2.0 SITE DESCRIPTION

2.1 Regional Locality

Mandalong Mine is an existing underground coal mine operation located in the Lake Macquarie LGA. It is situated approximately 130 kilometres north of Sydney and 35 kilometres south-west of Newcastle near Morisset within the Newcastle Coalfield of NSW. **Figures 1** and **2** show the Mandalong Southern Extension Project in its regional setting on the western side of Lake Macquarie within both the Lake Macquarie and Wyong LGAs.

The nearest major population settlements to the Project Application Area are Morisset and Dora Creek to the east and north-east, respectively, of the Mandalong Mine Access Site, and Wyee to the east of the Southern Extension Area. The Sydney-Newcastle F3 Freeway and the Main Northern Railway Line both traverse on a north-south alignment through the Project Application Area.

Lake Macquarie, being the dominant natural feature in the area, extends into the north-eastern extent of the Project Application Area. Dora Creek, which is a major tributary of Lake Macquarie, also flows into the north-eastern extent of the Project Application Area. Several other watercourses traverse the Project Application Area, including Morans Creek, Wyee Creek and Mannering Creek draining into Lake Macquarie, and Buttonderry Creek and Jilliby Jilliby Creek draining into the Wyong River.

The Project Application Area also includes parts of the Olney State Forest and Jilliby State Conservation Area (SCA).

2.2 Project Application Area

The Project Application Area encloses approximately 13,467 hectares and, as identified on **Figure 2**, comprises:

- The existing Mandalong Mine, including Mandalong Mine Access Site, encompassing underground workings and associated surface infrastructure near Morisset;
- The extent of existing workings of the Mandalong Mine;
- The extent of existing underground workings beneath the surface of the Cooranbong Entry Site near Dora Creek for water management, mine ventilation and delivery of coal, along with the mine ventilation shaft, ventilation fan and Borehole Dam at the surface of the Cooranbong Entry Site (see below);
- The proposed Mandalong Southern Extension Project mining area within EL 6317, which is referred to as the Southern Extension Area; and
- The proposed new surface facilities site, referred to as the Mandalong South Surface Site, within the Southern Extension Area.

Although the surface footprint of the Cooranbong Entry Site and Delta Entry Site are located within the Project Application Area (see **Figure 2**), the infrastructure and operations at the surface of these sites do not form part of the Mandalong Southern Extension Project (see **Section 1.8.2**). The exceptions to this are the mine ventilation shaft, ventilation fan and Borehole Dam at the surface of the Cooranbong Entry Site.

In relation to the Cooranbong Entry Site, a description of the currently approved infrastructure and operations at the surface of this site is in **Sections 1.8.1** and **3.0**). As stated above, the extent of the existing underground workings beneath the surface of the Cooranbong Entry Site, along with the mine ventilation shaft, ventilation fan and Borehole Dam at the surface of the Cooranbong Entry Site, are part of the Project in order to facilitate the continuation and/or augmentation of the following operations and infrastructure for the Project:

- The underground drift conveyor that delivers ROM coal from the underground workings of the Mandalong Mine to the surface of the Cooranbong Entry Site (see **Sections 3.8.2** and **4.10**);
- The ventilation of the main headings that accommodate the underground conveyors that run from the Mandalong Mine workings through to both the Cooranbong Entry Site and the Delta Entry Site, incorporating the mine ventilation shaft (see **Sections 3.6** and **4.7**); and
- The underground management of water, including the storage of water in goaf areas and then the pumping of water via a dewatering bore to the Borehole Dam at the surface of the Cooranbong Entry Site (see **Sections 3.11.1**, **4.11.1** and **4.11.3**).

2.2.1 Mandalong Mine

The Mandalong Mine comprises the Mandalong Mine Access Site, which is located adjacent to the Sydney-Newcastle F3 Freeway approximately 2.5 kilometres to the west of Morisset on Mandalong Road, and underground mine workings. The Mandalong Mine Access Site comprises mine support infrastructure including a decline tunnel, mine ventilation shafts and fans, gas drainage plant, workshop buildings, administration buildings and bathhouse facilities.

2.2.2 Cooranbong Entry Site

The Cooranbong Entry Site is located on the eastern side of the Sydney-Newcastle F3 Freeway approximately 2 kilometres north of Dora Creek. It comprises old underground mine workings (Cooranbong Colliery), a coal handling plant (CHP) and mine support infrastructure, including decline tunnels, coal stockpiles, conveyors, mine ventilation shaft and fan, water management system and workshop buildings. Coal extracted from the underground workings of Mandalong Mine is transported to the surface at Cooranbong Entry Site via an underground conveyor system for processing and transportation to Newstan Colliery and Eraring Power Station.

While the infrastructure and operations at the surface of the Cooranbong Entry Site (with the exception of the mine ventilation shaft and fan and Borehole Dam) do not form part of the Project because they will become part of Centennial's Northern Coal Logistics Project (SSD 5415), which is the subject of a separate development application, the extent of existing underground workings beneath the surface of the Cooranbong Entry Site are part of the Mandalong Southern Extension Project for the purposes of the coal delivery system, mine ventilation and water management do form part of the Mandalong Southern Extension Project and as such have been addressed within this EIS.

Although the management of surface water at the Cooranbong Entry Site is intended to be regulated by the development consent sought for the Northern Coal Logistics Project and does not form part of the Mandalong Southern Extension Project, mine water collected in the Project's underground workings is to be pumped to the surface of the Cooranbong Entry Site to the Borehole Dam. On this basis, the Borehole Dam does form part of the Mandalong Southern Extension Project and has been addressed within this EIS. Given that the mine water collected in the Borehole Dam will be pumped to other surface water management structures and licensed discharge points at the Cooranbong Entry Site, it was considered appropriate to include in this EIS a description and assessment of surface water management at the Cooranbong Entry Site.

2.2.3 Delta Entry Site

The Delta Entry Site is located on the eastern side of the Sydney-Newcastle F3 Freeway approximately 2.5 kilometres north of Wyee. It comprises the Mandalong Coal Delivery System, which links the underground workings of the Mandalong Mine to the Wyee coal unloader by an underground tunnel, approved under Development Consent DA 35-2-2004. Once the coal reaches the surface at the Delta Entry Site it is handled (received and sized) by surface infrastructure approved under Development Consent DA 2501/2004 at the Wyee coal unloader site before being transported to the Vales Point Power Station by the Delta Electricity overland conveyor.

While the infrastructure and operations at the Delta Entry Site are covered by separate development consents to Mandalong Mine's Development Consent DA 97/800, the existing coal delivery system is critical to the Mandalong Southern Extension Project (refer **Section 1.8.2**).

2.2.4 Southern Extension Area

The Southern Extension Area comprises approximately 4,467 hectares of land immediately south of the existing Mandalong Mine and is bounded to the west by the Watagan Mountains. It is located to the west of Wyee on the western side of the Sydney-Newcastle F3 Freeway. It is within this area that Centennial Mandalong proposes to extend Mandalong Mine's existing underground mining operations and establish the Mandalong South Surface Site, including a new access road from Mandalong Road.

2.3 Land Ownership

Land ownership within the bounds of the Project Application Area is shown on **Figure 4.** The Site comprises both privately-owned freehold land (including residential and commercial areas) and land owned by the NSW State Government, as listed below:

- Centennial Fassifern Pty Limited (subsidiary company of Centennial Coal).
- The Crown, including –
  - Olney State Forest, under the care and control of the Forestry Corporation of NSW (Forests NSW);
  - Jilliby SCA, under the care and control of the NSW Office of Environment and Heritage (OEH);
  - Sydney-Newcastle F3 Freeway corridor, under the care and control of the NSW Roads and Maritime Service (RMS); and
  - Great Northern Railway Line corridor, under the care and control of the Rail Corporation of NSW (RailCorp).
- Lake Macquarie City Council, including various public road reserves.
- Wyong Shire Council, including various public road reserves and the Buttonderry Waste Management Facility.
- Eraring Energy.

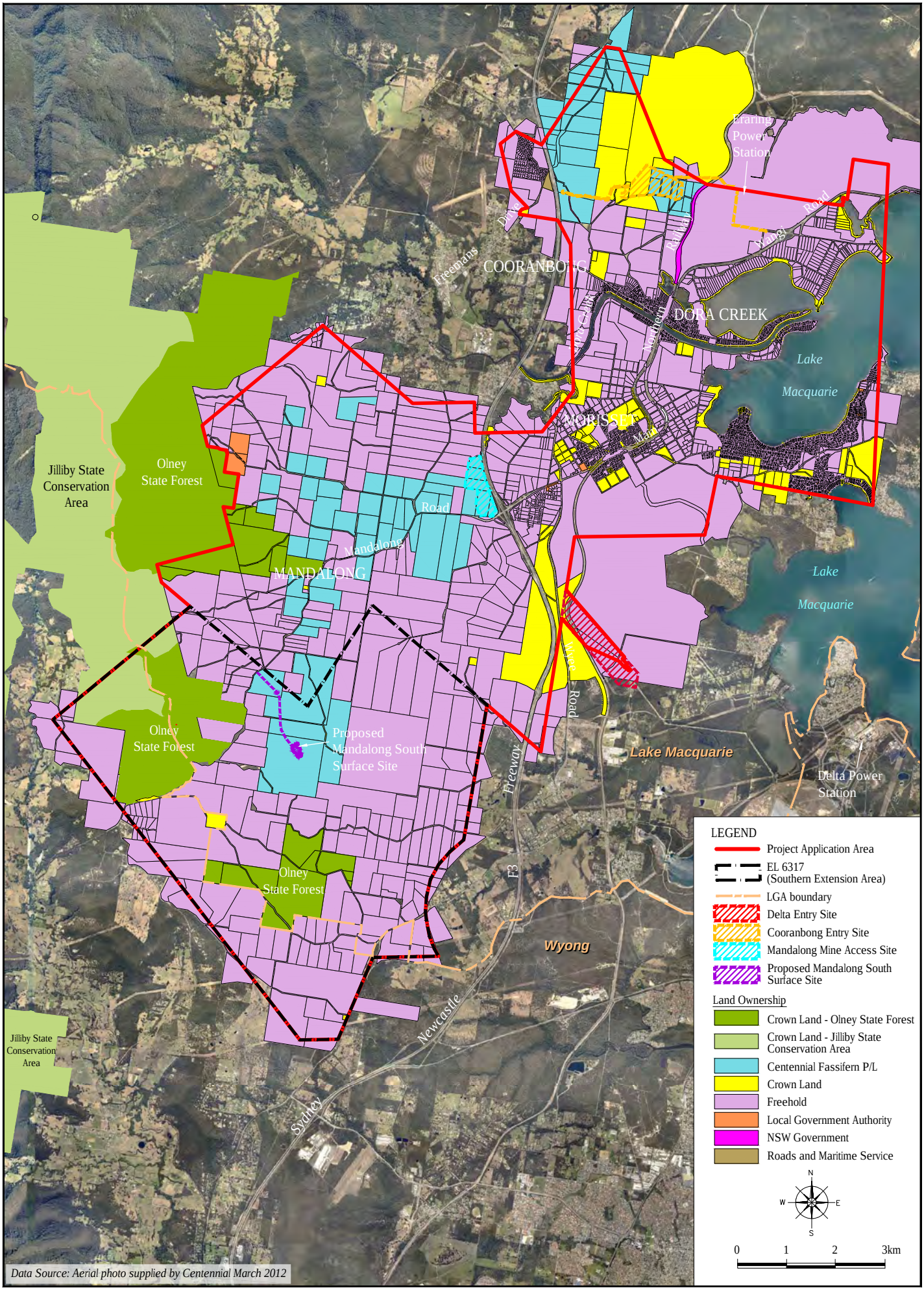
The remaining properties are privately-owned freehold land.

The consultation undertaken with these landholders/stakeholders is outlined in **Section 8.0**.

2.4 Existing Land Use

The predominate land uses within the Project Application Area include residential and rural-residential, industrial and commercial, utility easements, underground mining and surface operations associated with the Mandalong Mine, power generation, cattle grazing and production, poultry production, transport corridors and recreational use, including holiday accommodation.

As shown on **Figure 5**, parts of the Olney State Forest are located within the Project Application Area. The Olney State Forest is popular for recreational activities, including hiking, camping and four-wheel driving. Forests NSW advises that the forests in this area have been harvested for timber for many decades and today comprise regrowth forests. Jilliby SCA, which was created in 2003, extends into the north-western extent of the Southern Extension Area. Additional notable land uses are the Buttonderry Waste Management Facility, owned and operated by Wyong Shire Council (WSC), in the southern extent of the Project Application Area (Southern Extension Area), and several major service infrastructure lines, including TransGrid's 330 kilovolt power lines.



G:\Drafting\Mandalong\CCC14-009\Figures\Final\CAD\FINAL FIGS EB Report\MANDALONG EIS FIGURES\CAD (2nd External Review)\Fg4_CCC14-009_Land Ownership_V3.dwg

To be printed A4

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Land Ownership

FIGURE 4

Inset 1
COORANBONG ENTRY SITE
Inset 2
PROPOSED MANDALONG SOUTH SURFACE SITE
Inset 3
MANDALONG MINE ACCESS SITE
Inset 4
DELTA ENTRY SITE
Olney State Forest
See Inset 1
Eraring Power Station
Drive
Railway
Road
Wangi
Freemans
COORANBONG
Gradwells Road
Jilliby State Conservation Area
Dora Creek
Northern
DORA CREEK
Lake Macquarie
See Inset 3
MORISSET
Gimberts Road
Main
Lake Macquarie State Conservation Area
Olney State Forest
Road
See Inset 4
MANDALONG
See Inset 1
Mandalong
Lake Macquarie
T25/26
Wyee
Road
Rutleys
Road
Proposed Mandalong South Surface Site
Freeway
Delta Power Station
T24
Olney State Forest
F3
T22
Buttonderry Waste Management Facility
Newcastle
Wyong
Jilliby State Conservation Area
Sydney
Data Source: Aerial photo supplied by Centennial March 2012

LEGEND
- Project Application Area
- EL 6317 (Southern Extension Area)
- LGA boundary
- Delta Entry Site
- Cooranbong Entry Site
- Mandalong Mine Access Site
- Proposed Mandalong South Surface Site
- Transgrid 330kV Transmission Line
- Ausgrid 33kV Transmission Line
- Residences (in close proximity to Surface Sites)

N W E S

0 1 2 3km

G:\Drafting\Mandalong\CCC14-009\Figures\Final\CAD\FINAL FIGS EB Report\MANDALONG EIS FIGURES\CAD (2nd External Review)\Fg5_CCC14-009_SurrLandUse_V3.dwg

To be printed A3

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Surrounding Land Use and Sensitive Receptors

FIGURE 5

2.5 Surrounding Residences

The population settlements of Morisset and Dora Creek are located within the Project Application Area approximately 2.5 kilometres to the east and 5 kilometres to the north-east, respectively, of the existing Mandalong Mine Access Site. Wyee is also a population settlement and is located outside of the Project Application Area approximately 6 kilometres to the east of the proposed Mandalong South Surface Site. There are numerous small settlements within and surrounding the Project Application Area, including Cooranbong, Bonnells Bay, Beauty Point, Lemon Tree, Dooralong and Jilliby. There are also some large-lot rural-residential developments within the Southern Extension Area, including in the Durren Durren and Kiar localities.

As evident in **Figure 5**, the nearest privately-owned residences to the existing Mandalong Mine Access Site are identified to the east of the site on Gimberts Road, which is on the eastern side of the Sydney-Newcastle F3 Freeway, and to the south and west of the site on Mandalong Road. The nearest privately-owned residences to the existing Cooranbong Entry Site are located on Gradwells Road to the south, and the nearest privately-owned residences to the existing Delta Entry Site are on Rutleys Road and Simmons Close to the south and south-east, respectively.

There are 114 privately-owned residences identified within the Southern Extension Area, with the nearest privately-owned residences to the proposed Mandalong South Surface Site located over 950 metres to the south and west along Mandalong Road and Wyee Farms Road.

2.6 Climate

The meteorology data presented in this section has been sourced from long-term data collected at the Bureau of Meteorology's (BoM) nearest operational weather stations, along with information provided in the *Water Management Impact Assessment* (GHD 2013b) and *Air Quality Impact Assessment* (SLR 2013a). The use of recorded information from the weather monitoring station at the Mandalong Mine Access Site by specialist consultants for modelling and assessment purposes was limited as the station has not been operational long enough to adequately represent the long-term average annual conditions.

Temperature

The Project Application Area is located in a temperate climate zone with no designated wet season, although the area can be susceptible to occasional heavy showers and thunderstorms due to easterly troughs during warmer months. The local climate is characterised by warm to hot summers and cool to mild winters. Based on the long-term climate statistics sourced from the BoM between 1994 and 2012, mean monthly maximum temperatures in the area range between 15.1 degrees Celsius (^{0}C) in July to 26.9 ^{0}C in January. Mean monthly minimum temperatures range between 6 ^{0}C in July to 17 ^{0}C in February. Autumn and spring are generally mild with sporadic temperature fluctuations.

Rainfall and Evaporation

GHD (2013a) obtained a continuous daily rainfall dataset as SILO Patched Point Data, using SILO data from the BoM Cooranbong (Avondale) weather station (station number 061012), which is located approximately 10 kilometres north-east of the Southern Extension Area, with missing data "patched" in from interpolations from nearby stations. The available rainfall data extended from January 1901 through to December 2012, with the representative statistics reported as:

- Minimum annual rainfall – 531 millimetres (in 1944).
- Average annual rainfall – 1,106 millimetres.
- Median annual rainfall – 1,041 millimetres.
- Maximum annual rainfall – 2,040 millimetres (in 1990).

The average annual evaporation total was approximately 1,187 millimetres, compared to the annual average rainfall of 1,106 millimetres. This gives an annual deficit (difference between annual rainfall and annual evaporation) of approximately 81 millimetres.

Wind

To adequately characterise the dispersion meteorology for the air quality assessment, SLR (2013a) developed a three-dimensional prognostic meteorological dataset for the region surrounding the Project Application Area using the CALMET meteorological model. A summary of the annual wind behaviour predicted by CALMET for the five years between 2006 and 2010 are presented as wind roses in the *Air Quality Impact Assessment* (SLR 2013a) contained in **Appendix C**. These wind roses indicate that the area predominantly experiences light to moderate winds (between 1.5 and 8 metres per second), with high-speed winds (greater than 8 metres per seconds) prevailing for a low fraction of time. Wind direction is seasonally dependent (SLR 2013a).

While winds occur reasonably evenly from all quadrants, based on the modelled wind roses for 2006 to 2010, summer winds appear to be generally from the east-northeast and winter winds appear to be predominately from the west-northwest. Calm wind conditions (less than 0.5 metres per second) were predicted to occur just over 1 percent of the time during each year (SLR 2013a).

Atmospheric Stability

The term "atmospheric stability" refers to the dispersive capacity of the atmosphere. As listed in **Table 2**, the Pasquill-Gifford scheme classifies the atmosphere into six (sometimes seven) classes:

Table 2 – Atmospheric Stability Classes

Atmospheric Stability Class	Description
A	Very unstable, low wind, clear skies, hot daytime conditions
B	Unstable clear skies, daytime conditions
C	Moderately unstable, moderate wind, slightly overcast daytime conditions
D	Neutral, high winds or cloudy days and nights
E	Stable, moderate wind, slightly overcast night-time conditions
F	Very stable, low winds, clear skies, cold night-time conditions

Source: SLR (2013a)

Using the CALMET model, SLR (2013a) predicted the frequency of each stability class within the area over the five years between 2006 and 2010, with the results indicating a high frequency of conditions typical to Stability Class F. Stability Class F is indicative of very stable night time conditions, conducive to a low level of pollutant dispersion due to mechanical mixing (SLR 2013a). In 2009 and 2010 a higher percentage of Stability Class D was predicted, which is indicative of neutral conditions, conducive to a moderate level of pollutant dispersion due to mechanical mixing (SLR 2013a).

2.7 Natural Features and Topography

Lake Macquarie, being the dominant natural feature in the area, extends into the north-eastern extent of the Project Application Area. Dora Creek, which is a major tributary of Lake Macquarie, also flows into the north-eastern extent of the Project Application Area.

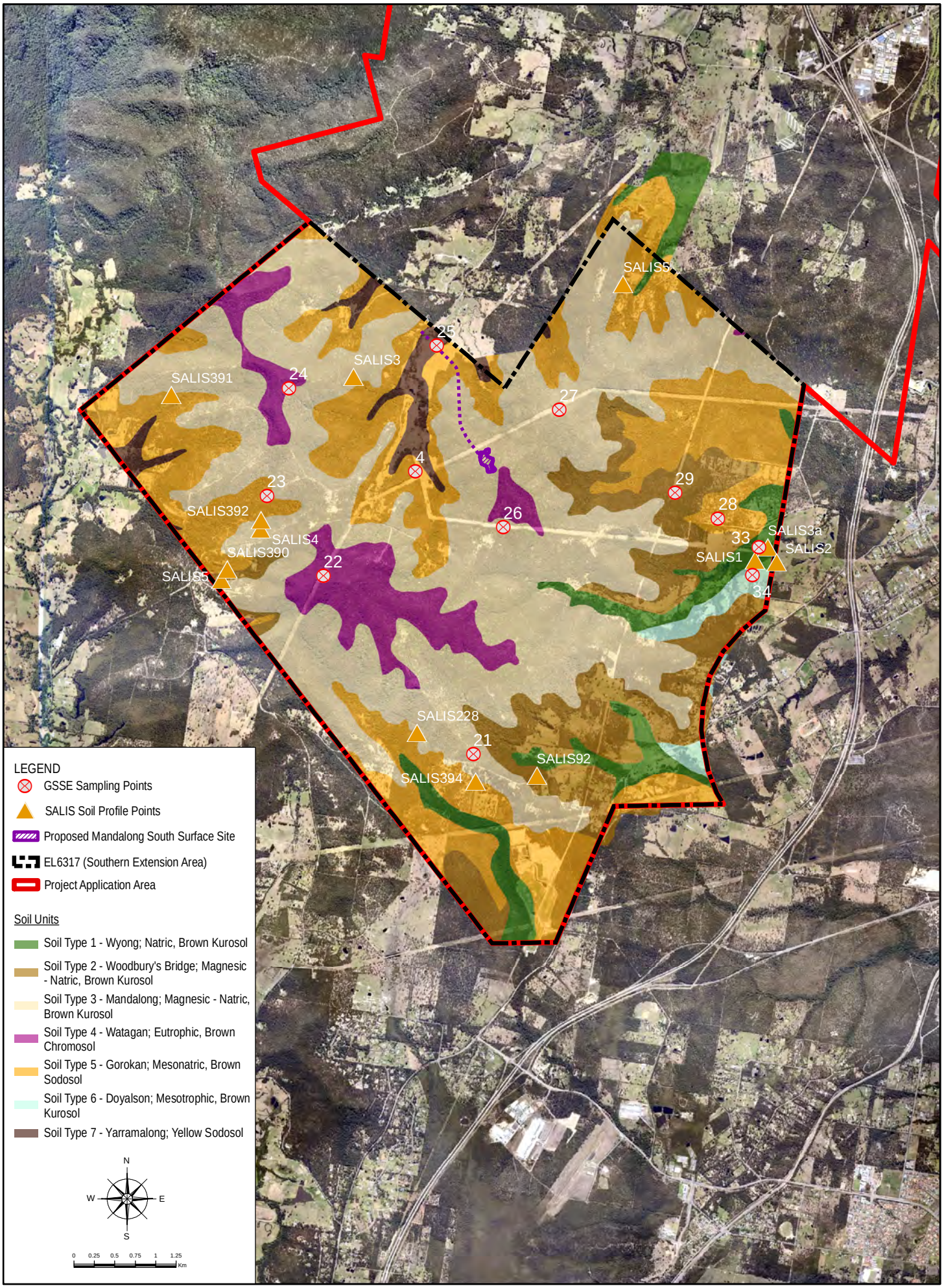
The Project Application Area is located in the Mandalong Valley. Diverse landforms are present, including broad flat floodplains of the Stockton Creek and Morans Creek catchments, and undulating hills and rugged ridgelines associated with the surrounding Watagan Mountain range. **Figure 5** shows parts of the Olney State Forest and Jilliby SCA within the Southern Extension Area, along with the current extent of existing tree cover.

The Southern Extension Area is dominated by two densely timbered ridgelines which trend generally north-west to south-east and from the south to the north-east corner. Elevations on these ridgelines can exceed 200 metres Australian Height Datum (AHD). Spurs from these ridgelines descend toward drainage lines in relatively flat areas to the north, east and south of the ridgelines, some of which have been cleared or partially cleared. These valleys are relatively low lying with surface elevations generally less than 50 metres AHD.

2.8 Soil Landscape Units

The soil landscape units within the Project Application Area have been previously mapped at a scale of 1:100,000 (Murphy 1993). The soil landscape units, as described by this publication are “areas of land that have recognisable and specific topographies and soils that can be presented on maps and described by concise statements”. GSSE was engaged by Centennial Mandalong to undertake a soil and land capability assessment for the Project, specifically for the proposed Southern Extension Area. Based on desktop review and field survey (including soil sampling and analysis), and as illustrated on **Figure 6,** GSSE (2013a) determined that seven soil landscape units are present within the Southern Extension Area.

As evident on **Figure 6**, the Mandalong soil landscape unit is the dominant unit within the Southern Extension Area, followed by the Gorokan soil landscape unit.



V:\CCC14-009\Figures\Final\CAD\FINAL FIGS EB Report\MANDALONG EIS FIGURES\CAD (Final Internal Draft)\Fg6_CCC14-009_Soil Types_V1.mxd

To be printed A4

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Soil Landscapes within Southern Extension Area

FIGURE 6

Table 3 provides an overview of each of these soil landscape units, including representative soil type.

Table 3 – Soil Landscape Units in Southern Extension Area

Representative Soil Type	Description
1 – Wyong Soil Landscape Unit	
Natric, Brown Kurosol	Broad, poorly drained deltaic floodplains and alluvial flats of Quaternary sediments on the Central Coast Lowlands. Slope gradients are less than 3 percent, and local relief is less than 10 metres. Meander scrolls, oxbows and swamps are common in this landscape. The land is extensively cleared open-forest.  Limitations to this unit include flooding, seasonal waterlogging, foundation hazard, permanent waterlogging (localised), stream bank erosion (localised), acid sulfate potential (localised), strongly acidic, poorly drained and impermeable soils of low fertility with saline subsoils. The land capability is deemed to have generally low limitations for cultivation except for water logged areas, which have high to severe limitations. Generally, there are low to moderate limitations for grazing.
2 – Woodbury's Bridge Soil Landscape Unit	
Magnesic – Natric, Brown Kurosol	Gently undulating rises to rolling low hills on Patonga claystone. The landscape has local relief at 40-80 metres, with slope gradients up to 20 percent. Sandstone capping on crests of steeper hills is common and the land is predominately cleared tall open-forest.  Limitations to this unit include extreme erosion hazard, high foundation hazard, seasonal waterlogging (localised) and acidic soils of low fertility with high erodibility and low wet-bearing strength. The land capability is deemed to have generally high to severe limitations for regular cultivation due to the severe erosion hazard. There are moderate limitations for judicious grazing provided a protective permanent groundcover is maintained.
3 – Mandalong Soil Landscape Unit	
Magnesic – Natric, Brown Kurosol	Rolling to steep low hills on Patonga Claystone in the Watagan Mountains. The landscape has local relief to 120 metres and slope gradients of between 20 and 60 percent.  The landscape is characterised by narrow crests and ridges, short steep slopes and narrowly spaced drainage lines. The land is regenerating tall open-forest. The limitations of this unit include mass movement hazards, steep slopes, erosion hazards and foundation hazards. Soils have low wet-bearing strength, can be acidic, sodic and have low fertility. The land capability is deemed to have generally high to severe limitations to both cropping and grazing.

4 – Watagan Soil Landscape Unit	
Eutrophic, Brown Chromosol	Rolling to very steep hills on fine-grained Narrabeen Group sediments. Local relief is 50 to 220 metres, with slopes greater than 25 percent. The landscape is characterised by narrow convex crests and ridges, steep colluvial sideslopes, occasional sandstone boulders and benches.  The land is predominately uncleared tall eucalypt open-forest with closed-forest in sheltered position. Limitations to this unit include mass movement hazards, steep slopes, soil erosion hazards, foundation hazards, occasional rock outcrops and seasonal waterlogging (localised). The rural land capability is deemed to have generally high to severe limitations to both cropping and grazing.
5 – Gorokan Soil Landscape Unit	
Mesonatric, Brown Sodosol	Undulating low hills and rises on lithic sandstones of the Tuggerah Formation. Local relief is less than 30 metres, with slope gradients less than 15 percent.  The landscape is characterised by broad crests and ridges, long gently inclined slopes and broad drainage lines. The land is partially cleared low open-forest. Limitations to this unit include very high erosion hazard, foundation hazard (localised), seasonal waterlogging, hardsetting, strongly acidic, low fertility, plastic and impermeable soils. The land capability is deemed to have generally high to severe limitations for regular cultivation, however there are low limitations for grazing.
6 – Doyalson Soil Landscape Unit	
Mesotrophic, Brown Kurosol	Gently undulating rises on Munmorah Conglomerate. Slope gradients are less than 10 percent and local relief is to 30 metres.  The landscape is characterised by broad crests and ridges and long gently inclined slopes. The land is partially cleared eucalypt open-forest. Limitations to this unit include high erosion hazard, foundation hazard (localised), high run-on (localised), seasonal waterlogging (localised), hardsetting, stony and strongly acidic soils of low fertility. The land capability is deemed to have generally high to severe limitations for regular cultivation and moderate limitations for grazing.

7 – Yarramalong Soil Landscape Unit	
Yellow Sodosol	Floodplains on Quaternary alluvium with level to gently undulating narrow to moderately broad dissected alluvial plains. Slope gradients are less than 3 percent and local relief is less than 10 metres. This unit includes meander scrolls, terraces, oxbows and backswamps.  Limitations to this unit include flooding, foundation hazards, seasonal waterlogging, streambank erosion and low fertility. The land capability is deemed to have generally low limitations for cultivation and grazing. Localised areas of heavier soils on the poorer drained country in the lower tract floodplain have high to severe limitations.

Source: GSSE (2013a)

2.9 Geology

The information in the below sub-sections on regional geology, igneous geology and target coal geology has been sourced from the *Exploration Report* prepared by Centennial Mandalong in August 2012 for the Mandalong Southern Extension Project.

2.9.1 Regional Geology

Geologically the Project Application Area is located in the south-west of the Newcastle Coalfield, a geological subdivision of the north-eastern Sydney Basin. The coal deposits of this area are contained within sedimentary rocks of the Late Permian Age Newcastle Coal Measures, which are characterised by complex patterns of splitting and coalescence of the various coal seams.

The significant coal seams within the Southern Extension Area are the Wallarah, West Wallarah, Great Northern and Fassifern seams. The term “West Wallarah Coal Seam” was introduced by Centennial Mandalong and has been used at Mandalong Mine to define the coal seam formed by the westerly convergence of the Wallarah and Great Northern seams.

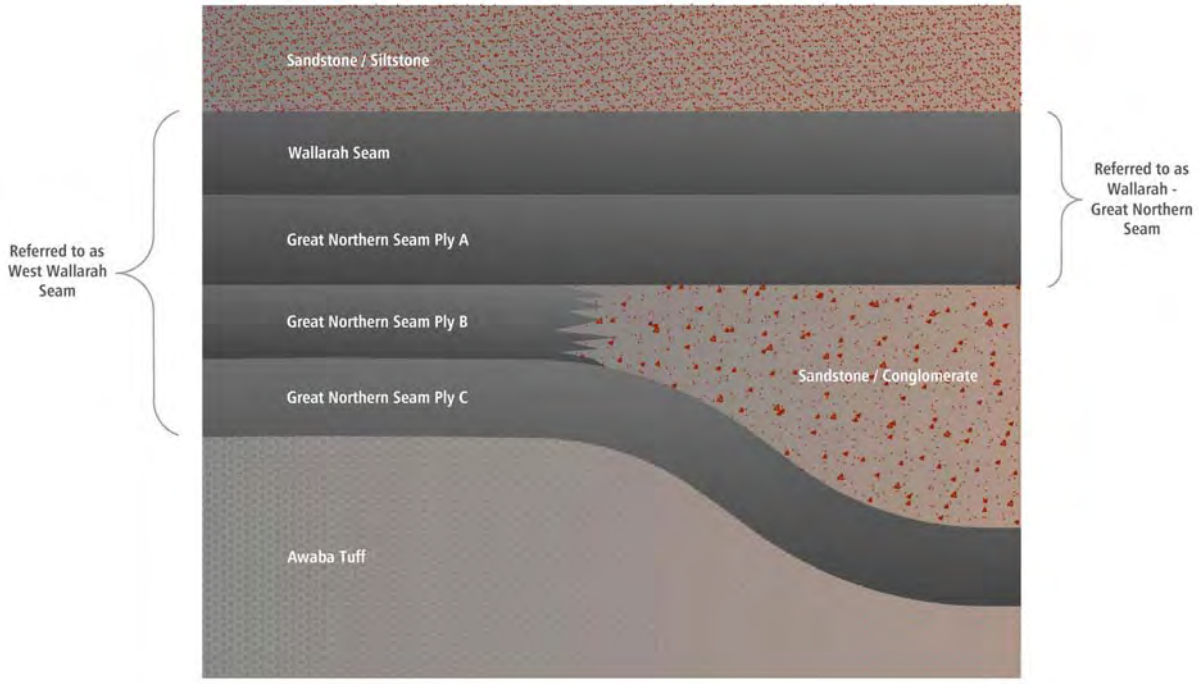
Other significant units, which lie within the stratigraphic section, are the Awaba Tuff Formation, which lies between the West Wallarah and Fassifern Seams, and the Munmorah Conglomerate, which sits within the Triassic Age Narrabeen Group sediments between 80 and 110 metres above the West Wallarah Seam and Wallarah-Great Northern Seams. This conglomerate beam has a significant impact on the subsidence profile for the Mandalong Mine due to its spanning potential.

The stratigraphy of the Newcastle Coal Measures is summarised in **Table 4**.

Table 4 – Stratigraphy of the Newcastle Coal Measures

Group	Formation	Coal Seams		
Newcastle Coal Measures	Moon Island Beach	Vales Point Wallarah Great Northern		
	Awaba Tuff			
	Boolaroo	Fassifern Upper Pilot Lower Pilot Hartley Hill		
	Warners Bay Tuff			
	Adamstown	Australasian Montrose Wave Hill Fern Valley Victoria Tunnel		
	Nobbys Tuff			
	Lambton	West Borehole	Young Wallsend	Nobbys
				Dudley
			Yard	
			Borehole	
	Waratah Sandstone			

Following detailed correlations of historic borehole intersections, four coal plies, ranging in thickness, were defined for the target Wallarah and Great Northern Seams. These plies can be identified across the Southern Extension Area and are illustrated in **Figure 7.**



N.B Not to scale

Figure 7 – Wallarah and Great Northern Seam Naming Convention

2.9.2 Igneous Geology

The exploration drilling program (and associated surveys) undertaken within the Southern Extension Area under the provisions of EL 6317 identified a number of igneous intrusions in the form of a sill, a number of dykes and two diatremes, which are shown on **Figure 8** and outlined below.

Sill

A sill intrudes the West Wallarah Seam in the western extent of the Southern Extension Area. There is also silling identified in the Fassifern Seam, however this is not a target coal seam for this Project. The boundary of similar sills seen in other Centennial operations in the Lake Macquarie area are known to be highly variable and complex, which is difficult to predict ahead of mining.

Dykes

Six igneous dykes trending northwest-southeast have been interpreted in the Southern Extension Area. Both magnetic and non-magnetic dykes have been intersected in the existing adjacent Mandalong Mine workings. The magnetic doleritic dykes that have been intersected generally follow the regional structural trend of north-east to south-west and are typically relatively easy to mine through. The non-magnetic silica rich dykes that have been intersected tend to trend west to east. The silica rich dykes are hard to cut through and are required to be removed by drilling and blasting prior to being mined through. It is possible that similar undetected non–magnetic dykes exist within the Southern Extension Area.

Diatremes

A ground magnetic survey interpreted two volcanic plugs in the Southern Extension Area. A magnetic anomaly previously identified along Woods Road was confirmed as a volcanic plug with an associated sill. A second volcanic plug was identified approximately 1.5 kilometres south-east of the Woods Road plug.

2.9.3 Deposit Geology

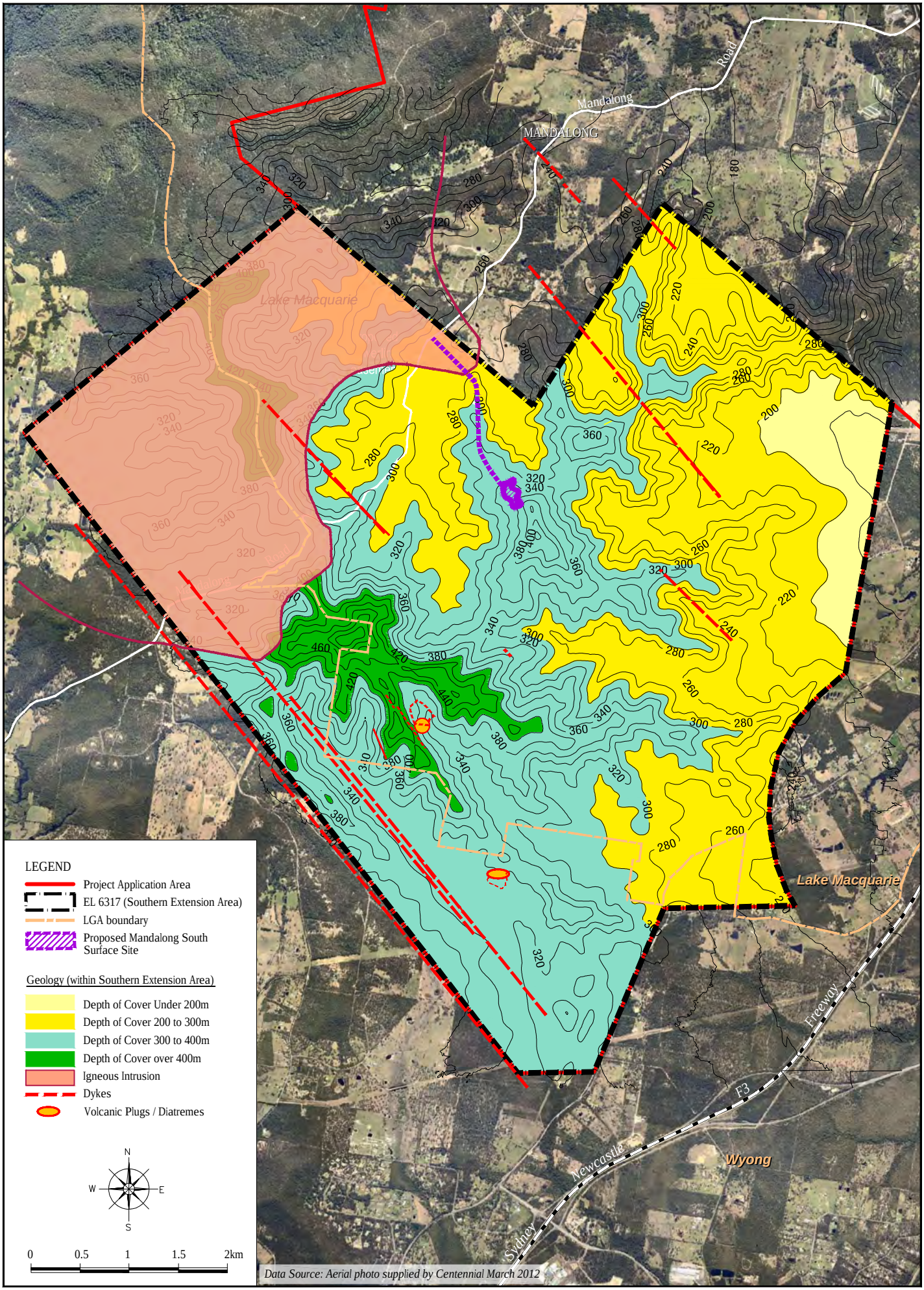
Depth of Cover

As evident on **Figure 8**, the depth of cover to the target coal seam within the Southern Extension Area generally increases to the south-west as the seam dips. It ranges from 180 metres in the north-east where the seam is it at its thinnest, to 480 metres in the south-west. The majority of the proposed mining area is at greater than 300 metres depth.

West Wallarah and Wallarah-Great Northern Seams

The coal seams occurring at the top of the Newcastle Coal Measures provide the target resource within the Southern Extension Area. As schematically illustrated on **Figure 7**, the resource section is a combination of the Wallarah Seam and some or all of the Great Northern Seam. A seam split develops within the Great Northern Seam that strikes generally north to south through the middle of the Southern Extension Area. As a result, the Southern Extension Area can be divided into two separate domains, being the western and eastern domains.

Within the western domain the Wallarah and Great Northern Seams are converged producing what is known at Mandalong Mine as the West Wallarah Seam. In the north-west extent of the western domain the West Wallarah Seam is extensively intruded by an igneous sill (see **Figure 8**). Generally, the West Wallarah Seam thins to the south-west to a minimum thickness of 3.4 metres. The seam is at its thickest, at 4.4 metres, along the northern boundary of the Southern Extension Area.



G:\Drafting\Mandalong\CCC14-009\Figures\Final\CAD\FINAL FIGS EB Report\MANDALONG EIS FIGURES\CAD (2nd External Review)\Fg8_CCC14-009_Geology_V6.dwg

To be printed A4

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Depth of Cover and Igneous Intrusion within Southern Extension Area

FIGURE 8

In the eastern domain the Great Northern Seam is affected by complex splitting and deterioration due to the development of a thick, almost north-south trending sedimentary paleochannel within the seam horizon. Along the seam split line small mudstone bands begin to develop within the Great Northern Seam. The basal plies of the Great Northern Seam begin to split from the main seam, leaving only the Wallarah Seam and top ply of the Great Northern Seam as the resource section. To the east of the split the lower plies of the Great Northern Seam diverge and deteriorate sitting between 8 and 10 metres below the resource section and thin from 1 metre down to 0.2 metres.

The resource section in the eastern domain, known locally as the Wallarah-Great Northern Seam, regionally thins to the north-east. The seam ranges in thickness between 3.1 metres in the very south to less than 1.6 metres in the north. The seam deteriorates to the east with further splitting occuring along the north-eastern boundary.

Coal Quality

Centennial Mandalong's exploration drilling program in the Southern Extension Area (EL 6317) identified economic coal reserves within the West Wallarah Seam and the Wallarah-Great Northern Seam that are high in heat energy and low in ash content, making the coal ideal for electricity generation.

The Wallarah-Great Northern Seam generally contains higher quality coal than the West Wallarah Seam. Raw ash content (air dried basis) of the West Wallarah Seam ranges between 15 and 19 percent, while raw ash content of the Wallarah-Great Northern seam ranges between 13 and 18 percent, with the majority being less than 16 percent.

The quality of the West Wallarah Seam in the Southern Extension Area is comparable to the quality seen within the existing Mandalong Mine, if not slightly better. The coal quality in the current workings decreases to the west with raw ash content increasing to greater than 20 percent. This trend is not seen in the Southern Extension Area due to the presence of the sill.

2.10 Hydrology

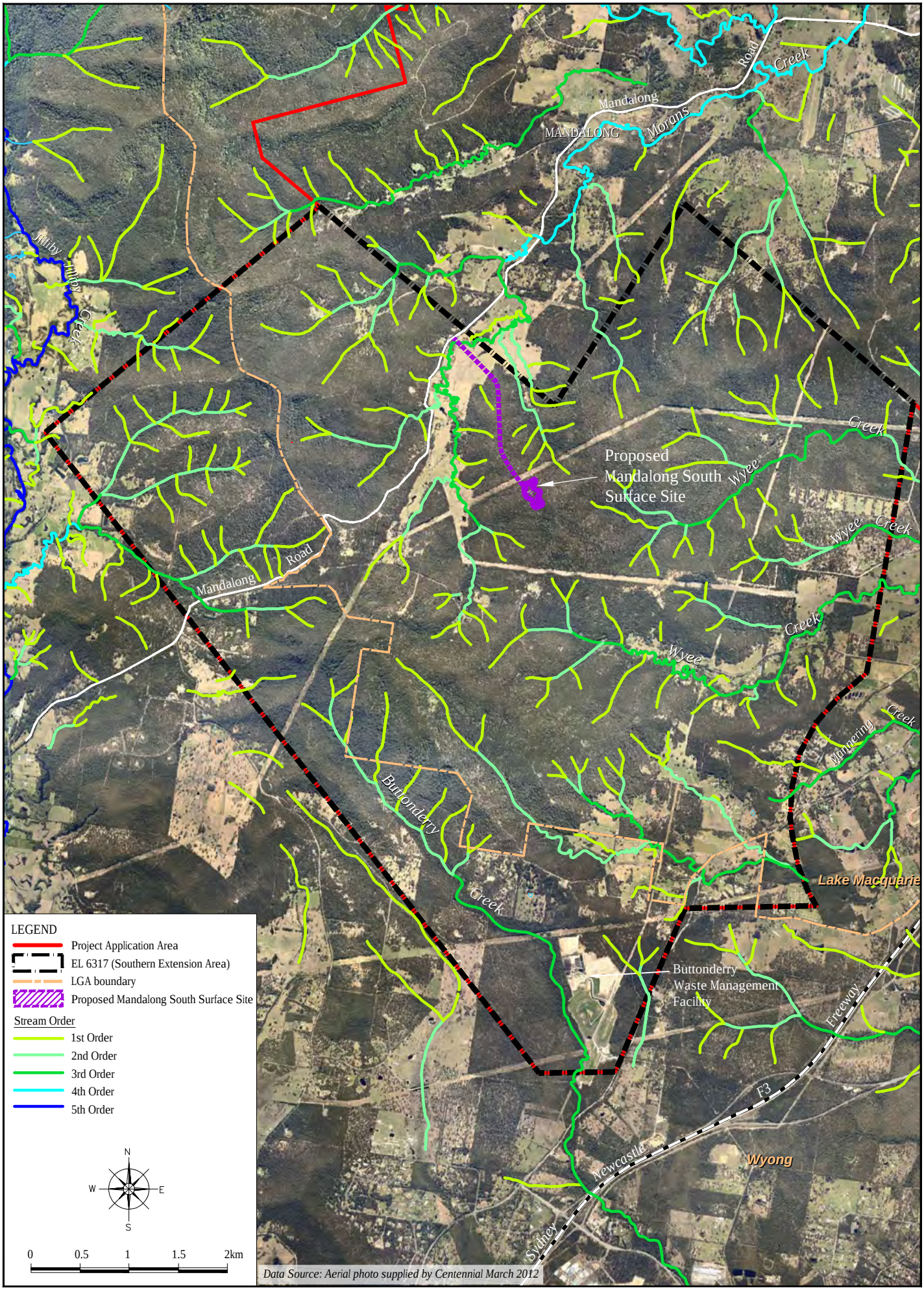
Lake Macquarie, being the dominant natural feature in the area, extends into the north-eastern extent of the Project Application Area. Dora Creek, which is a major tributary of Lake Macquarie, also flows into the north-eastern extent of the Project Application Area.

The following is a summary of the existing surface water environment within the Southern Extension Area, including catchment areas and watercourses, flooding and downstream water users, as detailed in the *Surface Water Assessment* (Umwelt 2013) prepared for the Project.

2.10.1 Catchment Areas and Watercourses

The Southern Extension Area lies predominantly within the catchment of Lake Macquarie, with the southern portion within the Wyong River catchment. The Southern Extension Area intersects five sub-catchment areas, these being Morans Creek, Wyee Creek and Mannering Creek flowing to Lake Macquarie, and Buttonderry Creek and Jilliby Jilliby Creek flowing to the Wyong River (see **Figure 9**).

In characterising the watercourses in the area, Umwelt (2013) referred to the Strahler stream classification system as presented in the *Management of Stream / Aquifer Systems in Coal Mining Developments, Hunter Region* (Department of Infrastructure, Planning and Natural Resources (DIPNR) 2005). Watercourse ordering is a hierarchical numbering system based on the degree of branching within a waterway and provides an indication of the complexity of a creek system. The Strahler ordering system begins at the origin of a waterway, the initial watercourse being a first order watercourse.



G:\Drafting\Mandalong\CCC14-009\Figures\Final\CAD\FINAL FIGS EB Report\MANDALONG EIS FIGURES\CAD (2nd External Review)\Fg9_CCC14-009_SurfHydrology_V4.dwg

To be printed A4

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Surface Hydrology within Southern Extension Area

FIGURE 9

DIPNR (2005) classifies waterway orders into three schedules linked to their ordering:

- Schedule 1 are usually intermittent and consisting of first or second order waterways;
- Schedule 2 are third and higher order waterways that drain into primary catchment rivers; and
- Schedule 3 are major rivers, including their primary tributaries and associated alluvial groundwater zones.

Key characteristics of each of the catchment areas within the Southern Extension Area are summarised in **Table 5**.

Table 5 – Sub-Catchment Areas

Catchment	Sub-Catchment	Schedule (Order)[1]	Catchment Area (ha)	
			Total	Southern Extension Area
Lake Macquarie	Morans Creek	2 (3rd)	2,930	1,274
	Wyee Creek	2 (3rd)	1,522[2]	1,216
	Mannering Creek	2 (3rd)	990[2]	639
Wyong River	Buttonderry Creek	2 (3rd)	634[2]	505
	Jilliby Jilliby Creek	2 (3rd)	~ 10,000	661

1 - DIPNR (2005)

2 – Total catchment area upstream of the Sydney-Newcastle F3 Freeway

Morans Creek

Morans Creek, located in the Lake Macquarie catchment, flows in an approximately north-easterly direction through the Southern Extension Area before flowing into Stockton Creek approximately 4 kilometres north of the Southern Extension Area. Stockton Creek subsequently flows into Dora Creek west of Morisset, which flows into Lake Macquarie. Approximately 1,274 hectares (43 percent of the total catchment area) of Morans Creek lies within the Southern Extension Area. Existing ponding areas were observed during June 2011, primarily within second order tributaries of Morans Creek.

In contrast to the sections of Morans Creek in the vicinity of the approved Mandalong Mine, the portion of the Morans Creek catchment area within the Southern Extension Area is predominantly well forested, with sandy soils and some rocks. The soil landscapes within the Morans Creek catchment include Watagan and Mandalong soil landscapes within upper slope areas, Gorokan soil landscape within the footslope areas and Yarramalong and Wyong soil landscapes within the floodplain area (see **Figure 6**).

Plate 1 – Typical Section of Morans Creek Catchment Area

Wyee Creek

Wyee Creek generally flows in an easterly direction to the north of Wyee before flowing into Mannering Bay at the southern end of Lake Macquarie. Three third order branches of Wyee Creek lie within the Southern Extension Area, with the southernmost branch (see **Figure 9**) having the clearest defined bed and banks of the three branches. The catchment area of Wyee Creek within the Southern Extension Area is approximately 1,520 hectares (80 percent of the catchment area upstream of the Sydney-Newcastle F3 Freeway).

The catchment areas of Wyee Creek range from well forested with medium to large trees, thin underscrub and minimal groundcover within the upper catchment areas, to areas largely cleared for use as livestock pasture within the lower catchment areas. Approximately 72 hectares of Olney State Forest lies within the catchment area of Wyee Creek. The soil landscapes within the Wyee Creek catchment include Watagan and Mandalong soil landscapes within upper slope areas, Gorokan soil landscape within the footslope areas and Yarramalong and Wyong soil landscapes within the floodplain area.

Mannering Creek

Mannering Creek generally flows in an easterly direction before being intercepted upstream of Mannering Dam east of Wyee and diverted into Wyee Creek to the north by way of a diversion drain downstream of the Southern Extension Area. The diversion is intended to prevent the flow of clean water into Mannering Lake, which is currently used as an ash dam for Vales Point Power Station.

The catchment area of Mannering Creek within the Southern Extension Area is approximately 639 hectares (65 percent of the total catchment area). The catchment ranges from well forested with medium to large trees, thin underscrub and minimal groundcover to areas largely cleared for use as livestock pasture. The forested areas are generally located within the upper catchment areas, including a portion of the Olney State Forest. The soil landscapes within the Mannering Creek catchment include Watagan, Mandalong and Woodbury's Bridge soil landscapes within upper slope areas, Gorokan soil landscape within the footslope areas and Wyong and Doyalson soil landscapes within the floodplain area.

Plate 2 – Typical Section of Mannering Creek

Buttonderry Creek

Buttonderry Creek flows in a southerly direction to the west of WSC's Buttonderry Waste Management Facility, and flows into the Wyong River approximately 6 kilometres south of the Southern Extension Area. Approximately 505 hectares (80 percent of the total catchment area) of Buttonderry Creek lies within the Southern Extension Area.

Within the Southern Extension Area, the catchment is predominantly forested with a thick canopy of medium-sized trees with minimal underbrush. The soil landscapes within the Buttonderry Creek catchment include Watagan, Mandalong and Woodbury's Bridge soil landscapes within upper slope areas, Gorokan soil landscape within the footslope areas and Wyong soil landscapes within the floodplain area.

Jilliby Jilliby Creek

Jilliby Jilliby Creek flows in a southerly direction west of the Southern Extension Area. Whilst the main fifth order channel lies outside of the Southern Extension Area, three second order tributaries and a section of a third order tributary lie within the western portion of the Southern Extension Area, with a catchment area within the Southern Extension Area of approximately 660 hectares (approximately 7 percent of the total catchment area).

The catchment is predominantly forested, including approximately 385 hectares of Olney State Forest. The lower slopes are typically pasture improved for animal grazing. The upper slopes of the Jilliby Jilliby Creek catchment include Watagan, Mandalong and Woodburys Creek soil landscapes, with the lower slopes including Gorokan and Yarramalong soil landscapes.

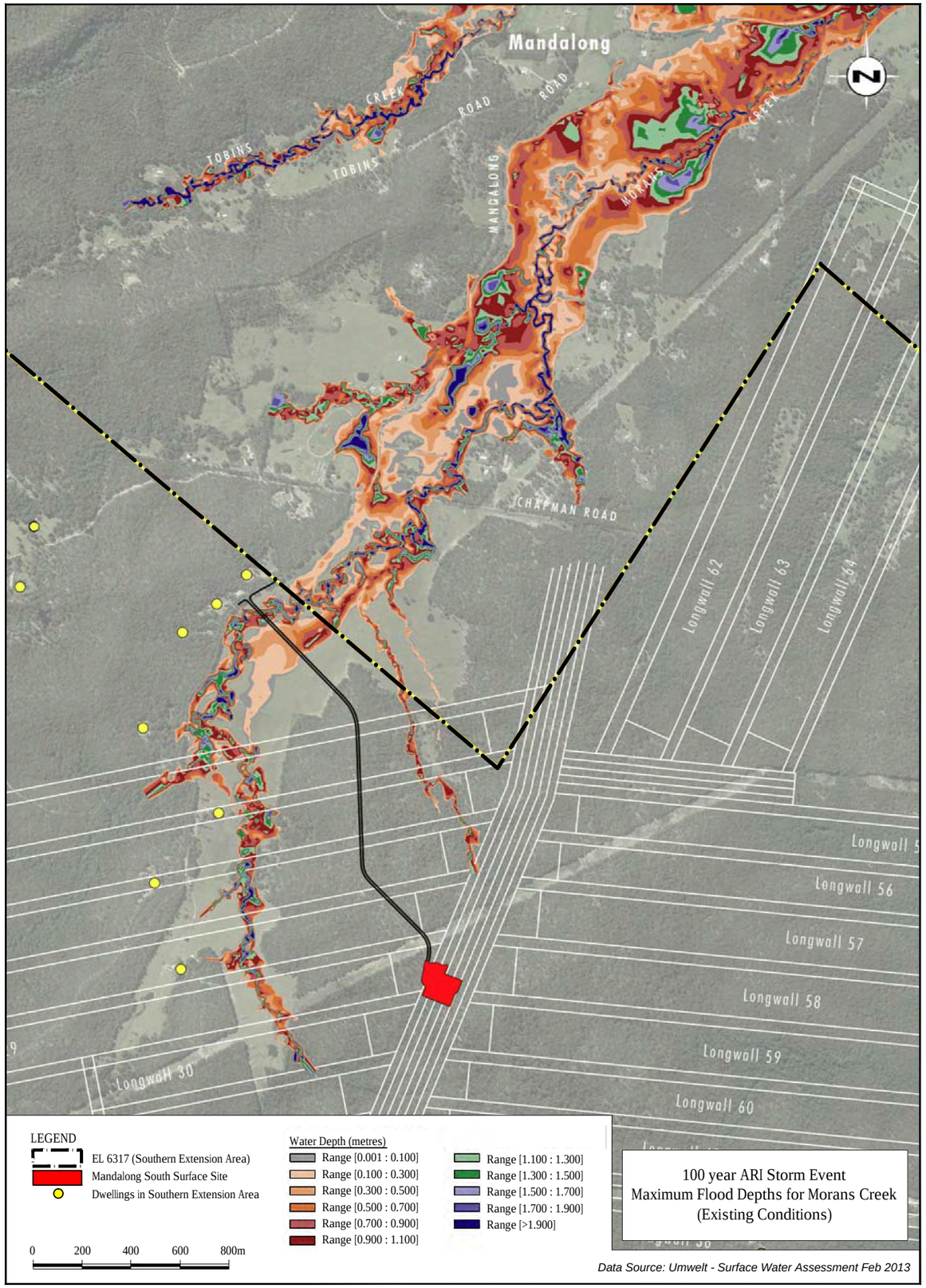
2.10.2 Flooding

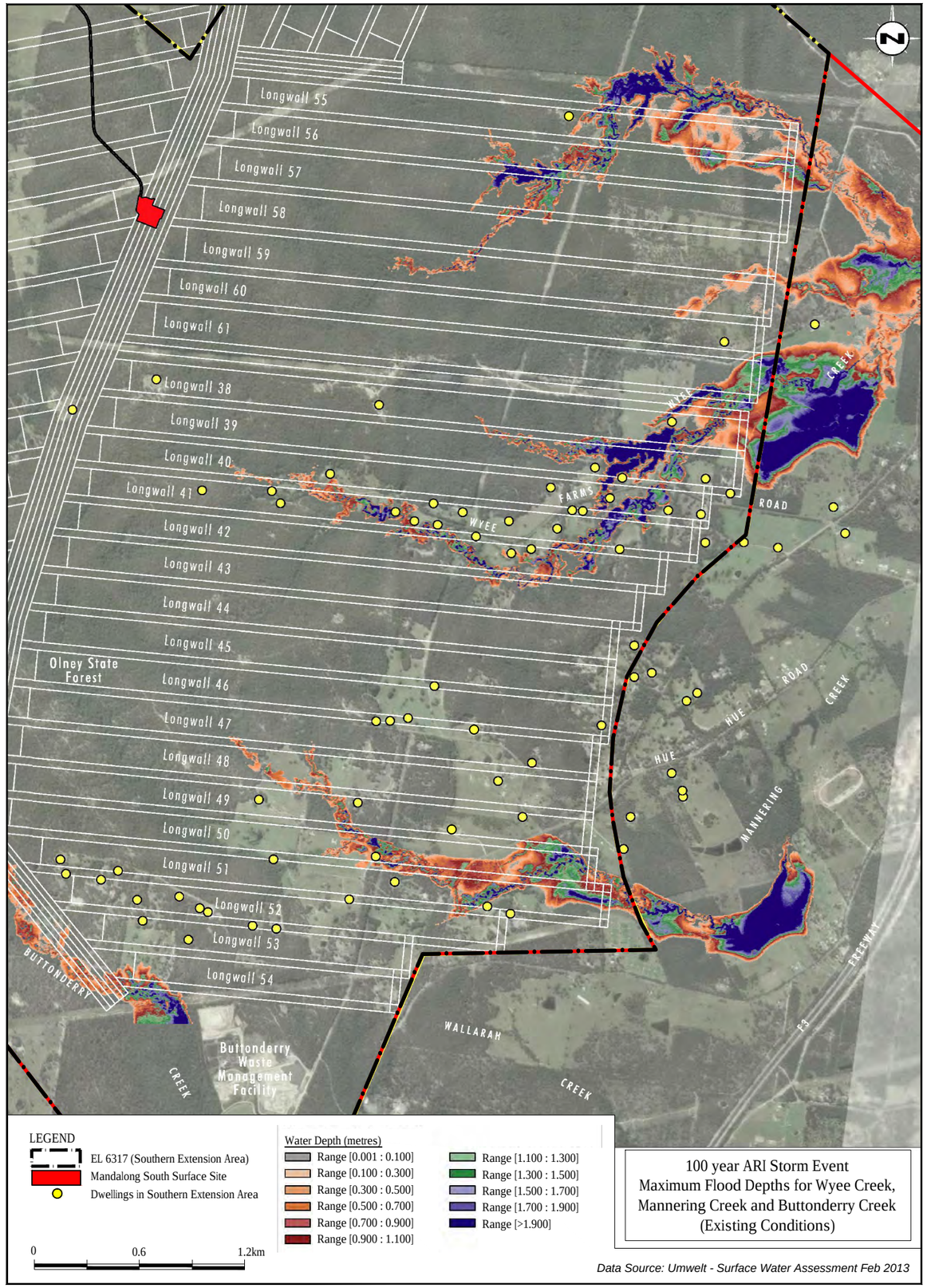
Hydrodynamic flood models were used by Umwelt (2013) to estimate the flood response of the existing conditions of six watercourses within the Southern Extension Area for several design storm events. **Figure 10** illustrates that the maximum modelled 100 year Average Recurrence Interval (ARI) storm event flood depths for the existing conditions in Morans Creek and the three tributaries of Wyee Creek, Mannering Creek and Buttonderry Creek within the Southern Extension Area. The upper reaches of Jilliby Jilliby Creek are typically first and second order watercourses (i.e. Schedule 1) within the Southern Extension Area and therefore were not included in the hydraulic modelling.

Anecdotal evidence, in addition to historical flood reports (Hughes Trueman 2004, cited in Umwelt 2013), indicates that the Mandalong area has a history of flooding.

2.10.3 Downstream Water Users

Umwelt (2013) advises that the watercourses within the Southern Extension Area are ephemeral, with periods of limited or no flow during periods of low rainfall. The ephemeral nature suggests that dependence of downstream agricultural users on flows within these watercourses is likely to be limited. See **Section 6.6.5** for information regarding the water sharing plans that apply to the Southern Extension Area.





G:\Drafting\Mandalong\CCC14-009\Figures\Final\CAD\FINAL FIGS EB Report\MANDALONG EIS FIGURES\CAD (2nd External Review)\Fg10_CCC14-009_PreMineFloodLev100_V4.dwg

To be printed A3

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Pre-Mining Flood Levels (100 Year ARI Event)

FIGURE 10