	

TABLE 9 TOPSOIL BALANCE – VOLUME REQUIRED

Soil Land Capability Class	Recommended Spreading Depth	Disturbance Area (ha)	Volume Required (m^3)
VI	0.20	11	22,000
VII	0.15	3	4,500
Total Area (ha)		**14**	
Total Volume (m^3)			**26,500**

Notes:

1. Note that the disturbance area includes associated infrastructure such as mine facilities, roads, etc. However does not include the disturbance area situated at the Tooheys Road Site as it is understood that it will not return to pre-mining land condition but will be used for industrial purposes.

The topsoil balance shown in Table 8 indicates that approximately 300,195 m^3 of material from the Disturbance Area is available for reuse at the rehabilitation stage (10% handling loss included). As a result, the Project retains a topdressing surplus of 273,695 m^3.

12 STRIPPING AND TOPDRESSING MANAGEMENT

12.1 General material handling recommendations

In areas where topsoil (and subsoil) stripping and transportation is required we recommend the following general topsoil handling techniques in order to prevent or minimise soil deterioration:

- when stripping, the depths presented in Table 8 are adhered to (subject to further field observations made during works);
- during stripping all excavated material should be maintained in a slightly moist condition to minimise dust generation during dry periods. Stripping activities should not be carried out during excessively dry or wet periods;
- where applicable, preferential less aggressive soil handling procedures are to be employed to minimise the effects of compression and erosion. Examples of these procedures include grading of stockpiles and construction of windrows and minimisation of excessive stockpiling;
- where required, all stockpiles and stockpiling areas should be clearly identified to ensure that mixing of different soil types does not occur;
- stockpiles should be erected to a maximum height of 3 m and free draining. Clayey soils (which, based upon the desktop study comprise the majority of the soil types encountered to date on the Disturbance Area) should be maintained in lower stockpiles for shorter periods of time than coarser textured sandy and gravelly soils;
- when visibly dispersive soils are excavated and placed in long-term stockpiles, mulch is to be blended into the material for the purpose of enhancing the breakdown of vegetation material and minimising dust generation and soil erosion. Where it is considered viable incorporating organic matter should be carried out as an integral part of maintaining and improving the suitability of soil for the end landuse, post-closure (livestock grazing);
- any long-term stockpiles (greater than 6 months) need to be seeded and fertilised as soon as possible to promote vegetation growth and stabilise the stockpile slopes. For the purpose of these works it is recommended that a rapid-growing, sterile annual pasture species should provide sufficient cover while minimising the potential for the emergence of weed species. If there is difficulty in establishing vegetative cover a watering and (where economically viable) fertilising program should be initiated until vegetation is established; and
- weed infestations should be inspected and controlled during the management of soil stockpiles.

Ongoing monitoring of the stockpiles should be carried out for the life of the Project and records of observations should be kept as well as any corrective action required and undertaken. An inventory of available soil should be maintained to ensure adequate topsoil materials are available for planned rehabilitation closure activities.

12.2 Specific recommendations for acid sulfate soil or potential acid sulfate soils

PASS and ASS areas of the site are currently outside of the Disturbance Area and so the likelihood of disturbance is low. In the event that land noted as ASS or PASS may be disturbed or impacted by altered hydrogeological conditions as a result of mining operations (however as discussed in Section 2.1 this is considered unlikely), prior to the commencement of activities, the proponent must prepare an Acid Sulfate Soils Management Plan to assess and manage any Acid Sulphate Soils (ASS) or potential ASS (PASS). The Plan shall be prepared in accordance with the Acid Sulfate Soils Manual 1998 published by the NSW Acid Sulfate Soil Management Advisory Committee.

It is understood that none of the surface infrastructure areas are located within areas of identified ASS risk, however there are implications resulting from impacts to shallow groundwater and also any minor disturbances resulting from small-scale activities not noted in the general Project description (for example, test pitting or erosion and sediment control structures and the management of spoil). General considerations for minimising the impacts of ASS disturbance include:

- Management of hydrogeological conditions in the areas of PASS and ASS risk to ensure that PASS aren’t exposed to oxygen and cannot acidify;
- If possible characterise the risk prior to disturbance through a detailed soil assessment;
- Minimise the disturbance area and depth;
- Actual ASS (i.e. pH less than 4.5) should be treated with lime prior to reuse onsite. The liming rate should consider not only the actual acidity but the residual acidity from unoxidised or partially oxidised sulfides that remain;
- PASS should be preferably reburied within hours to days of disturbance (depending on the soil texture – sands in hours , clays within a week) beneath the water table in a similar environment to which they were extracted;
- Alternatively PASS can the treated with lime at a rate that will buffer all potential acidity, including consideration of the mixing efficiency, prior to reuse onsite
- Note neither treated or untreated ASS or PASS are suitable for disposal offsite as excavated natural material (ENM) or virgin excavated natural material (VENM);
- Offsite disposal of PASS, ASS, or treated ASS or PASS should be undertaken following waste classification in accordance with NSW DECCW 2009 *Waste Classification Guidelines: Part 1: Classifying Waste* and the NSW DECCW 2008, *Waste Classification Guidelines: Part 4: Acid Sulfate Soils;*
- Stockpiles of ASS or PASS should be appropriately bunded with a sealed sump available to collect any leachate. The soil and leachate water should be monitored regularly by a suitably qualified person until treatment can occur; and
- Treated stockpiles should have verification testing undertaken to show that the liming rate is sufficient to mitigate acid generation.

12.3 Topsoil re-spreading and seedbed preparation

Where feasible during the construction stage, all stripped topsoil materials should be re-spread directly onto reshaped landscaping areas with no prior stockpiling and storage. Where topsoil resources allow, topsoil should be spread to a general depth of at least 100 mm on regraded spoil. Upon being spread, topsoil should be treated with fertiliser and seeded simultaneously to minimise the risk of opportunistic colonisation by weed species. The rapid growth of vegetation cover over the exposed topsoil will also substantially minimise the risk of dust generation and water and wind erosion.

Light contour ripping should be carried out on topsoiled areas following spreading for the purpose of ensuring optimum establishment and growth of vegetation. All ripping should be conducted along the contour when the soil is moist (immediately prior to sowing of seedstock). Scarifying of the topsoil should be carried out prior to or during sowing to increase infiltration and minimise runoff generation.

12.4 Erosion and sediment control

The construction of contour furrows and contour banks at intervals down slopes is considered to be an effective means of management of surface flow across disturbed areas. The purpose of these erosion and sediment control structures (if deemed necessary to be installed) is to divide long sections of slope into shorter sections and thus reducing runoff flow velocity and depth and also the potential for soil erosion to occur.

As previously stated, contour ripping on disturbed areas should be undertaken for the purpose of erosion protection and preparation of the soil for planting and revegetation activities.

Graded banks can also be used to minimise erosion and sediment generation. The banks are constructed away from the true contour at a gradient of between 0.5% and 1% to drain water away from one part of a slope to another (e.g. a watercourse or dam).

All water that has flowed off disturbed areas should be disposed downslope through engineered waterways and sediment control dams designed to remove sediment from the water column prior to runoff entering natural water bodies. Such techniques are presented in detail in NSW Department of Environment and Climate Change (now Office of Environment and Heritage) (June 2008) Managing Urban Stormwater: Soils and Construction (Volume 2E – Mines and Quarries).

13 LIMITATIONS

This letter report has been prepared by Environmental Earth Sciences NSW ABN 109 404 006 in response to and subject to the following limitations:

1. The specific instructions received from Hansen Bailey;
2. The specific scope of works set out in PO612014_V2 issued by Environmental Earth Sciences NSW for and on behalf of Hansen Bailey, is included in Section 4.0 (Scope of Work) of this report;
3. The soil survey results rely predominantly on desktop sources with accompanying information gathered during the site walkover undertaken on 26 March 2012. As a result the assessment is not as accurate as one with a more detailed field and laboratory investigation component and these results are broad and limited in nature;
4. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences NSW (which consent may or may not be given at the discretion of Environmental Earth Sciences NSW);

5. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
6. The report only relates to the Project Boundary referred to in the proposal;
7. The report relates to the Project Boundary as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
8. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report, and
9. Our General Limitations set out at the back of the body of this report.

Should you have any further queries, please contact us on (02) 9922 1777.

On behalf of
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ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services
The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report
A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change
Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

Problems with interpretation by others
Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability
This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

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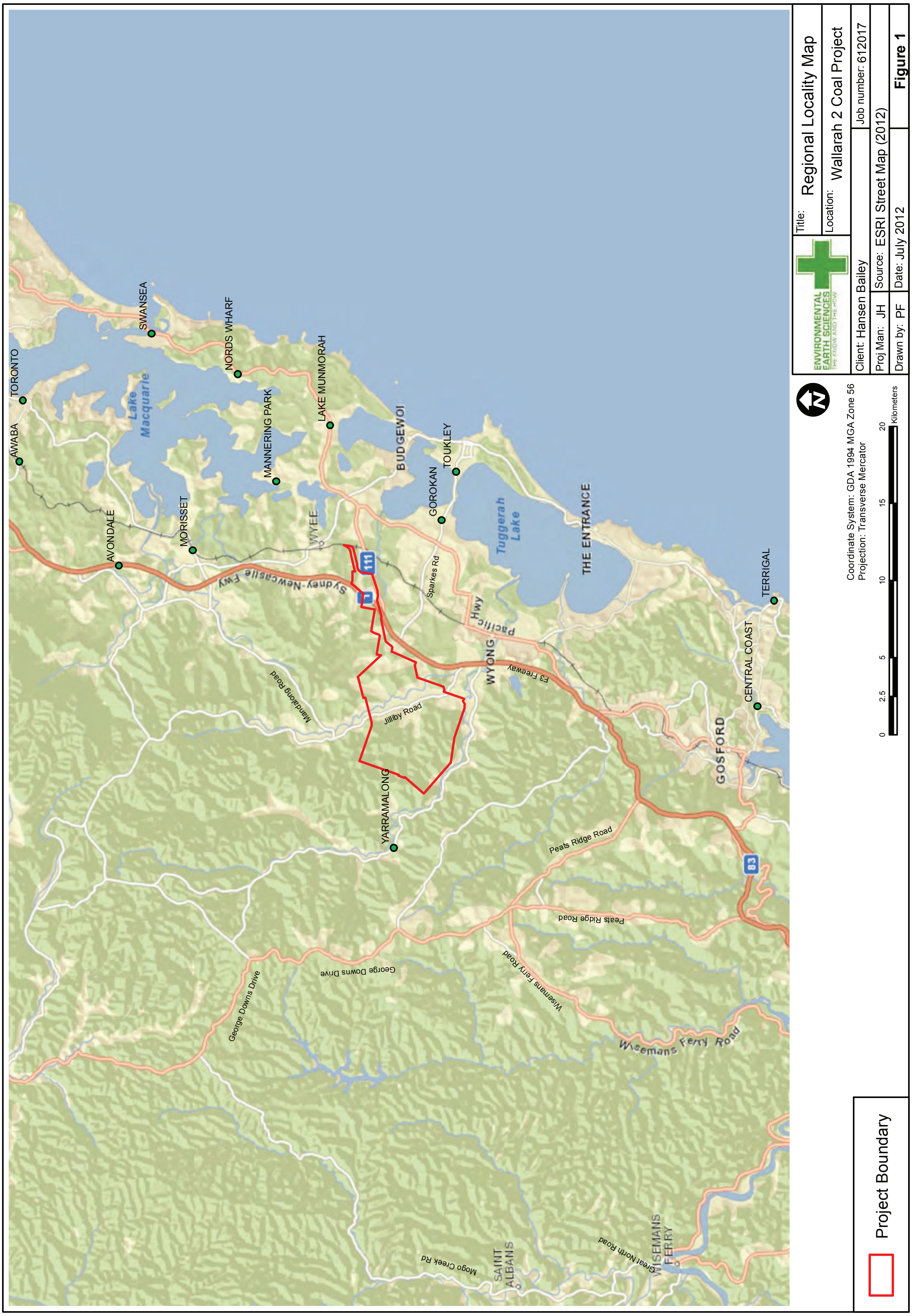
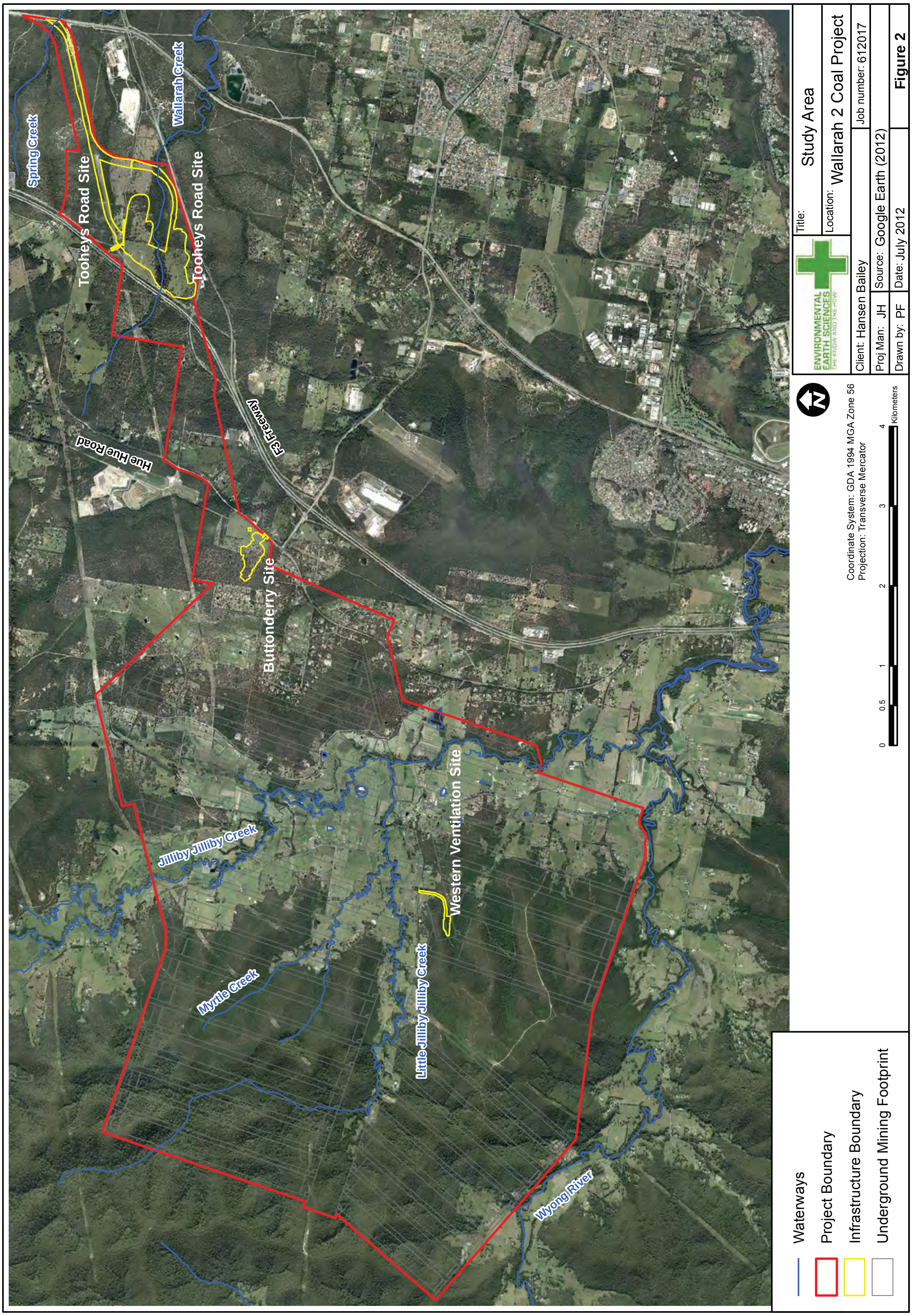
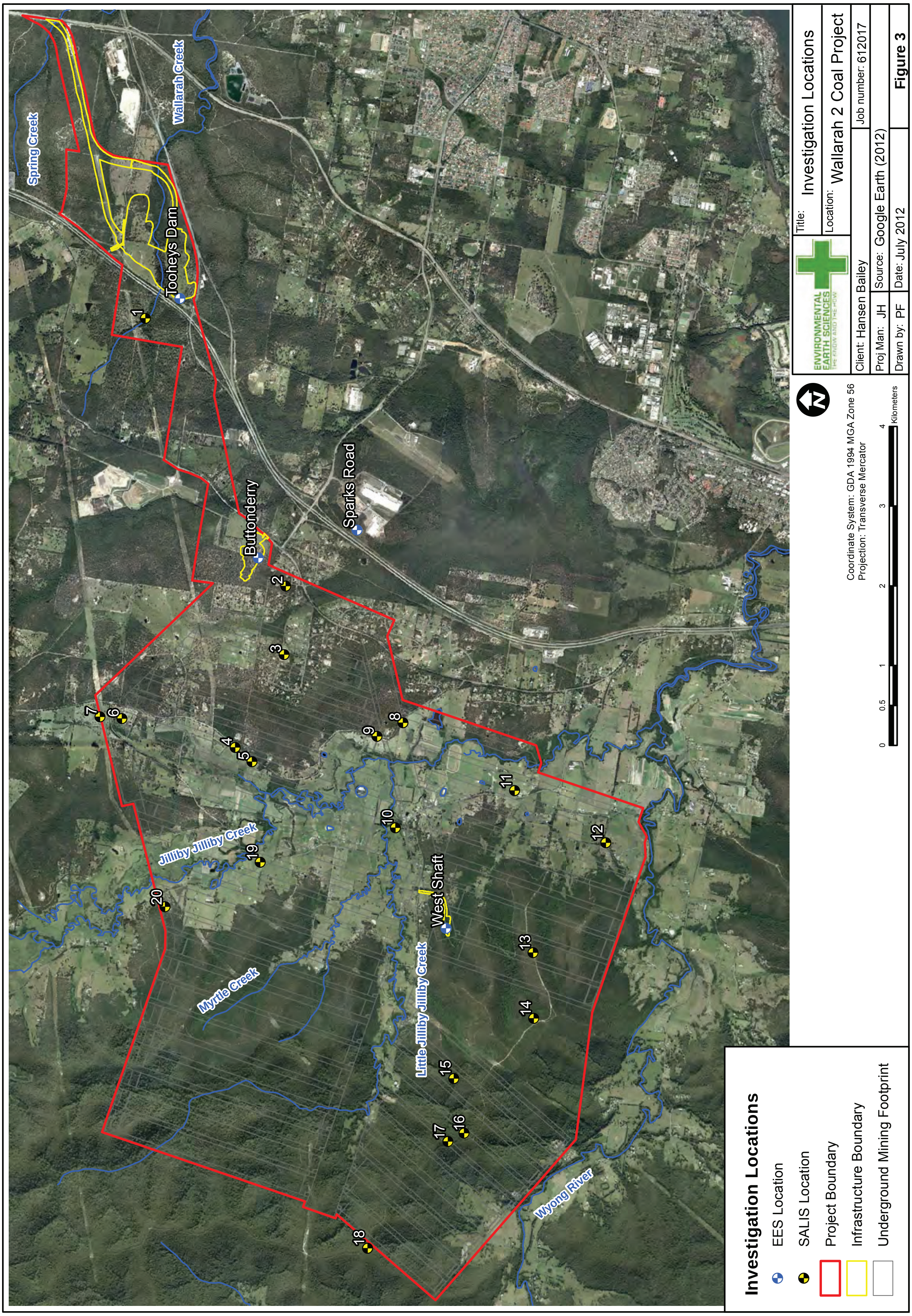
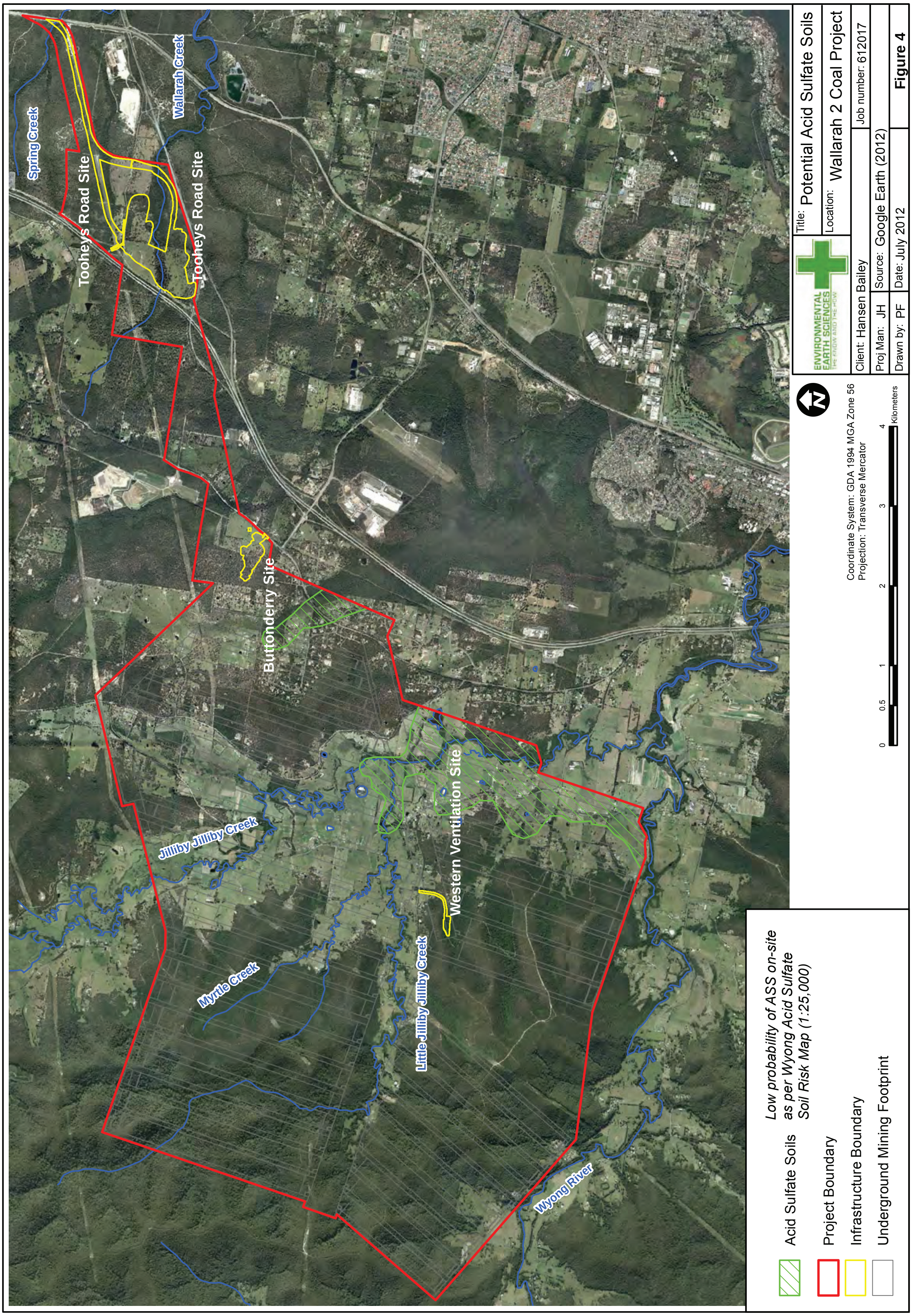
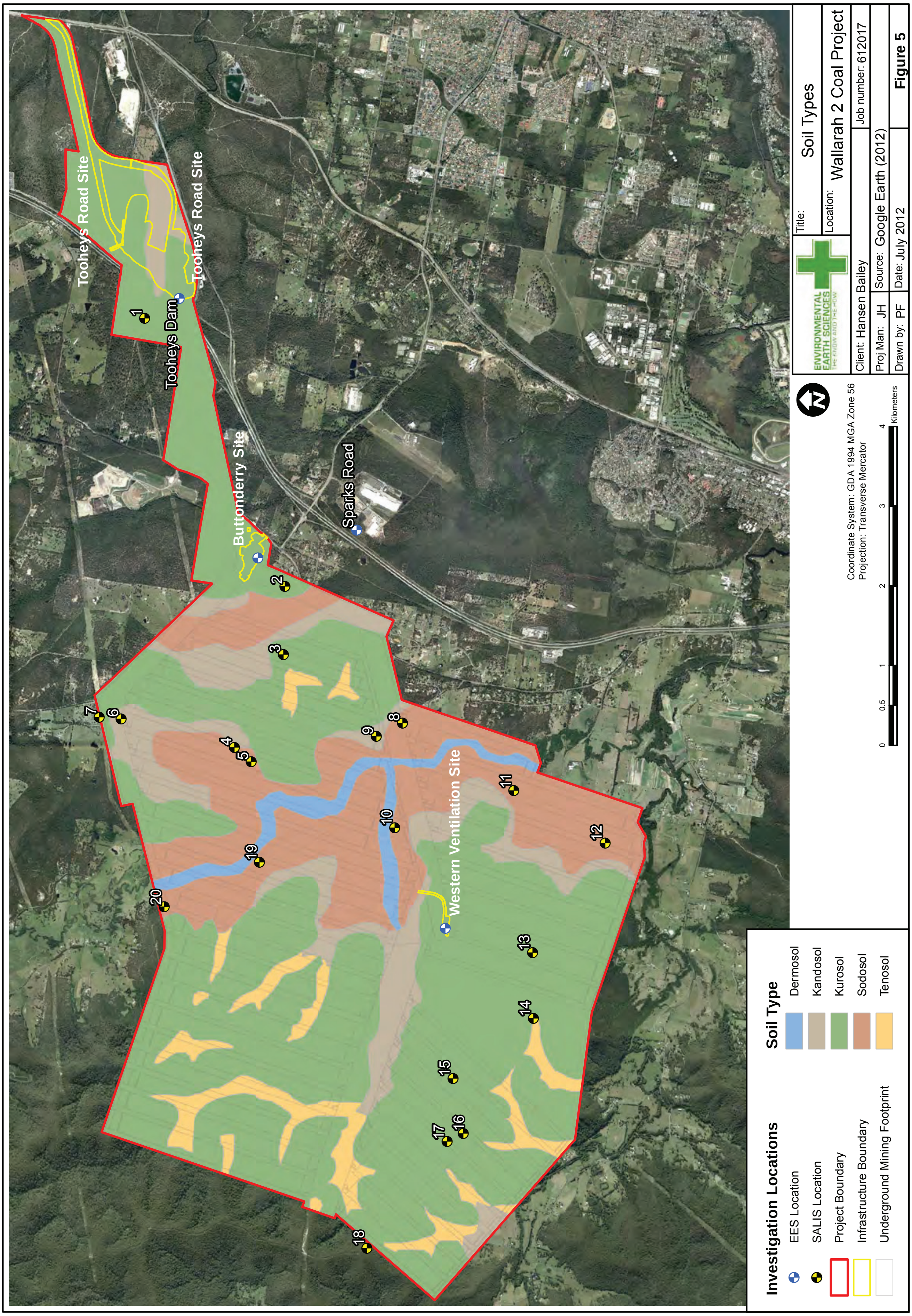


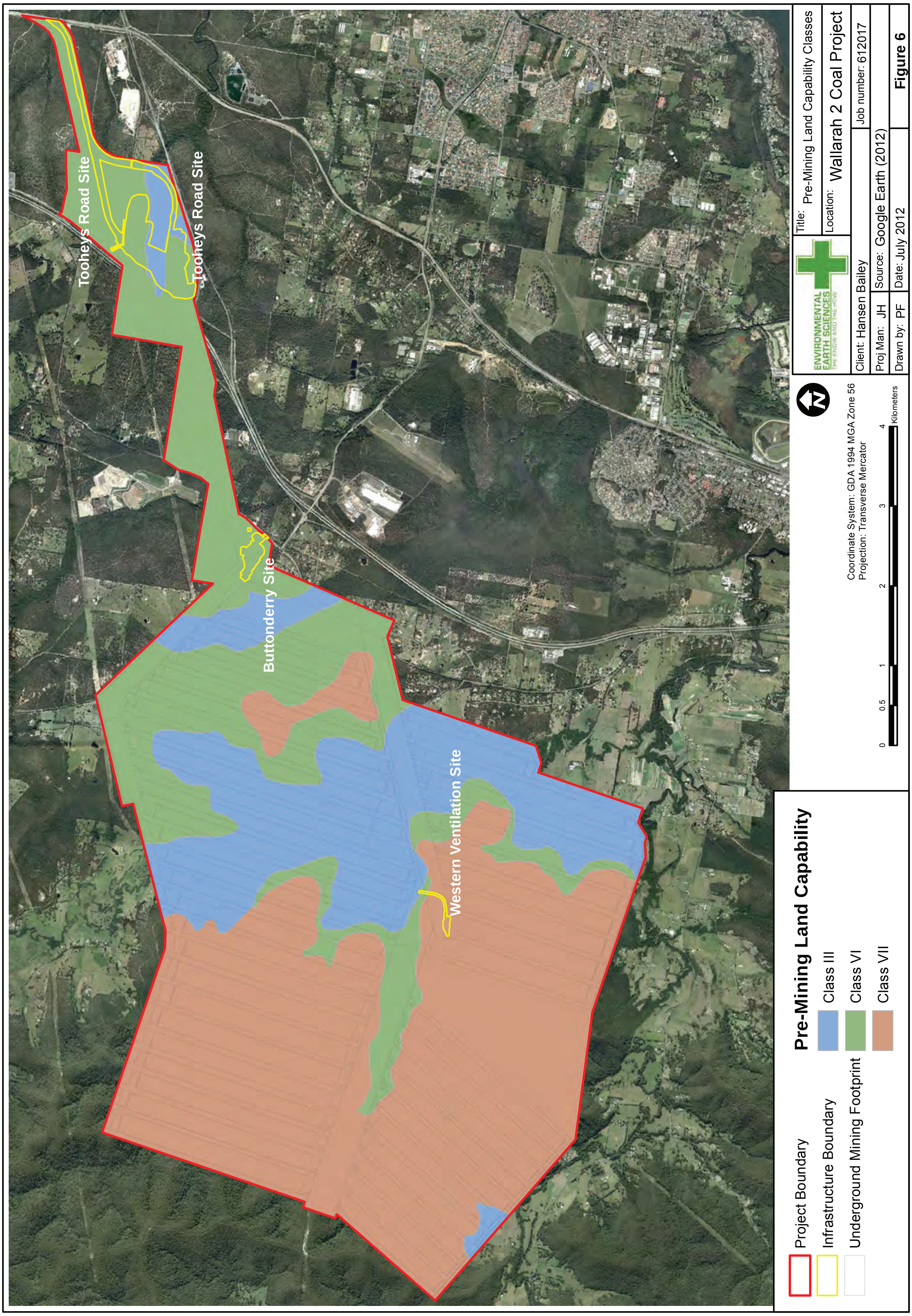
Hansen Bailey
ENVIRONMENTAL CONSULTANTS

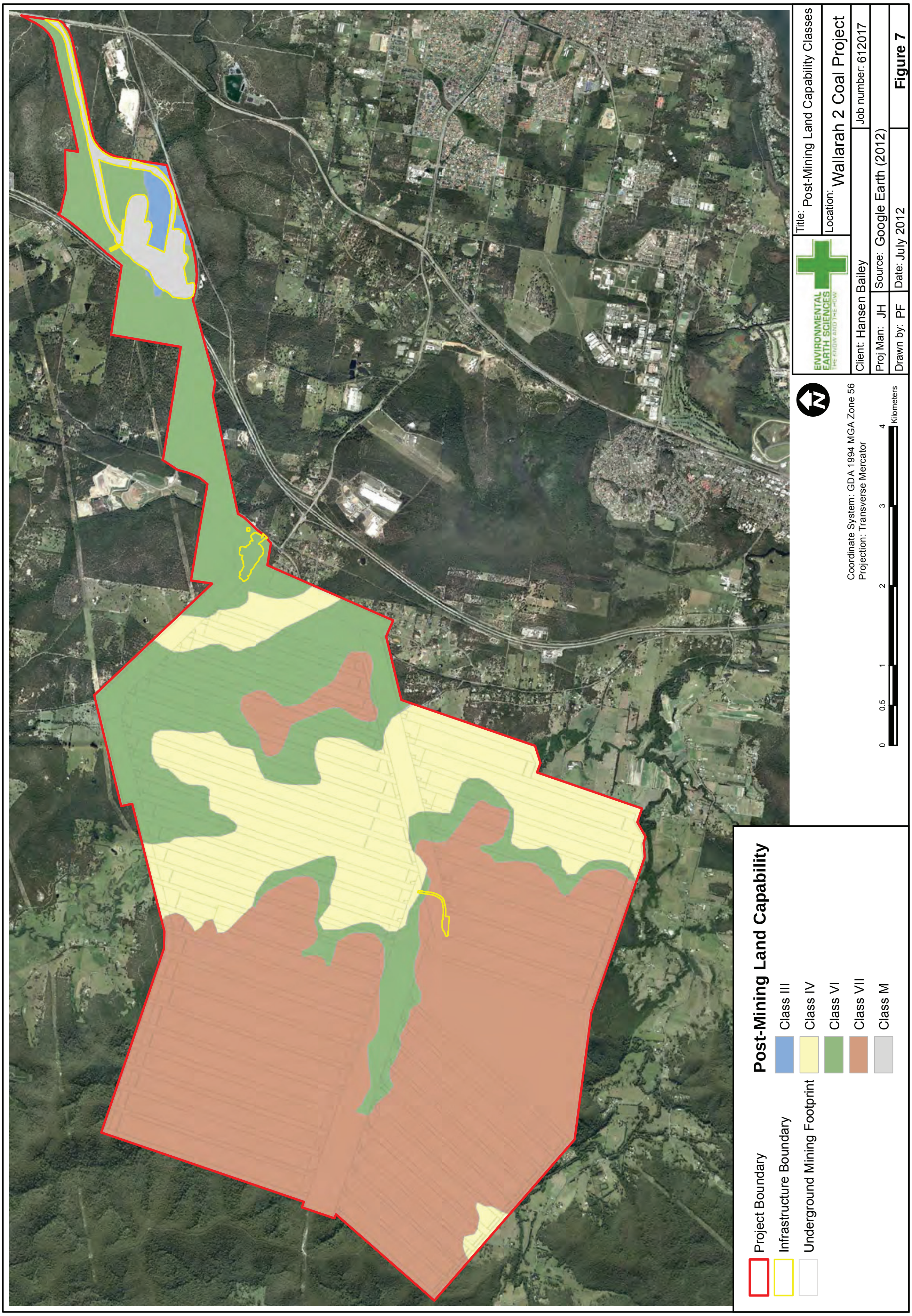

Spring Creek
Tooheys Road Site
Wallarah Creek
Tooheys Road Site
F3 Freeway
Hue Hue Road
Buttonderry Site
Western Ventilation Site
Jilliby Jilliby Creek
Myrtle Creek
Little Jilliby Jilliby Creek
Wyong River
Waterways
Project Boundary
Infrastructure Boundary
Underground Mining Footprint
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
0 0.5 1 2 3 4 Kilometers
Title: Study Area
Location: Wallarah 2 Coal Project
Client: Hansen Bailey
Job number: 612017
Proj Man: JH
Source: Google Earth (2012)
Drawn by: PF
Date: July 2012
Figure 2

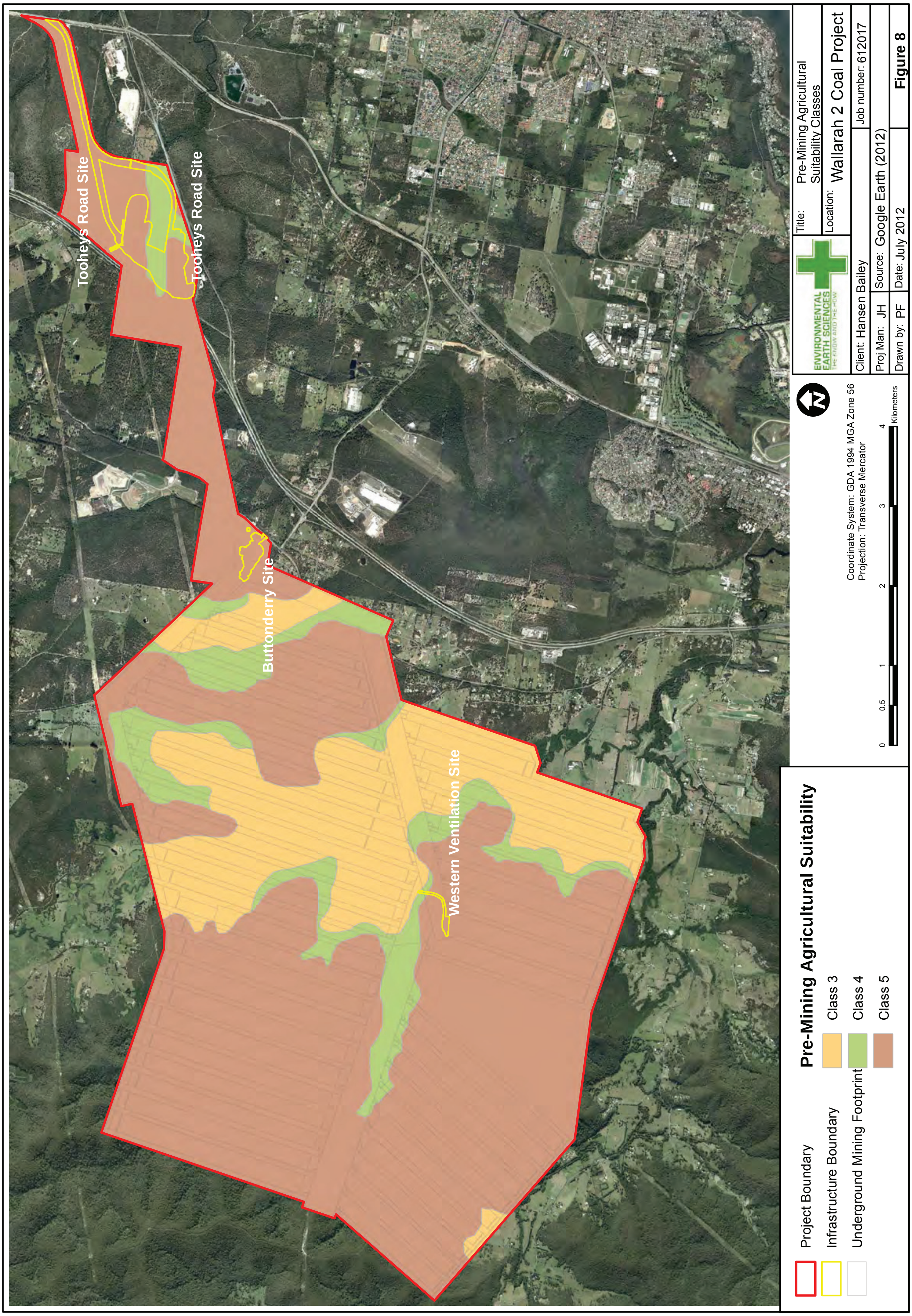

Title: Investigation Locations
Location: Wallarah 2 Coal Project
Job number: 612017
Client: Hansen Bailey
Proj Man: JH
Drawn by: PF
Source: Google Earth (2012)
Date: July 2012
Figure 3
ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
0 0.5 1 2 3 4
Kilometers
Investigation Locations
EES Location
SALIS Location
Project Boundary
Infrastructure Boundary
Underground Mining Footprint
Spring Creek
Wallarah Creek
Tooheys Dam
Buttonderry
Sparks Road
Jilliby Jilliby Creek
Myrtle Creek
Little Jilliby Jilliby Creek
West Shaft
Wyong River
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

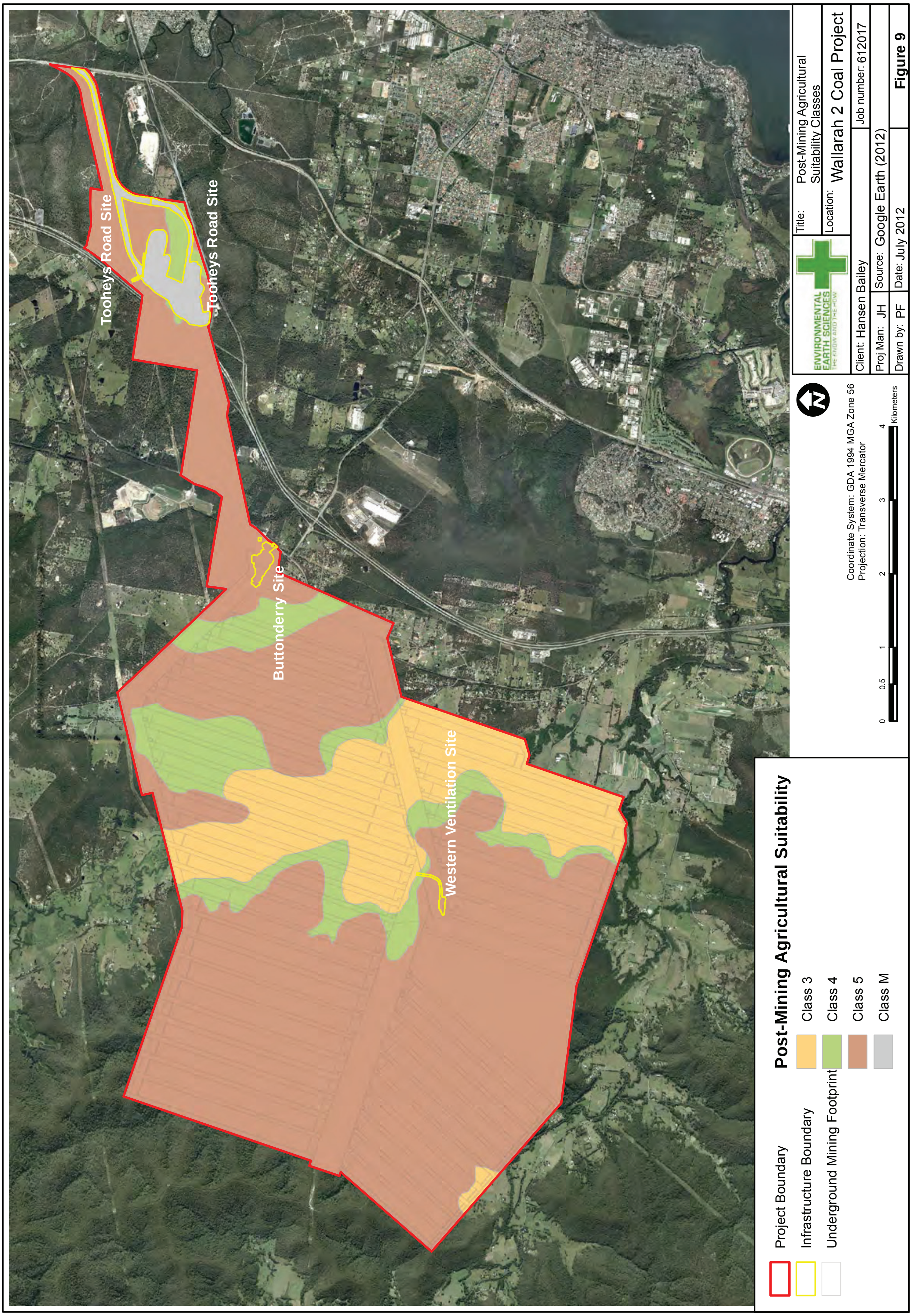

Title: Potential Acid Sulfate Soils
Location: Wallarah 2 Coal Project
Client: Hansen Bailey
Job number: 612017
Proj Man: JH
Source: Google Earth (2012)
Drawn by: PF
Date: July 2012
Figure 4
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Kilometers
Acid Sulfate Soils
Low probability of ASS on-site as per Wyong Acid Sulfate Soil Risk Map (1:25,000)
Project Boundary
Infrastructure Boundary
Underground Mining Footprint
Spring Creek
Wallarah Creek
Tooheys Road Site
Buttonderry Site
Western Ventilation Site
Jilliby Jilliby Creek
Myrtle Creek
Little Jilliby Jilliby Creek
Wyong River


Tooheys Road Site
Tooheys Road Site
Tooheys Dam
Buttonderry Site
Sparks Road
Western Ventilation Site
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Investigation Locations
EES Location
SALIS Location
Project Boundary
Infrastructure Boundary
Underground Mining Footprint
Soil Type
Dermosol
Kandosol
Kurosol
Sodosol
Tenosol
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
0
0.5
1
2
3
4
Kilometers
Title: Soil Types
Location: Wallarah 2 Coal Project
Client: Hansen Bailey
Job number: 612017
Proj Man: JH
Source: Google Earth (2012)
Drawn by: PF
Date: July 2012
Figure 5


Tooheys Road Site
Tooheys Road Site
Buttonderry Site
Western Ventilation Site
Pre-Mining Land Capability
Project Boundary
Infrastructure Boundary
Underground Mining Footprint
Class III
Class VI
Class VII
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
0
0.5
1
2
3
4
Kilometers
ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW
Title: Pre-Mining Land Capability Classes
Location: Wallarah 2 Coal Project
Client: Hansen Bailey
Job number: 612017
Proj Man: JH
Source: Google Earth (2012)
Drawn by: PF
Date: July 2012
Figure 6


Post-Mining Land Capability
Project Boundary
Infrastructure Boundary
Underground Mining Footprint
Class III
Class IV
Class VI
Class VII
Class M
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
0 0.5 1 2 3 4
Kilometers
N
Title: Post-Mining Land Capability Classes
Location: Wallarah 2 Coal Project
ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW
Client: Hansen Bailey
Job number: 612017
Proj Man: JH
Source: Google Earth (2012)
Drawn by: PF
Date: July 2012
Figure 7


Tooheys Road Site
Tooheys Road Site
Buttonderry Site
Western Ventilation Site
Pre-Mining Agricultural Suitability
Class 3
Class 4
Class 5
Project Boundary
Infrastructure Boundary
Underground Mining Footprint
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
0 0.5 1 2 3 4
Kilometers
N
Title: Pre-Mining Agricultural Suitability Classes
Location: Wallarah 2 Coal Project
Job number: 612017
Client: Hansen Bailey
Proj Man: JH
Source: Google Earth (2012)
Drawn by: PF
Date: July 2012
Figure 8
ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW



Tooheys Road Site
Tooheys Road Site
Buttonderry Site
Western Ventilation Site
Post-Mining Agricultural Suitability
Project Boundary
Infrastructure Boundary
Underground Mining Footprint
Class 3
Class 4
Class 5
Class M
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
0 0.5 1 2 3 4 Kilometers
Title: Post-Mining Agricultural Suitability Classes
Location: Wallarah 2 Coal Project
Client: Hansen Bailey
Job number: 612017
Proj Man: JH
Source: Google Earth (2012)
Drawn by: PF
Date: July 2012
Figure 9
ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW