Wallarah 2
COAL PROJECT

Wallarah 2 Coal Project

Environmental Impact Statement

April 2013

Appendix C

Geology Report

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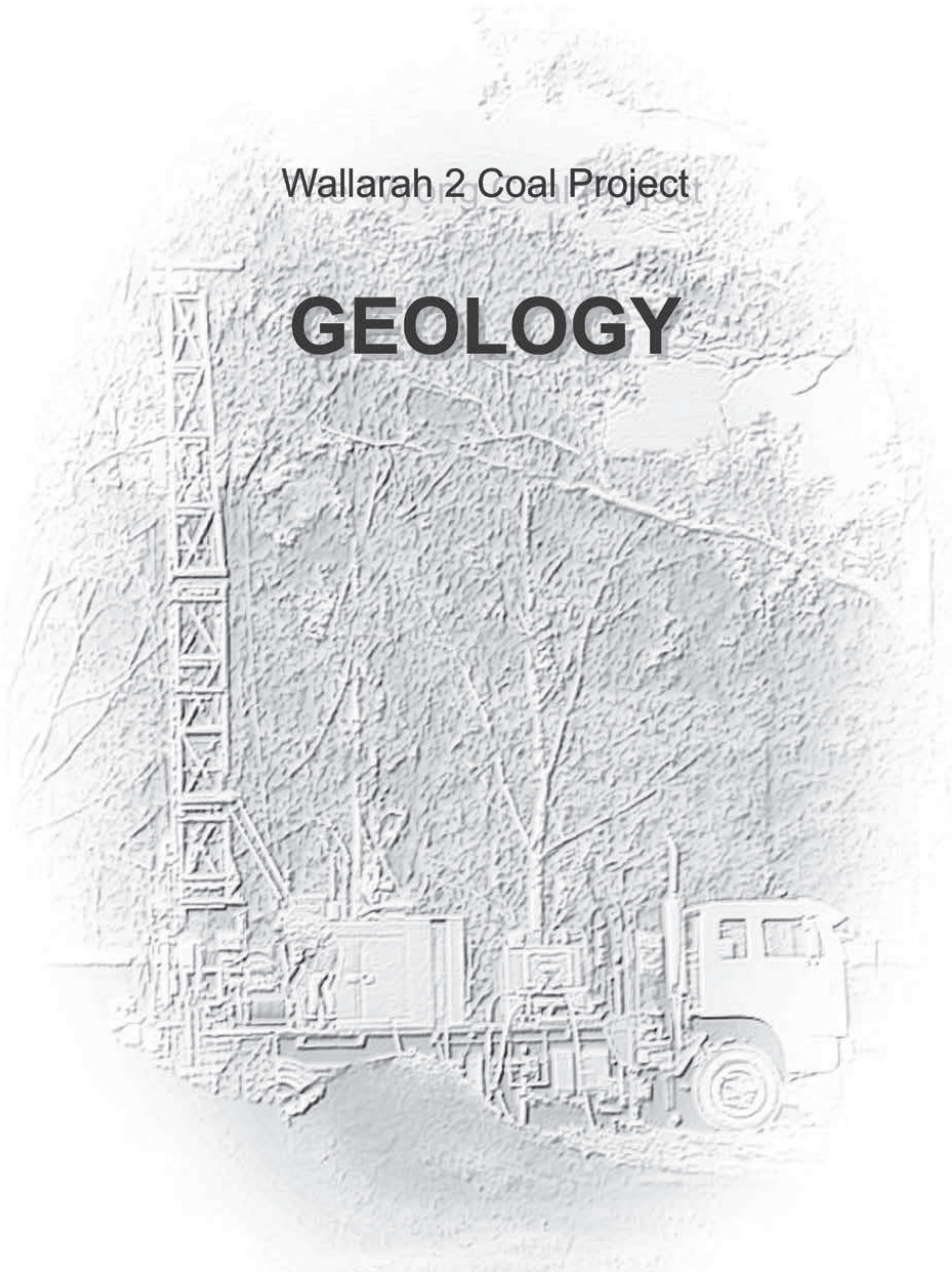
ENVIRONMENTAL CONSULTANTS

Wallarah 2 Coal Project

GEOLOGY



Wyong Areas Coal Joint Venture

February 2013

Wallarah 2 Coal Project
Geology Report

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Glossary & List of Abbreviations

ACARP	Australian Coal Association Research Program
ad	air dried
ar	as received
AHD	Australian Height Datum
AWT	Awaba Tuff
CCS	Central Channel Split Seam
daf	dry ash free
ESS	Eastern Split Seam
ETS	Eastern Thick Seam
F.L.A.C.	Fast Langrangian Analytical Computing
FAS	Fassifern Seam
kcal/kg	kilocalories per kilogram
km	kilometres
km^2	square kilometres
kPa	kilopascals
m/day	metres per day
MJ/kg	Megajoules per kilogram
MPa	megapascals
GPa	Gigapascals
GTN	Great Northern Seam
HQ	Nominal size drill rods 96mm
JORC	Joint Ore Reserves Committee
LAS	Log ASCII Standard
LIC	Land Information Centre
L/s	Litres per second
m	metres
m^3/t	cubic meters per tonne
Mini Sosie	
mm	millimetres
NATA	National Association of Testing Authorities
PTA	Primary Target Area
RD	Relative Density
RQD	Rock Quality Designation
R.L.	Relative Level
SCT	SCT Operations Pty Ltd
SE	specific energy
t	tonnes
The Project	Wallarah 2 Coal Project
TD	Total Depth
UCS	Uniaxial Compressive Strength
VPT	Vales Point Seam
VULCAN	Unix based computer system
WAL	Wallarah Seam
WCP	Wyong Coal Project
WGN	Wallarah Great Northern seam combined
WSS	Western Split Seam
WTS	Western Thick Seam
XRD^2	X-Ray Diffraction

Prepared By Wyong Areas Coal Joint Venture

For Wallarah 2 Coal Project

1. LOCATION

The Wallarah 2 Coal Project (the Project) is located on the east coast of New South Wales, approximately 70 kilometres south of Newcastle and 80 kilometres north of Sydney (**Figure 1.1**). A number of collieries to the north of the Project currently mine the Wallarah, Great Northern and Fassifern coal seams.

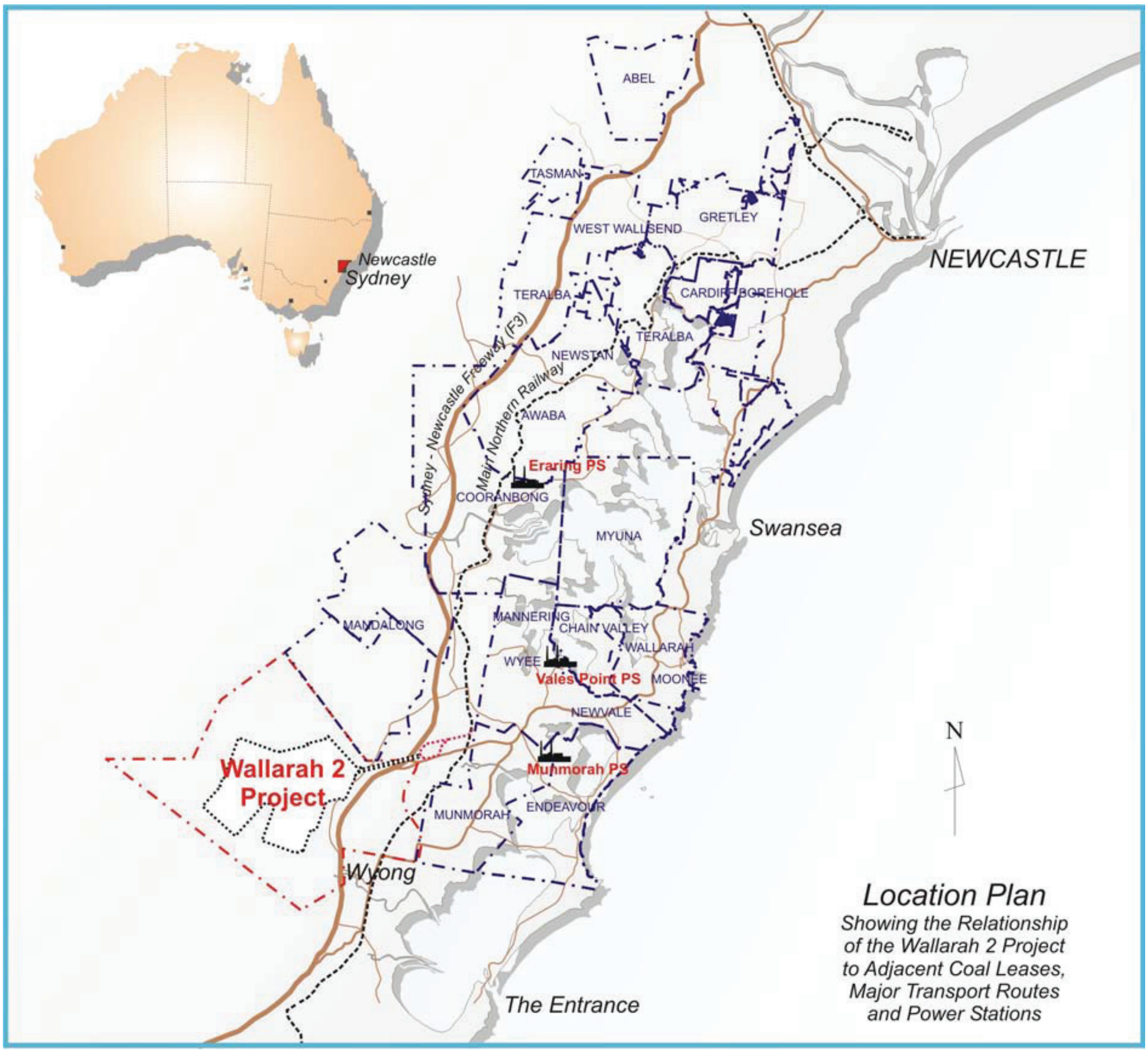

Figure 1.1 Project Location

The Project lies mainly west of the Main Northern Railway (Sydney to Newcastle) and the Sydney – Newcastle Freeway (F3 Freeway), extending from Tuggerah in the south to Dooralong in the north (**Figure 3.1**). Two significant floodplains, the Dooralong and Yarramalong Valleys, traverse the area. The Dooralong Valley is a broad, flat, low-lying region occupied by small farms and two villages (Jilliby and Dooralong). Yarramalong Valley is similar to Dooralong Valley, but much narrower, and includes the village of Yarramalong to the west of the Project.

The land adjacent to both valleys rises steeply in the order of 150 metres. The Wyong and Olney State Forests have largely been subsumed by the Jilliby State Conservation Area (JSCA) which occupies most of the land between these valleys and to the north-west of the Project. The north-eastern area is mostly undulating to steep, privately owned, rural land. A number of small-acreage semi-rural subdivisions have been developed immediately west of the Sydney-Newcastle Freeway, north of Wyong, including the Hue Hue area which is partly within the Project Boundary.

2. CONVENTIONS

2.1 SURVEY

The New South Wales Integrated Survey Grid (ISG) and Australian Height Datum (AHD) were utilised for all survey control. All boreholes are located using GPS survey equipment operated by registered surveyors and are reported relative to ISG and AHD. Accuracy conforms to Class 'C' as per the "Manual of the New South Wales Integrated Survey Grid".

2.2 BOREHOLE NAMING

The borehole naming convention adopted for the project reflects the coordinates of each borehole's planned grid position. All borehole names have a maximum length of eight characters. The first 4 characters represent the easting of the grid position and the last 4 characters represent the northing. Easting and northing ISG values are divided by 10. The remaining last three digits are then preceded by a letter representing the leading digits. **Table 2.1** gives examples of this naming convention.

Table 2.1 Borehole Naming Convention

ISG Easting Range	Alpha Character	ISG Northing Range	Alpha Character
32000(0)-33000(0)	A	130000(0)-131000(0)	U
33000(0)-34000(0)	B	131000(0)-132000(0)	V
34000(0)-35000(0)	C	132000(0)-133000(0)	W
		133000(0)-134000(0)	X
Grid Position Examples:-			
Grid Easting	Grid Northing	Borehole name	
327000	1324000	A700W400	
330000	1320000	B000W000	
336500	1324500	B650W450	
344500	1308000	C450U800	

2.3 COAL SEAM SUBDIVISION NAMING

Following detailed correlations of borehole intersections, 14 coal plies, each in the order of 0.5 metres thick, were defined for the Vales Point, Wallarah and Great Northern Seams. These plies can be identified within the Project Boundary (**Figure 2.1**). An alphanumeric naming system has been adopted with odd numbers being used for stone bands and even numbers for coal plies, e.g., A6 is a coal ply underlain in most areas by the A7 stone band. A further 13 plies have been defined for the generally uneconomic Fassifern Seam; some of the lower Fassifern plies may actually equate to parts of the Upper Pilot Seam.

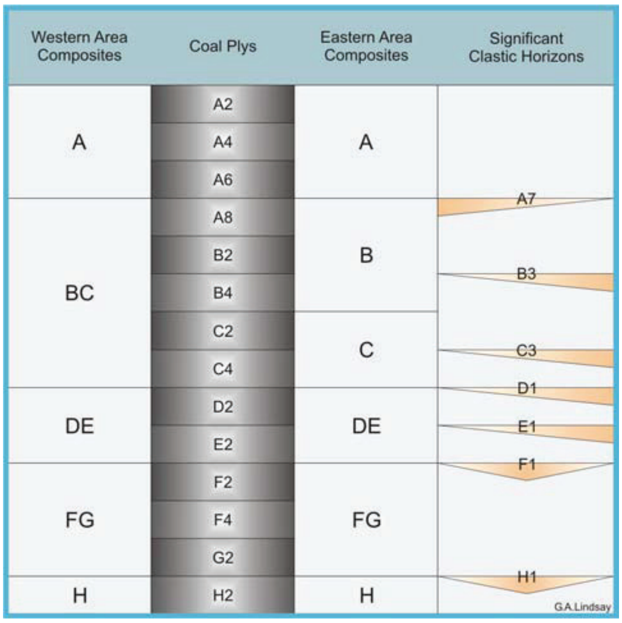

Figure 2.1 Wallarah – Great Northern Seam Naming Convention

3. TENURE

In 1994 the then New South Wales Minister for Mineral Resources invited companies to tender for the right to explore for coal in two areas near Wyong (the Wyong Coal Development Areas). The Wyong Areas Coal Joint Venture (WACJV) was granted the right to explore the areas in October 1995. The Wyong Coal Development Areas incorporated three Exploration Licences, A405 and EL4911 covering the Western Area (including the area now covered by the Project) and EL4912 covering the Eastern Area, a total area of approximately 280 km^2 (refer to **Figure 3.1**). An additional exploration licence, EL 5903, was granted on 1 November 2001 to facilitate the assessment of potential connecting underground workings. EL 5903 encompasses a small area between the Eastern and Western Areas (Refer to **Figure 3.1**).

A405 was originally included in A254 (held by the New South Wales Department of Mineral Resources) which was split in 1988 into A404 (to the north) and A405. At the time of granting in 1995, A405 covered an area of 114.5 km^2. As a result of transfers and relinquishment of areas since that time, A405 has been substantially reduced in size to 42 km^2. EL4911 was originally part of A255 held by the Electricity Commission of New South Wales which explored for resources for the previously proposed Mardi Power Station. EL4911 was originally 99.5 km^2 at the time of granting in 1995. As a result of relinquishment of areas since that time, EL4911 has been reduced in size to 92 km^2. Exploration activities are reported to the New South Wales Division of Minerals and Energy on an annual basis.

Negotiations were successfully undertaken with more than 100 individual landowners to access and explore on their properties, including drilling and seismic testing. Virtually all land required for the development of surface facilities has already been purchased by the company.

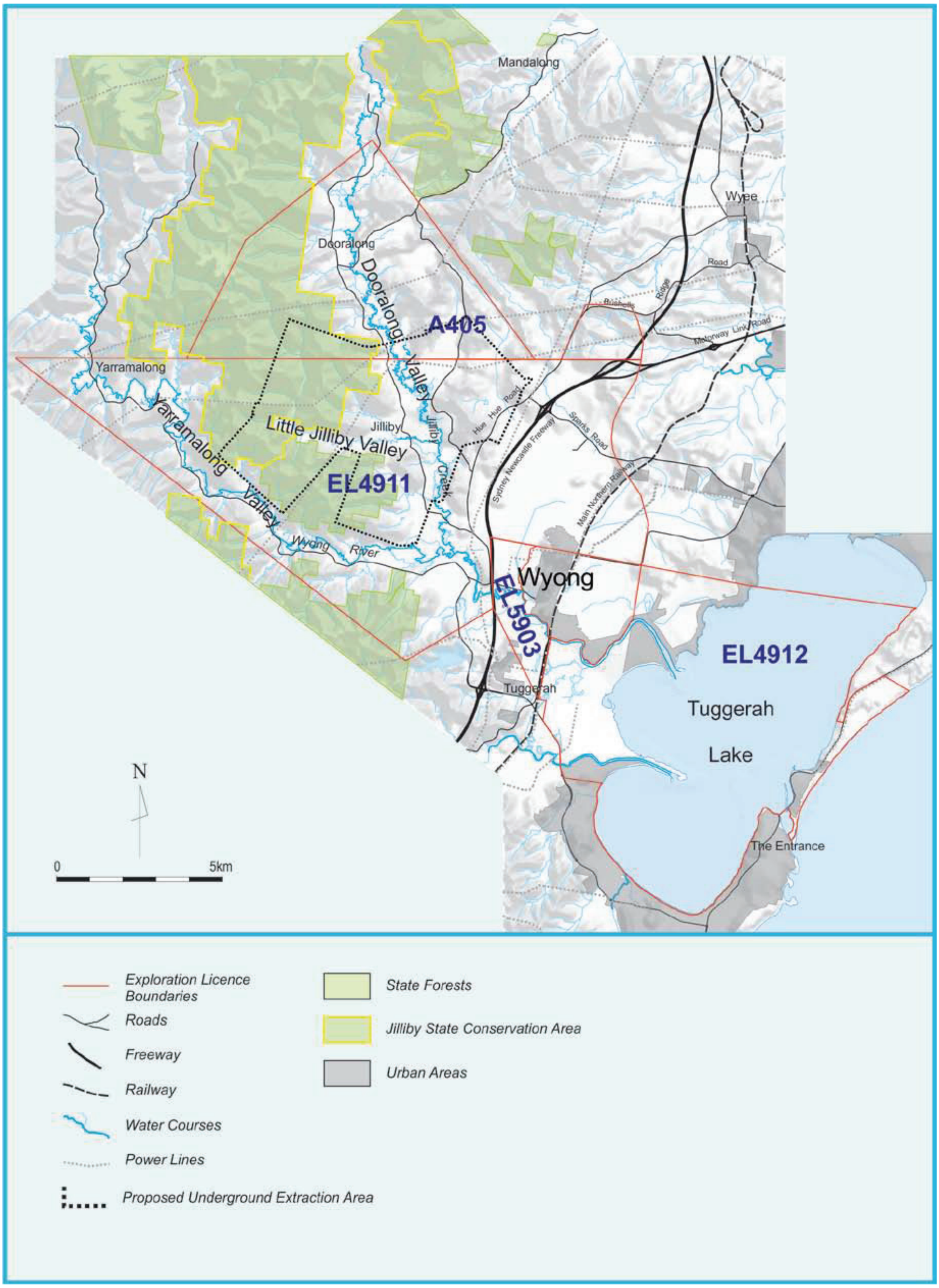

Figure 3.1 Exploration Licences

4. REGIONAL GEOLOGY

The Project is located within the north-eastern margin of the Sydney Basin and in the southern part of the Newcastle Coalfield (see **Figure 4.1**). The coal resources are contained within the upper part of the Permian Newcastle Coal Measures. These strata outcrop to the north and north-east of the area and dip gently to the south-west beneath the exploration area at grades of 1 in 30 to 1 in 50. Depth of cover to the uppermost coal seam ranges from 200 metres in the north-east to 680 metres in the south-west

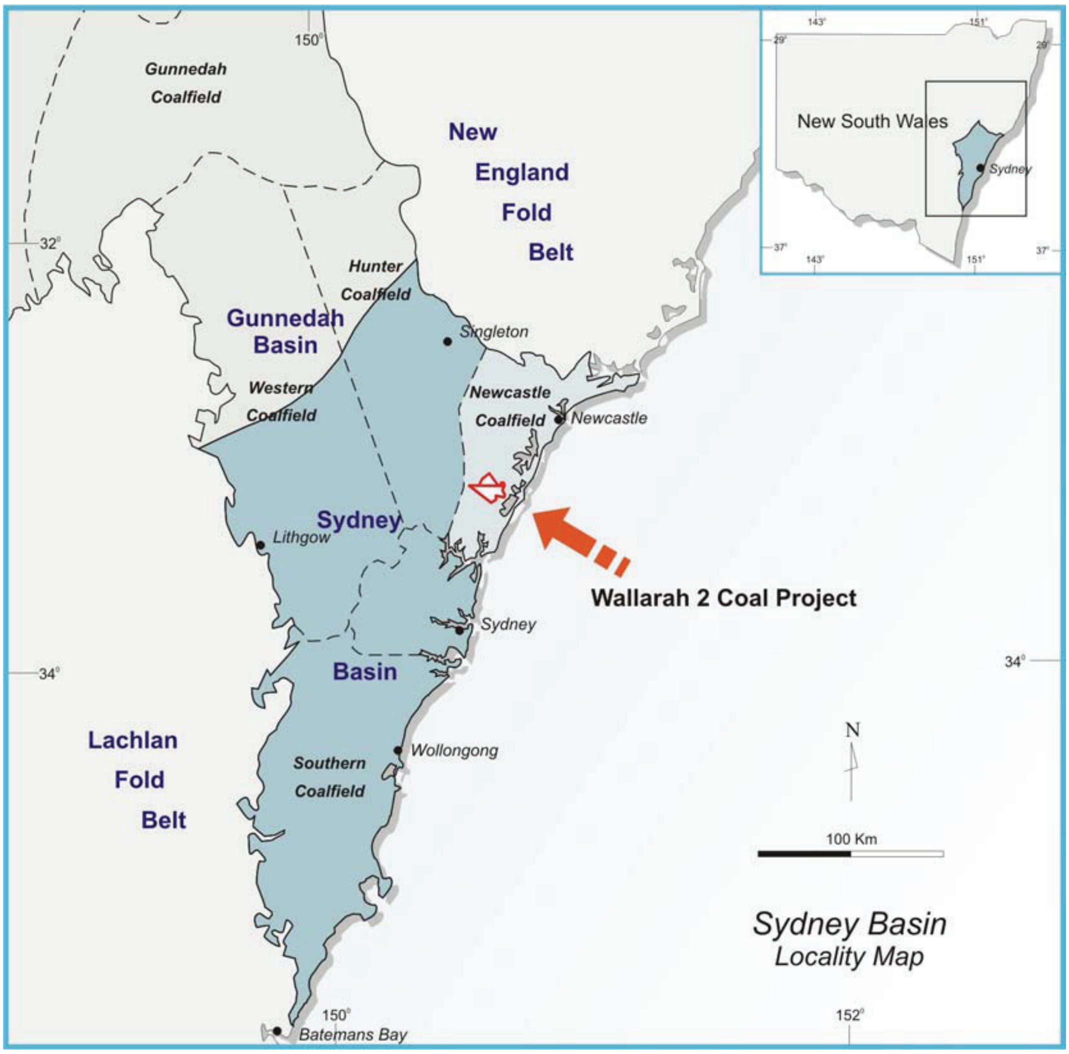

Figure 4.1 Sydney Basin

Previous exploration programmes have indicated that the only seams of significant economic potential within the area are the uppermost seams of the Newcastle Coal Measures, namely the Vales Point (VPT) Wallarah (WAL) and Great Northern (GTN) Seams in various combinations (combined seam WGN). The underlying Fassifern Seam (FAS) has little to no potential, generally being too thin because of splitting in all but limited areas. All other lower seams generally occur at depths and thicknesses that render them uneconomic. This Project has only investigated seams down to the Fassifern Seam.

The Newcastle Coal Measures are overlain by the Triassic Narrabeen Group, which outcrops across the area being explored (**Figure 4.2**). The lowermost strata of the Narrabeen Group is the Dooralong Shale which consists of between 50 and 70 metres of shales and laminites; this sequence coarsens upwards to contain beds of pebbly sandstone. The overlying Munmorah Conglomerate is generally 70 to 80 metres thick and consists of coarse and pebbly sandstones with occasional green-grey shales. Neither of these sequences outcrop in the exploration area. Outcropping in the north-east of the area is the Tuggerah Formation, a 200 metre thick sequence of sandstones with minor siltstones and rare conglomerates. The Patonga Claystone, which consists of 80 to 110 metres of interbedded grey-green and red-brown claystones and minor fine-grained sandstones commonly outcrops in the lower, more undulating areas through the Yarramalong and Dooralong Valleys. The uppermost strata of the Narrabeen Group in the area belong to the Terrigal Formation and consist of sandstones and minor siltstones. This sequence occurs through the more elevated zones of the south-western half of the Project Boundary, which is typically covered by state forests. Unconsolidated Quaternary silts and sands occur as fill along the Yarramalong and Dooralong Valleys and throughout Tuggerah Lake. Thicknesses of up to 50 metres have been recorded.

Two broad synclines, which are recognised regionally, traverse the area within the Project Boundary. The Macquarie Syncline traverses the western edge of Tuggerah Lake (east of the Project Boundary) in a north-easterly direction. The Yarramalong Syncline traverses the extreme western edge of the Project Boundary in a similar orientation. These structures are well documented in the literature and clearly defined on the Newcastle Coalfield Regional Geology sheet (NSW Dept Mineral Resources, 1995). The extensive, detailed exploration undertaken as part of this Project has confirmed the existence and location of these synclines whilst conversely providing no support for the “Coastal Lineament” proposed by Mauger et al (1985) or the “Northern Geosciences Faults” proposed by Jones (2005). Regional geology and the major structural features are shown on **Figure 4.3**.

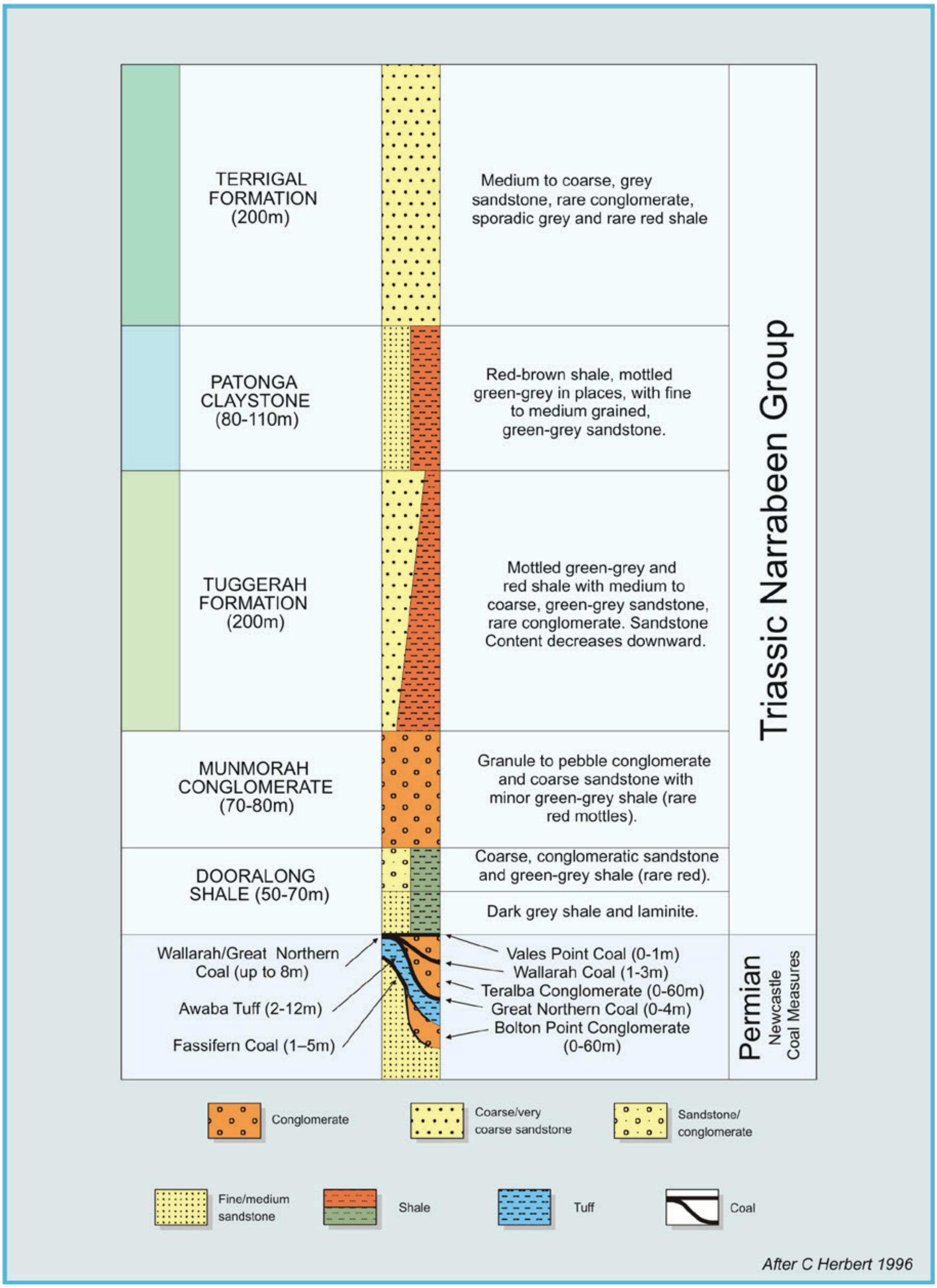

Figure 4.2 Generalised Stratigraphic Column

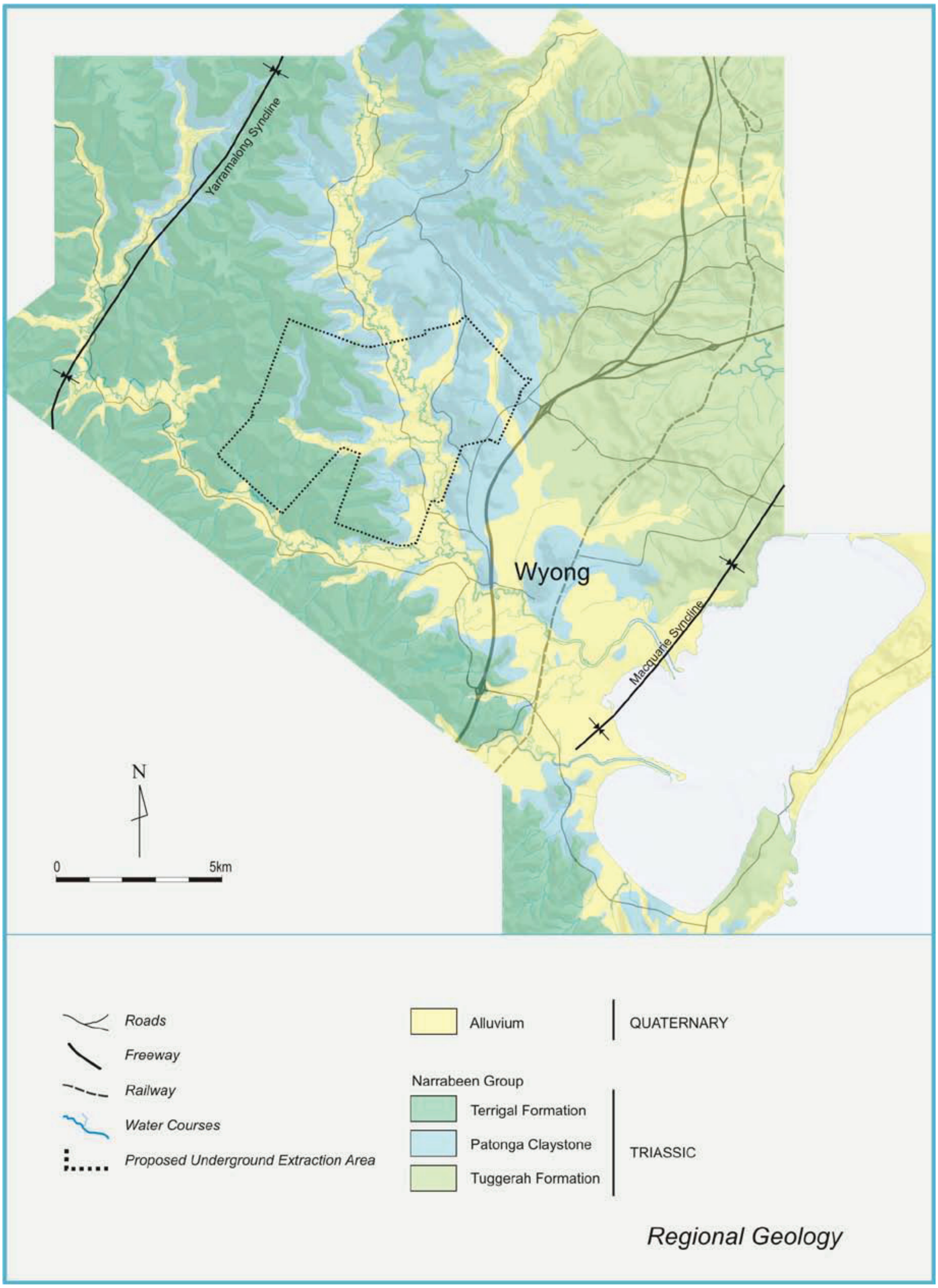

Figure 4.3 Regional Geology

5. EXPLORATION HISTORY

Twelve separate exploration programmes have been undertaken in the Wyong region since the first drilling was undertaken in 1882. Targets varied from determination of regional structure for oil and gas exploration, to regional assessment of the coal resources of the Newcastle Coal Measures and ultimately more detailed drilling to determine potential reserves of energy coal for planned power stations. Results from 96 pre-existing boreholes formed part of an information package supplied to all companies who tendered for the right to explore the Wyong Coal Development Areas in 1994. Just over half of these boreholes are located within the Project Boundary.

The Department of Mines drilled the earliest boreholes in the Wyong area in 1882. These boreholes confirmed the presence of coal at depth. No further drilling activities are recorded until 1957 when Australian Oil & Gas Corporation completed three boreholes.

During the period from 1960 to 1968, the Electricity Commission of New South Wales (Elecom) drilled 20 boreholes in the Wyong area (11 within the Eastern Area). These boreholes were designed to examine the continuation of energy coal resources in the WAL, GTN and FAS Seams that were being mined to supply coal to the nearby Vales Point and Munmorah Power Stations.

Between 1973 and 1982 several drilling programmes were conducted by the Department of Mineral Resources and the Joint Coal Board to explore the coal resources of the entire Newcastle Coal Measures. Seventeen boreholes were drilled for a total of 10,159 metres.

Due to the potential energy coal reserves contained within the WAL and GTN Seams in the immediate Wyong area, Elcom carried out a large drilling programme of 46 boreholes (24,533 metres) between 1981 and 1986 with the view of developing a major mine-mouth power station complex. During this same period, the New South Wales Department of Mineral Resources conducted several small programmes aimed at resource evaluation and land use conflict issues. The Australian Gas Light Company also drilled another borehole in the area to examine potential for oil and gas reservoirs.

Table 5.1 lists the programmes described above and details the boreholes and metres drilled. It also indicates the number of those boreholes falling within the current exploration area.

Historical boreholes located outside of the Project Boundary have been used in geological modelling to control edge effects and structural control. Coal quality data from historical boreholes has not been used to date because of the different basis on which analyses were performed. Within the areas of highest mining potential, boreholes have been drilled during the current project close to virtually all historical boreholes.

Table 5.1 Details of Previous Exploration

			Boreholes located within				Metres Drilled		
Drilling Programme	Bore hole Names	Year	Western Area	Eastern Area	Outside Project	Total Bore holes	Slim Core (m)	Non-Core (m)	Total (m)
Alisons - Wallarah - Dept. of Mines	ALWA 01	1882			1	1	246.30	-	246.30
Alisons - Wyong - Dept. of Mines	ALWAY01	1882			1	1	250.14	24.50	274.64
Australian Oil & Gas - Morriset	AOGM2	1957	1			1	213.1	10.67	223.77
Elecom - Vales Point	EVP11-12	1960-1961		1	1	2	645.41	-	645.41
Elecom - Ourimbah Creek	EOC1-5	1962		4	1	5	2770.51	53.22	2823.73
Elecom - Wyong	EWY1-10	1964-1966		3	7	10	4643.33	194.99	4838.32
Elecom - Tuggerah	ET1-3	1967-1968		3		3	994.66	71.81	1066.47
Dept. of Mineral Resources - Dooralong/Jilliby	DMD1/ DMJ1	1973	1		1	2	1397.19	36.88	1434.07
Joint Drilling Programme - Mandalong	JDPM1-11	1975	5		5	10	3983.97	2041.47	6025.44
Dept. of Mineral Resources - Mandalong	DMM1-3	1981			3	3	1483.13	58.20	1541.33
Dept. of Mineral Resources – Olney	DMO1	1981	1			1	444.49	12.91	457.40
Dept. of Mineral Resources - Stowe	DMST1	1982			1	1	683.32	18.89	702.21
Dept. of Mineral Resources - Wyong Land Use	DMW1-5	1981-1982	4		1	5	2486.75	40.06	2526.81
Australian Gas Light	AGL3	1982			1	1	166.01	240.00	406.01
Elecom - Tuggerah/Dooralong	ETD01-47	1981-1986	19	8	19	46	14255.57	10278.30	24533.87
Dept. of Mineral Resources - Mandalong	DMM5/6	1987	2			2	214.30	374.00	588.30
Dept. of Mineral Resources - Wyong Land Use	DMW6/8	1987	1		1	2	374.40	370.00	744.40
TOTAL			34	19	43	96	35252.58	13825.90	49078.48

6. DATA ACQUISITION

6.1 TOPOGRAPHIC AND CADASTRAL INFORMATION

Cadastral, topographic and cultural information was obtained in digital format from the New South Wales Land Information Centre (LIC). Topographic information at 10 metre contours was obtained for the entire area and more detailed 2 metre contours for smaller areas of specific interest. Topographic contours at 0.5 metres intervals were generated from ground-controlled aerial photography for the floodplains up to RL 40 m AHD as input data for flood modelling. An extensive three-dimensional database of all topographic, cadastral and cultural features covering the entire area has been produced. Land ownerships were obtained from Wyong and Lake Macquarie Shire Councils.

Aerial photography at 1:10,000 scale was conducted over the area within Project Boundary at the commencement of exploration. Airborne laser survey and photography over the Project was commissioned by WACJV in 2006 to supplement the existing significant bank of geological and spatial information held by WACJV. These images have been used for lineament and drainage analysis. Geological mapping of road cuttings and areas of suspected diatremes and dykes has been undertaken.

6.2 DRILLING AND GEOPHYSICS

Before the commencement of drilling, the entire area within the Project Boundary was covered by an aeromagnetic survey (see **Figure 6.1**). High-resolution ground magnetic surveys were then undertaken on anomalous areas particularly where access to properties had been obtained for drilling (see **Figure 6.2**); the area above the proposed drift alignment was also covered in 2007.

Exploration drilling is based on a staged grid pattern that progressively reduces the spacing of boreholes. Stage **I** comprised fully cored HQ boreholes drilled on a 2 kilometre square grid. Stage **II** involved partially cored HQ boreholes on a 2 kilometre offset grid and Stage **III** encompassed partially cored HQ boreholes to cover the area with a 1 kilometre square grid. To support mine planning, drilling on a 500 metre grid was undertaken within the area of maximum mining potential. All boreholes were geophysically logged. Geophysical probes run in boreholes included Gamma, Density, Sonic, Neutron, Induction and Dip Meter. Televiewer (acoustic scanner) and Temperature probes were run in selected boreholes. The drilling contracts called for at least 95% core recovery through coal seams. If this was not achieved, re-drilling was conducted.

Drilling for the Project commenced in June 1996. At the end of July 2002, a total of 352 HQ boreholes (excluding redrills) had been drilled. Five large diameter (200 mm) boreholes were drilled to assist coal characterisation. **Table 6.1** summarises the boreholes by area and grid. **Figure 6.2** shows the locations of boreholes drilled prior to the exploration programme for the Project and all boreholes drilled to the end of July 2002.

6.3 SEISMIC

An In-Seam Seismic Survey was conducted early in the exploration programme to test the effectiveness of installing in-seam geophones. Installations were discontinued because of poor and inconclusive results.

All subsequent seismic surveys conducted by WACJV for the Project were seismic reflection. In spite of its generally higher cost to undertake (in the order of 3 to 5 times), this technique was chosen rather than seismic refraction which was used on the Boomerang Tunnel Project to the west (Milenko and Neville, 1991) because it is more suitable for targeting much deeper anomalies (determined by the energy source) whilst achieving a much higher vertical resolution.

Seismic refraction techniques are generally employed to target near-horizontal density contrasts at depths of less than 30 metres. A typical use is to determine depth of weathering (as required by the Boomerang Tunnel Project).

A trial Reflection Seismic Survey along three 1.5 kilometre lines was completed to assess the effectiveness of three different sources. Mini SOSIE gave good resolution with minimal environmental disturbance. This allowed the seismic contractor to specifically design all future seismic undertakings to target the coal seam whose depth was well known from exploration boreholes.

The potential pit bottom area and initial longwall development area (approximately 2 kilometre x 1 kilometre) were then covered by a 3-D Mini SOSIE Seismic Survey. A total of 30 kilometres of 2-D Mini-SOSIE traverses were completed to form a rough 1 kilometre grid over the eastern half of the Western Primary Target Area (PTA) (see **Figure 6.2**). Velseis Pty Ltd was engaged to conduct all reflection seismic surveys.

Table 6.1 Exploration Drilling Summary by Grid and Area

	Boreholes Drilled					
	2km	2km Offset	1km	500m	Geotech	Total
East	13	11	23	50	1	98
West	48	39	64	99	3	253
EL5903	1	0	0	0	0	1
Total	62	50	87	149	4	352
			Redrill	Terminated	LargeD	Total
East			1	1	1	3
West			6	0	4	10
Total			7	1	5	13

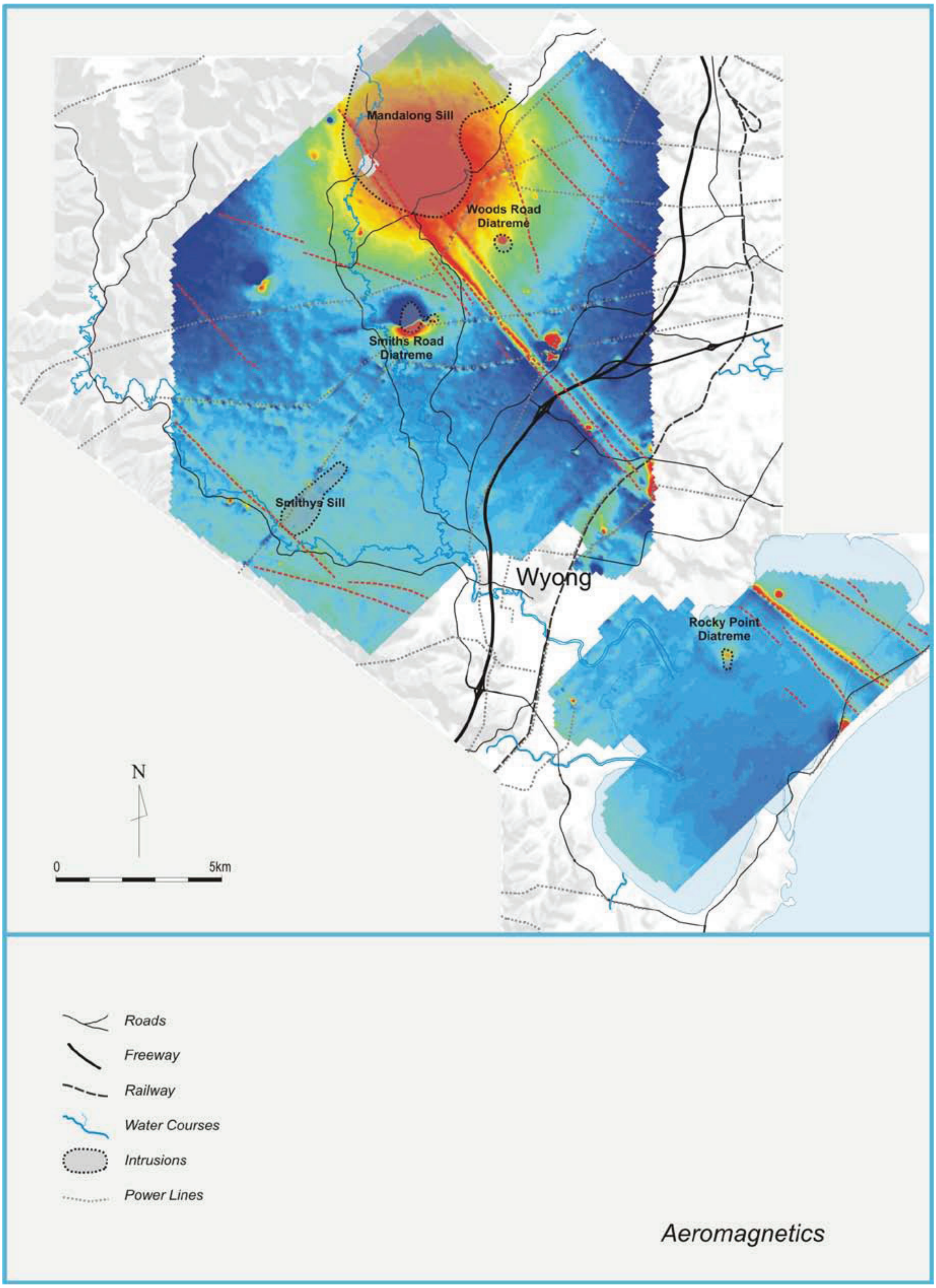

Figure 6.1 Aeromagnetic Survey

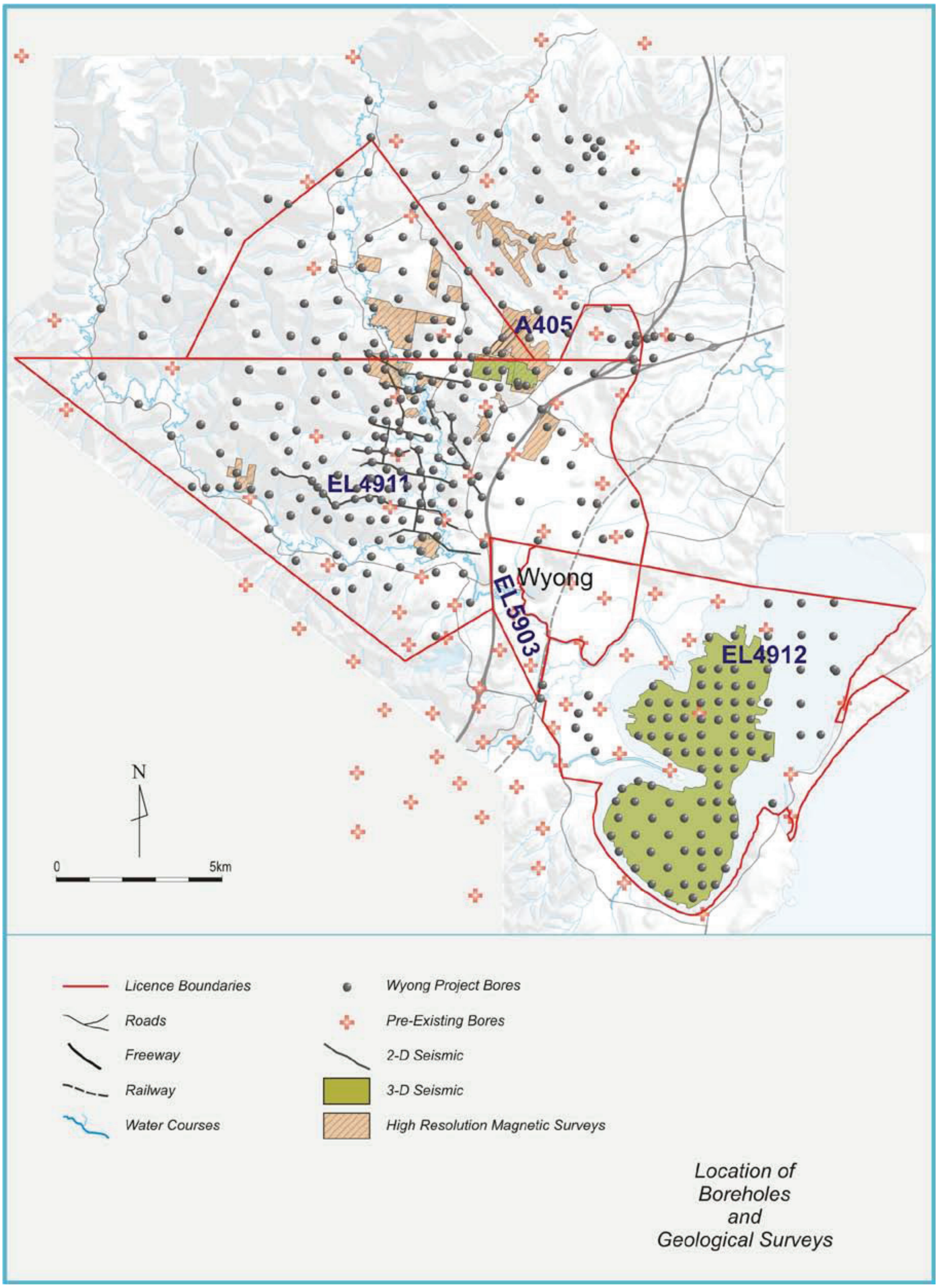

Figure 6.2 Data Acquisition

6.4 GEOTECHNICAL

A staged geotechnical appraisal was undertaken. During the first stage a number of boreholes were selected for geotechnical sampling. The purpose for this sampling procedure included:

- Floor heave and trafficability assessment;
- Roof stability, primary and secondary support design;
- Periodic weighting, wind blast and caving assessment;
- Fracturing and caving assessment;
- Subsidence-induced deformation and fracturing; and
- Potential shaft site issues.

Material was sampled from the seam floor, the immediate roof, the first 40 metres above the roof and the uppermost 140 metres of the borehole. In three boreholes, samples were taken from throughout the entire length of the borehole.

Tests conducted on these samples included:

- Uniaxial Compressive Strength (UCS);
- Triaxial;
- Slake Durability(Awaba Tuff);
- XRD[2] (Awaba Tuff); and
- Petrographic Analysis.

Sonic velocities from down-hole geophysics were examined to develop a correlation between UCS and sonic velocity.

Detailed studies were performed on six fully cored boreholes in which down-hole in situ stress and permeability tests were performed. Four different techniques, listed below in increasing order of reliability, were used to assess the stressfield:

- Assessment of borehole breakout using a 4-arm caliper (in situ);
- Core relaxation (laboratory);
- Assessment of borehole breakout using the acoustic scanner (in situ); and
- Hydraulic fracturing (in situ).

An analysis of these four techniques found that the acoustic scanner used in conjunction with rock strength measurements gave a good interpretation of the stressfield. This technique correlated well with the more expensive hydraulic fracturing technique. As a result the acoustic scanner tool was run in most 500 metre grid boreholes in an attempt to determine changes in stress direction across the area.

The second more detailed geotechnical investigation was designed to assess the stress conditions and strength characteristics of the strata with regard to their impact on:

- Roadway stability and reinforcement;
- Longwall caving and strata fracture interaction with surface aquifers;
- Subsidence; and
- Mine pillar sizes required for development and extraction operations.

This study included two-dimensional finite difference numerical modelling with the software package F.L.A.C., geotechnical sampling and stress measurements.

A major internal review and consolidation of all geotechnical investigations and testing has been undertaken. This review included:

- Analysis and interpretation of geotechnical data;
- Analysis of stress field anomalies;
- Assessment of jointing;
- Assessment of faulting.

The review process sought to:

- Assess the type, amount and distribution of data available to the project;
- Determine the extent to which various data sets have been assessed and integrated into a well cross-referenced geotechnical model on which a robust mine plan can be based;
- Provide an accumulation and synthesis of existing data into a series of databases for ongoing analyses;
- Prepare a scope of work required to:
  - maximise the contribution of each component of the geotechnical model;
  - construct valid relationships within the model to use as a basis to predict rock mass behaviour, with particular emphasis on the utilisation of geophysical logs to satisfactorily characterise rock mass properties and defects;
  - ensure that all of these factors are considered in the prediction of roadway and face stability, caving behaviour and surface subsidence;
  - ensure that the final mine design is optimised to accommodate these issues.

Additional interpretations of acoustic scanner and dipmeter records have been undertaken in an attempt to analyse the orientation of jointing and faulting. The W H Bryan Mining Geology Research Centre at the University of Queensland has commenced an exhaustive structure modelling project using the probabilistic approach developed in their Australian Coal Association Research Programme (ACARP) Project C7025.

6.5 GROUNDWATER

A programme using down-hole packers to conduct bedrock porosity/permeability tests in exploration boreholes was conducted. Tests were performed over intervals as short as several metres or over stratigraphic units tens of metres thick. A total of 171 packer tests were performed on 32 boreholes.

A programme of installing groundwater monitoring piezometers in potential deep bedrock aquifers was undertaken. Installations at depths ranging from 30 metres to 170 metres were completed at 3 sites. An associated programme to investigate the properties of alluvial valley fills was also implemented. Piezometers and production wells were installed along 4 traverse lines in the Dooralong Valley and one in the Yarramalong Valley. Groundwater levels have been monitored on a 1 to 2 monthly interval since February 1998. Pump tests were conducted on two piezometer installations in the alluvial flats including one programme to assess the water connectivity between bedrock and overlying alluvium.

A detailed aquifer model using MODFLOW software has been developed by Mackie Environmental Research using exploration and other modelling results including state-of-the-art subsidence modelling techniques.

6.6 LOGGING, SAMPLING AND DATA MANAGEMENT

Field and office procedures were documented and catalogued . The following is a list of those procedures and the Project catalogue number. Full details of each document have been included in the Reference List at the end of this Section -

- Drill Site Selection, Preparation and Rehabilitation (Byrne, 2001)
- Lake Drilling (Conquest, 2002)
- Land Drilling (Byrne, 2001)
- Borehole Cementing (Bartlett and Conquest,1999)
- Core Logging (Conquest, 2002)
- Data Handling (Lindsay, 2002)
- Core Photography (Conquest and Ewart, 2002)
- Gas Sampling and Testing (Conquest, 2002)
- Packer Testing (Ewart,1998)
- Analytical Flow; Sampling and Testing Campbell,1996)

Coal seam intersections were measured in the field and marked at 1 metre intervals before transport to the core storage facility. All core logging was performed directly onto computer. The digital borehole logs were transferred electronically to a program that displayed geophysical traces for correlation purposes. This program also generated durable sample tags, which contain logged depth, seam and ply information, which were sent to the laboratory with the sampled coal.

Coal seams from the three stages of drilling were subdivided into recognisable continuous coal plies. Samples were submitted to NATA registered laboratories for analysis and testing.

The laboratory stored and reported all results in an Access database. This database was emailed to the project office monthly and included procedures to generate tables for loading into modelling packages.

Geophysical results were provided electronically in Log ASCII Standard (LAS) format. Recorded results were combined into three LAS files -

- Low Resolution LAS: Full borehole with 0.1 metre sampling interval including Depth, Natural Gamma, Caliper, Long Spaced Density, Short Spaced Density, Compensated Density, MicroResistivity, Near Time, Far Time, Delta-T, Focussed Guard Resistivity and Neutron. A script was run on the database to calculate and store Sonic Velocity from Delta-T;

- High Resolution LAS: From 40 metres above the top of the seam to borehole TD, with 0.02 metre sampling density including Depth, Natural Gamma, Caliper, Long Spaced Density, Short Spaced Density, Compensated Density and MicroResistivity; and

- Sonic LAS: From 40 metres above the top of the seam to borehole TD with 0.02 metre sample interval including Depth, Near Time, Far Time, DeltaT, Near Amplitude, Far Amplitude and Power. A script was run on the database to calculate and store Sonic Velocity from Delta-T.

The software package Vulcan was used to store all geographical, geological, analytical, geophysical, survey and design data for modelling and presentation purposes

Borehole deviation measurements were available for all boreholes in which the dipmeter was run. The deviation directions and amount of deviation were routinely assessed. Discussions were held with the drilling contractors whenever deviation became excessive, allowing them to respond and adjust drilling procedures where necessary. This has resulted in minimal problems with borehole deviation. Deviation direction showed a strong tendency to deviate to the north-east (opposite to regional dip). There are slight variations in deviation direction between the eastern and western project areas and these appear to be related to variation in the geological dip direction. The deviation direction data was used in the planning of re-drilled boreholes and the positioning of large diameter boreholes to minimise the risk of running back into the original borehole. The majority of the boreholes 89% (300) have a maximum deviation from the vertical, at TD, of less than 15 metres. These boreholes require an average depth correction of 0.1m varying from no correction to a maximum of 0.6 metres.

6.7 ANALYSIS

All plies were float-sunk at densities of 1.35, 1.40, 1.45, 1.50 and 1.60 with ash and yield determined for each fraction. Raw ash and RD were determined for each complete ply.

Composite section(s) for each seam intersection were selected and the following tests performed on the cumulative float 1.60 and raw fractions:

Relative Density	Moisture
Ash	Volatile Matter
Total Sulphur	Specific Energy
Crucible Swelling Number	Ash Fusion
Ash Fusibility	Ultimate Analysis
Ash Analysis	

Additional trace element determinations in ash have been carried out on selected boreholes for the elements listed below:

Antimony	Arsenic	Barium	Beryllium	Boron
Bromine	Cadmium	Chromium	Cobalt	Copper
Fluorine	Germanium	Lanthanum	Lead	Lithium
Manganese	Mercury	Molybdenum	Nickel	Rubidium
Selenium	Silver	Strontium	Thallium	Thorium
Tin	Uranium	Vanadium	Yttrium	Zinc
Zirconium				

Trace element determination for the following elements and petrographic analyses have been carried out on other selected bores:

Chlorine	Arsenic	Fluorine	Mercury	Selenium
Vanadium	Sulphur			

6.8 COAL SEAM GAS

Over 100 samples of HQ core from 19 exploration boreholes were chosen for gas content tests. In these boreholes, NQ wedges were drilled off the primary borehole to recover full seam samples of the WGN Seam for analytical testing. Samples of HQ core were also selected from coal intersections that showed no potential for mining, e.g., FAS Seam and thin splits of the WGN Seam. Samples were "bombed" and sent to GeoGAS in Wollongong for fast desorption method testing.

A second, more detailed study was designed to assist with mine planning and ventilation. Detailed down-hole permeability tests were performed on six boreholes in the Western Primary Target Area in conjunction with in situ stress measurement testing. Three fully cored boreholes were drilled in early 1999 and subjected to down-hole in situ stress measurements and detailed permeability measurements and multiphase analyses. An additional three boreholes with similar testing were drilled in late 2000 at sites further west and south in the Western Area to give a broader coverage of potential mining areas. The purpose of these studies was to determine the characteristics of the hydraulic and gas reservoirs of the coal seam and surrounding strata. Gas content measurements carried out on core from these boreholes confirmed the relationship developed from earlier studies for predicting gas content from depth, ash and volatile matter.

7. DEPOSIT GEOLOGY

7.1 GENERAL STRUCTURE

The coal seams outcrop to the north and north-east of the area and dip gently to the south-west beneath the exploration areas at grades of 1 in 30 to 1 in 50. Depth of cover to the uppermost coal seam within the original exploration areas ranges from 200 metres in the north-east (minimum cover 350 metres within Extraction Area) to 680 metres in the south-west (see **Figure 7.1**). A major north-south trending conglomerate-filled channel approximately 5 kilometre wide extends along the eastern side of the western area, sub-parallel to the regional synclines (to the east of the Extraction Area).

7.2 IGNEOUS GEOLOGY

A number of sills, dykes and diatremes have been identified by magnetic surveys and drilling. These features are displayed in **Figure 7.2**.

7.2.1 Sills

The Mandalong Sill (identified by the early aeromagnetic survey and exploration drilling) to the north of the Extraction Area exhibits a very strong aeromagnetic anomaly and was intersected in 10 boreholes. It covers an area of more than 20 square kilometres. Both the WGN and FAS Seams have been completely replaced by medium grained dolerite. Silling in the underlying FAS Seam appears to be more extensive than in the WGN Seam. High gas contents have been recorded immediately adjacent to this body.

Smithys Sill, in the south of the Extraction Area, has been identified by drilling. Six boreholes intersected this feature. The sill was crossed by a Mini-SOSIE traverse and could be identified by a change in signal amplitude. The sill replaces the WGN Seam but the FAS Seam appears unaffected.

7.2.2 Dykes

A number of dykes in the exploration area were identified by aeromagnetics. Some of these structures have been confirmed by high-resolution ground magnetics and drilling. The dominant orientation of these features is north-west, with a secondary orientation west-north-west. This is consistent with dykes reported in existing mines to the north-east. Preliminary interpretations from high-resolution ground magnetics indicate that some dykes could be up to 20 metres thick. Higher than normal gas contents have been noticed in some boreholes drilled immediately adjacent to dykes. A 900 metre wide zone containing multiple dykes traverses the Extraction Area from the Mandalong Sill in the north-west to the northern part of Tuggerah Lake.

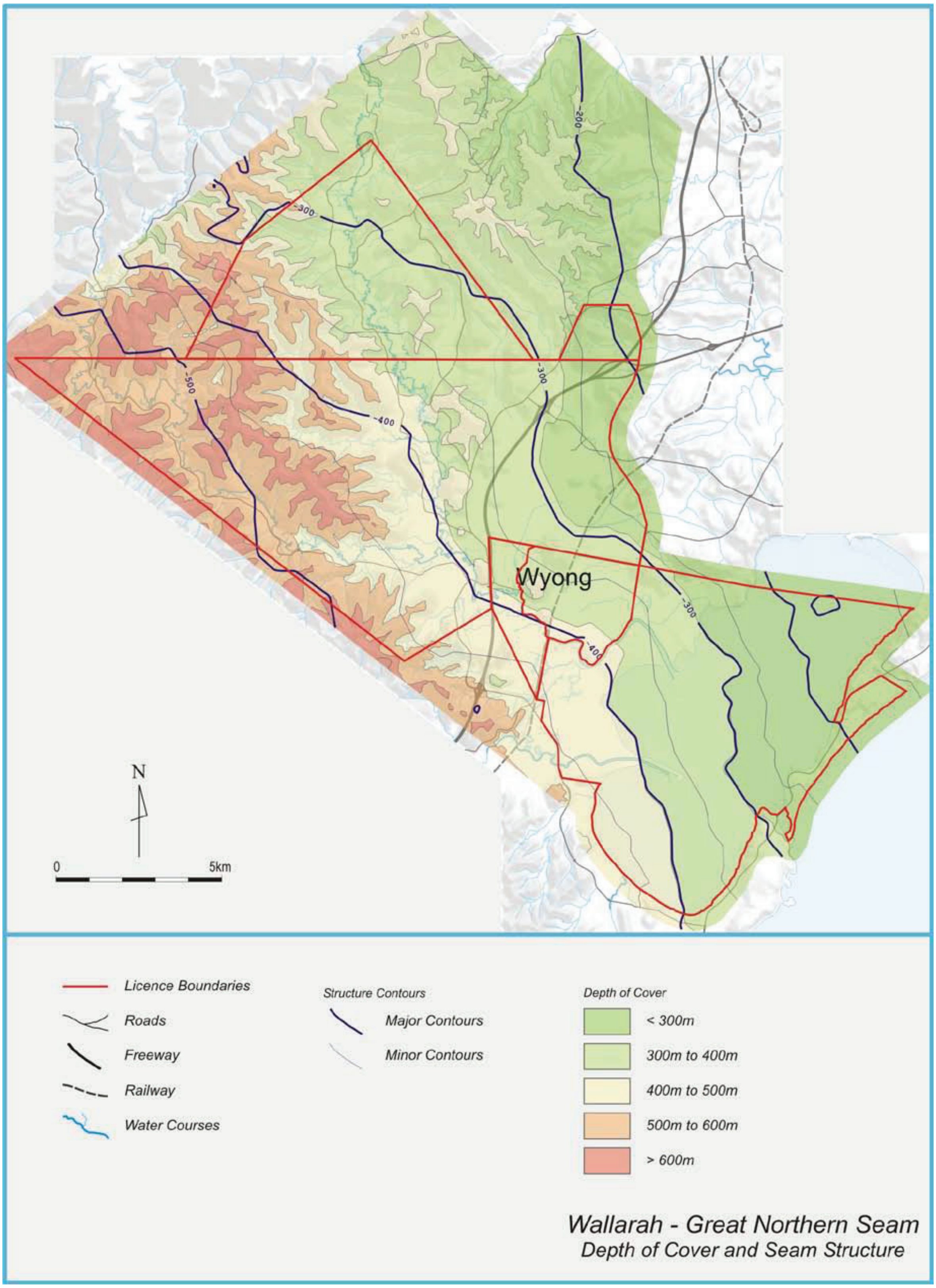

Figure 7.1 WGN Structure Roof & Depth of Cover

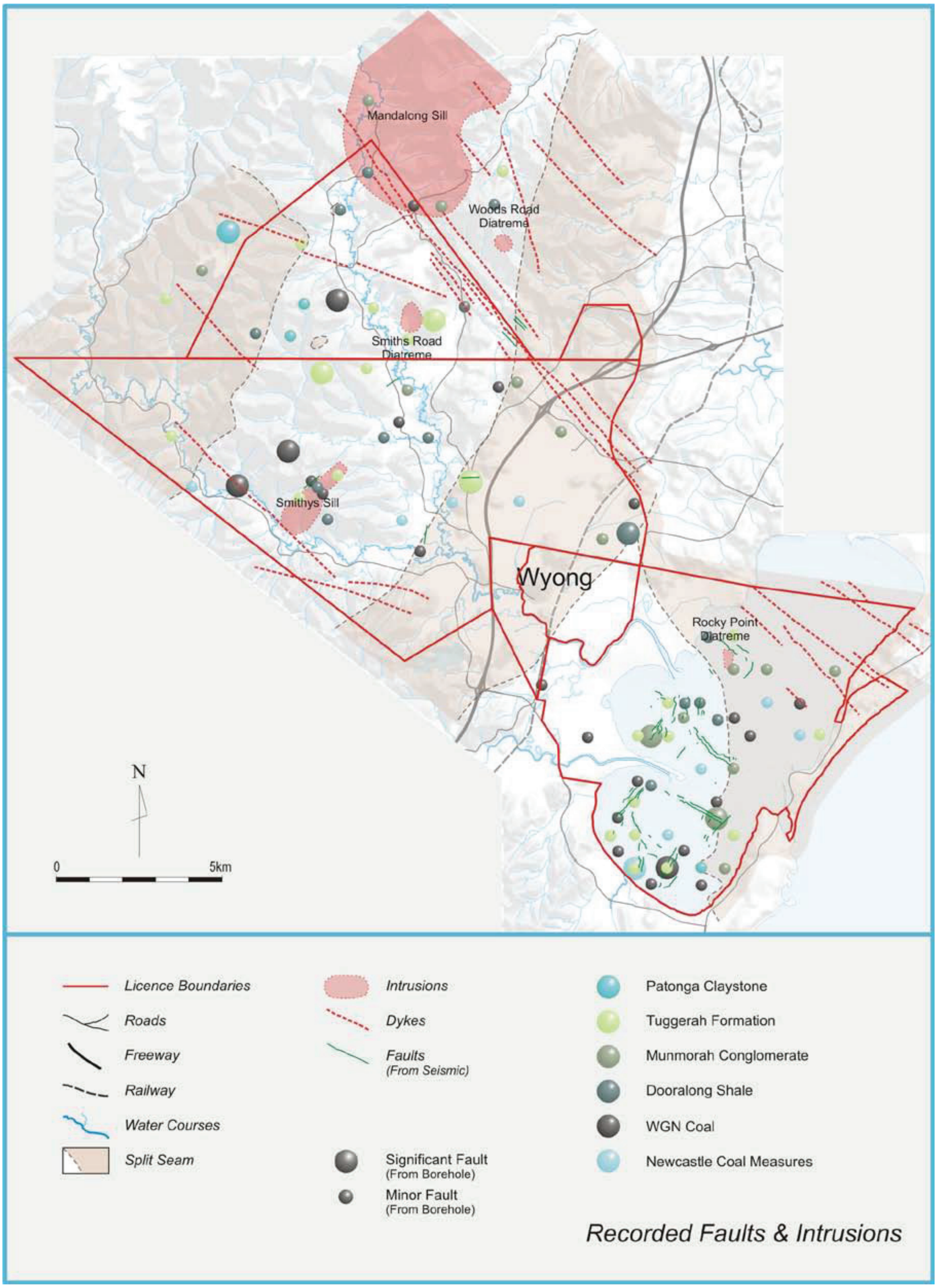

Figure 7.2 Recorded Faults, Sills, Dykes and Diatremes

7.2.3 Diatremes

The Woods Road Diatreme exhibits a strong dipolar magnetic anomaly. A borehole drilled within the anomaly intersected unaffected coal. Field mapping located fresh basaltic outcrop. The Smiths Road Diatreme also exhibits a strong dipolar magnetic anomaly. Investigations revealed that the anomaly had been examined as a source of material for road construction. One borehole drilled within the anomaly intersected unaffected coal, however a second encountered breccia and doleritic material from a depth of 16 metres. Field mapping and ground magnetics has confirmed the presence of igneous material on the surface. The extent of this feature has been interpreted by aerial photograph interpretation. The Rocky Point Diatreme has been identified by aeromagnetic and seismic results. In seismic records, the structure appears as a vertical column of completely deteriorated reflections. The coal seam dips steeply towards the feature but cannot be traced through the diatreme.

7.3 FAULTING

The South Newcastle Coalfield is typified by two principal fault directions; one trends to the north-west and another to the north-east (Mauger et al, 1984). North-west trending normal faults are dominant and may be associated with dykes while north-east trending faults are less numerous and occur in discrete zones; dykes may also be associated with these structures (Creasey and Huntington, 1985).

It is important to note that the aim of the report prepared by Mauger et al "*was to provide a structural analysis of the Sydney Basin by identifying major fracture zones and lineaments that could be deleterious to future underground coal mining. The regional analysis would provide a framework on which further detailed structural geology studies at the mine lease scale could be conducted*." Some of the features identified in that report have been substantiated by detailed work.

The Kooree Ck Lineament was intersected in the Boomerang Creek Tunnel some 15-20 km to the west of the Extraction Area. Other lineaments correlate to dykes identified by the project's magnetometer (both airborne and high resolution on-ground) surveys and exploration drilling. It is significant to note that the area covered by the Extraction Area is virtually devoid of structures (see **Figure 7.3**) except for the "Coastal Lineament". This particular feature is classified by Mauger et al as a 3rd order Fracture Trend Trace and described by them as "*a poorly expressed but extensive lineament that trends more easterly than other Group III lineaments*". While the suggestion has been made that the Coastal Lineament is a fault structure (possibly similar to the Kooree Ck Lineament), there is no evidence to support this claim in the extensive drill hole or seismic data that has been gathered by the project. The project data does however suggest that the Coastal Lineament was misinterpreted by Mauger et al as a fault, and is more likely to be an expression of the western flank of the Central Channel Zone that defines the eastern limit of the Extraction Area.

While faulting has been recorded in a number of boreholes, a thorough assessment of the possible faulting in the Extraction Area was undertaken using seismic reflection technology. An area of 2sq km of 3-D Mini-SOSIE seismic was undertaken over the proposed pit bottom area (see **Figure 7.4**). Approximately 30kms of high resolution 2-D Mini-SOSIE seismic surveying, including a number of traverses directly across the valley floor, was specifically designed to investigate the possible presence of faulting that is not able to be identified by vertical boreholes.

Comparison of CSIRO Regional Structures with Published and Mapped Data
(Base Map Structures from:
Mauger, Creasey and Huntington, 1984,
Structural Synthesis, Gosford-SBFA 6D)

- Regional Synclines from Geological Sheet 9231 (1995)
- Boomerang Creek Tunnel and Mapped Structures
- Comparable Structures for Scaling
- Seam Splits from Project Drilling
- Igneous Dykes from Project Aeromagnetics
- Proposed Underground Extraction Area

Figure 7.3 Regional Structure

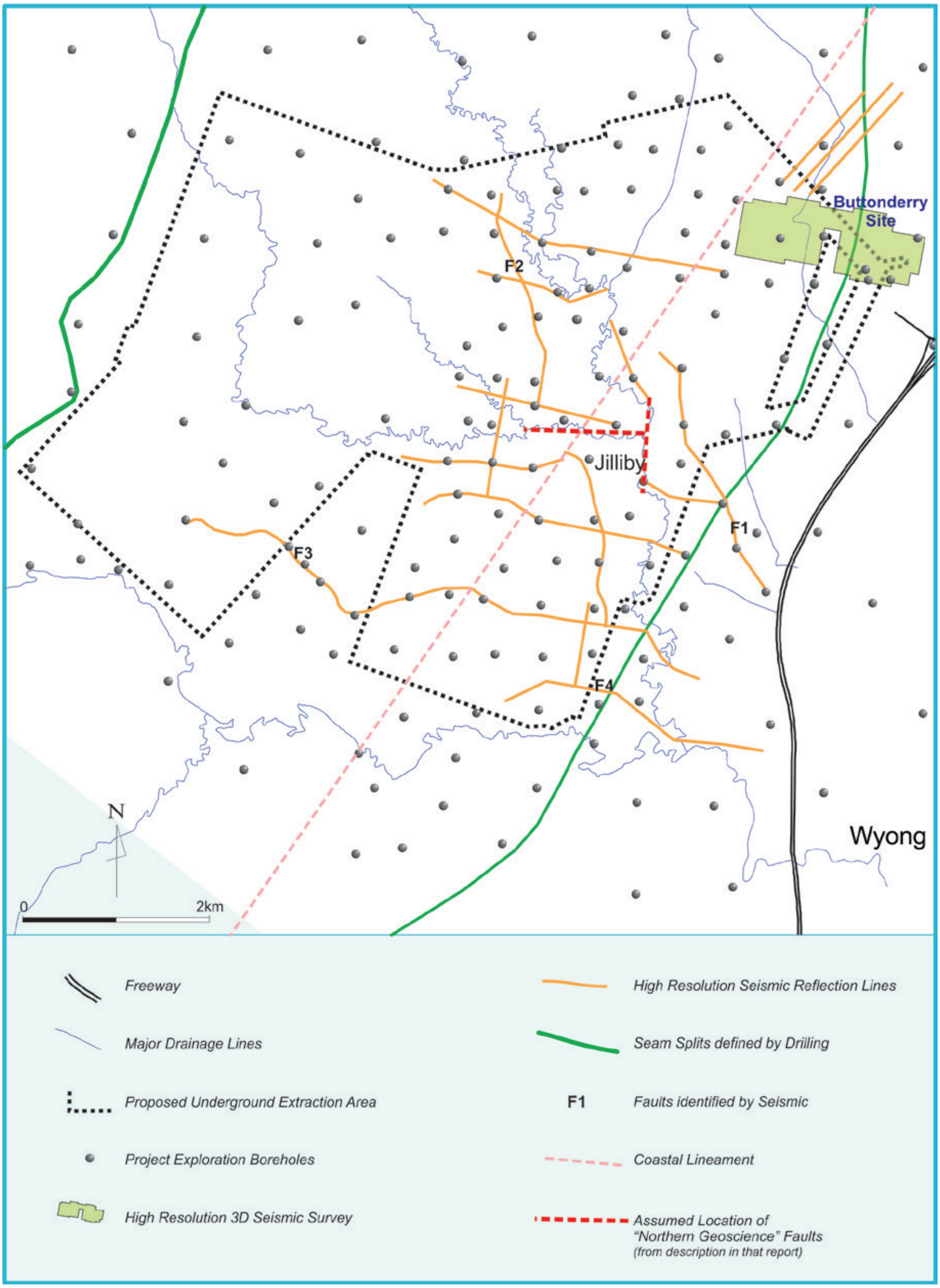

Figure 7.4 Boreholes and Seismic Lines

The following is a summary only of the individual lines that identified interpreted features, extracted from the interpretation report by the seismic contractor, Velseis Pty Ltd. This is followed by a final interpretation incorporating the entire suite of exploration data.

Line X7

Fault	S.P	X	Y	Throw	Confidence
F3	205	332247	1319642	7m	High

Borehole data indicates that the seam is intruded in holes B250V950 and B260V930 which are located in the vicinity of the F3 Freeway. The corresponding seismic data between these holes displays a distinct character change in the horizon identified as the roof of the Wallarah Seam. This character change at F3 is interpreted as a sill influencing the seam rather than fault.

Line X8

Fault	S.P	X	Y	Throw	Confidence
F4	250	335716	1318104	4m	Low

Fault F4 has been interpreted with low confidence primarily due to its size. However, this structure occurs in close proximity to the Wallarah / Great Northern seam split line and the seismic response is considered to be an interference effect relating to the seam split rather than a fault.

Line N2

Fault	S.P	X	Y	Throw	Confidence
F2	252	334706	1322670	<4m	Low

Fault F2 has been interpreted with low confidence primarily due to its size.

Line N6

Fault	S.P	X	Y	Throw	Confidence
F1	330	337062	1319773	8m	High

Fault F1 has been interpreted as a normal fault down thrown to the South East. Borehole B700V950 indicates however that the Wallarah seam has been intruded at this location and that the seam horizon is absent. These combined data significantly reduce the confidence of the original seismic interpretation.

Structures identified by the seismic surveys can be more accurately summarised as:-

F1 is associated with an intrusion near the intersection of Hue Hue Road and Dickson Road;
F2 is a low confidence, low displacement fault;
F3 is considered to be a sill rather than a fault, and
F4 is considered to be a split line.

The seismic surveys not only failed to identified the "Coastal Lineament" postulated by Maugher et al, they also were unable to find any expression of a fault system proposed by Jones (2005) who asserted that "*a major geological feature of the Jilliby Creek is that it aligns with a fault zone*" which "*provides a significant transient pathway to groundwater movement and discharge*". The report was prepared in January 2005 to support the Australian Gas Alliance's opposition to investigations being carried out in the Dooralong Valley by Sydney Gas; the alleged structural features postulated in the report are referred to by the Project team as the "Northern Geoscience Faults".

The report goes on to say:-

"*A major geological feature of Jilliby Jilliby Creek is a fault zone approximately 1.3km west of Mount Alison. The drainage runs along this fault line in almost a direct line south for approximately 1.5km, midway along this feature Little Jilliby Creek converges into Jilliby Jilliby Creek. The whole of the Little Jilliby Creek is at right angles from Jilliby Jilliby Creek and is interpreted as a conjugate fault zone.*"

Since the analysis by Jones (2005) could only be based on surface maps and/or aerial photographic interpretation it should be noted that, while lineaments can indicate the location of faults, such interpretations are only valid in areas of little or no alluvial cover. During early 2010, WACJV installed one of a number of a groundwater monitoring bores approximately 100m west of Jilliby Jilliby Creek. Bedrock was intersected at a depth of 20 metres. Consequently, it would not be possible to interpret a fault at this location when the bedrock is masked by such a depth of alluvium. Furthermore, by definition, conjugate faults do not meet at right angles as referred to in Jones (2005).

The orientations of the alleged Northern Geoscience Faults are also inconsistent with the structural grain of the area as they are essentially N-S and E-W whereas the NW and NE structural trends are well established as discussed above.

During the exploration phase a significant amount of structural data was gathered which included; Faulting exposed in mines to the north; Faulting in Tuggerah Lakes (by seismic survey); Joint orientations; Igneous dyke orientations and sedimentary strata bedding orientation.

The graphs in Figure 7.5 show the distributions of various structural features relative to the proposed orientation of the Northern Geoscience Faults and the alignment of Jilliby Jilliby Creek.

In March 2005, the report by Jones (2005) was the subject of a review by the Department of Primary Industries - Mineral Resources (Barry, 2005) which states, among other things:

> *"DPI-MR Response (L):*
>
> *There is unlikely to be any real potential for connection between near-surface aquifers and the deeper coal seam aquifers on the Dooralong and Yarramalong Valleys. See DPI-MR responses (C), (F), (G) and (K)."*

Furthermore, even if such connectivity were to exist, the practical experience when intersecting the most significant faults during the drivage of the Boomerang Creek Tunnel was, that while inflows of an estimated 2,000 L/min occurred when these faults were initially exposed, this rate dropped to only several litres per minute within a few hours (Milenko and Neville, 1991). Such evidence suggests that even major structures are unlikely to provide a *"significant transient pathway to groundwater movement and discharge"*.

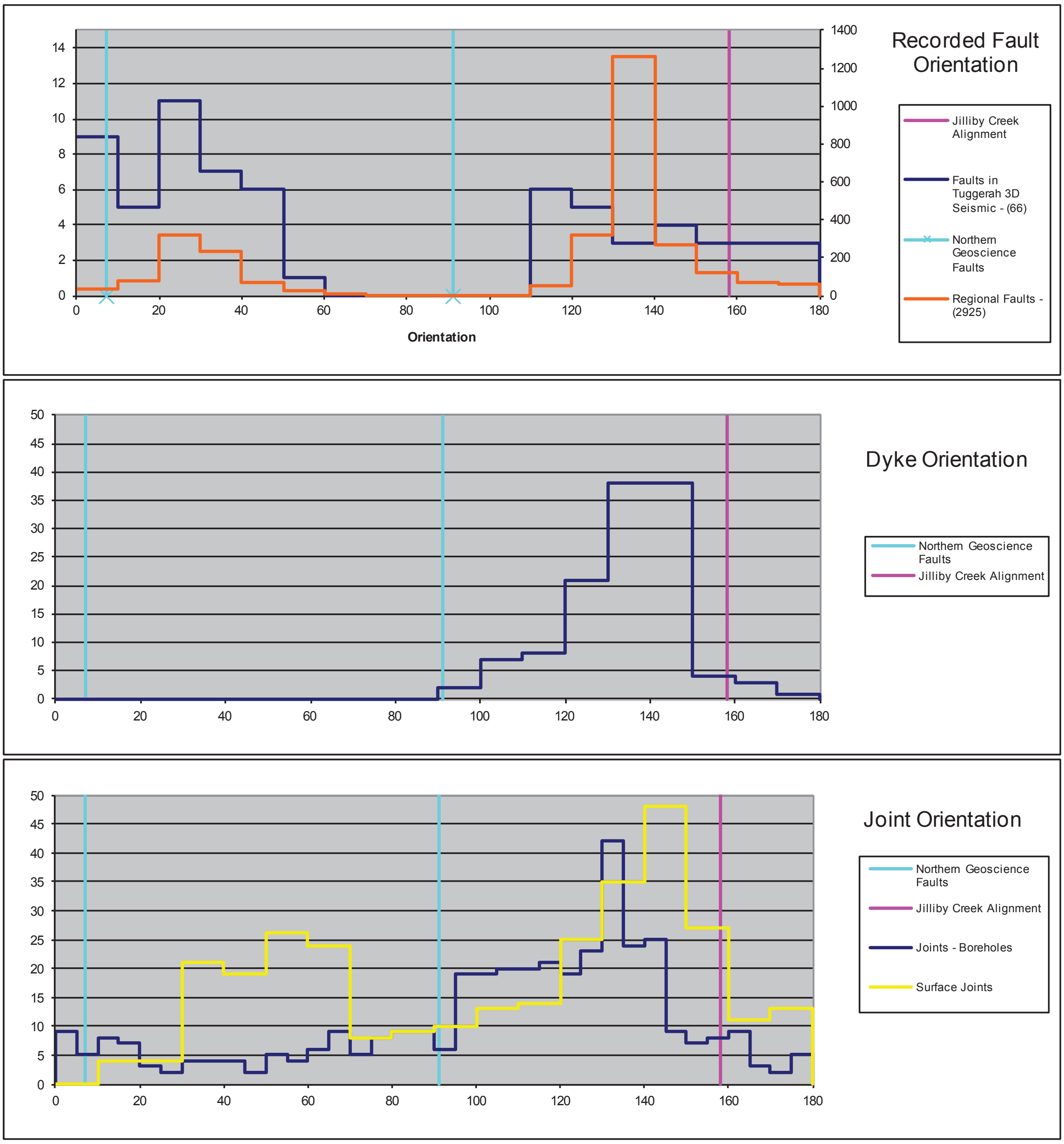

Figure 7.5 Orientation of Structural Features

Furthermore, there is no support for the notion that Jilliby Jilliby Creek is structurally controlled, since an examination of the surface geology of the area indicates that Jilliby Jilliby Creek (Dooralong Valley) follows the outcrop of the soft Patonga Claystone between the sandier, more resistant Terrigal and Tuggerah Formations. Bedding of strata in the area dips generally to the SW. Jilliby Jilliby Creek clearly reflects this by occupying a down-dip position adjacent to the more resistant sandier Terrigal Formation. This is further supported by the distribution of bedding strike within the Terrigal Formation and Patonga Claystone which shows a much closer correlation with the orientation of Jilliby Jilliby Creek than any structural features. This can be seen in **Figures 7.6, 7.7** and **7.8**.

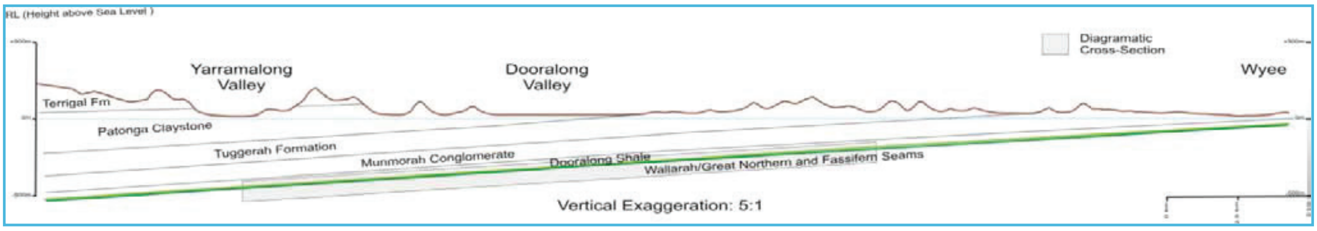

Figure 7.6 Vertical Section across Dooralong Valley

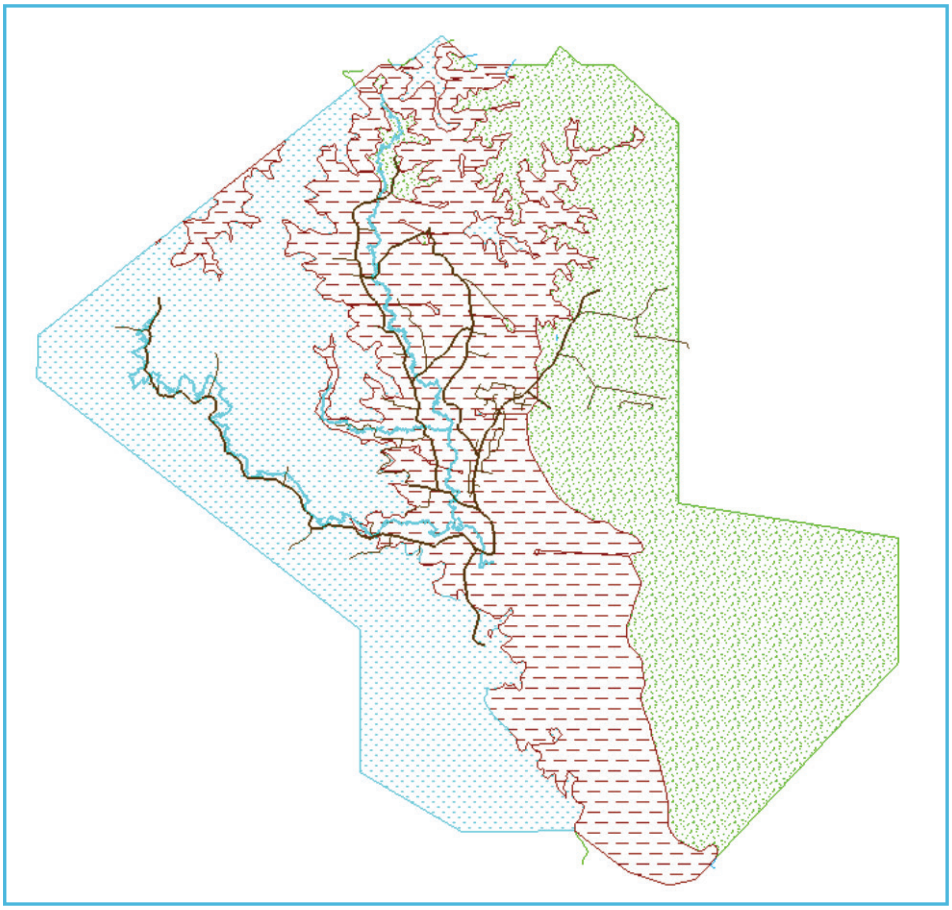

Figure 7.7 Surface Geology of Dooralong Valley

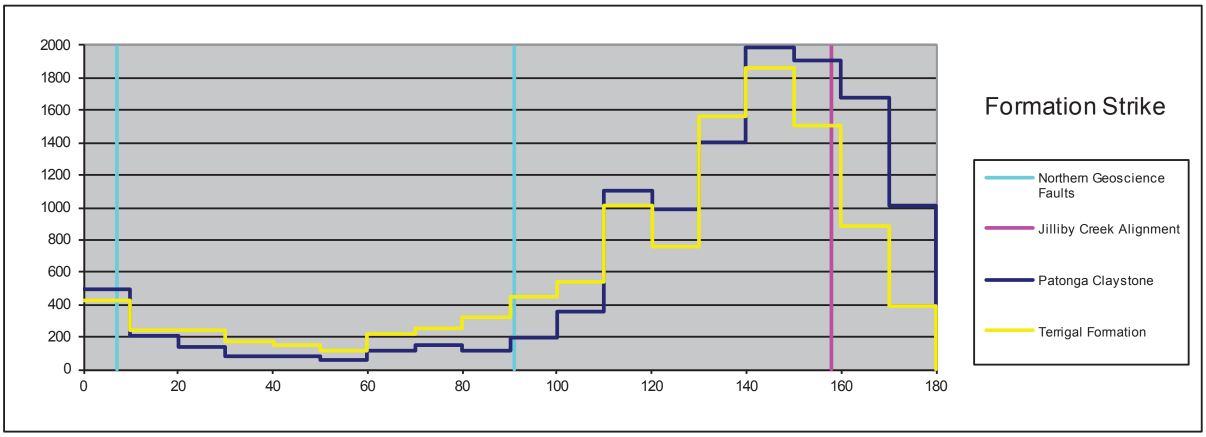

Figure 7.8 Alignment of Dooralong Valley

7.4 JOINTING

Jointing has been mapped in surface exposures throughout the Extraction Area. A plot of total joint directions shows a dominant south-east trend (identical to the regional dyke trend) with a secondary north-east trend approximately at right angles to the dominant trend. A minor north-north-east trend can also be detected (see **Figure 7.9**). These trends compare closely with the orientation of lineaments identified on aerial photographs. Acoustic scanner and dipmeter logs were used to determine joint orientations in and around the coal seam and overlying strata.

7.5 GEOTHERMAL GRADIENT

Temperature logs were run in six boreholes during exploration. The geothermal gradient varies from 2 to 2.5 degrees Celsius per 100 metres of depth (**see Figure 7.10**).

7.6 STRESS

Acoustic scanner results have been used to determine the principal horizontal stress direction for approximately 50 boreholes in the Western Area (see **Figure 7.11**). The mean direction for principal stress is 30 to 35 degrees east of north with variations of ± 20 degrees. A number of boreholes towards the south of the Extraction Area have anomalous stress directions closer to 110 degrees east of north.

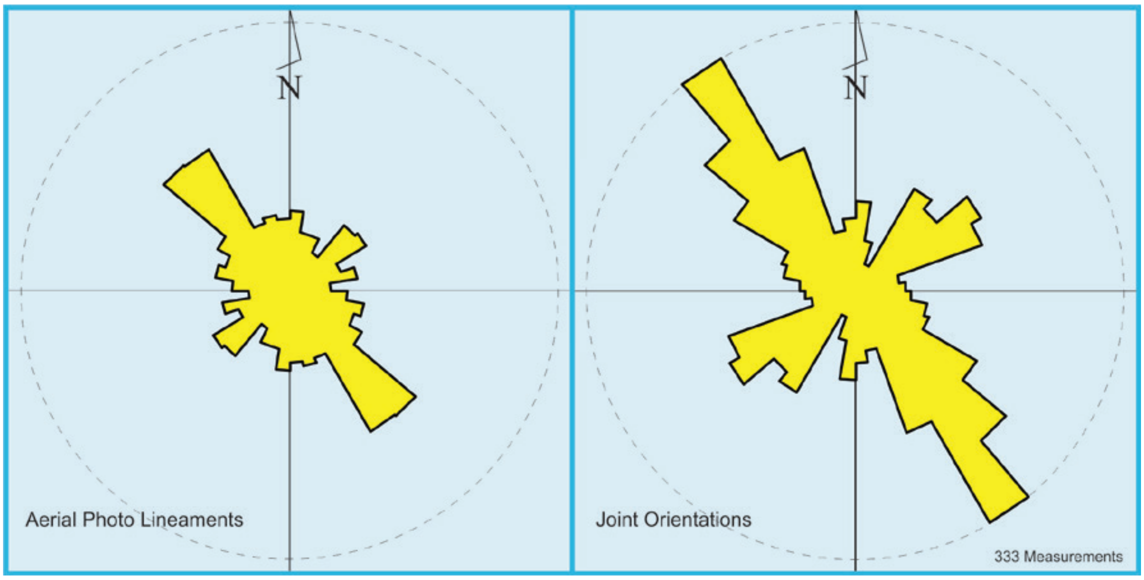

Figure 7.9 Surface Jointing and Aerial Photo Lineament Analysis

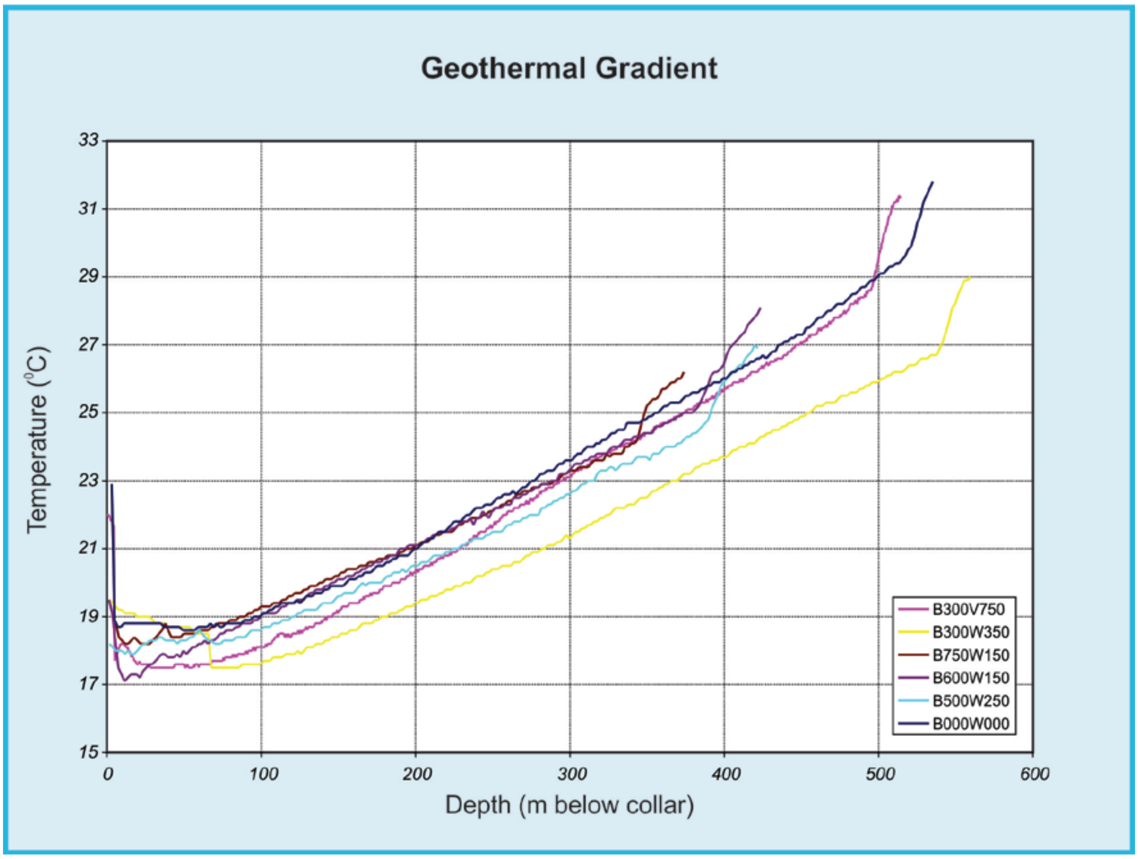

Figure 7.10 Geothermal Gradient measured in Exploration Boreholes

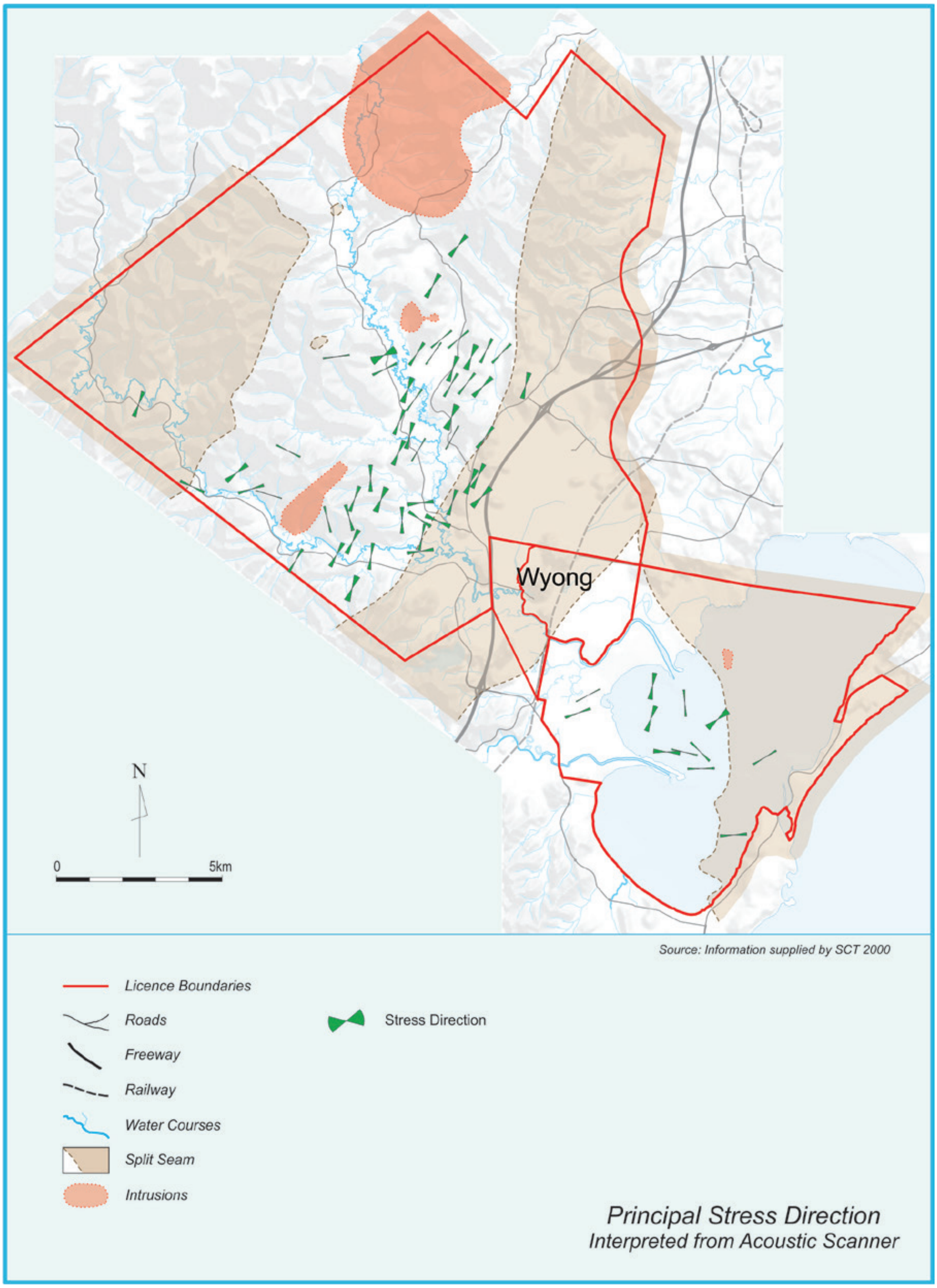

Figure 7.11 Principal Stress Directions from Acoustic Scanner Interpretations

The magnitude of the maximum horizontal stress is expected to increase by approximately 2.5 MPa/100 metres of cover. At 400 metres depth it is anticipated to be 10-12 MPa (in a 10 GPa rock) similar to that of the Southern Coalfield to the south of Sydney where mines operate at similar depths. Hydraulic fracture data indicates the potential for higher magnitudes to occur.

7.7 COAL SEAM DETAIL

In the Wyong area, the Wallarah (WAL) and Great Northern (GTN) Seams coalesce to form a single seam, Wallarah – Great Northern Seam (WGN). In a limited area the Vales Point (VPT) Seam also merges with the combined seam to produce a maximum coal thickness of approximately 8.7 metres. The seams are subject to splitting and coalescence through the development of conglomerate filled fluvial channels. **Figure 7.12** shows a diagrammatic east-west section through the deposit and clearly defines the zones of seam development and the conglomerate channels. The area being subdivided into a number of zones, as illustrated in **Figure 7.13**:

Western Split Zone	Western Thick Zone
Central Channel Zone	
Eastern Split Zone	Eastern Thick Zone

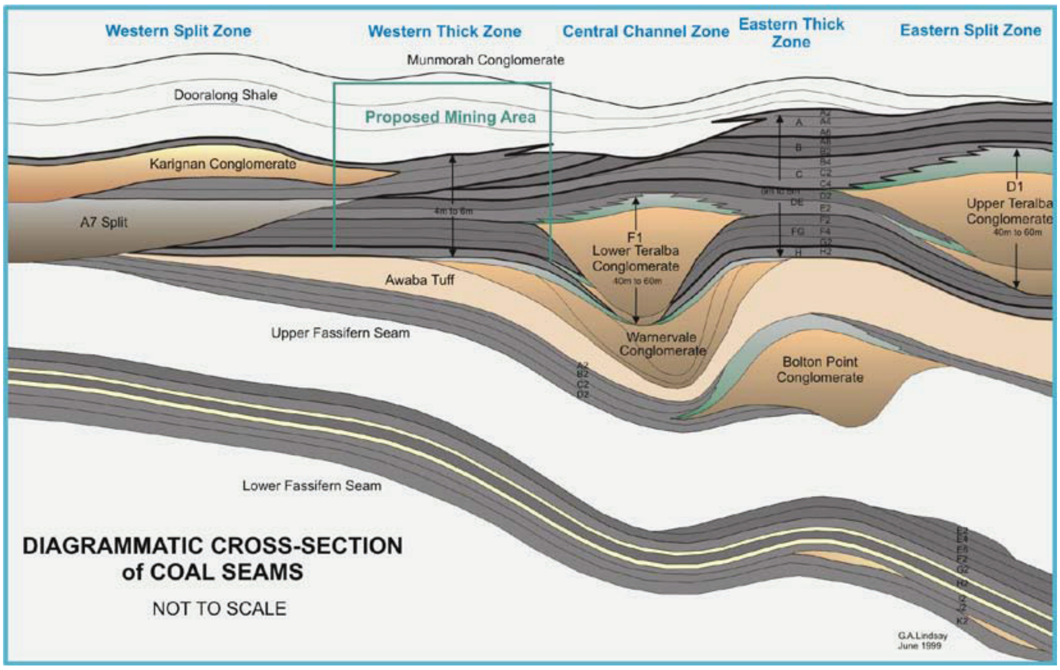

Figure 7.12 Diagrammatic E-W Section

Maximum seam thickness is developed in the Western and Eastern Thick Zones. In the southern half of the Western Thick Zone, the WGN ranges from 4.2 to 6.8 metres thick; to the north the seam thins to 3.5 metres. In the Eastern Thick Zone the seam is generally 6 to 7.5 metres thick but reaches a maximum of 8.7 metres when the overlying VPT Seam merges. In the Central Channel Zone, the WAL Seam is generally less than 3 metres thick but reaches 3.5 metres thick along the western boundary while the GTN Seam is completely removed.

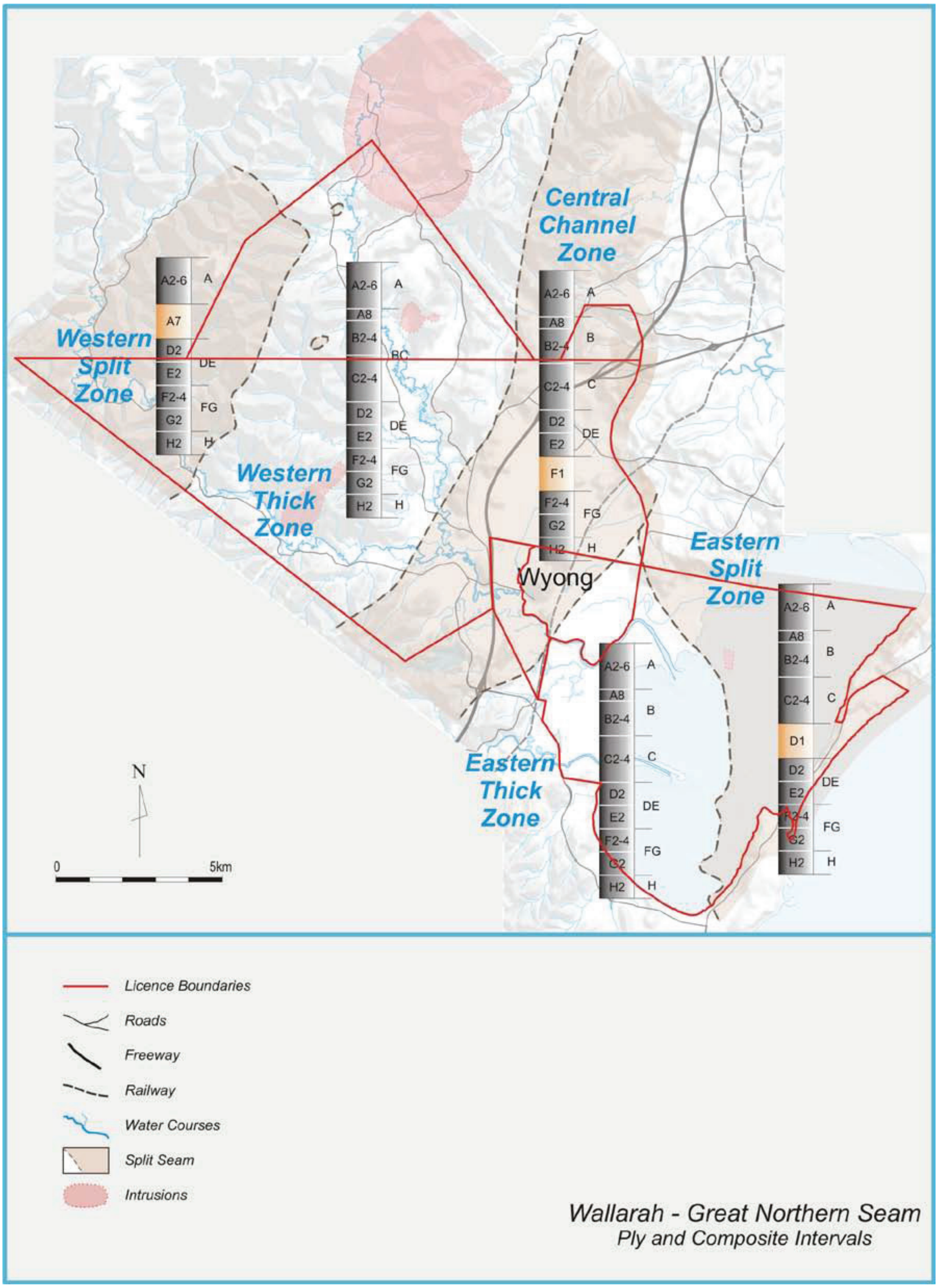

Figure 7.13 WGN Ply Combinations and Seam Zones

In the Western Split Zone, the WAL Seam thins to 2 metres and in places totally deteriorates; the GTN Seam reaches 2.5 metres thick in the south-west. In the Eastern Split Zone, the Wallarah Seam maintains a thickness of over 3 metres along the split line but quickly thins and deteriorates to the east; the GTN Seam deteriorates and thins from the split line.

Figure 7.14 illustrates the WGN full seam thickness.

A Primary Target Area (PTA) in the Western Area was defined by geological and mining constraints and detailed mine planning for the Project has been undertaken.

The area is defined as follows.

- The eastern limit for longwall planning is the split line marking the western edge of the Central Channel Zone;
- Pit bottom and main headings development have been planned in the Central Channel Zone immediately adjacent to the split line where seam thickness is approximately 3 metres;
- The western limit of longwall planning is the western split line; west of this split line, seam thinning and increasing ash decrease mining potential;
- The southern limit of the Western PTA is defined by a significant dyke, which was delineated by magnetic surveys;
- The northern boundary of the Western PTA is the north-west dyke zone, the Smiths Road Diatreme and seam thinning.

The resulting area covers approximately 55 square kilometres (see **Figure 7.14**).

As previously noted in “Faulting” the area is virtually devoid of structures identified in other studies.

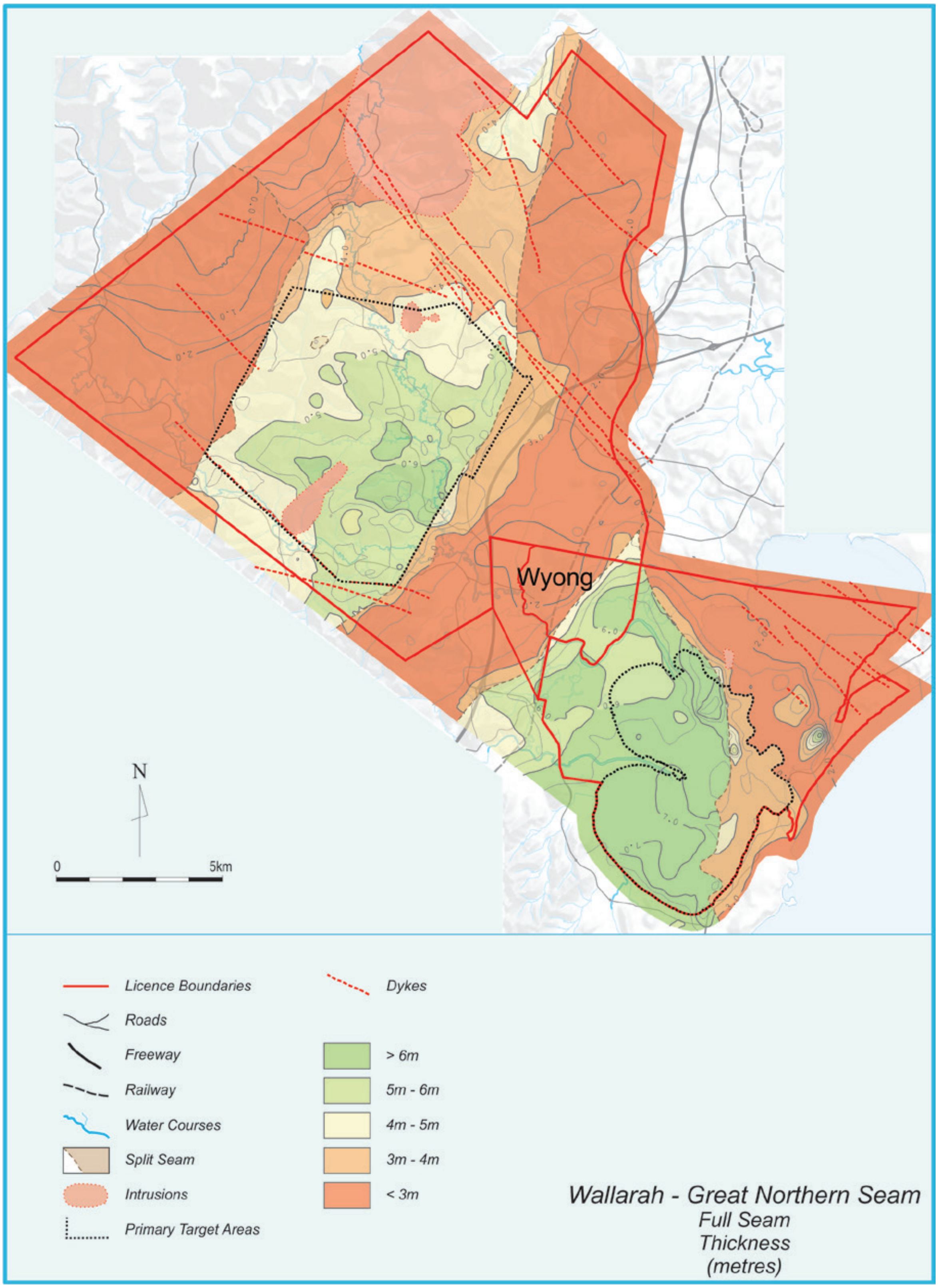

Figure 7.14 WGN Full Seam Thickness

8. RESOURCE ESTIMATION

Mine plans were developed for the Western Area to focus on environmental, gas, subsidence, flooding and groundwater studies. These plans were re-designed to optimise the mining proposal, which is the subject of the current Environmental Impact Statement. As per the Joint Ore Reserves Committee (JORC) standard, Coal Resources have been calculated but Coal Reserves are not yet estimated. Because of the limited extent and poor quality of significant thicknesses of the deeper FAS Seam, resources have been calculated only for the WGN Seam.

Including pre-existing boreholes, two kilometre spaced boreholes exist over virtually the entire exploration area. One kilometre spaced boreholes have been completed over the Western Area east of the western split line, with the exception of the far northern and southern extremities where the seam is thin or intruded. Boreholes on a 500 metre grid have been completed within Primary Target Area in the Western Area.

Borehole spacing allows resources in the eastern half of the Western Primary Target Area (incorporating the Extraction Area) to be classified as Measured. Resources in the Western Split Zone (to the west of the Extraction Area) can be classified as Inferred. All other resources can be classified as Indicated.

Split lines have been defined as the 0.3 metre thickness contour of relevant stone bands to reflect mining practice in existing mines to the north.

Relative density and moisture values used in resource estimations are modelled, air dried laboratory values. No calculations have been performed for moisture adjustment or to determine in situ relative density.

For resource purposes, the area has been subdivided into blocks which are bordered by significant geological structures and geographic and cultural features. These blocks are displayed in **Figure 8.1** and **Figure 8.2**. Coal resources within these blocks have been categorised into three thickness ranges – 1.5 to 2 metres, 2 to 3 metres and greater than 3 metres. All geological modelling has been performed in the software package VULCAN using grids with 100 X 100 metre cell size and the triangulation interpolator.

A number of zones have been excluded from the calculations. The area of igneous sill in the north-west has been excluded because coal has been replaced by igneous material. The Smiths Road and Rocky Point Diatremes and Smithys Sill have also been excluded. A boundary has been drawn around the north-west dyke zone traversing both areas; no coal resources have been estimated within this zone because of the unknown effect the presence of these dykes has had on the coal.

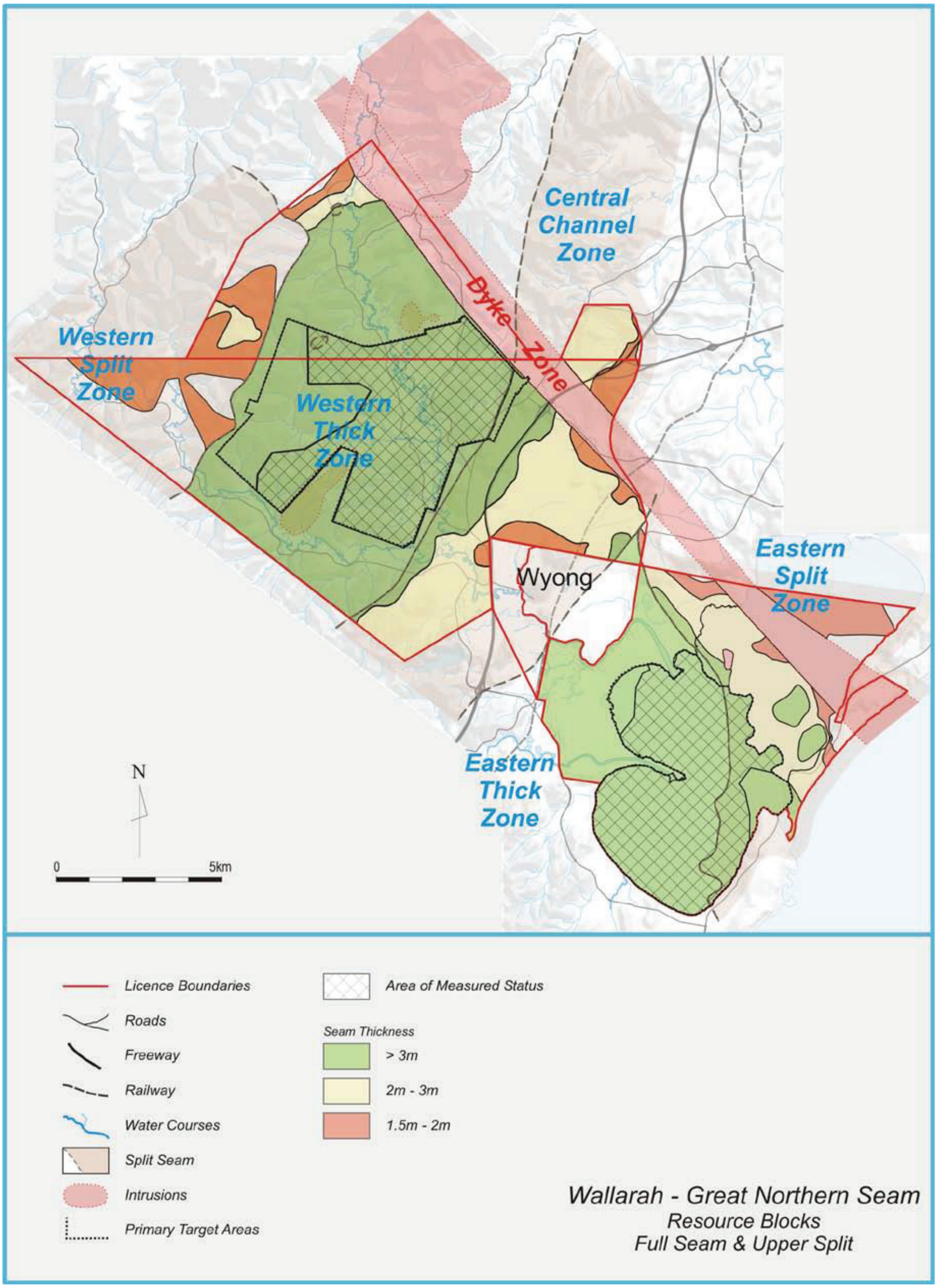

Figure 8.1 WGN Full Seam and Upper Split Resource Blocks

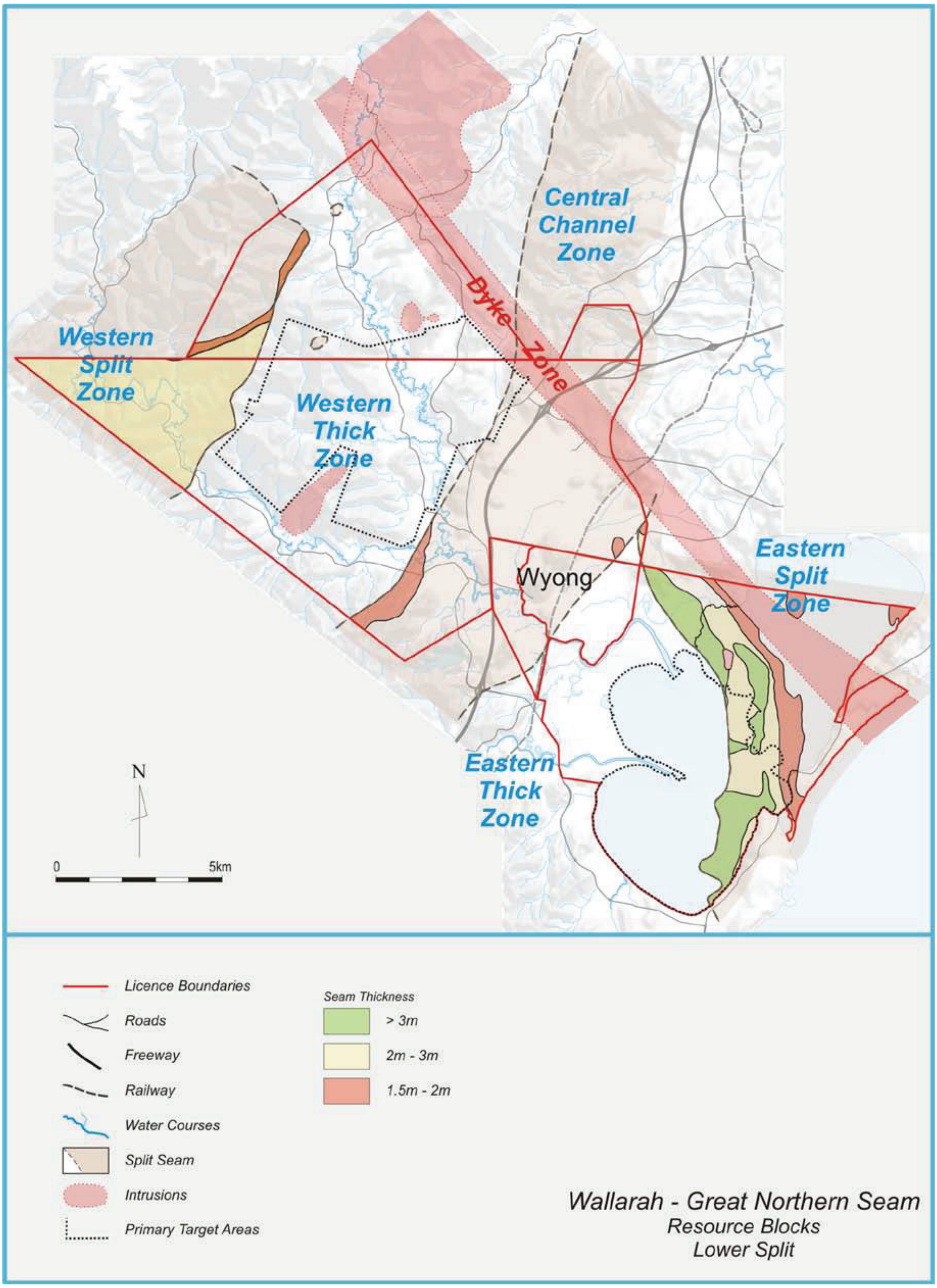

Figure 8.2 WGN Lower Split Resource Blocks

9. SEAM GAS

Results from tests described previously were compiled by GeoGAS Pty Ltd (1997) and a comprehensive assessment was undertaken. The following conclusions were made and are being incorporated into mine planning:-

- Gas content for areas not affected by intrusions can be predicted confidently from depth, ash content, and volatile matter;
- The predicted regional gas content gradient is determined by depth below sea level. Gas contents measured from boreholes ranged from 5.5 to 11.0 m^3/t;
- Low gas desorption rates and relatively high gas retention characteristics of the coal should result in gas emissions significantly lower than would be expected for the recorded gas contents;
- Outburst potential is low but will be further assessed prior to mining in proximity to igneous structures; and
- Some form of gas drainage or gas capture may be required to achieve satisfactory gas levels with high production rates and acceptable ventilation levels.

Gas composition recorded from core samples is displayed in **Figure 9.1**. Gas is predominantly methane although variable amounts of carbon dioxide and nitrogen were identified. No hydrogen sulphide was detected. Increases in gas contents, gas desorption rates and the proportion of carbon dioxide in the seam gas were noted adjacent to some intrusions. These increases are expected to be very localised in extent and are avoided by the Project.

Table 9.1 Gas Composition from Borecore Samples

Gas	Minimum (%)	Average (%)	Maximum (%)	Standard Deviation
Methane	74.9	89.3	94.2	3.8
Carbon Dioxide	0.4	2.0	3.9	0.9
Nitrogen	5.1	8.7	22.9	3.6

To assist mine planning and ventilation studies, the gas content relationship has been used to develop a three dimensional gas content model. This model extends from 30 metres above the potential working section (includes all overlying coal) to 70 metres below the potential working section. Calculations for this model utilised all existing quality and structural information, using model estimates where possible and default values for deeper unnamed and not-modelled seams. The final model takes into account coal left in the roof and floor above and below the working section. Indicative gas content variations across the area for the potential working section derived from the gas model are displayed in **Figure 9.1**.

Gas emission modelling to assist ventilation planning has been conducted by GeoGAS.

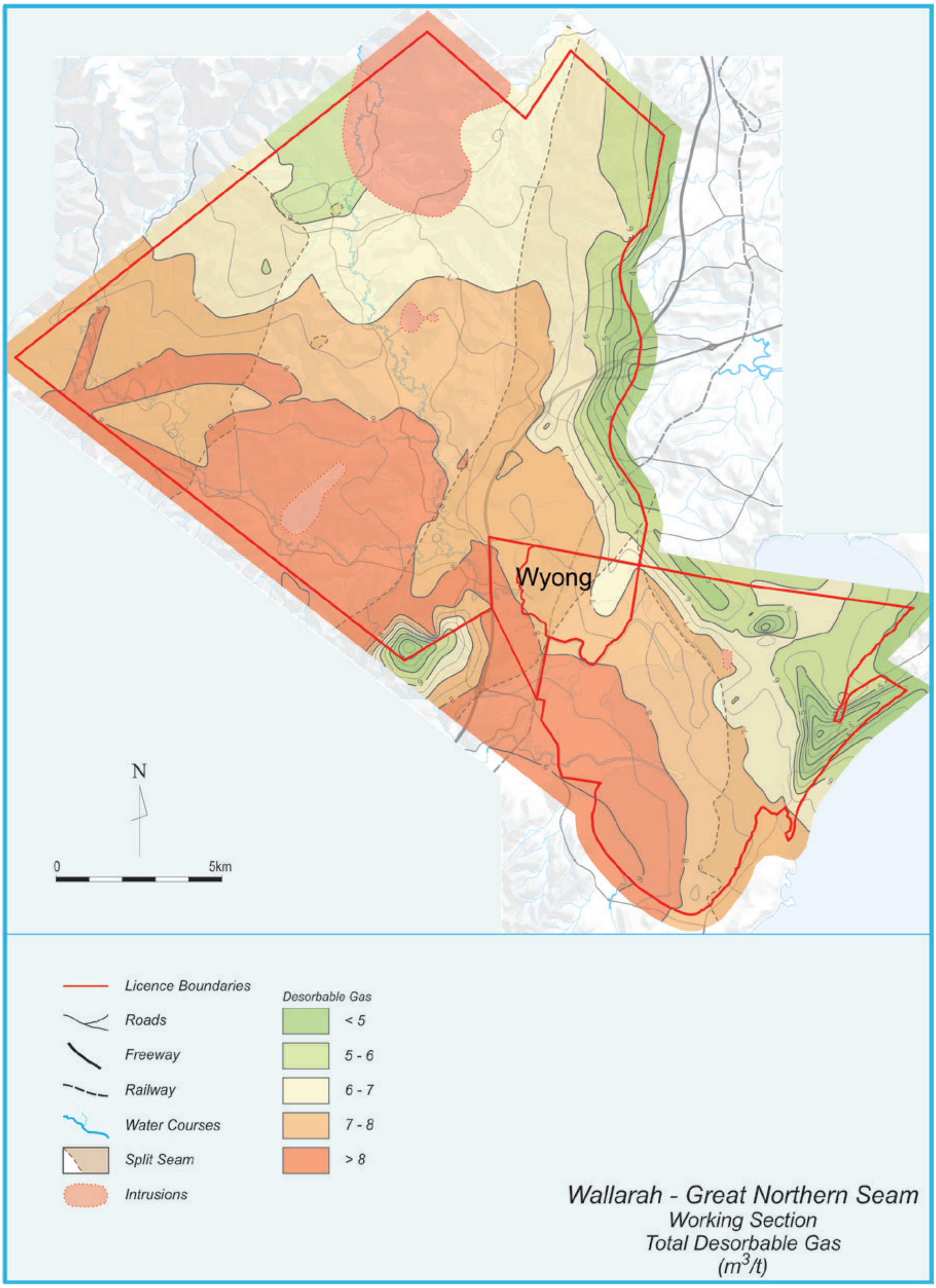

Figure 9.1 WGN Working Section Gas Content

10. GEOTECHNICAL APPRAISAL

10.1 GENERAL

Two geotechnical investigations for the Wyong Project were undertaken. The Stage I investigation, undertaken by Coffey Partners International Pty Ltd (1998), provided for specific testing of strata and the relationship of rock strength to roof and floor conditions.

The Stage II investigations (carried out by and reported in Strata Control Technology, 1999) were of a more interpretative nature and assessed stress conditions and strength characteristics of strata with regard to roadway stability, longwall caving and pillar size. Central to both of these investigations was the establishment of relationships with UCS test results and sonic velocity.

The following sections synthesise the major issues discussed in the reports described above.

10.2 ROOF CONDITIONS

The initial geotechnical appraisal examined roof stability based on failure mechanisms and interpreted rock strengths. Geotechnical assessments on the stone roof were made on the following two horizons:

- The "primary/immediate roof" i.e., up to 2 metres above the top of the seam, encompassing the horizon likely to be supported using normal roof bolts; and
- The "secondary roof" between 2 metres and 6 metres above the top of the seam, encompassing the zone that may soften with time, and may require secondary support if the primary support is unable to maintain roof stability.

Over the exploration area, the immediate roof of the seam consists of the Dooralong Shale. This unit comprises mainly sandstone, laminite, mudstone and siltstone. Minor occurrences of conglomerate are found mainly in the Eastern Area. The strengths of the primary and secondary roofs intersected by all boreholes with sonic logs were classified according to strengths interpreted from sonic data. The strength classes were then digitally encoded to allow the contouring of the distribution of strengths for both primary and secondary roofs. The high strength roof zones generally agree with areas of sandstone roofs.

Four different support regimes were then developed based on failure mechanisms.

- Regime A: Both primary and secondary roof are likely to develop compressive failures. As a result, roof supports have to deal with at least 6 metres of failed ground above the roofline, indicating that secondary supports are required;
- Regime B: The primary roof is weak but not the secondary roof. As a consequence the support strategy is assessed to be the suspension of the broken primary roof to the intact secondary roof horizon;

- Regime C: Both primary and secondary roofs are assessed to be strong, which is indicated for most of the Primary Target Area. In this case, support is based on beam building to resist shear movement, i.e., bolting; and

- Regime D: The secondary roof is weak but not the primary roof. This case requires careful assessment of site conditions. If the intact primary roof is mechanically strong, the support strategy would be similar to Regime C, albeit bolting density would be a practical and economic issue.

Figure 10.1 indicates the distribution of these support regimes which were recognised across the Extraction Area. It is generally assessed that roof behaviour within gateroads will be competent on development and retreat. The rock mass strength however will allow good goaf formation in the Primary Target Area.

10.3 FLOOR CONDITIONS

The strengths of the immediate 2 metres of floor strata were classified according to interpreted strengths. Similar to the studies on roof strengths, the strength classes were digitally coded and contoured. Distribution of the four classes of floor material recognised across the area is displayed in Figure 10.2. Rocks with UCS greater than 25 MPa and horizontal partings are more likely to be affected by hydraulic pumping, producing potholes and stepped floors. Rocks with UCS less than 10 MPa may experience bearing capacity or stress-related failures due to water-induced strength reduction and produce rutting behaviour. Rocks with a UCS range from 10 to 25 MPa may experience either of these failures depending on traffic loads and presence of mine water. It was concluded that

"*the key for the prevention of floor degradation process is the management of mine water*".

In mining operations to the immediate north of the Extraction Area, the deterioration of the Awaba Tuff in the floor has resulted in poor floor conditions and pillar instability. This unit is highly variable and may range from a soft clay soil consistency to high strength rocks with a UCS greater than 120 MPa. The soft units are often in thin layers near the top or at the bottom of the stratigraphic unit or around the interfaces between the claystone and hard tuffaceous sandstone.

The Awaba Tuff occurs stratigraphically below the Wallarah – Great Northern Seam. It varies significantly in thickness and composition. In parts of the Western PTA it is overlain by a sandy unit referred to as the Warnervale Conglomerate. Implications of the behaviour of this unit relate not so much to practical mining and roadway development, but to long term subsidence effects. Because of the deterioration of the Awaba Tuff in the presence of water experienced in existing mines, a coal floor will be required to protect travelling roads in areas where this unit forms the immediate seam floor.

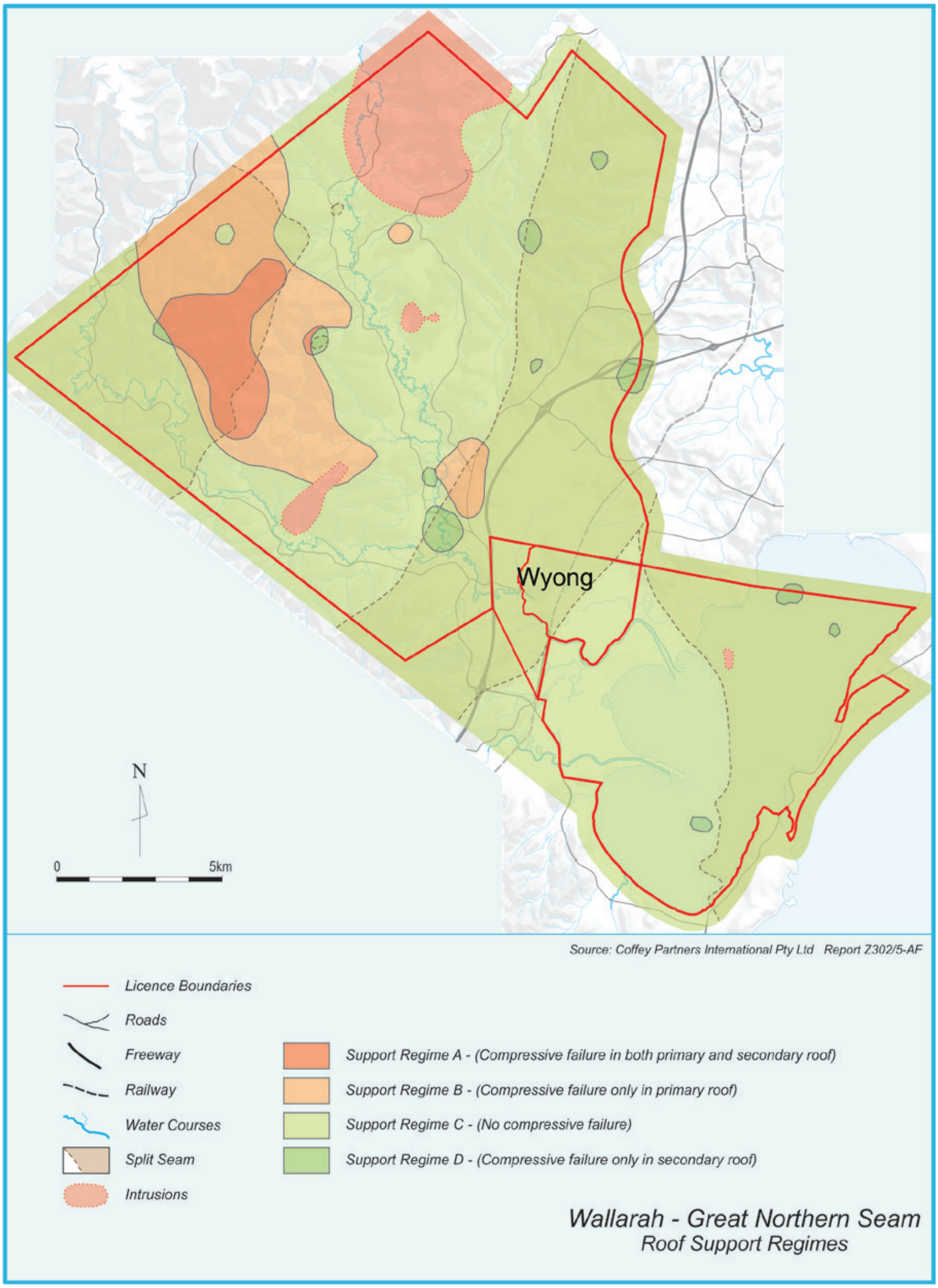

Figure 10.1 WGN Roof Support Regimes

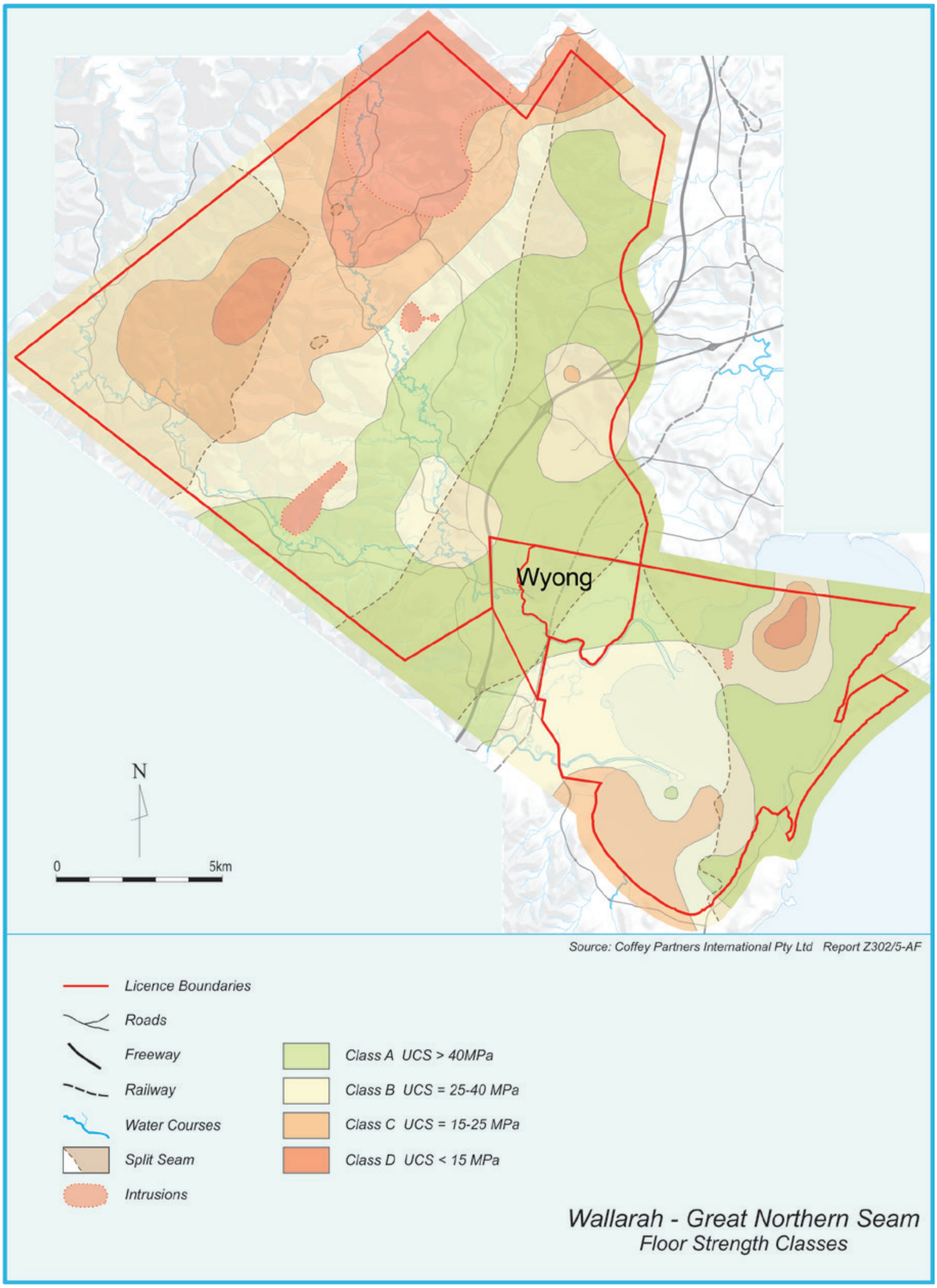

Figure 10.2 WGN Floor Strength Classes

10.4 STRESSFIELD

The Stage II geotechnical assessment examined the effect of in situ stress on development roadway stability, rock fracture above longwall panels, longwall support behaviour and pillar strength characteristics. Extensive computer modelling was utilised for this assessment. The available data indicates a consistent major horizontal stress direction oriented north-north-east throughout the north of the Primary Target Area and in the north of Tuggerah Lake.

The magnitude of vertical stress is expected to be related to the depth of overburden, whereby the vertical stress increases by 2.5 MPa/100 metres. Using breakout analysis the stress magnitude was found to be approximately 12 MPa (in a 10 GPa rock unit). The major horizontal stress in the coal is in the 7 MPa range. The magnitude is considered to be moderate and of a similar tectonic regime as experienced in some of the mines of equivalent depth on the South Coast of New South Wales. Towards the south around Yarramalong Valley and Chittaway Point, a significant swing in stress direction towards the east has been recorded.

Roadways are expected to maintain roof stability during development driveage up to a stress level of 19-20 MPa. On this basis, roadways are expected to have relatively good roof conditions down to depths of at least 500 metres in unstructured ground conditions. In structured ground, local stress effects are possible and the integrity of the roof may require secondary reinforcement.

It is anticipated that cut and flit mining is feasible under the sandier roof sections. Rib stability will be a major factor in evaluating the cut-out length. Further work is necessary to assess the cut out issues.

Rib deformation and floor breakup are the major deformation modes around the roadways. Rib stability is improved by reducing the roadway height. The effect of roadway height was assessed and a roadway height in the range of 3 to 3.5 metres would be considered suitable.

Gateroads oriented within 30 degrees of the major horizontal stress would be expected to maintain stable maingate end conditions with only localised secondary support about intersections and structured areas. Roof stability should be maintained under the moderate vertical stresses anticipated for maingate ends and travel roads.

The vertical stress at the tailgate area will be dependent on the residual strength of the chain pillars. However the results indicate that whilst roof conditions may be maintained, additional support may be required to control the ribsides, floor and intersections. It is anticipated that standing support will be required about intersections and certain areas of the tailgate affected by weak floor conditions.

The geometry and nature of rock fracturing above longwall panels was determined from computer simulation of the caving process. The strata will goaf readily on retreat with initial caving extending 15-20 metres above the seam. The fractures may extend upwards 200-225 metres once full caving and subsidence is established. There appears to be no vertical connection between the surface cracking zone and the mined seam which would allow direct aquifer leakage from the surface to the mine.

Floor strata computer simulation showed fracturing penetrated to the Fassifern Seam and that fluid migration from the Fassifern Seam to the goaf was likely.

The ground movement and support loading characteristics were simulated within the computer model. The results indicate that there are no major caving problems such as cyclic block weighting, however a regular cycle of rock fracturing appears to occur similar to a process recognised in other mines of comparable depth south of Sydney. Modelling suggests that a two leg 800-900 tonne support system is expected to be suitable.

The strength of pillars is dependent on the location and strength of clay bands within the floor strata. The main unit of concern is the Awaba Tuff, which in mines to the north has significantly reduced pillar strength characteristics.

The geological floor section over the study area is variable from thick conglomerate in the east, through a transitional zone and then into the Awaba Tuff unit in the west. Modelling to date indicates that chain pillars may be weaker than their nominal empirical capacity due to rock fracture in the weak strata above and below the coal seam. Two and three heading panels were modelled. For two heading developments, a 55-60 metre pillar, with cut through spacing of at least 95 metres, in depths from 400-500 metres has been considered. This size would be expected to maintain acceptable travel road conditions and significantly improve tailgate conditions during extraction relative to a 40 metre wide pillar.

Three heading panels would be needed to allow stable gateroad conditions and to allow subsidence to occur without major strain effects. Panel geometry could be optimised to a combination of 35 metre and 40 metre wide pillars, with the smaller pillar on the maingate side.

10.5 POTENTIAL ROOF CONTAMINATION

Roof dilution potential was assessed for broad roof “domains” delineated by modelling three physical attributes of the rocks logged in the boreholes, namely, sand/shale ratio, Rock Quality Designation (RQD) and Uniaxial Compressive Strength (UCS). This assessment focussed on the immediate 200 mm of roof above the potential working section. Results were forwarded to SCT to estimate potential degrees of contamination during mining through the mapped domains.

The methodology used can be applied to any amount of roof material. This exercise modelled only the first 200 mm, but sand/shale ratio and RQD models were also developed for 100 mm, 500 mm, 1 m, 2 m and 10 m of roof material. Potential exists to extend the domain mapping to thicker roof intervals to assist with roof stability assessments.

10.6 GEOTECHNICAL REVIEW

Existing data from previous investigations was tabulated to identify the type of available data and to analyse relationships (Edwards, 2002”). Three databases were generated:

- A rock property database designed to collate all existing test results and establish links between rock property data and geophysical data for numerical modelling purposes;
- A breakout database to identify trends in the orientation of maximum horizontal stress for consideration in mine layout design;
- A joints database to identify trends in the orientation of jointing for consideration in mine layout design.

Acoustic scanner and dipmeter logs (particularly of faulted sections) of boreholes were examined to investigate fault and joint orientation details. These structural features have been added to the databases and related to anomalies identified in surface seismic profiles.

Relationships were determined between Sonic Velocity (determined from geophysical logs) and UCS and between Sonic Velocity and Young's Modulus for individual rock types. This work was provided to SCT to remodel caving and subsidence predictions which are addressed in detail in a separate report (refer to Subsidence Predictions and Impact Assessment (WACJV 2013) within the EIS).

11. RESOURCE STATEMENT

Table 14.1 summarises the resource by category calculated by VULCAN.

Table 14.1 Resource Summary, June 2006

	Tonnage	Raw Ash	Raw Moisture	Raw Specific Energy	Raw Sulphur	Raw VM
		(% ad)	(% ad)	(kcal/kg daf)	(% ad)	(% ad)
Western Lease						
Measured	212,251,347	15.8	1.8	8,085	0.34	27.80
Indicated	468,198,416	18.7	2.0	8,087	0.34	26.90
Inferred	27,416,580	15.8	2.0	8,142	0.31	25.27
Subtotal	707,866,343	17.7	1.9	8,089	0.34	27.11

REFERENCES

Banwell LD, August 2002
Wyong Coal Project – Roof Dilution Modelling, Internal Wyong Coal Project Report COAL-0079

Barry (2005)
NSW Department of Primary Industries - DPI - *Mineral Resources Assessment Report: Northern Geosciences / Draft) Report on Hydrogeological Investigations, Dooralong and Yarramalong Valleys* (January 2005)

Bartlett KE and G Conquest, November 1999
Wyong Coal Project – Borehole Cementing Procedure, *Internal Wyong Coal Project Report COAL-0065*

Byrne C, July 2001
Wyong Coal Project – Land Drilling Procedure - includes Borehole Folder Sheets & Packer Test Procedure, *Internal Wyong Coal Project Report COAL-0067*

Campbell M, 1996
Wyong Coal Project – Analytical Flow (Allied Testing), *Internal Wyong Coal Project Report COAL-0072*

Coffey Partners International Pty Ltd, 1998
Geotechnical Assessment of Stage 1 Exploration – Wyong Project

Conquest G, April 2002
Wyong Coal Project – Lake Drilling, Internal Wyong Coal Project Report COAL-0068

Conquest G, April 2002
Wyong Coal Project – Core Logging Procedure, Internal Wyong Coal Project Report COAL-0069

Conquest G, April 2002
Wyong Coal Project – Gas Sampling & Testing, Internal Wyong Coal Project Report COAL-0070

Conquest G and M Ewart, April 2002
Wyong Coal Project – Core Photography, Internal Wyong Coal Project Report COAL-0071

Creasey J W and Huntington J F 1985
CSIRO – Lineament Patterns of the Sydney Basin - An Overview

Edwards J L, September 2002
Wyong Coal Project – Geotechnical Review 2002, *Internal Wyong Coal Project Report COAL-0064*

Ewart M, 1998
Wyong Coal Project – Packer Testing Procedure, *Internal Wyong Coal Project Report COAL-0059*

GeoGAS, 1997
Report on Gas Content Testing and Analysis of Samples, The Wyong Areas Coal Joint Venture

Jones (January 2005)
Northern Geoscience – (Draft) Report on Hydrological Investigations, Dooralong & Yarramalong Valleys, Wyong, Central Coast, NSW (Submitted to Tony Davis & Associate, Australian Gas Alliance, Dooralong NSW 2259 and posted on their and other web sites)

Lindsay G, April 2002
Wyong Coal Project – Data Handling, Internal Wyong Coal Project Report COAL-0077

Lindsay G, July 2002
Wyong Coal Project – Borehole Deviation, Internal Wyong Coal Project Report COAL 0075

Mauger A J, Creasey J W and Huntington J F 1984
CSIRO – The Use of Pre-development-Data for Mine Design: Sydney Basin Fracture Pattern Analysis

Milenko M and Neville M J 1991
Geotechnical Centre, Public Works – Report No. 90244: Boomerang Creek Tunnel – Geological Report of Construction

SCT Operations Pty Ltd, 1999
Geotechnical Feasibility Study for Wyong Lease

SIMTARS 1999
Spontaneous Combustion Testing from the Wyong Project – Borehole B650W350