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Geological Study and Economic Evaluation of the Paardeplaats Coal Exploration Project

By

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A dissertation submitted in partial fulfilment of the requirements for the degree of

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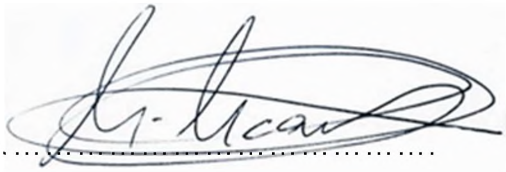
DEDICATION

Dedicated to my parents and children, thank you for the inspiration.

DECLARATION

I, Mr Gcobani Gcayi declare this dissertation to be my own work. It is submitted in fulfilment of the Degree of Master of Science at Rhodes University. It has not been submitted before for any degree or examination in any other University or tertiary institution.

Signature of the candidate: ………………………………………………….



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ABSTRACT

For a coal mining company the coal resources are an important asset, and they are acquired in a number of different ways, such as obtaining a prospecting permit from government or an existing permit from another entity and or purchasing an operating colliery from another entity. The Paardeplaats Project is a brownfields project located approximately 7 km south west of the town of Belfast in Mpumalanga Province, South Africa, on the far eastern edge of the Witbank Coalfield. The project is located adjacent to an operating mine, Glisa Colliery, owned by Eyesizwe Coal.

Eyesizwe Coal was awarded the prospecting permit in 2006 by the Department of Mineral Resources. Subsequent exploration activities, which included airborne magnetic survey and borehole drilling, were conducted between 2008 and 2010. The results of the drilling confirmed the presence of coal resources, which are classified in the Measured, Indicated and Inferred categories.

Mining and beneficiation methods from the adjacent Glisa Colliery, which has similar geology to the project area, were assumed in order to generate a coal reserve statement. The Coal Reserve qualities are suitable to the domestic market, particularly Eskom.

South Africa's coal supply is demand driven, primarily from Eskom for electricity generation followed by the export market and thirdly by Sasol for synthetic fuel generation. The majority of Eskom's existing coal-fired power stations are located in the Mpumalanga Province, which provides a viable market for coal projects in Mpumalanga when considering existing transport infrastructure and transportation costs. Eskom's continued demand for coal in the Mpumalanga region, at least until 2040, provides a future market for advanced coal projects in the region.

A valuation of the project using the Cash Flow Approach showed the project to be economically viable.

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1. INTRODUCTION

1.1 Purpose of the study

For a coal mining company the coal resources and reserves are an important asset. Coal assets are acquired in a number of different ways, such as undertaking prospecting activities after obtaining a prospecting permit over a coal property from the relevant government authority, purchasing an already prospected coal property from another entity, and purchasing an operating colliery from another entity.

Whichever method is chosen, there will be a requirement to undertake detailed multidisciplinary investigations with the objective of: firstly, ascertaining the presence, quantity and quality of coal resources; and secondly, after having considered all the relevant factors, put a monetary value on the coal property. This study uses the Paardeplaats Coal Exploration Project (Paardeplaats Project) as a case study to focus on the approach of acquiring and evaluating a coal property starting at the prospecting phase.

The lateral and vertical extents of the coal resources in a coal property are delineated through exploration activities undertaken by geologists. After establishing the coal resource boundaries, and considering a multitude of modifying factors to convert coal resources to coal reserves, a monetary value can be put on a coal property. A business entity holding a coal property will do so with the purpose of either selling it for a profit, or for developing it into a producing colliery.

Investment decisions to develop a coal property into a producing colliery require a thorough appraisal of all available geological, mining, beneficiation, economic and financial data, and a rigorous testing of all postulated forecasts, assumptions and scenarios. For the investment decision to be good, it has to make both financial and economic sense, and it rests heavily on the exploration data provided by the geologist.

This study which was undertaken as part of the MSc Exploration Geology Programme was born out of the author’s personal needs to develop certain skills and knowledge in the field of mineral project evaluation. The author has been an ‘industry geologist’ for eight years, four of which were spent exclusively on coal exploration projects, with the main responsibilities being core logging, drill rig supervision and liaising with surface right owners. As a field geologist the main exposure and contribution to exploration projects has been in the form of data collection. The ambitions of the author as an exploration geologist go beyond data collection in the field. For future growth in the field of mineral exploration the author requires skills and knowledge to be able to undertake evaluations of mineral exploration projects.

The author was the project geologist for the Paardeplaats Project and uses its data in this study to present exploration results, consider economic and investment analysis considerations required for mining investment decisions. The author was responsible for all the field work during exploration drilling, which included borehole planning, borehole core logging, sampling and data capturing. Furthermore, the author was responsible for geological data interpretation, construction of the geological model (using Minex modelling software), coal resource estimation and classification. All exploration drilling work up to coal resource estimation and classification was the work of the author. Exploration activities on the Paardeplaats Project were conducted between 2008 and 2010. The study thus makes use of previously collected exploration data.

1.2 Locality of the study area

The Paardeplaats Project is located approximately 7 km south west of the town of Belfast in Mpumalanga Province, South Africa, on the far eastern edge of the Witbank Coalfield. It is located alongside the N4 national road towards Maputo approximately 260 km from Johannesburg (Figure 1).

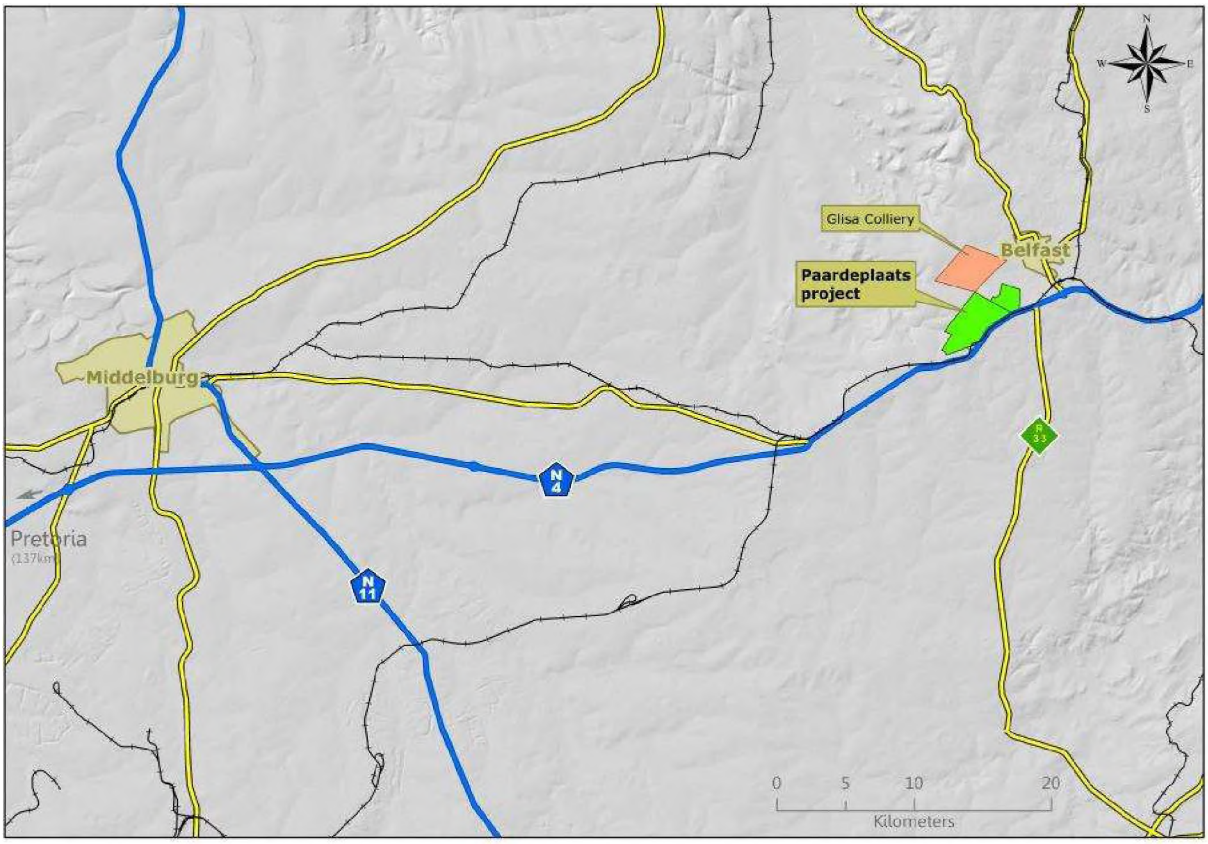


Figure 1: Locality of the study area.

1.3 Property description

The Paardeplaats Project consists of Portions 13, 28, 29, 30, 40 of the farm Paardeplaats 380 JT and the Remaining Extent of Portion 2 of the farm Paardeplaats 425 JS, which together cover an area of 1421.99 hectares (Figure 2).

The prospecting permit for the Paardeplaats Project was granted to Eyesizwe Coal, a wholly owned subsidiary of Exxaro Resources Limited, by the Department of Minerals and Energy (DME) on 2006/10/30 for a period of five years. The DME has since been split into two departments, namely the Department of Mineral Resources (DMR) and the Department of Energy. Prospecting and mining activities now fall under the jurisdiction of the DMR. Renewal of the permit after the expiry date, is permissible provided there was compliance with conditions set by DMR, and is at the discretion of the DMR. The prospecting permit was granted in terms of section 17 (1) of the Mineral and Petroleum Resources Department Act 2002 (Act No. 28 of 2002).

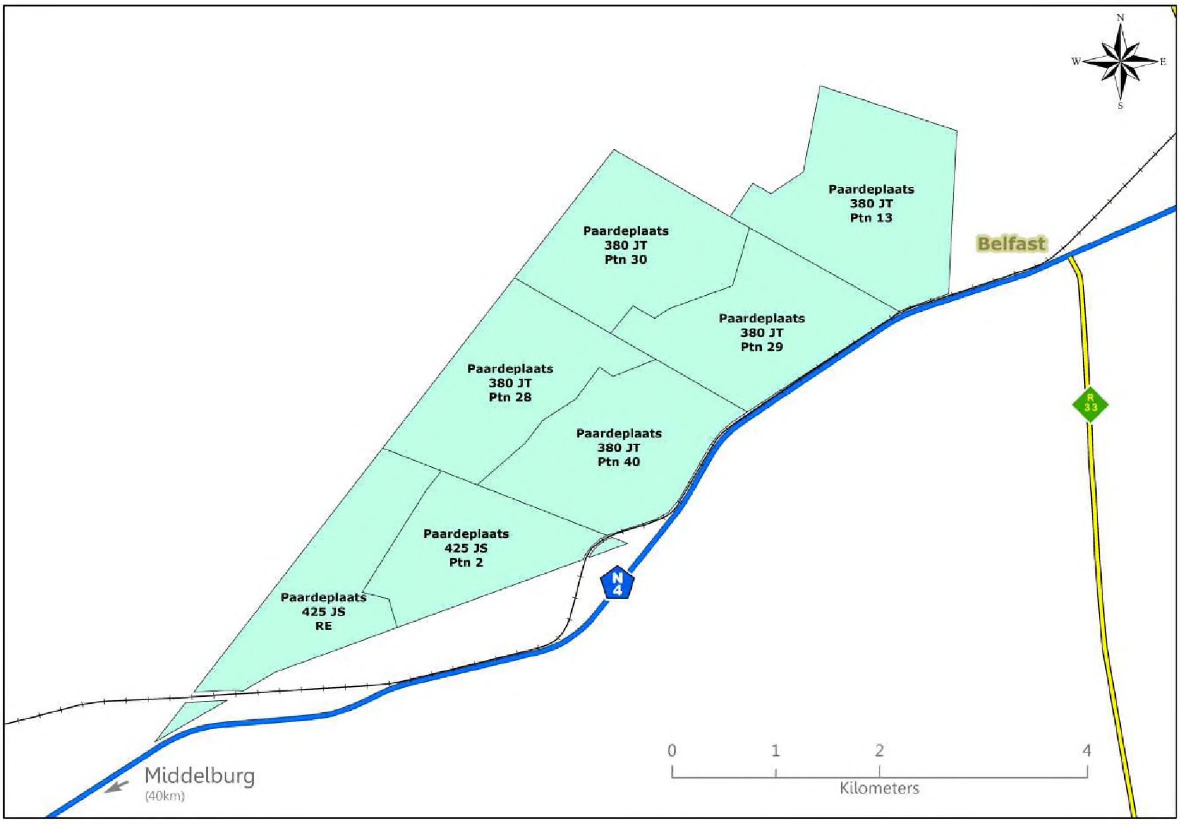


Figure 2: Paardeplaats farm portions covered by the prospecting permit.

1.4 Accessibility, Infrastructure, Climate and Physiography

The Paardeplaats Project is located adjacent to the N4 national route connecting Johannesburg and Maputo. The railway line to Maputo is also in close proximity, with loading facilities about 6 km away at the Belfast siding station. The project area is located adjacent to the existing Glisa colliery, which translates to easy access to infrastructure such as electricity supply. There are existing power lines servicing the current agricultural activities on the project area. The labour force can be sourced from the town of Belfast which is within a 10 km radius of the project area.

The Belfast area, located on the Drakensberg escarpment, is characterised by a gentle undulating to a relatively flat surface topography. This gentle topography generally dips towards the south, with wide, open and incised drainage lines. The area is dissected by an East-West-trending watershed, allowing surface drainage to flow west to the local stream and valley area of the Steelpoort catchment (part of the Olifants River Water Management Area). The Belfast Dam, located about 3 km north and downstream of the project area, is the main dam used by the Belfast town for domestic purposes.

The project area lies in the summer rainfall region of South Africa, in which more than 80% of the annual rainfall occurs in the form of convectional thunderstorms. The thunderstorms are occasionally accompanied by lightning, heavy rain, strong winds and sometimes hail. The area, occurring at an elevation of between 1840 m and 1890 m above mean sea level, is one of the coldest areas in South Africa, with temperature ranging 32°C to 14.6°C in the summer and between 21.6°C and -7.4°C in the winter.

Most of the project area is under *Eucaluptus* timber plantations but surrounding areas are used significantly for agricultural activities such as grazing land for sheep, cattle and dairy farming, and the production of maize, grain, sunflower, dry beans, potatoes and wheat. The Belfast area in general is probably most renowned for its fly fishing.

1.5 Exploration history

The Paardeplaats Project is located on the southern boundary of the Glisa Colliery (see **Figure 1**). The Glisa Colliery has a long history of production with some evidence that it was originally founded to supply coal to Paul Kruger's railways in the early 1900s (Mining Weekly, 2005). Eyesizwe Coal assumed ownership of the Glisa Colliery in the early 2000s, and discovered that the coal measures continued to the south. As a consequence, Eyesizwe Coal applied for a prospecting permit over the property, which was granted by the Department of Minerals and Energy (since 2009 the Department of Mineral Resources (DMR)) on 2006/10/30.

The conditions of the prospecting permit required that prospecting activities be undertaken on the license area within a period of five years from date of issue. Prospecting activities were carried out between 2008 and 2010; an airborne magnetic survey was flown in 2008 followed by a programme of diamond core drilling in 2009, which was completed in 2010. There is no information of prior prospecting activities on the license area that the author is aware of.

2. GEOLOGY

2.1 Geological setting

The Paardeplaats Project is located in the Witbank Coalfield, one of the nineteen coalfields in South Africa (Jeffrey, 2005: see **Figure 6**). The Witbank Coalfield is located within the Main Karoo Basin, which represents the relatively stable, cratonic paralic type of basin in which coal seams developed on the wide flank of the Kaapvaal Craton. The Karoo Basin (Figure 3) covers about 550,000 km² of the surface area in South Africa; the sedimentary succession is thickest in the southern margin, thins northwards and pinches out along the northern margin of the basin (Cadle, et al, 1993).

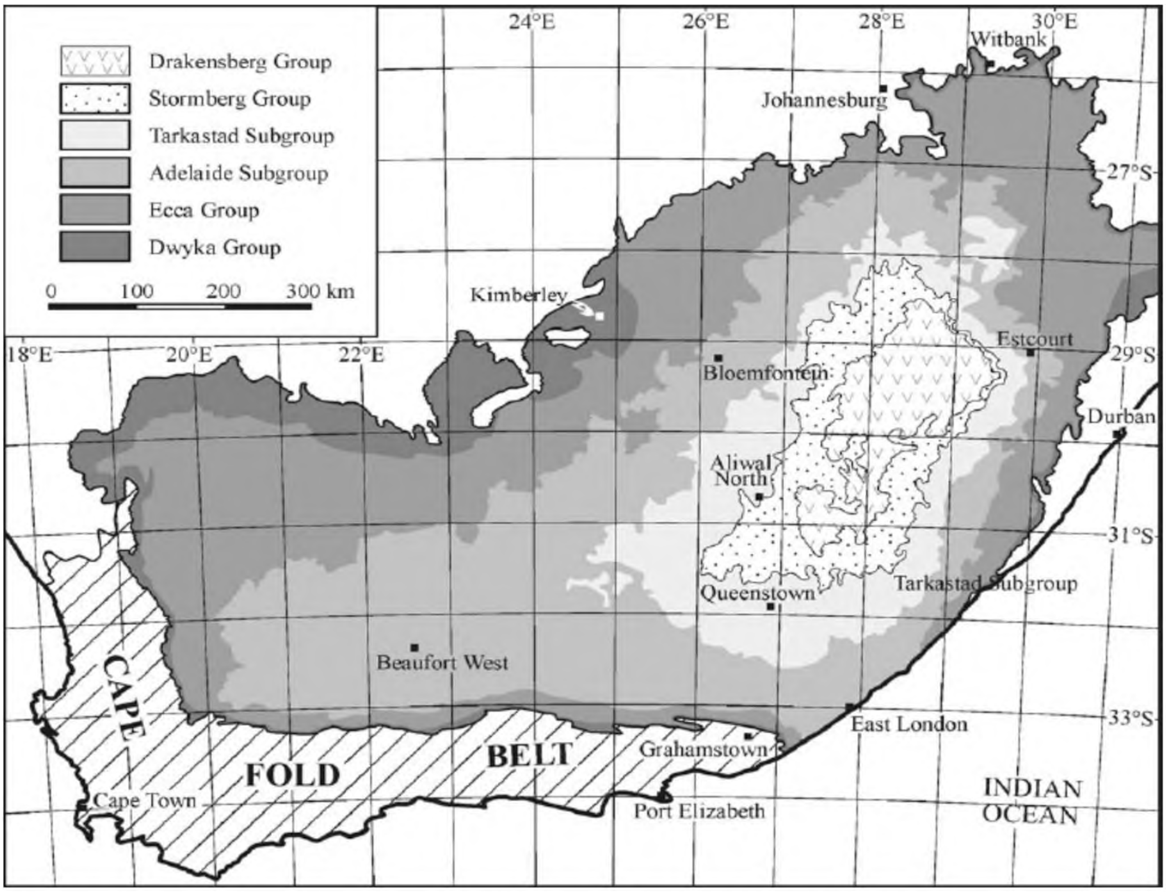


Figure 3: Geological map of the preserved Karoo Basin, showing the outcrop distribution of the main lithostratigraphic units of the Karoo Supergroup (from Catuneanu et al, 2002).

The Karoo Supergroup succession comprises four main stratigraphic units, which from bottom to top are the Dwyka, Ecca, Beaufort and Stormberg Groups (SACS, 1980). The depositional environments (see Figure 4) of the Karoo sediments range from glacial (Dwyka Group) to shallow marine and coastal plain (Ecca Group) to non-marine fluvial (Beaufort Group) and aeolian (Stormberg Group) (Hancox and Götz, 2014).

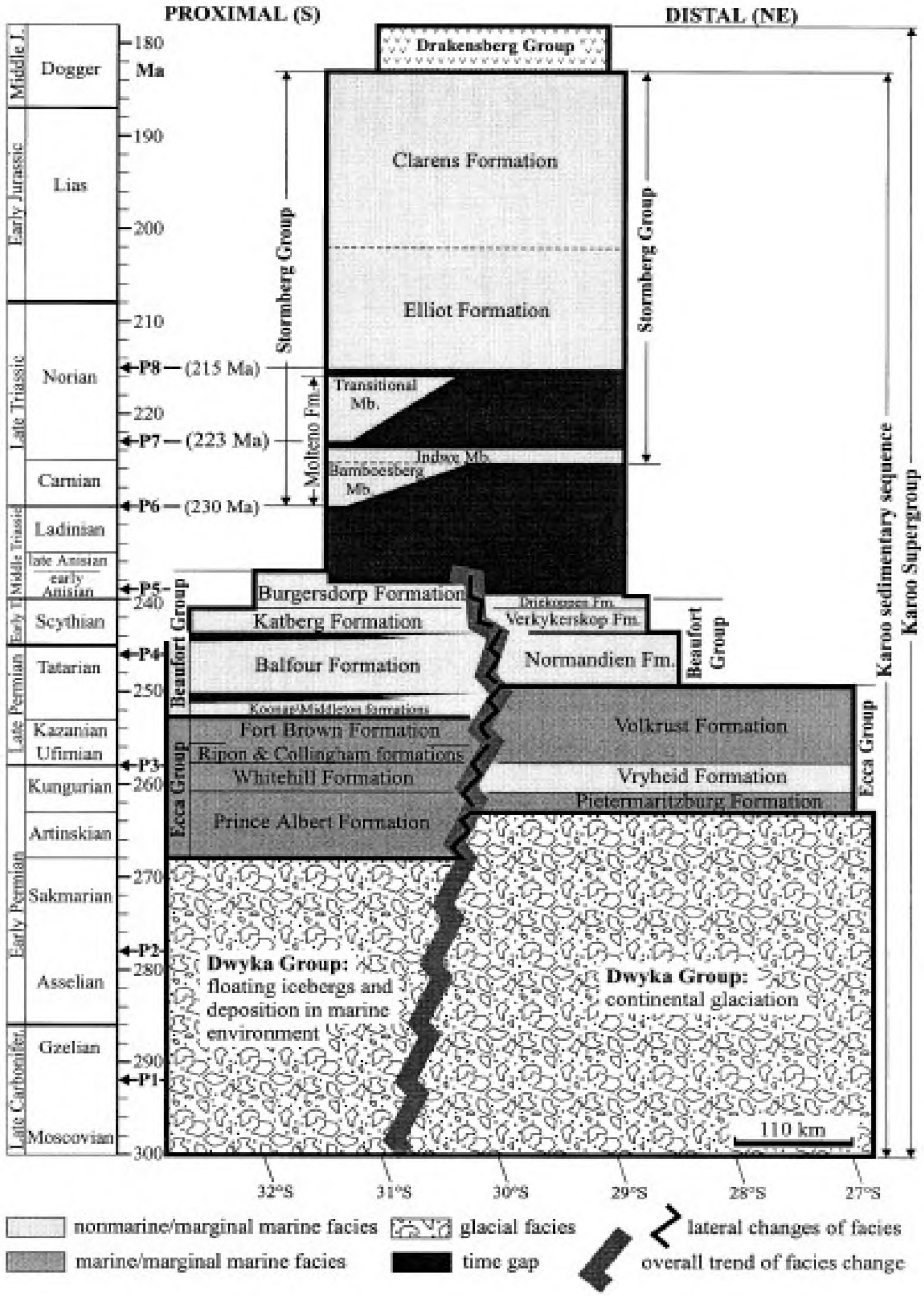


Figure 4: Lithostratigraphy of the Karoo Supergroup, showing varying depositional environments (from Catuneanu et al, 1998).

Coal in South Africa is developed at three stratigraphic positions, the Permian Vryheid and Volksrust Formations and the Middle Triassic Molteno Formation (Cadle et al, 1993). The Ecca Group which hosts the majority of South Africa's coal measures is subdivided into, bottom up, the Pietermaritzburg, Vryheid and Volksrust Formations. The coal seams of the Witbank Coalfield are found in the rocks of the Vryheid Formation. The Vryheid Formation ranges in thickness from less than 70 m to over 500 m (Figure 5).

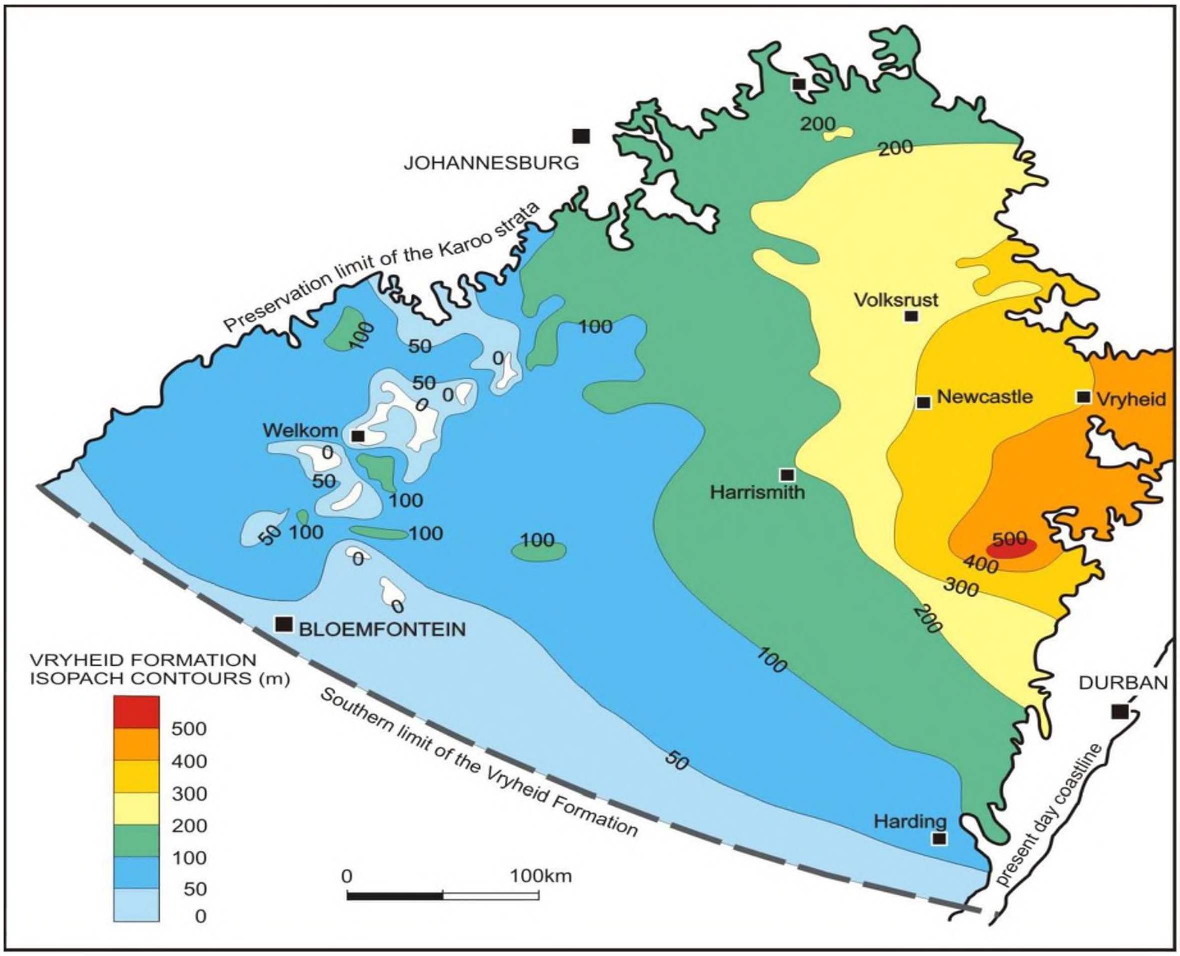


Figure 5: Isopach map of the Vryheid Formation showing increasing thickness towards the east (from Hancox and Götz, 2014).

The stratigraphy of the Vryheid Formation is a succession of five coarsening upward sequences which display lateral continuity across the entire distal region of the Karoo basin (Cadle, 1982). The coal seams occurring in the Vryheid Formation are associated predominantly with the coarser grained fluvial facies at the top of each sequence (Hancox and Götz, 2014).

2.2 The Witbank Coalfield

The Witbank Coalfield, shown as coalfield 7 in Figure 6 hosts the Paardeplaats Project and thus is reviewed briefly in this section.

The coalfield extends about 190 km west-east between the towns of Springs and Belfast and about 60 km in a north-south direction between the towns of Middelburg and Ermelo. For over a century the Witbank Coalfield has been the major coal producing area in South Africa, and continues to be so; it is estimated that since the first commercial exploitation of coal in 1870, over 50% of the coal produced in South Africa has come from the Witbank Coalfield.

Table 1 shows the Witbank Coalfield’s coal resources and reserves in relation to the other coalfields. At the end of 2001, 39 (55%) operating collieries in South Africa were located in the Witbank Coalfield (Jeffrey, 2005). South Africa relies heavily on coal for electricity generation, and as a result the majority of the coal-fired power stations are located in the Witbank Coalfield.

There are five palaeovalleys in the Witbank Coalfield which were scoured out by the migrating Dwyka ice sheets, and it is in these valleys that the sediments of the Dwyka and Ecca Groups were later deposited (Figure 7) (Hancox and Götz, 2014). The coal seams pinch out against the margins of the palaeovalleys and are either thin or absent above prominent basement highs (Cadle et al, 1993).

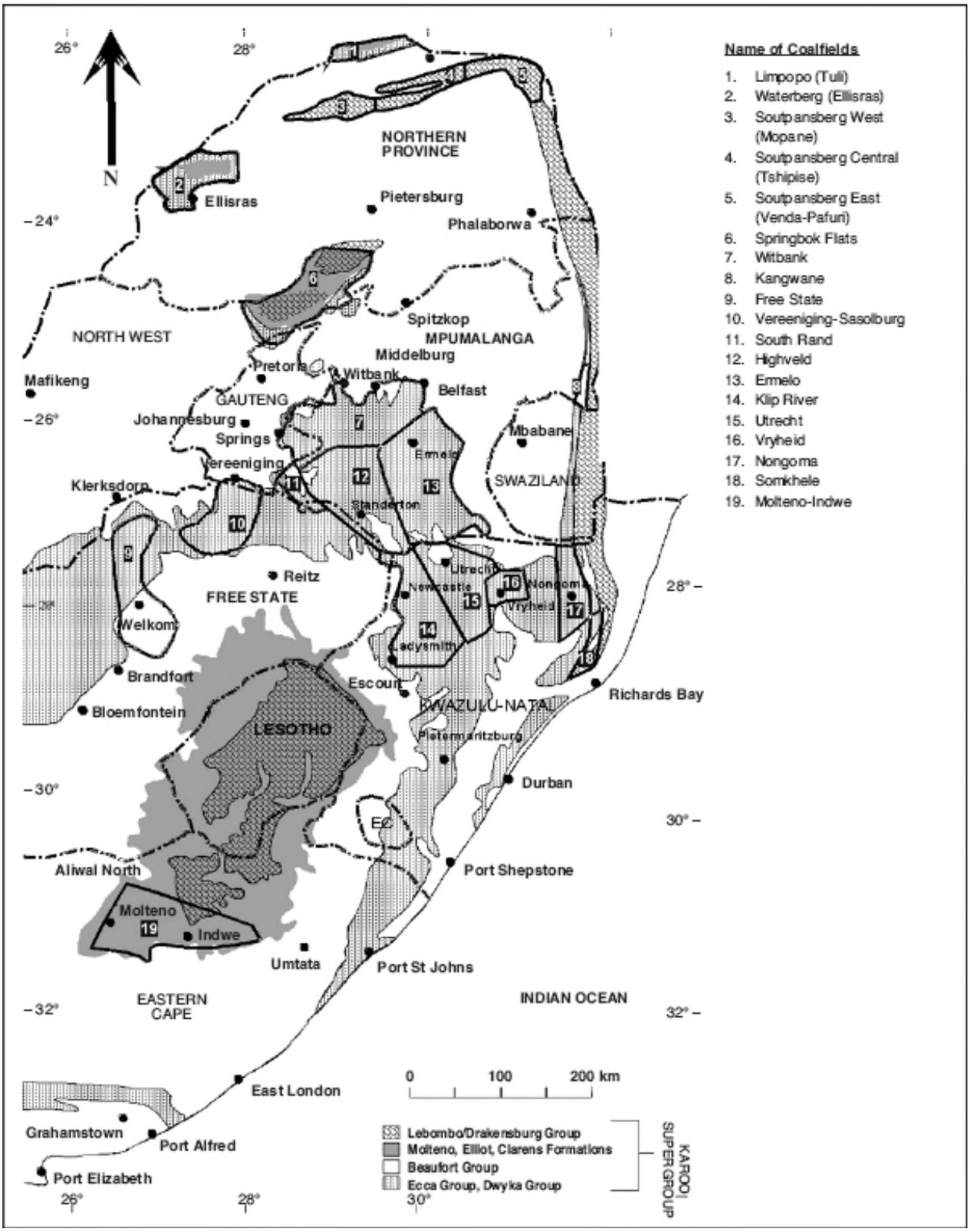


Figure 6: Distribution of coalfields in South Africa (from Jeffrey, 2005).

Table 1: Percentage distribution of coal resources and reserves in the different coalfields of South Africa (after Bredell 1987, quoted by Snyman 1998).

Coalfield	% of in-situ coal resources (121 Gt)	% of recoverable coal reserves (55 Gt)
Witbank	13.4	22.5
Highveld	14.0	19.8
Ermelo	6.2	8.5
Utrecht	0.9	1.2
Klip River	1.0	1.2
Vryheid	0.3	0.4
South Rand	2.5	1.3
Vereeniging - Sasolburg	3.9	4.0
Free State	7.3	8.8
Nongoma/Somkhele	0.2	0.2
Kangwane	0.4	0.3
Springbok Flats	2.7	3.1
Ellisras	45.8	28.0
Mopane/Tshipise/Pafuri	1.2	0.5
Tuli	0.2	0.2
Total	**100**	**100**

Five coal seams are contained in a 70 m thick succession of sandstone with subordinate siltstone and mudstone (Snyman, 1998), and are distinguished numerically in ascending order from the bottom upwards.

The distribution and attitudes of the No. 1 and 2 seams are largely determined by the pre-Karoo topography, whilst the present distribution of the No. 4 and No. 5 seams is controlled by the present day land surface (Snyman, 1998); in areas the No. 5 seam is either completely eroded or is patchily distributed, while the top part of the No. 4 seam is eroded or affected by weathering in places. The No. 3 seam is generally uneconomic, usually having a thickness of less than 0.5 m. At the Glisa colliery, on the most eastern edge of the Witbank Coalfield, 5 km south west of the town of Belfast, the No. 3 seam has an average thickness of 1.5 m and is exploited.

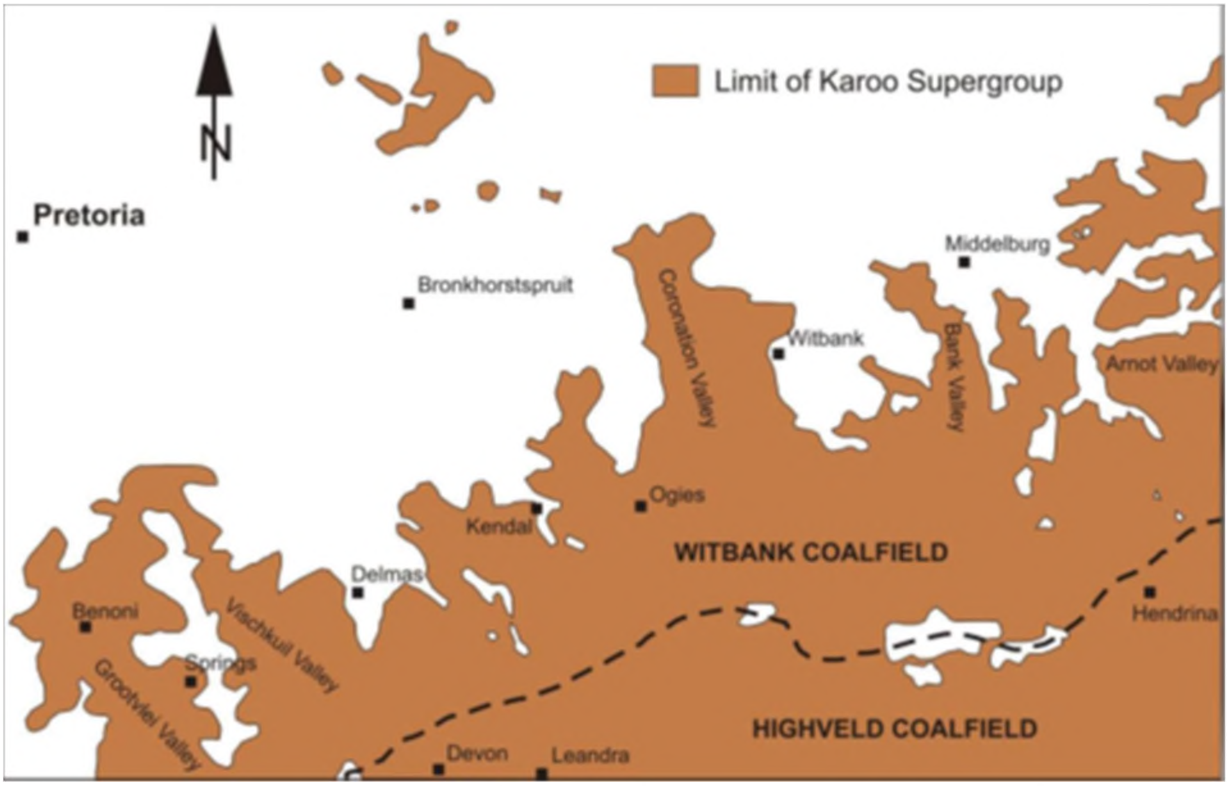


Figure 7: Five palaeovalleys in the Witbank Coalfield (from Hancox and Götz, 2014).

The No. 2 seam is the most economically important due to its relatively consistent distribution, thickness and qualities; it accounts for a greater portion (about 69%: Snyman, 1998) of the in-situ coal resource relative to the other seams. The thickness of the No. 2 seam varies between the different parts of the Witbank Coalfield: it is generally about 6.5 m in the central region, and about 3 m in the eastern region. The No. 2 seam can be subdivided into sub-seams by the presence of clastic partings, and into different zones for selective mining purposes on the basis of quality variations.

The No. 4 seam accounts for about 26% of the Witbank Coalfield's in-situ resource, and attains thicknesses of 2.5 m to 6.5 m (Snyman, 1998). The No. 4 seam can also be subdivided to sub-seams on the basis of clastic partings. The No. 5 and No. 1 seams account for about 4% and 2% respectively of the Witbank Coalfield in-situ resource.

In the east of the Witbank Coalfield, near Arnot, the No. 1 seam is between 1.5 m to 2 m thick but in other parts it is very thin, less than 30 cm. The No. 5 seam has a thickness varying from 0.5 m to 2.0 m.

Studies by Holland et al, (1989), revealed that coal seams associated with glaciofluvial and upper delta plain sedimentation, such as No. 2 and 4 seams are thick, laterally extensive and generally have higher inertinite and low vitrinite contents. The No. 3 seam which accumulated in a lower delta plain setting is relatively thin and laterally discontinuous with lower inertinite and higher vitrinite contents. Typical stratigraphic columns in five different areas of the Witbank Coalfield are shown in Figure 8.

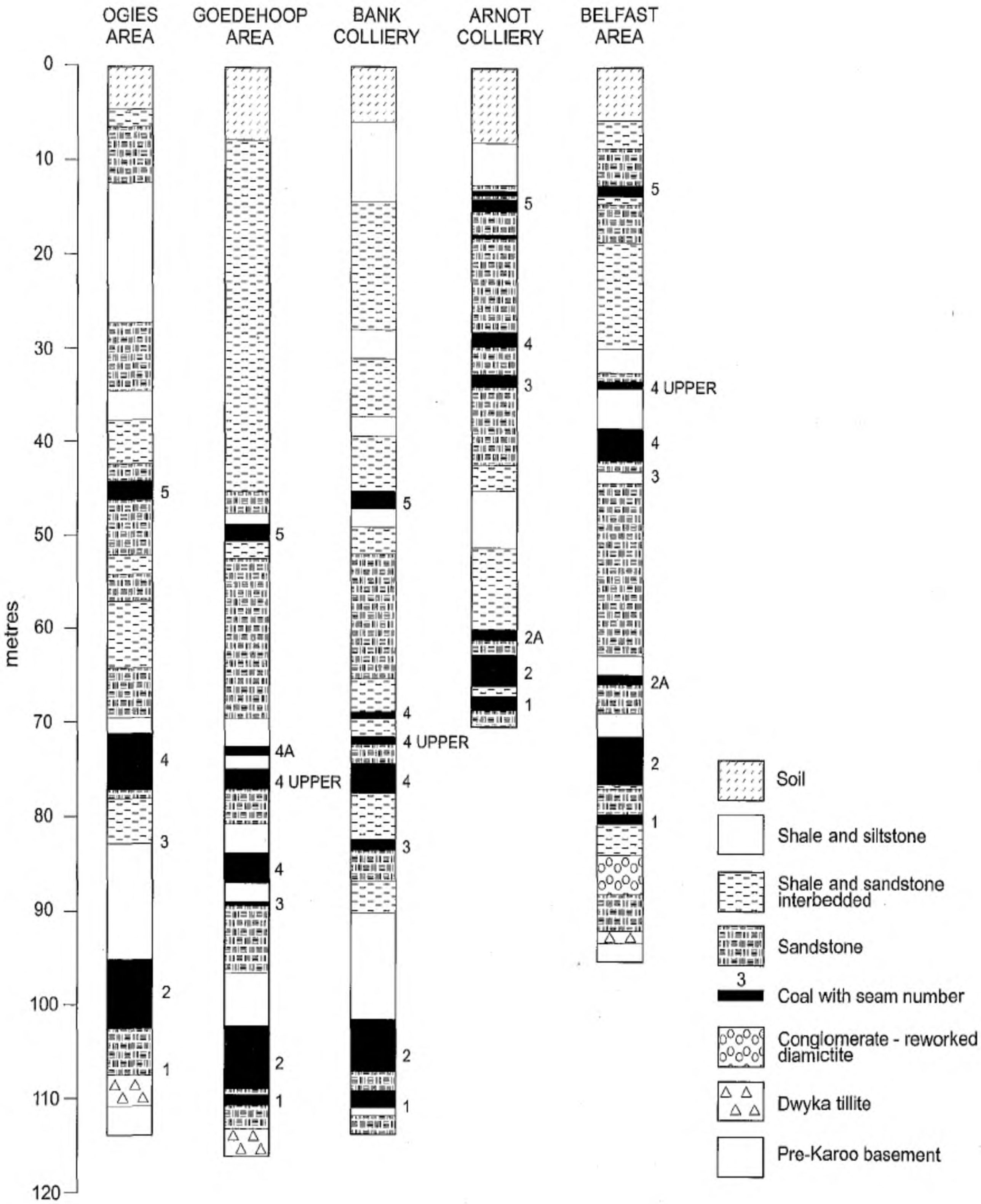


Figure 8: Typical stratigraphic columns in the Witbank Coalfield (from Snyman, 1998).

The coal seams are generally flat lying, to gently undulating, with a regional dip to the south and south-east of less than a degree (Hancox and Götz, 2014). Faulting of the strata is present, but displacements are largely small. Dolerite dykes are known in many parts of the Witbank Coalfield, and vary in width from less than 1 m up to 14 m. Dykes and sills are present at all stratigraphic levels, but often concentrate near the Dwyka Group Basement contact (Hancox and Götz, 2014). The most prominent dyke in the Witbank Coalfield is the Ogies Dyke, which has a strike length of over 100 km, stretching from the town of Ogies in the west to beyond Optimum Mine in the east. The Ogies Dyke has a maximum width of 14 m and the host rocks have been subjected to deformation and devolatilisation up to 20 m on either side (Hancox and Götz, 2014).

2.3 Project geology

A geological map of the project area was produced from surface mapping and is presented in Figure 9. This was supplemented by a study of cores of the 90 boreholes that were drilled in the project area. Coal seams were intersected in all but 17 of the drilled boreholes. The boreholes lacking coal seam intersections are located in the extreme north-eastern portion of the project area where a dolerite sill uplifted the coal measures, which were later eroded off by weathering. In the north-east, dolerite is the only lithology encountered, overlain by sandy soil and localised ferricrete.

The project area is predominantly underlain by sandstone interbedded with siltstone, shale and coal. The coal measures are underlain by Dwyka tillite. The dolerite sill consistently occurs below the coal measures and tillite.

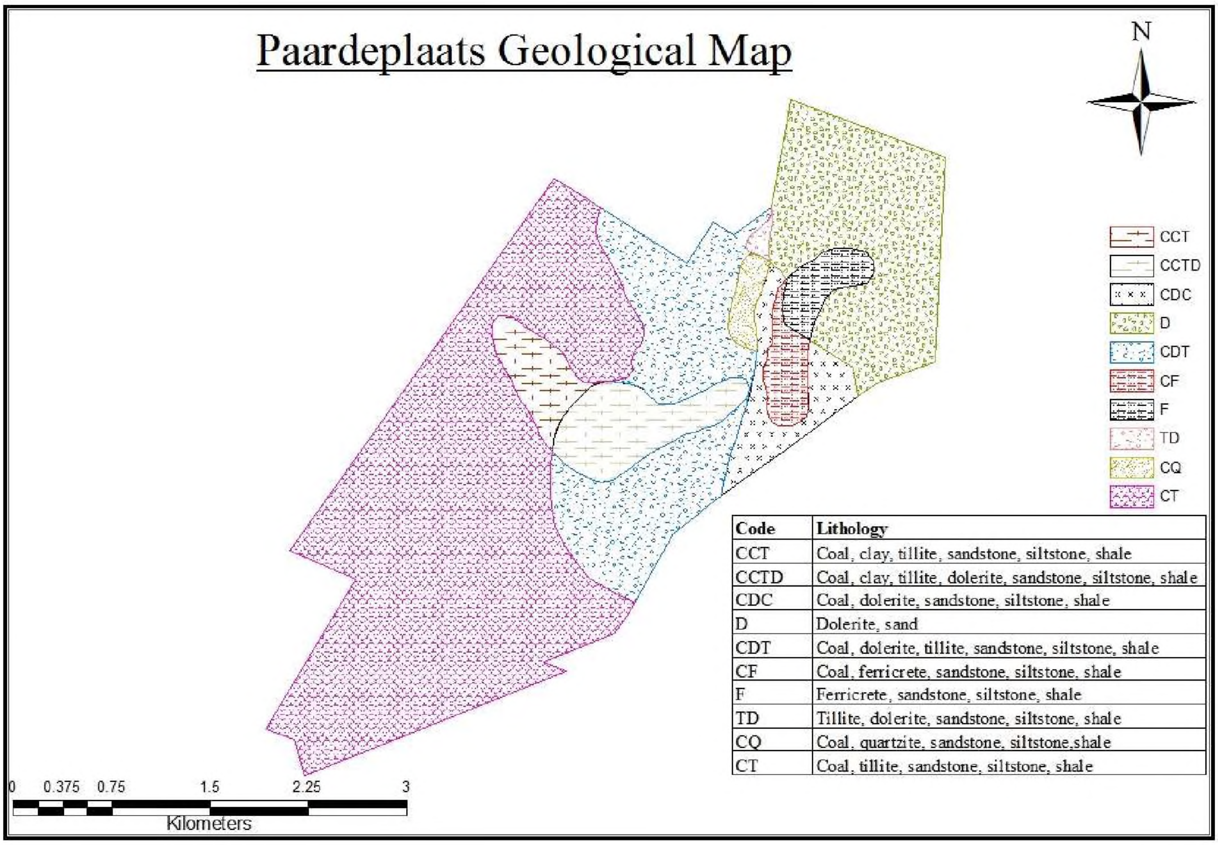


Figure 9: Geological map of the project area.

2.3.1 Stratigraphic sequence

The strata and coal seams encountered in the project area (see Figure 10) correlate with the Witbank Coalfield stratigraphy for the Belfast area (Snyman, 1998: see Figure 8).

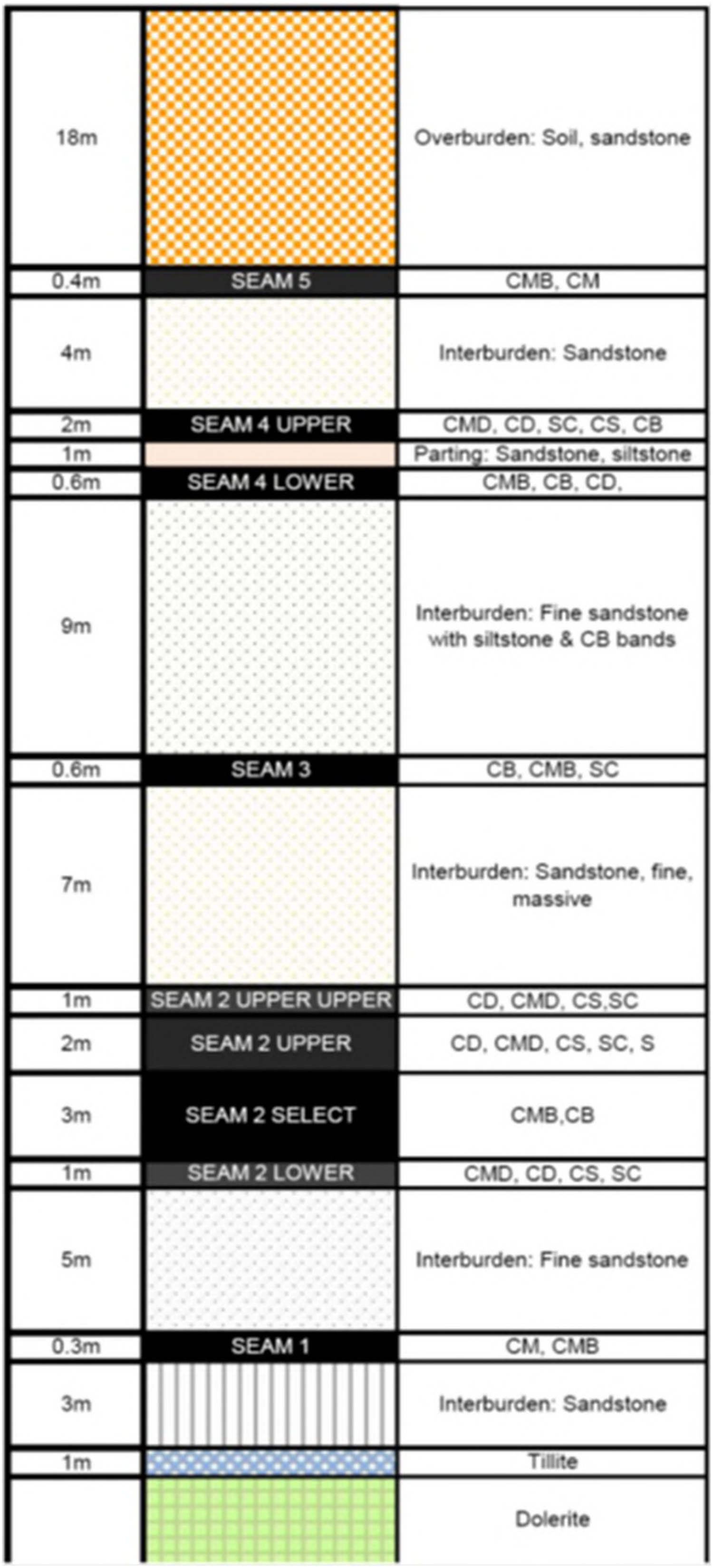


Figure 10: Stratigraphic column of the project area.

Coal is primarily described based on its appearance, being dull on the one extreme, and bright on the other. Bright coal is typically high in vitrinite, and dull coal high in inertinite. The author's terminology used to describe coal as coal bright to coal dull and the different variations in between is summarised in Table 2. The strata above the top most coal seam is referred to as overburden and the strata separating different seams is referred to as interburden. The thickness of the interburden generally exceeds the thickness of the individual coal seams. When an in-seam parting is thick enough, e.g. ≥ 50 cm, to be mined-out separately, it can be a basis for subdividing a seam, provided the sub-seams are within the minimum mining thickness cut-off. Pronounced quality (e.g. Calorific Value) variations within a coal seam can also be used as a criterion for subdividing a seam, and in such instances the subdivision is based on a 'quality contact'.

Table 2: Coal logging terminology

Code	Description	% lustrous coal bands	% dull coal bands
CB	Coal bright	≥ 80	≤ 20
CMB	Coal mixed, mainly bright	≥60	≤ 40
CM	Coal mixed	50	50
CMD	Coal mixed, mainly dull	≤ 40	≥60
CD	Coal dull	≤ 20	≥ 80
		Description	
CS	Coal shaley	Coal and shale unit, with greater coal portion	
SC	Shale coaly	Shale and coal unit, with greater shale portion	

- **Strata above Coal**

The overburden is comprised of sandy soil at top, and mainly sandstone at the bottom. Units of siltstone within the sandstone are also common. The top soil is mostly clayey sand, which is mainly cream and brown in colour. The thickness of the topsoil ranges from 4.0 m to 17.0 m and the average thickness is 7.2 m. The sandstone immediately below the soil is usually weathered and the weathered zone can on average be up to 2 m thick. The unweathered sandstone is grey (light grey to dark grey) and white. The grey zone usually overlies the white zone and is fine to medium grained commonly interbedded with shaley and silty laminae. The white sandstone zone at the bottom is massive and medium to coarse grained, and caps the first coal seam.

- **Seam 5**

Seam 5 occurs at an average depth of 18 m from surface, and has an average thickness of 0.43 m (range: 0.20 m to 1.12 m). The seam is mainly coal mix to coal mix bright; lustrous bands occur at places, but are more consistent towards the bottom contact. The bottom half of the seam has pyrite nodules and lenses at places. The seam usually overlies fine grained micaceous sandstone. At shallower depths of less than 10 m, the seam usually shows signs of weathering.

- **Seam 5 and Seam 4 Interburden**

The interburden ranges in thickness from 4 m to 29 m, with an average of 12 m. The interburden is mainly fine grained light grey to grey planar laminated sandstone and whitish medium grained massive sandstone towards the bottom contact. The fine grained light grey sandstone is also commonly interbedded with siltstone laminations.

- **Seam 4**

Seam 4 is split into Seam 4 Upper and Seam 4 Lower based on an in-seam parting.

- **Seam 4 Upper**

Seam 4 Upper is found at an average depth of 22 m below surface, and has an average thickness of 2.1 m (range: 0.70 m to 3.40 m). In certain areas Seam 4 Upper is further split into Seam 4 Upper Upper and Seam 4 Upper; this subdivision is primarily based on a parting, and in few instances on a quality contact. The seam is mainly coal mix dull and coal dull interbedded with coal shaley and shale coaly bands.

The coal shaley bands are associated with bright coal stringers. Towards the bottom contact there is commonly lustrous bands of coal bright and coal mixed bright. Calcite cleats and veinlets and pyrite nodules occur sporadically in the seam.

Where Seam 4 Upper is subdivided due to the parting, the parting ranges in thickness from 0.66 m to 1.23 m, averaging 0.93 m. The parting is comprised mainly of alternating shale and coal bands, and in some instances siltstone bands are present as well. The non-coal (shale + siltstone) portion of the parting is dominant, making up on average 70% of the parting, and this is the main reason for the subdivision. Where the quality contact is the basis for the seam subdivision, Seam 4 Upper Upper typically has better qualities (calorific value at 20.5 Mj/Kg, ash 28%) than Seam 4 Upper (calorific value at 14.0 Mj/Kg, ash at 45%).

- **Seam 4 Upper and Seam 4 Lower Parting**

The parting ranges in thickness from 0.66 m to 2.11 m, with an average of 1.0 m. In the main the parting is light grey and whitish fine grained sandstone interbedded with silty laminae. In small localised areas the parting is alternating coal and shale bands with fine to medium grained sandstone band at the bottom contact.

- **Seam 4 Lower**

Seam 4 Lower is found at an average depth of 26 m from surface, and has an average thickness of 0.63 m (range: 0.40 m to 1.64 m). The seam is generally made up of lustrous coal mix bright and coal bright bands at the top, bands of coal dull in the middle, and changing to lustrous coal bright at the bottom. Pyrite nodules and patches occur sporadically in the seam whilst calcite cleats are more common in the bottom half. Localised carbonaceous shale bands, usually less than 3 cm are also present at certain areas.

- **Seam 4 and Seam 3 Interburden**

The interburden ranges in thickness from 2 m to 23 m, with an average of 8.6 m. There are two distinct areas, in the northern portion the interburden thickness ranges from 2 m to 6 m with an average of 4 m, and in the southern portion the thickness ranges from 12 m to 23 m, with an average of 17 m. The northern portion is associated with a thin Seam 3 (considered to be uneconomic), and in the southern portion Seam 3 thickness is of economic consideration. The interburden is mainly grey (light grey – dark grey) fine-grained sandstone interbedded with siltstone. Units of whitish fine-medium grained sandstone are present at either or both the top and bottom contacts. There is a distinct lustrous coal bright or coal mix bright band of about 10 cm approximately 2 m above the bottom contact.

- **Seam 3**

Seam 3 is found at an average depth of 33 m from surface, and has an average thickness of 0.60 m (range: 0.10 m to 1.55 m). The seam is generally made up of alternating lustrous bands of coal bright and coal mix bright, sometimes interbedded with thin bands of carbonaceous shale. The qualities are relatively better as a result, calorific value averaging about 22 Mj/Kg. There are also in places occurrences of pyrite nodules and calcite cleats.

- **Seam 3 and Seam 2 Interburden**

The interburden ranges in thickness from 3 m to 12 m, with an average of 7 m. In the north western portion, the interburden is at its thickest, averaging 13 m, and in the south eastern portion it averages 5 m. The interburden is mainly fine grained light grey planar laminated sandstone and whitish medium to fine grained massive sandstone, commonly with a biouturbated zone of up to 30 cm towards the bottom contact. The fine grained light grey sandstone is also commonly interbedded with siltstone.

- **Seam 2**

Seam 2 is found at an average depth of 39 m from surface, and has an average thickness of 5 m (range: 1.0 m to 8.7 m). The seam has considerable quality variations, and where fully developed, four quality zones can be identified. The seam is thus mainly subdivided into Seam 2 Upper and Seam 2 select; in certain localised areas Seam 2 Upper is further sub-divided into Seam 2 Upper and Seam 2 Upper Upper, primarily based on a quality contact and on a very few instances on an in-seam parting; Seam 2 Lower is also developed below Seam 2 Select in certain localised areas, and the basis for the split is mainly a quality contact, and on a few instances an in-seam parting. A summarised subdivision of Seam 2 is shown in **Error! Reference source not found.**, and the subdividing parameters thereof.

Table 3: Subdivision of Seam 2

Whole Seam	Sub-seam	Parting	Thickness (m)			Quality: Calorific Value (Mj/Kg)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
Seam 2	S2UU		1.2	0.6	2.1	14.7	12.4	17.8
		S2UP	0.7	0.6	0.9			
	S2U		1.7	0.6	4.5	19.2	15.0	20.9
		S2USP	0.5	0.3	1.0			
	S2S		3.3	0.6	7.2	24.6	23.4	26.6
		S2SLP	1.4	0.4	2.4			
	S2L		1.4	0.8	2.5	19.2	17.2	20.9

- **Seam 2 Upper**

Seam 2 Upper was mapped in 55 drillholes (out of 70 drillholes with seam 2), with an average thickness of 1.7 m (range: 0.6 m to 4.5 m). In 17 of the 55 drillholes Seam 2 Upper Upper was mapped, with an average thickness of 1.2 m (range: 0.6 m to 2.1 m). The basis for the subdivision is mainly a quality contact, and only in 5 drillholes a parting was mapped. The qualities are better in Seam 2 Upper. Seam 2 Upper is mainly alternating zones of coal dull and coal mix dull interbedded with coal shaley and shale coaly bands. Pyrite nodules and calcite cleats randomly occur in the seam. Seam 2 Upper Upper is very similar to Seam 2 Upper, except that in addition it has pure shale bands, and this contributes to its poorer qualities. In the few instances where there is a parting, the Seam 2 Upper parting is fine grained, light grey to grey sandstone with an average thickness of 0.7 m.

- **Seam 2 Select**

Seam 2 Select was mapped in 70 drillholes, and has an average thickness of 3.3 m (range: 0.6 m to 7.2 m). Seam 2 Select is split from the overlying Seam 2 Upper based on a quality contact, with the former having better qualities. In the six drillholes where a parting was mapped, the seam 2 upper/select parting is an upward fining, medium to coarse grained, massive sandstone, with colour variations but mainly light grey. It can be gritty towards the bottom contact. Seam 2 Select is mainly alternating zones of lustrous coal bright and coal mix bright. There are random coal dull bands at places, but make a very minor portion of the seam. Pyrite nodules and calcite veinlets occur at places.

- **Seam 2 Lower**

Seam 2 Lower was mapped in 18 drillholes, and has an average thickness of 1.4 m (range: 0.8 m to 2.5 m). Seam 2 Lower is split from the overlying Seam 2 Select based on a quality contact, with the latter having better qualities. The seam is composed mainly of alternating coal mix dull and coal dull zones with interbedded coal shaley and shale coaly bands. In 3 drillholes in the southern most portion of the project area a parting was mapped, which ranges in thickness from 0.4 m to 2.4 m. The parting is mainly light grey and grey sandstone with grain size varying from fine to coarse between the different localities.

- **Seam 2 and Seam 1 Interburden**

The interburden ranges in thickness from 2 m to 8 m, with an average of 5 m. The interburden is mainly fine grained light grey to grey planar laminated sandstone and whitish medium grained massive sandstone towards the bottom contact. The fine grained light grey sandstone is also commonly interbedded with siltstone laminations. Coal bands of coal mix and coal bright, ranging in thickness from 6 cm to 17 cm are a common occurrence more or less in the middle of the interburden.

- **Seam 1**

Seam 1 is found at an average depth of 49 m from surface, and has an average thickness of 0.32 m (range: 0.10 m to 0.96 m). Due to the limited thickness it was not possible to get representative samples to perform quality analysis. In the very few instances where seam thickness is greater than 0.5 m it is due to the presence of an in-seam parting. The seam is mainly composed of coal mix interbedded with coal mix bright and coal bright at places. The one sample without in-seam parting showed a calorific value of 23.1 Mj/Kg.

- **Glacial Sediments**

Tillite of the Dwyka Group occurs at an average depth of 50 m from surface and forms the floor to Seam 1. In only two drillholes is the coal seam directly overlying the tillite, there is mainly light grey and whitish massive sandstone in between.

3. EXPLORATION WORK

3.1 Airborne magnetic survey

Total field magnetic data (Figure 11) was collected in the Belfast area in 2008 over an area covering approximately 14 km in a north-south direction and 9 km in an east-west direction. The specifications of the aircraft and acquisition system used are summarised in Table 4, and the basic survey parameters in Table 5. The Paardeplaats Project area falls inside the area covered by the survey. The magnetic data in conjunction with other data sets was used to interpret geological structures.

Table 4: Aircraft and acquisition systems (from Mahanyele, 2010)

Aircraft and Acquisition systems	
Aircraft type	Air Tractor
Survey navigator	AgNav
Data acquisition	XAGDAS
Data positioning	Real time differential GPS
GPS type	2100LR, 12 channel, Omnistar
Resolution	± 3 m
Magnetometers	1 x Geometrics G822A Cesium Vapor
Base station magnetometer	GEM Systems (GSM-19TW)
Compensation	RMS AARC5000
Resolution	0.001nT
Radar altimeter	King

Table 5: Basic survey parameters used (from Mahanyele, 2010)

Basic survey parameters used	
Line direction	North - South with respect to UTM Zone 35S, WGS84 coordinate system
Line spacing	100 meters
Tie line direction	East - West with respect to UTM Zone 35S, WGS84 coordinate system
Tie line spacing	1000 meters
Ground clearance	35 meters
Sample spacing	6.6 meters
Data collected	Total Field Magnetics with wing mounted Cesium Vapor sensor Digital Terrain Model with real time differential GPS and Radar altimeter

In the Belfast area, Mahanyele (2010) identified several dominant magnetic lineaments oriented in a NE-SW direction, which he interpreted as dykes. The amplitudes of the total field magnetic of the interpreted dykes revealed two sets of dykes: the induced magnetic dykes (positively magnetic) and remanently magnetised dykes (negatively magnetic) (Mahanyele, 2010). The remanent dykes are usually older than the positive dykes (Mahanyele, 2010).

Some of these dykes could be associated with the intrusion of the Bushveld Igneous Complex, and could also be associated with Olifants River Dyke Swarm (Mahanyele, 2010). The positions of the dykes in the project area are better seen in the first vertical derivative map (Figure 12). Mahanyele (2010) observed faults in the entire Belfast area with a general east-west trend; the faults with other interpreted geological structures superimposed on the analytic signal data map are shown in Figure 13.

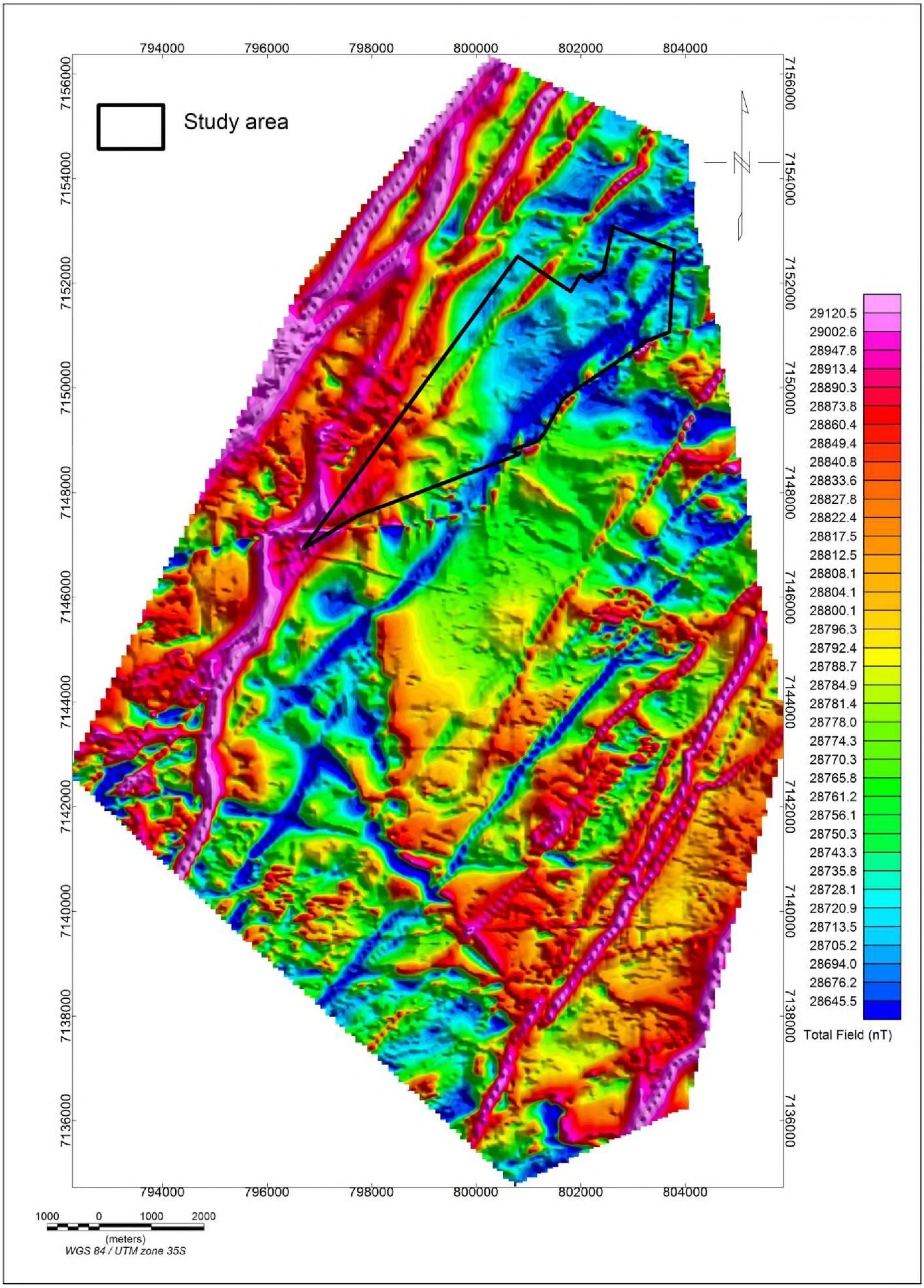


Figure 11. Total field magnetic intensity map for Belfast area (from Mahanyele, 2010).

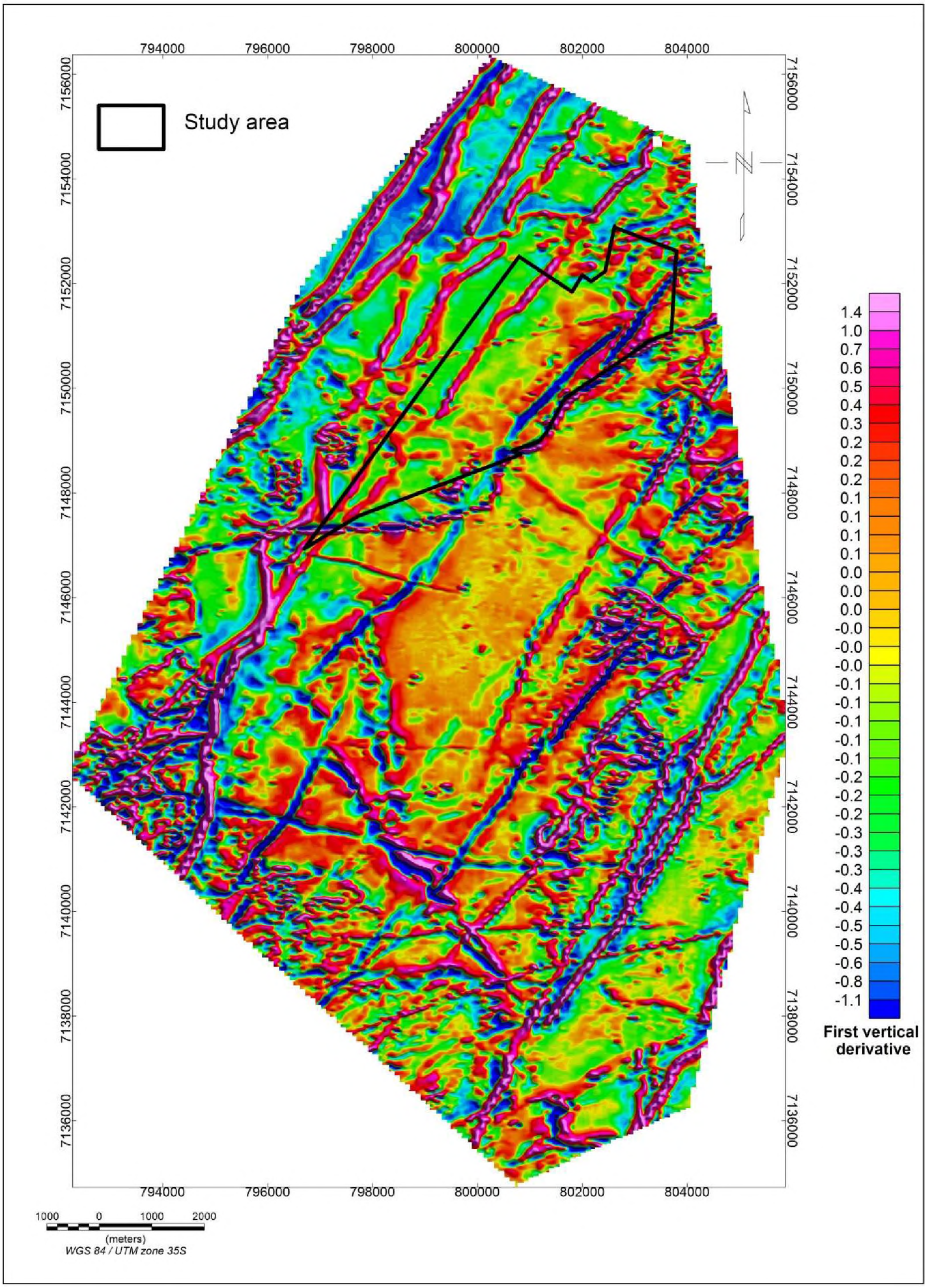


Figure 12. First vertical derivative map of the Belfast data (from Mahanyele, 2010).

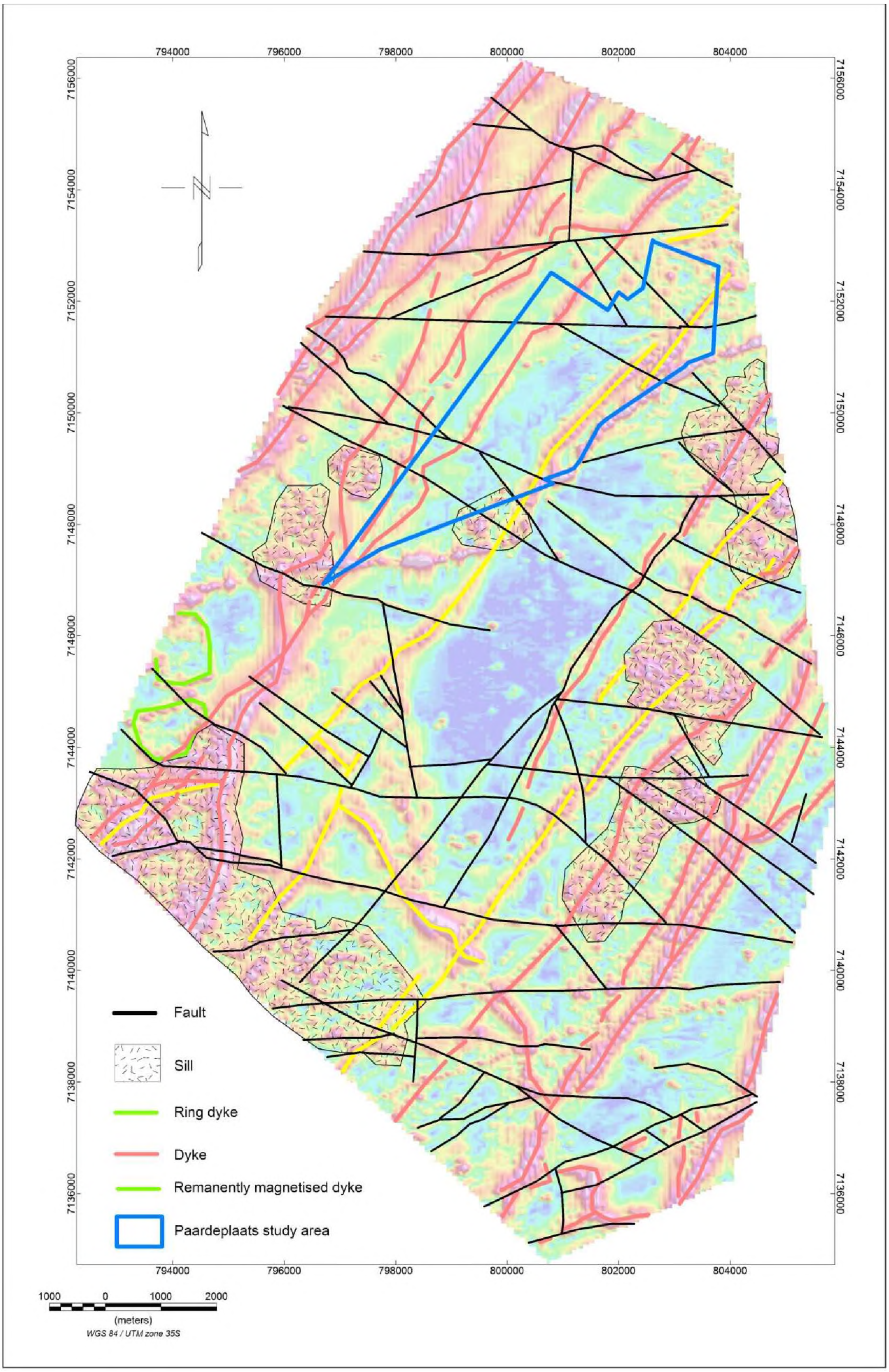


Figure 13. Interpreted structures for Belfast data superimposed on the analytic signal data (from Mahanyele, 2010).

3.2 Exploration drilling data

3.2.1 Objectives of exploration drilling

Extrapolation of the geological relationships observed in mine face exposures at the adjacent Glisa Colliery suggested coal measures would extend across into the Paardeplaats project area. The objective of the exploration drilling was therefore to confirm the presence of coal measures, delineate the vertical and lateral extents of the coal measures, and, through suitable tests, the quality of the coal. The resultant borehole data together with airborne magnetic survey data aides in identifying geological factors such as structures and intrusions that may affect mining. The product of the data analysis and interpretation feeds into the construction of a geological model, from which coal resources can be quantified and classified.

Exploration was planned as a two phase programme. The results of the first phase drilling were used to delineate areas of higher economic potential which were then targeted by a second phase of drilling to increase geological confidence.

3.2.2 Exploration drilling method

For the Paardeplaats project, diamond core drilling (Figure 14) was utilised, primarily due to its ability to generate representative undisturbed core samples. TNW core boreholes were drilled recovering cores with a diameter of 60.7 mm which proved sufficient for acceptable core recoveries, and generated sufficient sample material for the required analytical test work. It is general practice that core recovery through coal or coaly horizons should not be less than 95% (Thomas, 2013). Generally larger diameter core barrels give better core recovery through coal than smaller diameter core barrels.

Figure 14. A diamond drill rig in operation.

Ninety boreholes, totalling 4,290.51 meters were drilled over two phases. The average end of hole depth was 47.67 meters. The spatial distribution of the boreholes is shown in Figure 15.

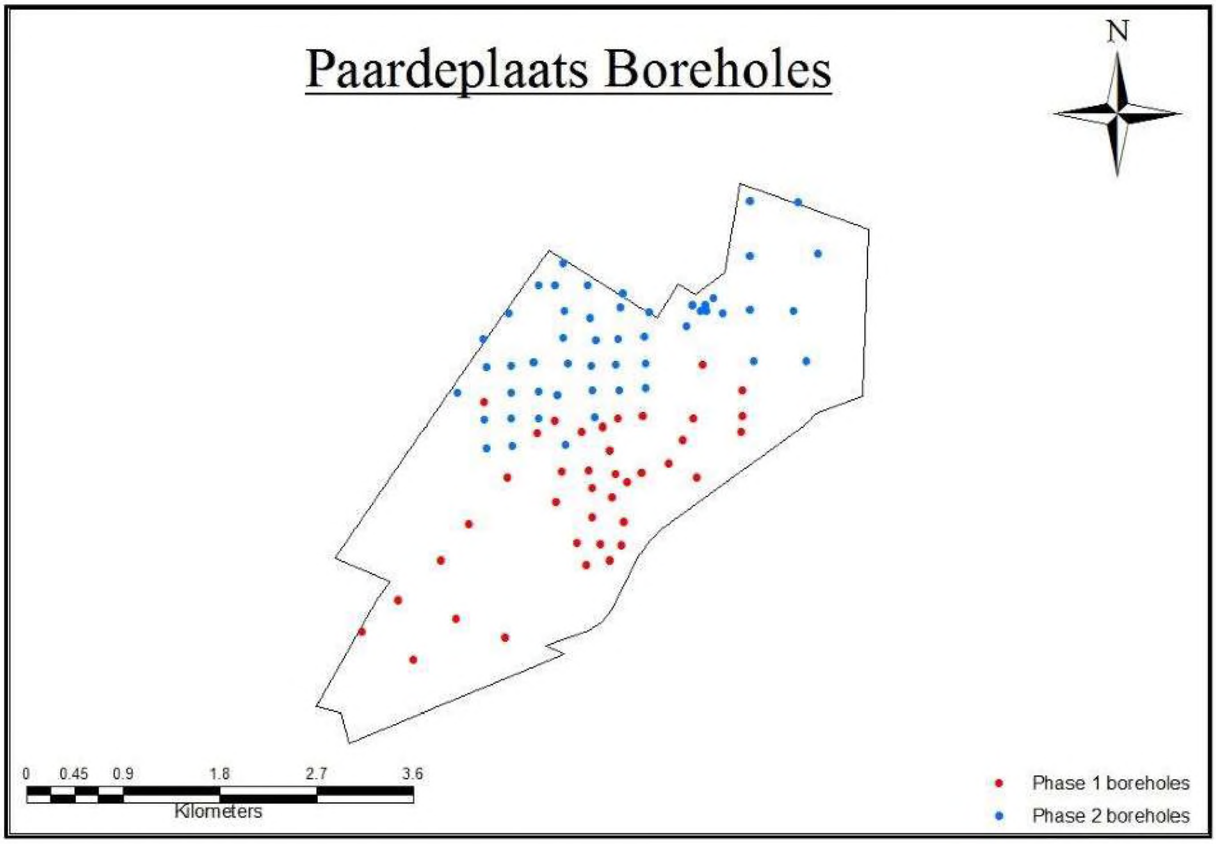


Figure 15. Distribution of drilled boreholes.

- **Accuracy of borehole location**

Planned borehole positions were staked out in the field by surveyors using the Trimble RTK GPS equipment with an accuracy level of ± 2 cm. The GPS equipment was calibrated on site using a minimum of five survey trig beacons in the near vicinity of the project area. Before drilling a borehole, the staked position was verified by the project geologist using a handheld GPS to check that the markers had not been moved. Final collar positions of completed holes were surveyed by professional surveyors.

Final XY coordinates and elevations (Z) were compared to the Digital Terrain Model (DTM) of the project area: any discrepancies were investigated and, where necessary, the positions re-surveyed.

3.2.3 Borehole logging

Geological core logging is of utmost importance during any exploration drilling operation. The borehole core, after being washed, was laid on corrugated zinc plates (Figure 16), from where it was logged. Detailed geological logging involved a top-down fine scale observation (centimetre scale) and recording of the observed data. Logging entailed the identification and description of lithologies, and the delineation of contacts between different lithologies.

The logging of the coal lithology followed a standardised classification of shale-coaly→ coal-shaley → coal dull → coal mixed, mainly dull → coal mixed → coal mixed, mainly bright → coal bright. Logging controlled the subsequent sampling of the coal, and as such had to be done correctly. Textures of the non-coal lithologies observed are based on the sphericity of the grains; sorting; maturity; cement type; vertical variations in grain sizes (grading); and mineral inclusions (sulphides, oxides and carbonates). The presence of sedimentary structures was recorded as well.

Logging data was captured in a predetermined format according to a logsheet template. The following information was captured on the log sheet:

- The farm or prospecting property name
- The borehole identity
- Drilling date; name of drilling company; core diameter
- Logging geologist; number of samples (if any)
- X, Y, Z coordinates; end of hole depth
- 'From and To' depths of lithological units and description of the lithological units

Figure 16. Borehole core ready for logging.

3.2.4 Sampling

a) Sampling method

The sampling of the core was preceded by core logging and was restricted only to the coal seam(s). Sampling data is applied during the planning phase of a mining operation, and therefore it is important during exploration drilling for the project geologist to have an insight on the possible mining method. Using an example of a shallow multi seam coal deposit with significant seam partings (≥ 1 m in thickness) that is suitable for open cast mining method, the project geologist would be better served knowing the mining thickness cut-off, how the different seams would be mined, how the seam partings would be dealt with, i.e., mined selectively or as part of the seam, because all these have an influence on deciding on sample boundaries. For this project, the selective mining method employed at the adjacent Glisa Colliery was assumed.

The following criteria were considered when deciding on sample boundaries:

- Coal quality zones, e.g., a clear boundary between a coal bright and a dull zone
- Sample thickness, e.g. a 4 m thick seam of homogenous coal mixed bright would still need to be split in order to have more data points along the seam.
- Mining thickness cut-off. Coal seams thinner than the minimum mining thickness cut-off of 0.5 m were not sampled.
- Mineral matter inclusions, e.g., a zone with a high concentration of pyrite nodules was sampled separately from a ‘clean’ bright coal zone.
- Seam partings: seam partings thick enough (≥ 0.5 m) to be mined selectively were not sampled as part of the coal seam
- Sample size. The laboratory ideally required a minimum sample mass of 5 kg to do float and sink analysis at nine relative density (RD) fractions.
- Sample boundaries vs. lithological boundaries. Sample boundaries honoured lithological boundary to prevent overlaps when doing geological modelling

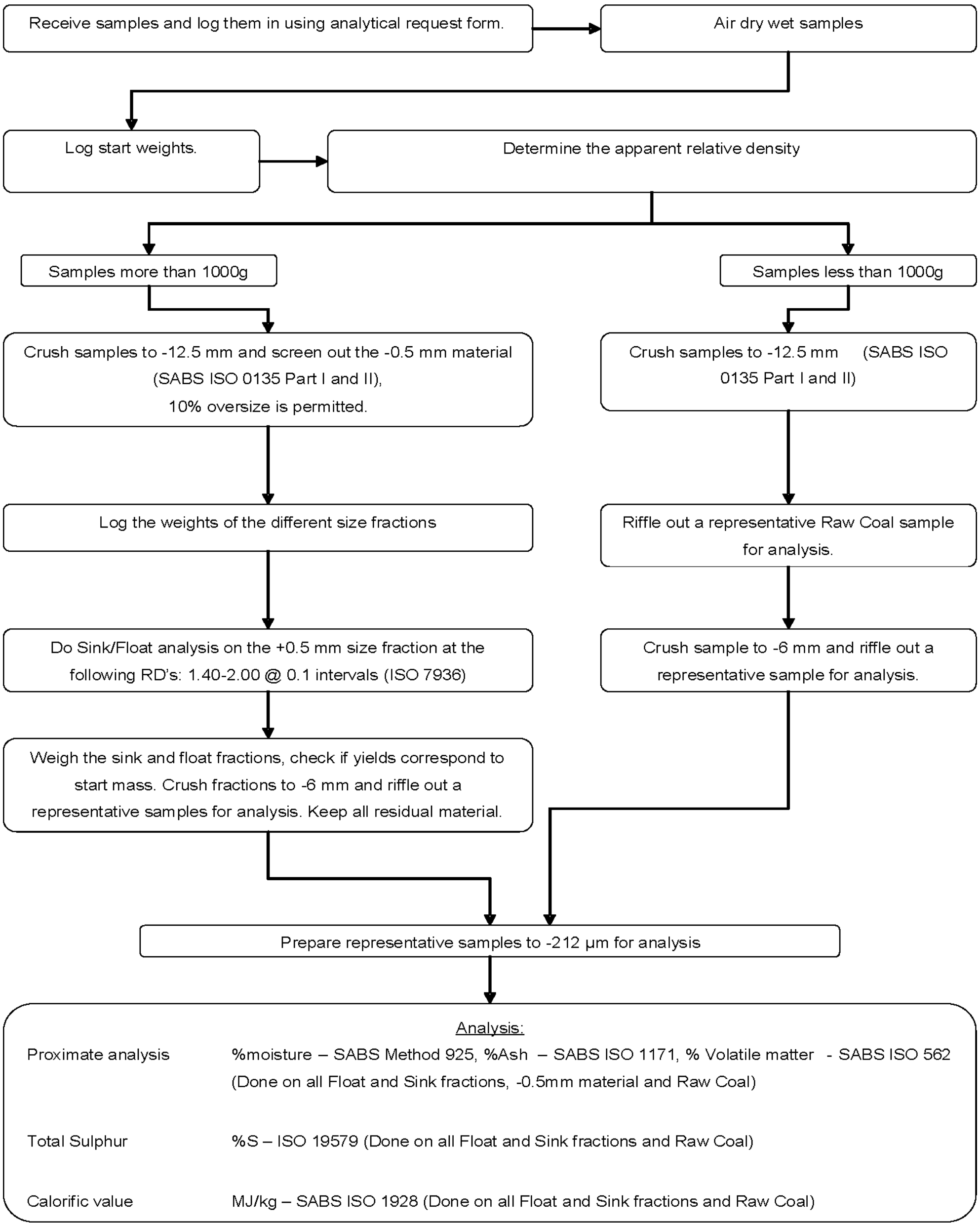
b) Sample preparation and analysis

The analytical testwork was undertaken by Advanced Coal Technology (ACT), an independent coal testing laboratory based in Pretoria, now part of the Bureau Veritas Group. The laboratory work flow covering receiving of samples, sample preparation and sample analysis is outlined in the flow chart below. The laboratory is accredited by the South African National Accreditation System (SANAS), which gives formal recognition of a laboratory’s competency in performing specified analytical work. The analyses that were performed are proximate analysis (moisture, ash and volatile matter), calorific value and total sulphur. The standards that were complied with in the sample preparation and analyses are contained in Table 6**Error! Reference source not found.**.

Table 6: Sample preparation and analysis methods

Sample preparation / analysis	Standard method
Crush sample to -12.5 mm & screen out -0.5 mm	SABS ISO 0135 Part I and II
Sink / Float analysis on + 0.5 mm size fraction	ISO 7936
Proximate analysis - Moisture content (wt. %)	SABS Method 925
Proximate analysis - Ash content (wt. %)	SABS ISO 1171:1997
Proximate analysis - Volatile matter content (wt. %)	SABS ISO 562:1998
Proximate analysis - Fixed carbon content (wt. %)	By difference
Total sulphur (wt. %)	ISO 19579
Calorific value (Mj/Kg)	SABS ISO 1928:1995

Laboratory work flow chart



3.2.5 Laboratory Quality Assurance and Quality Control

The laboratory followed internal quality assurance and quality control measures that comply with the requirements of ISO 17025:2005, and SANAS Regulatory Requirements to safeguard the reliability of its analytical testwork. The equipment used complied with the requirements of ISO17025:2005, and was calibrated periodically. Control samples, such as commercial reference material or in-house developed reference material, were used routinely to verify the calibration of the test equipment, and consequently validate the pursuant analysis. The results of the control sample, plotted on a quality control chart, indicate if the analysis result was within acceptable limits or not, and if not, necessary corrective actions were undertaken before exploration samples could be analysed.

As a quality control measure, each analysis was done in duplicate, and the results only accepted if the two sets were within the acceptable repeatability limit. The repeatability limit is a measure of precision, and it provides a limit within which the results of a duplicate determination carried out in the same Laboratory by the same Analyst with the same Apparatus within a short interval of time on two representative portions taken from the same analysis sample may differ. The repeatability limits for moisture, ash, volatile matter, sulphur and calorific value are shown in Table 7.

Table 7: Laboratory analyses repeatability limits

Coal quality parameter	**Repeatability limit**	**Standard**
Moisture (< 5%)	0.10%	ISO 11722:1999
Moisture (≥ 5%)	0.15%	ISO 11722:1999
Ash (<10%)	0.2% Absolute	ISO 1171:1997
Ash (>10%)	2.0% of the mean result	ISO 1171:1997
Volatile matter (<10%)	0.3% Absolute	ISO 562: 1998
Volatile matter (>10%)	3% of the mean result	ISO 562: 1998
Calorific value	0.12 Mj/Kg	ISO 1928: 1995
Sulphur	95% of Absolute difference	ISO 19579

4. GEOLOGICAL MODELLING AND COAL RESOURCE ESTIMATION

The geological data collected during the exploration phase and the subsequent geological interpretation were used as inputs in the construction of a geological model. The geological model, which shows the physical continuity of the coal seams and the distribution of the coal qualities, is a critical input in coal resource estimation.

4.1 Geological modelling

4.1.1 Data capturing and management

Borehole core logging data was recorded in the field on paper logsheets and later captured in Microsoft Excel spreadsheets. A validation process was done to ensure that the original logsheet data corresponded with the data on Excel spreadsheets. The paper logsheets were also scanned in order to keep an electronic record of the original logsheet. In Microsoft Excel, the data was formatted into a format compatible with Micromine's Geological Borehole Information System (GBIS*)* database management software. Laboratory analyses results were also received in Excel spreadsheets, and formatted to be compatible with GBIS database management software.

4.1.2 Data interpretation

Data interpretation for the purpose of constructing a resource model entailed the identification and correlation of the different coal seams, and other non-coal zones, which have an influence on mine planning such as the weathered zone in the overburden, the interburdens and the basement. The results of the data interpretation are summarised in Table 8

.

Table 8: Correlated coal seams and associated non-coal zones

Unit	Sub-unit	Description
Overburden	Softs (SFT)	Sandy soil that does not require drilling and blasting during mining
	Limit of weathering (LOW)	Determines the limits of the resource. Also has geotechnical applications in slope design
	Hards	Competent lithology that requires drilling and blasting
Seam 5		Coal seam
Seam 5 / Seam 4 interburden		Non-coal zone
Seam 4	Seam 4 Upper	Coal seam
	Seam 4 parting	Non-coal zone
	Seam 4 Lower	Coal seam
Seam 4 / Seam 3 interburden		Non-coal zone
Seam 3		Coal seam
Seam 3 / Seam 2 interburden		Non-coal zone
Seam 2	Seam 2 Upper Upper	Coal seam
	Seam 2 Upper Parting	Non-coal zone
	Seam 2 Upper	Coal seam
	Seam 2 Upper Select Parting	Non-coal zone
	Seam 2 Select	Coal seam
	Seam 2 Select Lower Parting	Non-coal zone
	Seam 2 Lower	Coal seam
Seam 2 / Seam 1 interburden		Non-coal zone
Seam 1		Coal seam
Dwyka tillite		Floor to the coal measures
Dolerite		Sill below the coal measures and tillite

4.1.3 Data validation

The input data to the modelling process was checked for the presence and correction of errors prior to modelling in order to safeguard the integrity of the resultant model. The following checks were performed:

- Borehole coordinates verification to identify errors in borehole collar positions. Collar XY positions were verified by plotting boreholes in ArcGIS together with cadastral and infrastructure data. The collar Z position was verified by using a surveyed Digital Terrain Model (DTM).
- Depth error checks to ensure that there were no gaps and overlaps in the 'from' and 'to' depths.
- Seam and sample correlation to ensure consistency between coal seam(s) and sample boundaries.
- Cumulative analyses results were checked for the following analyses errors:
    - Ash decreasing with increasing RD (Figure 17)

- CV increasing with increasing RD (Figure 18)
- Yield values not adding up to 100%

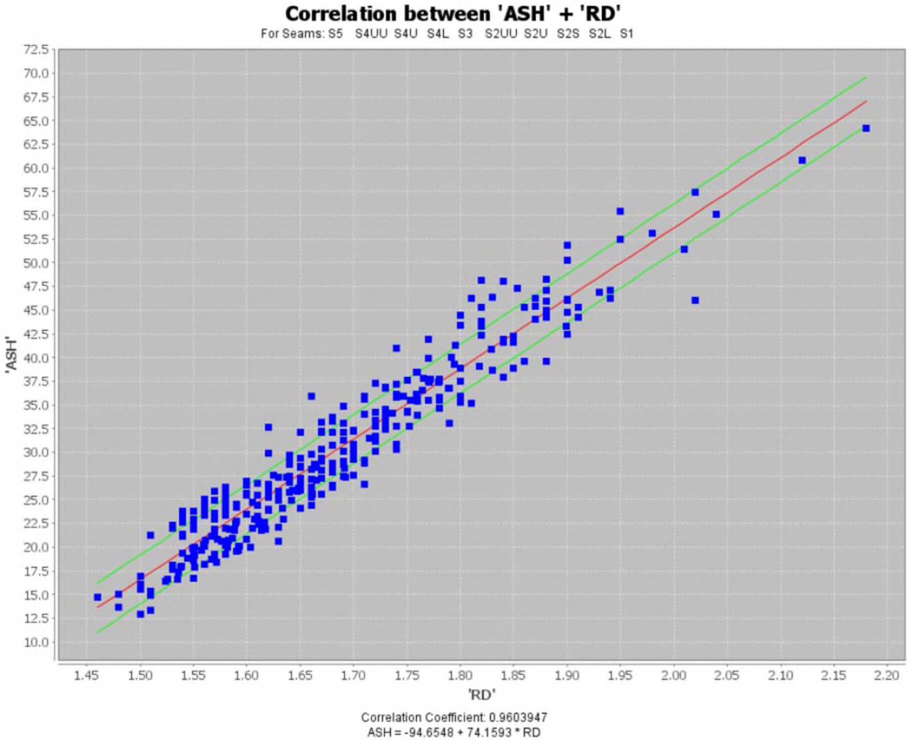


Figure 17. Correlation plot of Ash and Relative Density.

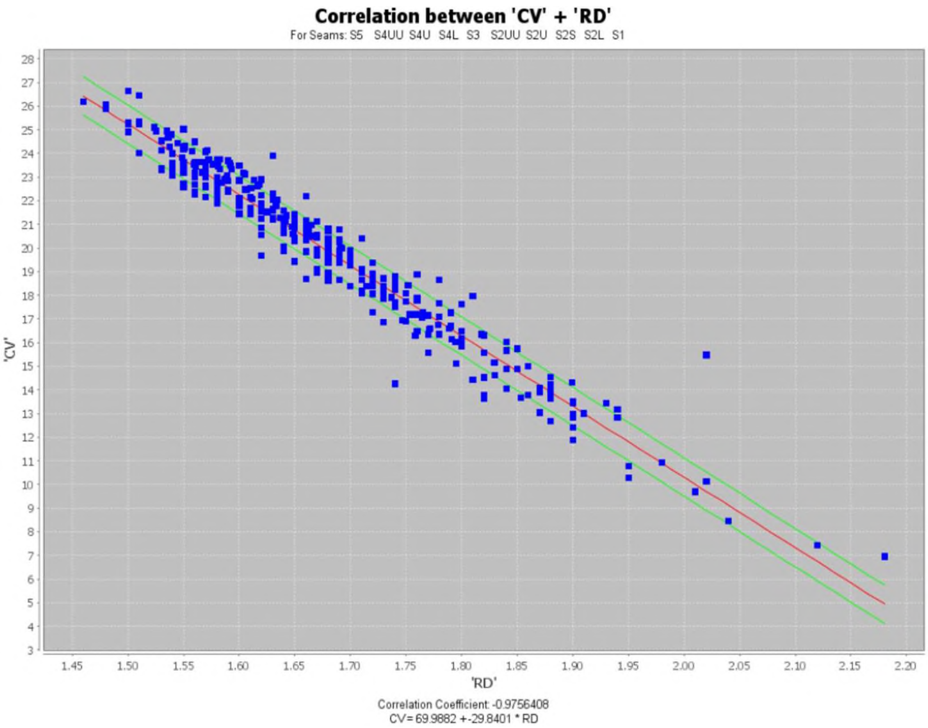


Figure 18. Correlation plot of Calorific Value and Relative Density.

4.1.4 Modelling

The following data from all the drilled boreholes was used to build a geological model:

- Collar file containing X, Y and Z data as well as dip and azimuth of boreholes.
- Seam file containing coal seams to be modelled and associated non-coal zones (see Table 8).
- Raw analyses data containing proximate analyses, calorific value and sulphur.

The model aims to display the three dimensional distribution of the coal seam characteristics. The model was built using Geovia's Minex modelling software for stratiform deposits, and has two components: (1) a seam model containing all the coal seams, overburden, tillite and dolerite; (2) a raw coal quality model for all the coal seams, except Seam 1 because of insufficient analyses data.

The following modelling parameters were used for the model:

- Grid Size: 25 m x 25 m
- Scan distance: 2000 m
- Data boundary: 200 m
- Extrapolation used: Seam model- Yes; Raw model - No
- Data limits: prospecting area boundary

The following raw coal quality parameters were modelled:

- Calorific value (CV);
- Ash content (AS);
- Volatile matter (VM);
- Inherent Moisture (IM); and
- Total sulphur (TS).

4.1.5 Model validation

The model was validated by plotting floor and thickness contours, checking bull's eyes in the contours and then validating borehole data or modifying model parameters to correct the error. Cross sections covering most of the boreholes were drawn to evaluate all seam correlations. Qualities from individual boreholes were compared to the quality grid model contours to determine whether the model honoured the borehole data.

4.2 Coal resource estimation

Coal resources are estimated from specific geological evidence and knowledge and are subdivided on the basis of geological confidence in the estimate of the in situ coal into high, moderate and low confidence categories (SANS 10320, 2004). Methods for resource estimation are generally divided into (1) traditional, geometric methods that are done manually on plans or sections and (2) interpolation methods such as inverse-distance weighting and kriging that require the use of a computer (Noble, 1992). The resource estimation for this project was done with Minex's Growth Technique. The Minex modelling software is widely used globally, and is an industry leader in the modelling of coal and other stratified deposits. The growth technique, unique to Minex, is a gridding algorithm that calculates the best-fitting surfaces for stratiform deposits, taking into account the regional trends while honouring the drillhole data, given the appropriate gridding parameters.

4.2.1 Coal resource classification criteria

The classification of coal resources into different categories, namely reconnaissance, inferred, indicated and measured is a function of increasing geological confidence in the estimate based on the density of points of observation, the physical continuity of the coal seams, the distribution and reliability of the coal sampling data, the coal quality continuity, the reliability of the geological model and the evaluation method (SANS 10320:2004). The South African National Standard (SANS) 10320:2004 is the South African guide to the systematic evaluation of coal resources and coal reserves.

SANS 10320:2004 defines a coal resource and the different categories as follows:

- A coal resource is an occurrence of coal of economic interest in or on the earth's crust in such form, quality and quantity that there are reasonable and realistic prospects for eventual economic extraction.
- An inferred coal resource is part of a coal resource for which tonnage, densities, shape, physical characteristics and coal quality can be estimated with a low level of confidence. The boreholes are limited or of uncertain quality and reliability, resulting in assumed physical continuity with or without coal quality continuity.
- An indicated coal resource is part of a coal resource for which tonnage, densities, shape, physical characteristics and coal quality can be estimated with a moderate level of confidence. The borehole locations are appropriate to confirm physical continuity, but are too widely spaced to confirm coal quality continuity.
- A measured coal resource is part of a coal resource for which tonnage, densities, shape, physical characteristics and coal quality can be estimated with a high level of confidence. The borehole locations are spaced closely enough to confirm physical continuity and coal quality continuity.

This classification is in accordance with SANS 10320:2004 and is based on the minimum cored borehole density per 100 ha. The criteria for the classification are presented in Table 9.

Table 9: Borehole density per 100 ha for resource classification for a multi-seam coal deposit

Resource category	Boreholes per 100	Minimum borehole	Required level of detail	Confidence
Measured	≥ 8	350 m	Detailed geological	Moderate - High
Indicated	≥ 4 - 7	500 m	Geological exploration	Moderate
Inferred	≥ 1 - 3	1 km	Geological exploration	Low
Reconnaissance	< 1	2 km	Geological exploration	Very low

4.2.2 Assessment of the resource estimate confidence level

Factors that contribute to the uncertainty in coal resource estimation include the key constraints used to construct the geological model, mainly, the density of the boreholes, seam thickness variation within the geological model and the coal quality distribution within the geological model (SANS 10320, 2004).

a) Density of boreholes

The density of the drilled boreholes is shown in Figure 19 below. The majority of the boreholes were drilled in the middle section of the prospecting area at a higher density because of better coal resource prospects.

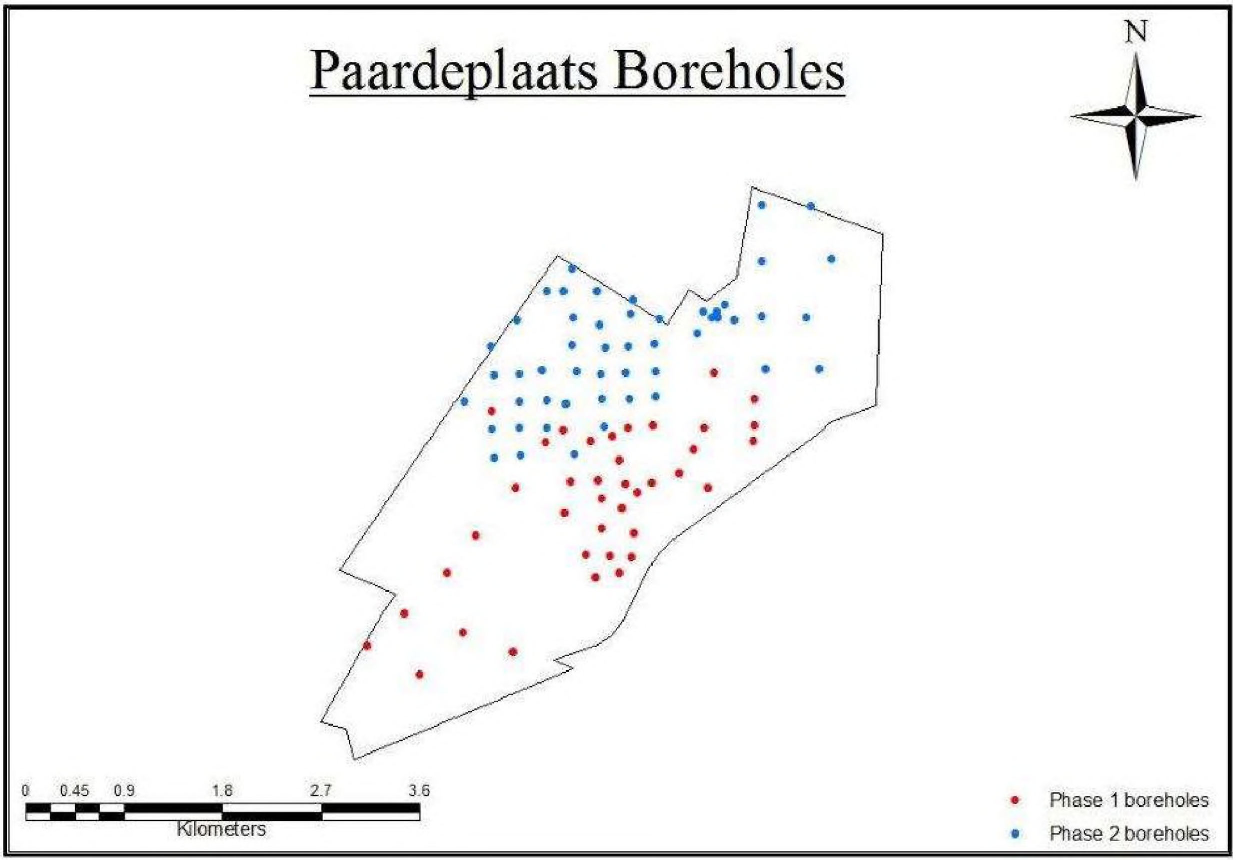


Figure 19. Borehole density map.

All boreholes were drilled into the floor of the coal-bearing formations ensuring that all possible coal seams in the succession were intersected. The physical continuity of the targeted coal seams was established by doing seam correlations between the different boreholes. Seven cross sections were drawn along North East to South West and East to West directions to provide adequate coverage of the resource area and demonstrate the physical continuity of the coal seams. A locality map showing positions of all the cross sections is shown in Figure 20 and two selected cross sections are presented in Figure 21 and Figure 22; the remainder are provided in Appendix A.

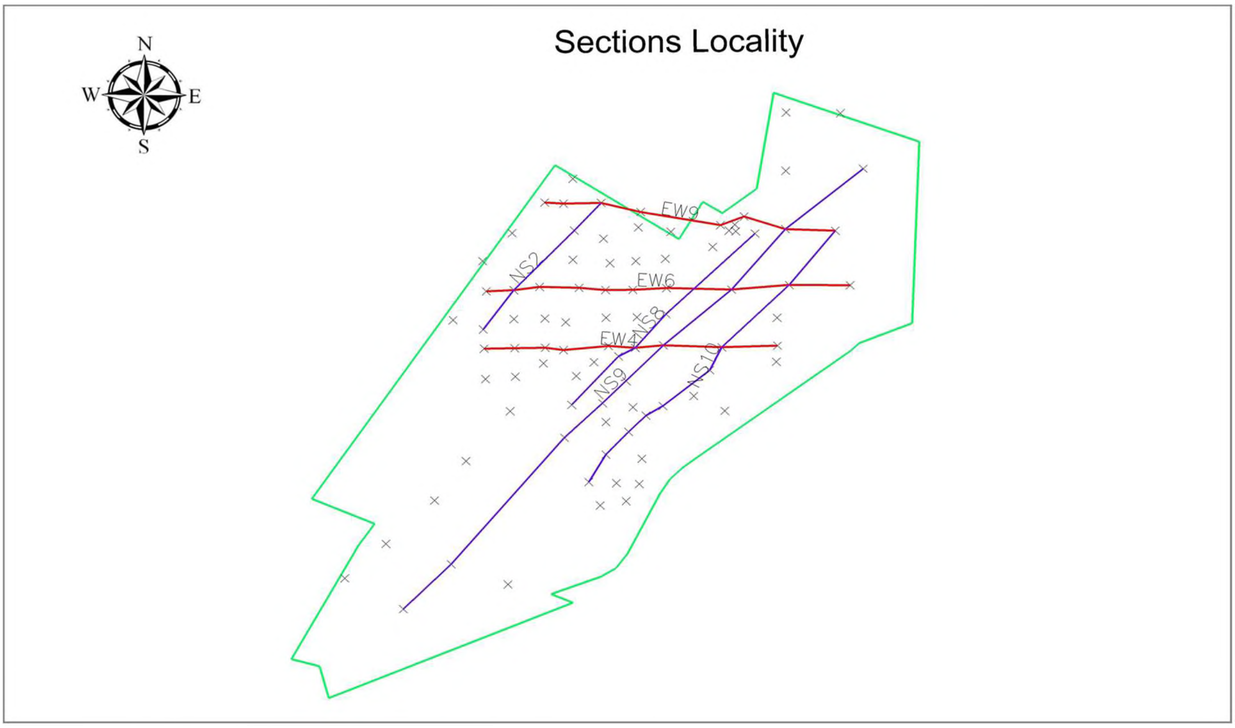


Figure 20. Cross sections locality map.

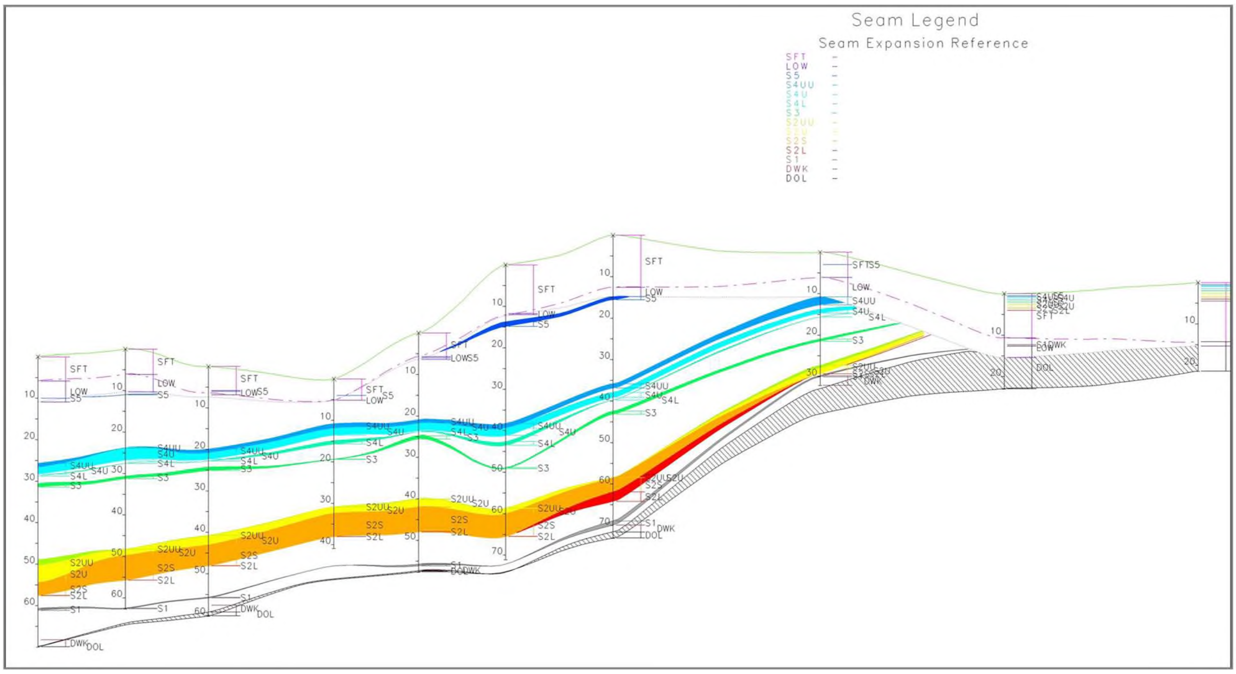


Figure 21. E-W 6 cross section.

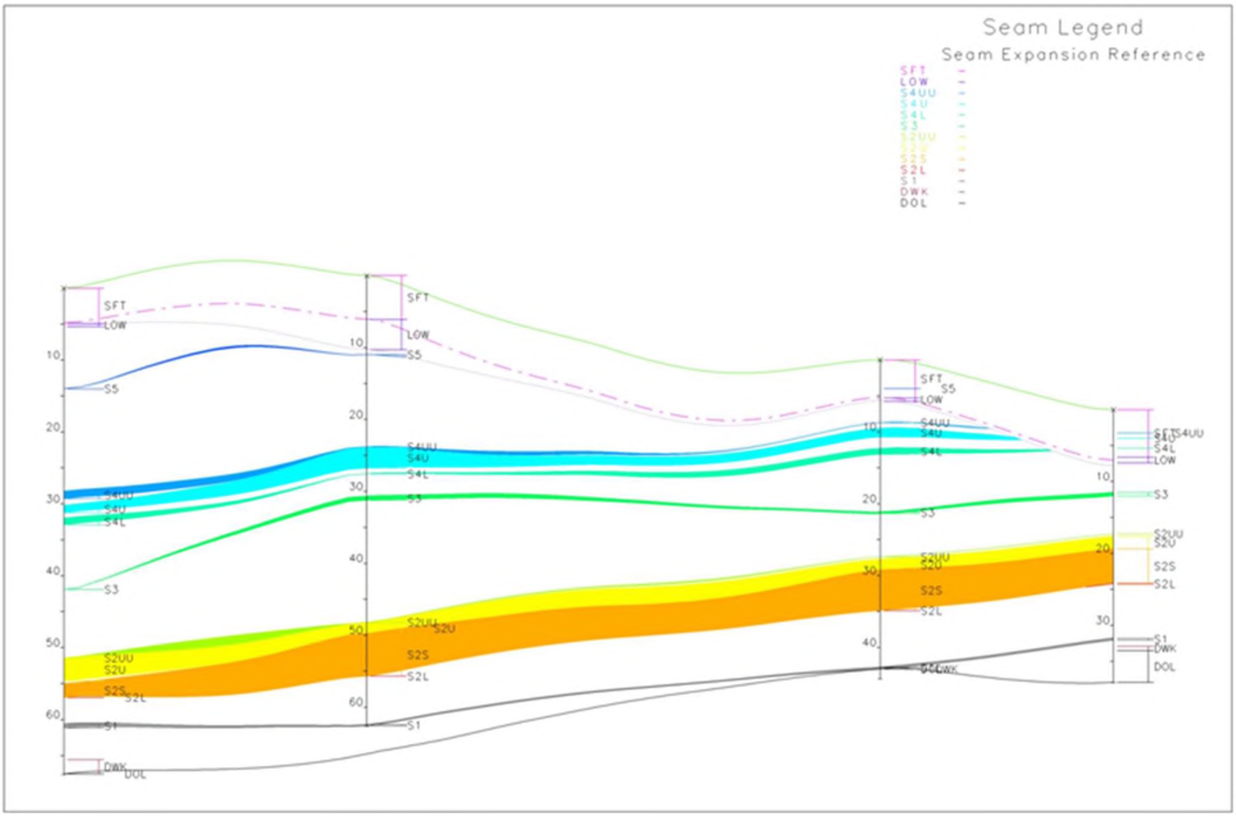


Figure 22. N - S 2 cross section.

b) Seam thickness distribution

The thicknesses of the coal seams are shown in Table 10, and the seam thickness distributions of selected seams across the resource area are provided in Figure 23 to Figure 27.

c) Coal quality distribution

All the intersected coal seams that were above the minimum sampling thickness cut-off of 0.5 m were sampled in accordance with a sound sampling protocol, as described under sampling method (3.3.5 (a)), to safe guard the reliability of the samples. The average raw qualities (proximate, CV and sulphur), of all the coal seams, except Seam 1, are shown in Table 11.

Table 10: Coal seam thicknesses

Whole Seam	Sub-seam	Thickness (m)		
		Average	Minimum	Maximum
Seam 5		0.4	0.2	1.1
Seam 4	S4UU	1.0	0.4	2.0
	S4U	2.1	0.7	3.4
	S4L	0.6	0.4	1.6
Seam 3		0.6	0.1	1.6
Seam 2	S2UU	1.2	0.6	2.1
	S2U	1.7	0.6	4.5
	S2S	3.3	0.6	7.2
	S2L	1.4	0.8	2.5
Seam 1		0.3	0.1	0.9

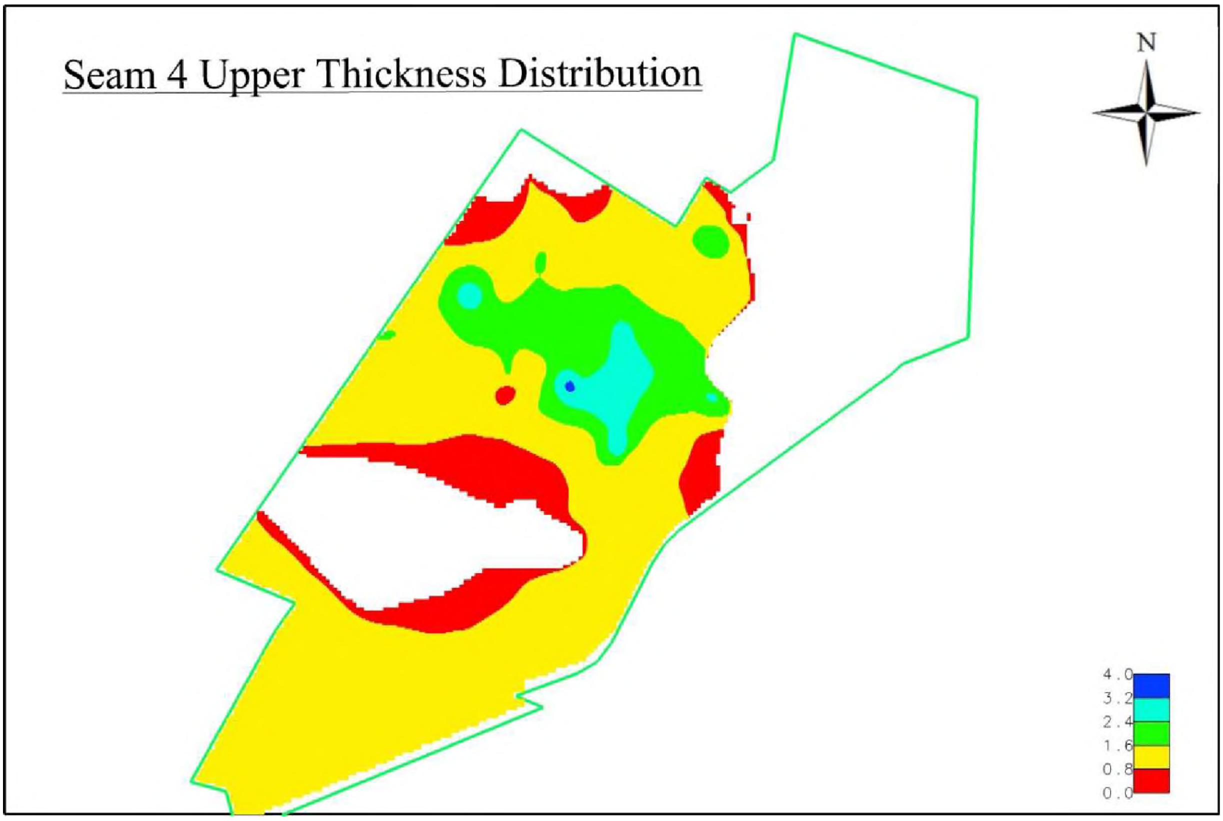


Figure 23. Seam 4 Upper thickness distribution map.

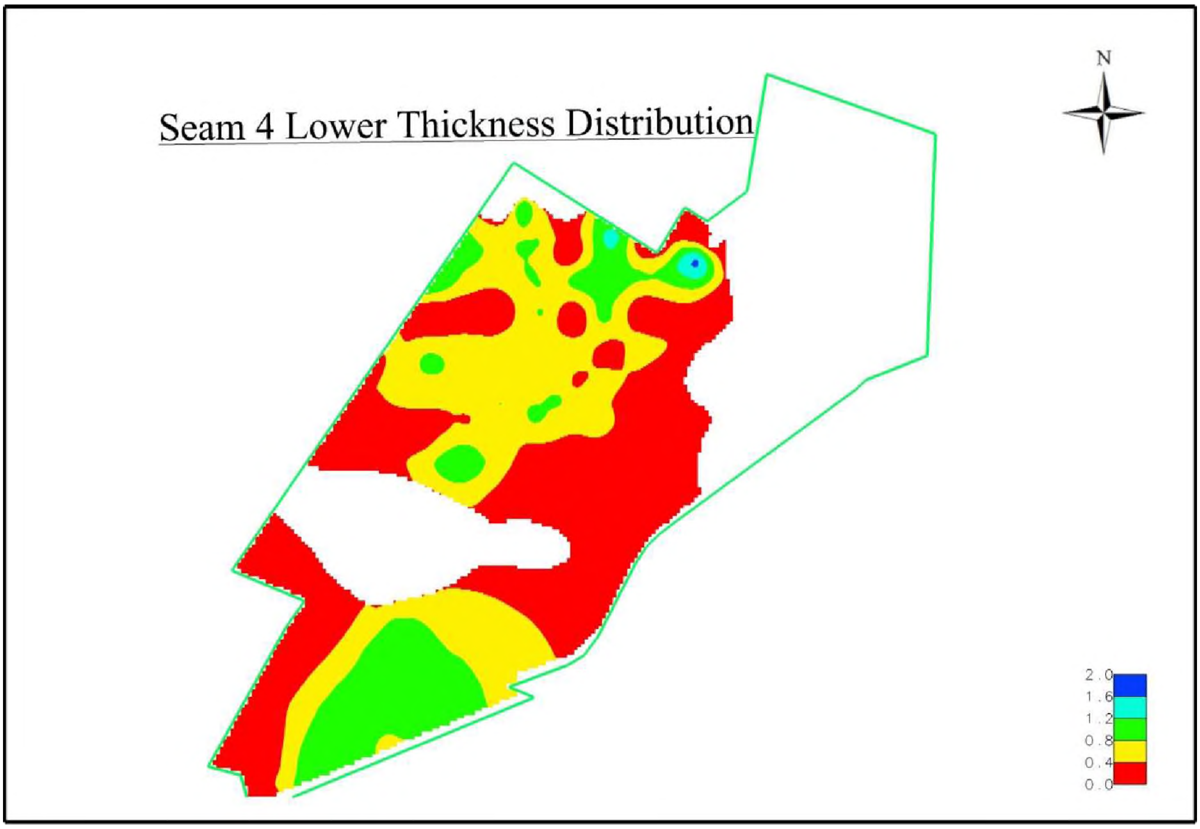


Figure 24. Seam 4 Lower thickness distribution map.

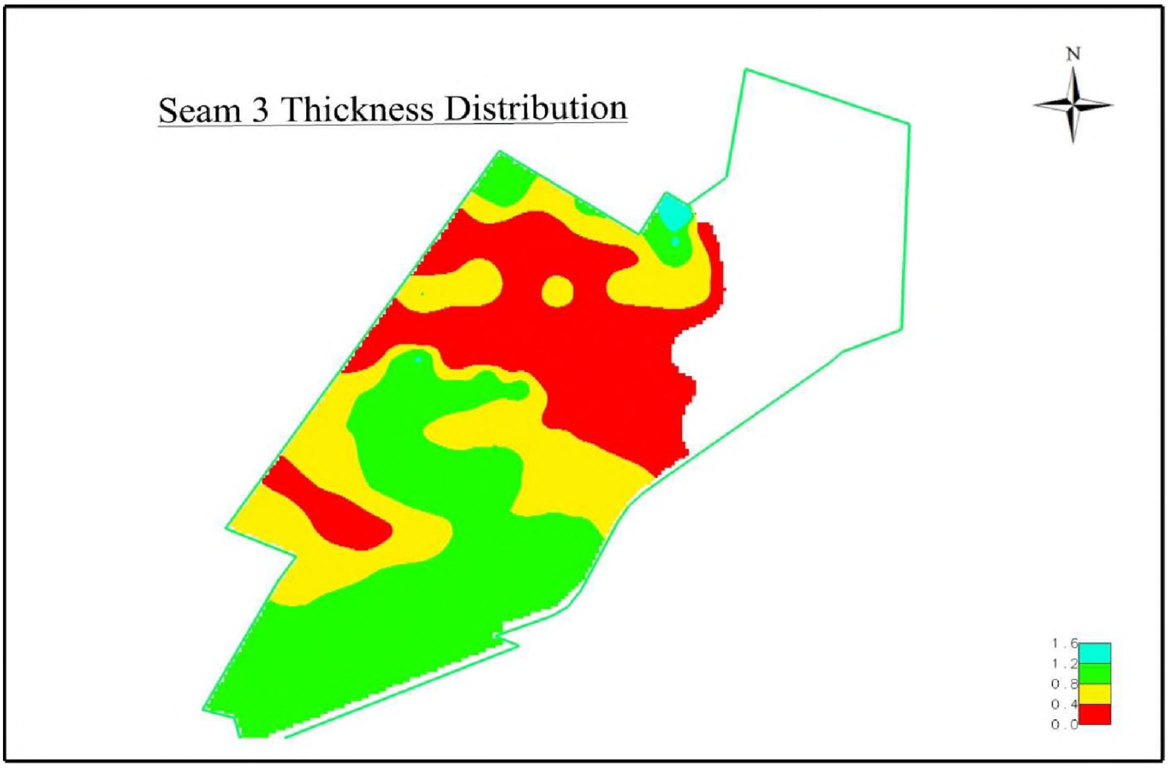


Figure 25. Seam 3 thickness distribution map.

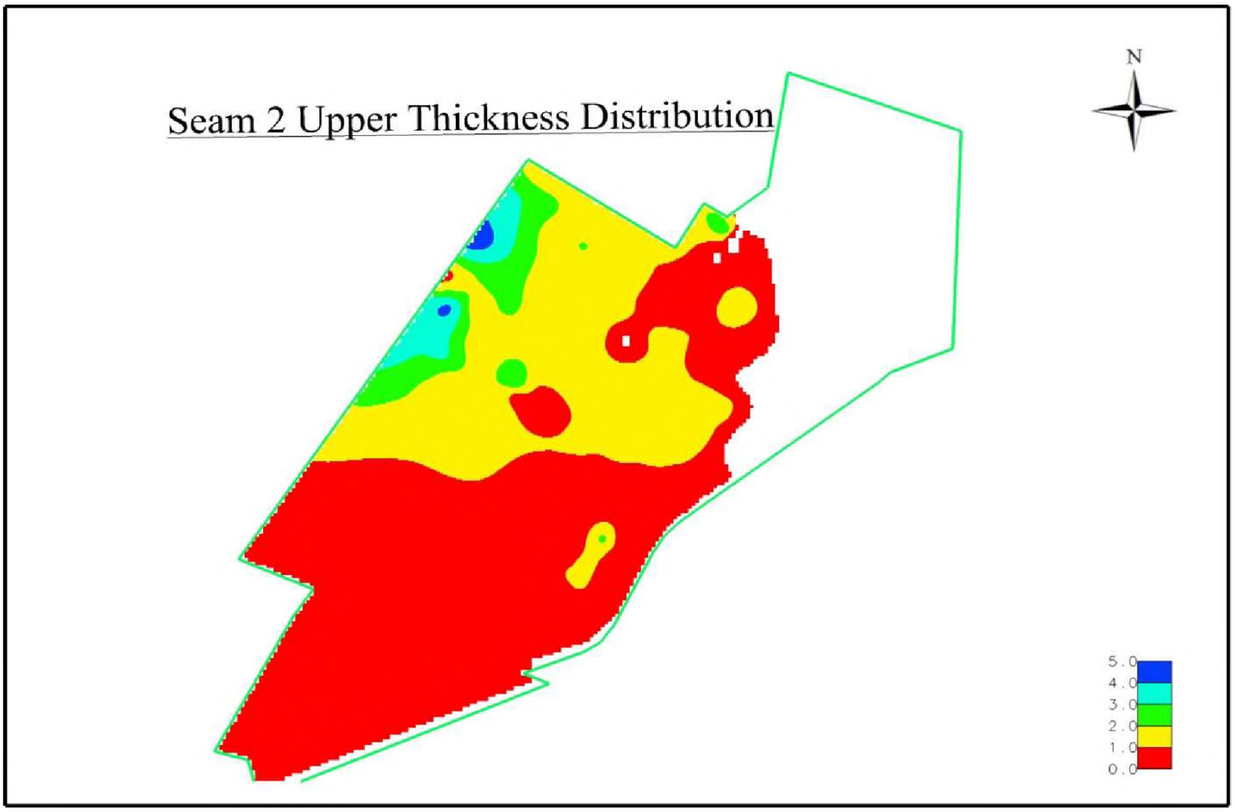


Figure 26. Seam 2 Upper thickness distribution map

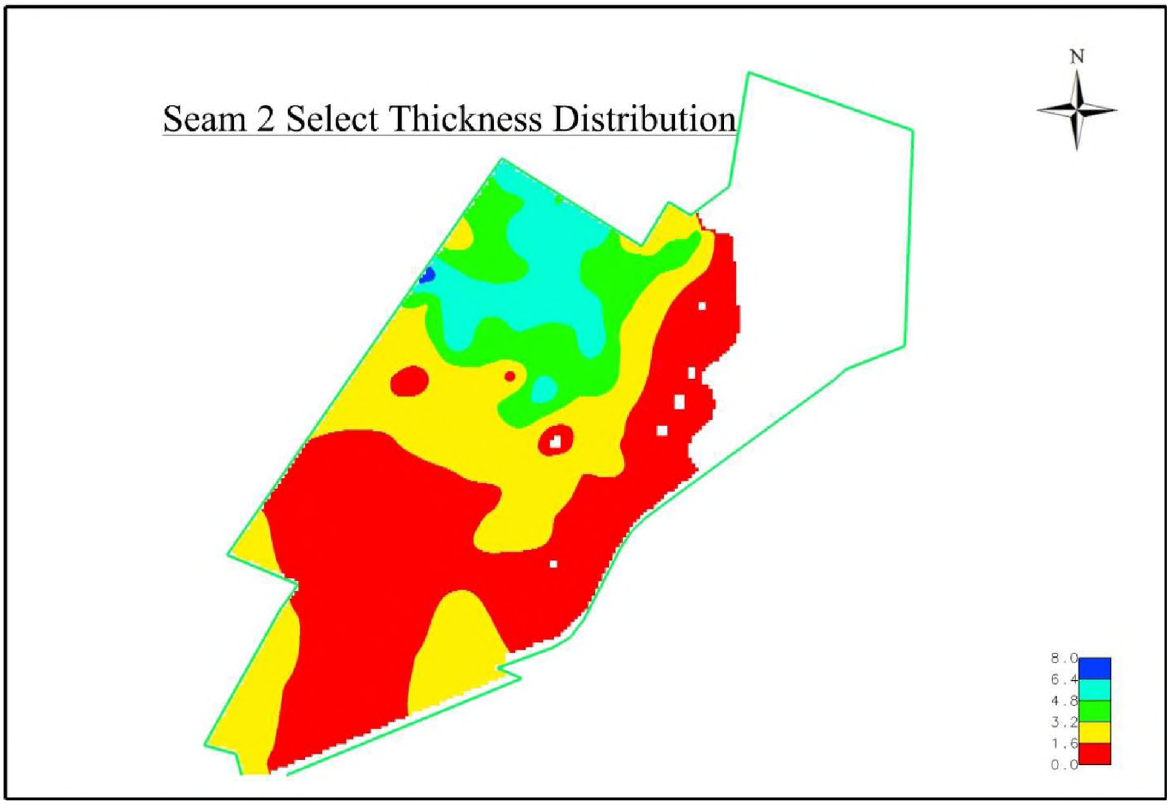


Figure 27. Seam 2 Select thickness distribution map.

Table 11: Coal deposit qualities

Seam	Calorific Value (Mj/Kg)	Ash (%)	Inherent Moisture (%)	Volatile Matter (%)	Sulphur (%)	Relative Density (g/cm³)
S5	19.72	32.78	3.05	21.75	1.86	1.68
S4UU	18.79	33.32	3.29	20.61	1.15	1.71
S4U	18.6	33.14	3.41	20.74	1.18	1.7
S4L	18.41	33.75	3.37	21.11	0.9	1.7
S3	21.55	27.25	3.38	22.91	1.15	1.61
S2UU	15.45	39.98	3.25	18.38	0.6	1.82
S2U	18.98	31.48	3.43	20.53	0.92	1.71
S2S	22.8	22.25	3.63	22.57	1.07	1.58
S2L	19.96	29.71	3.43	21.86	0.8	1.67

The distribution map of the sampling data is the same as in Figure 19, except for the area with no coal. Coal quality (calorific value) distribution maps of selected coal seams are shown in Figure 28 to Figure 32, and other quality parameters are provided in Appendix B.

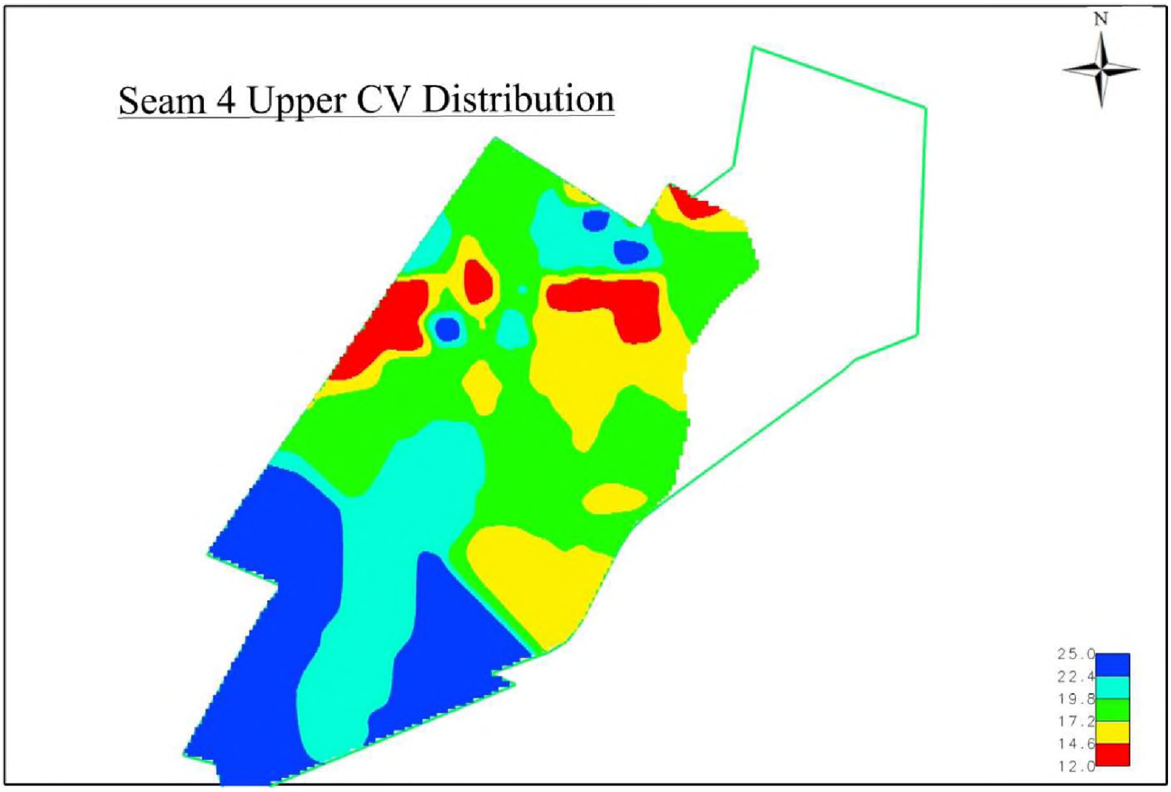


Figure 28. Seam 4 Upper Calorific Value distribution map.

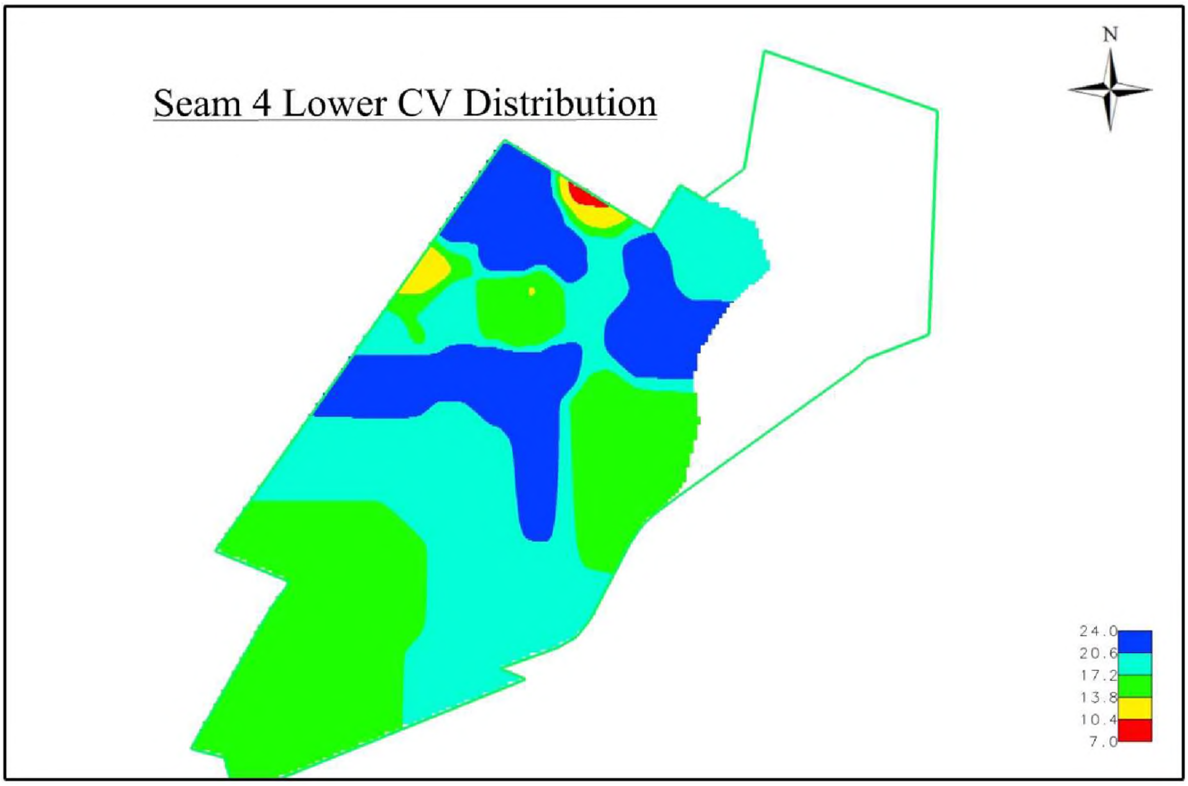


Figure 29. Seam 4 Lower Calorific Value distribution map.

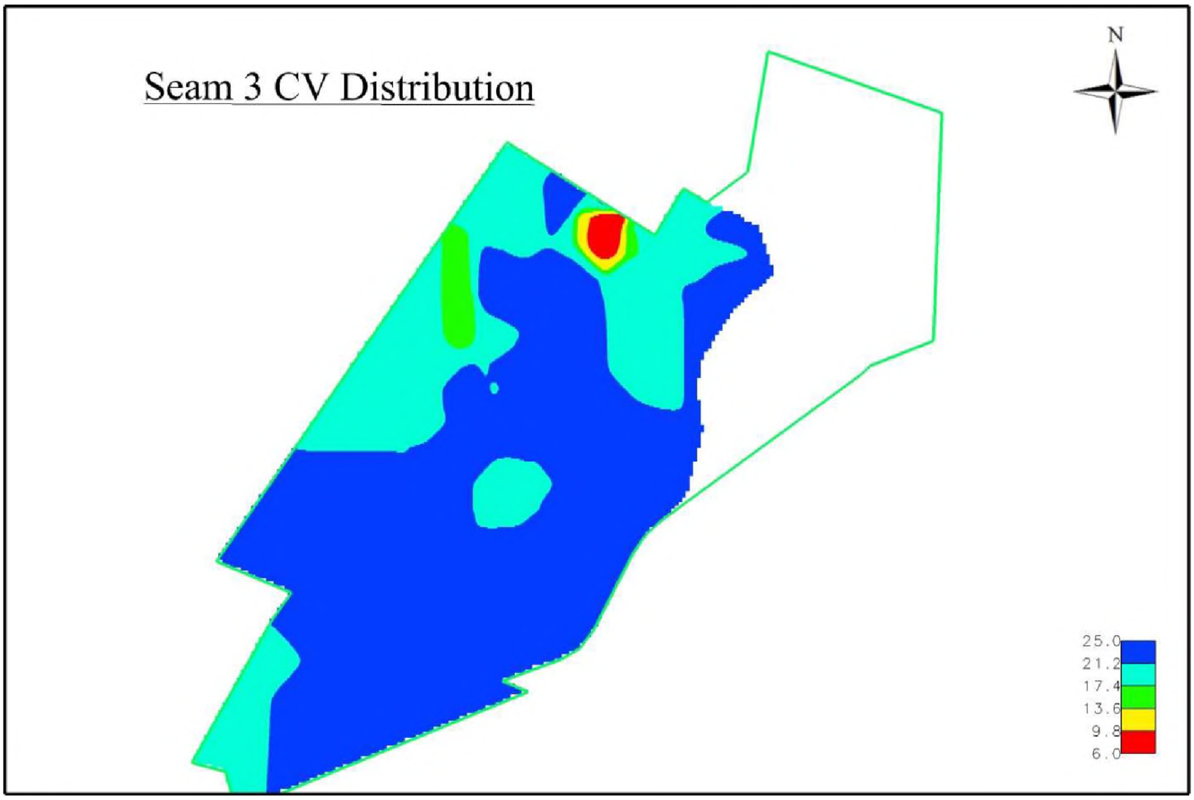


Figure 30. Seam 3 Calorific Value distribution map.

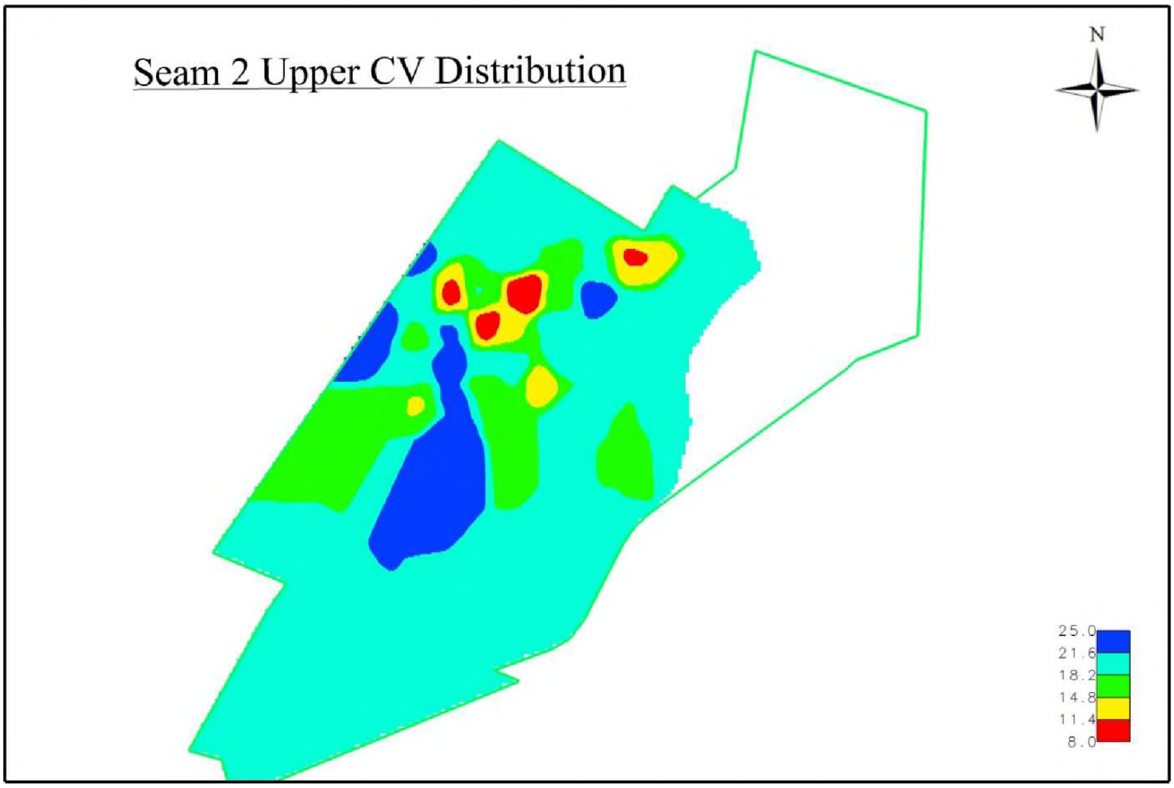


Figure 31. Seam 2 Upper Calorific Value distribution map.

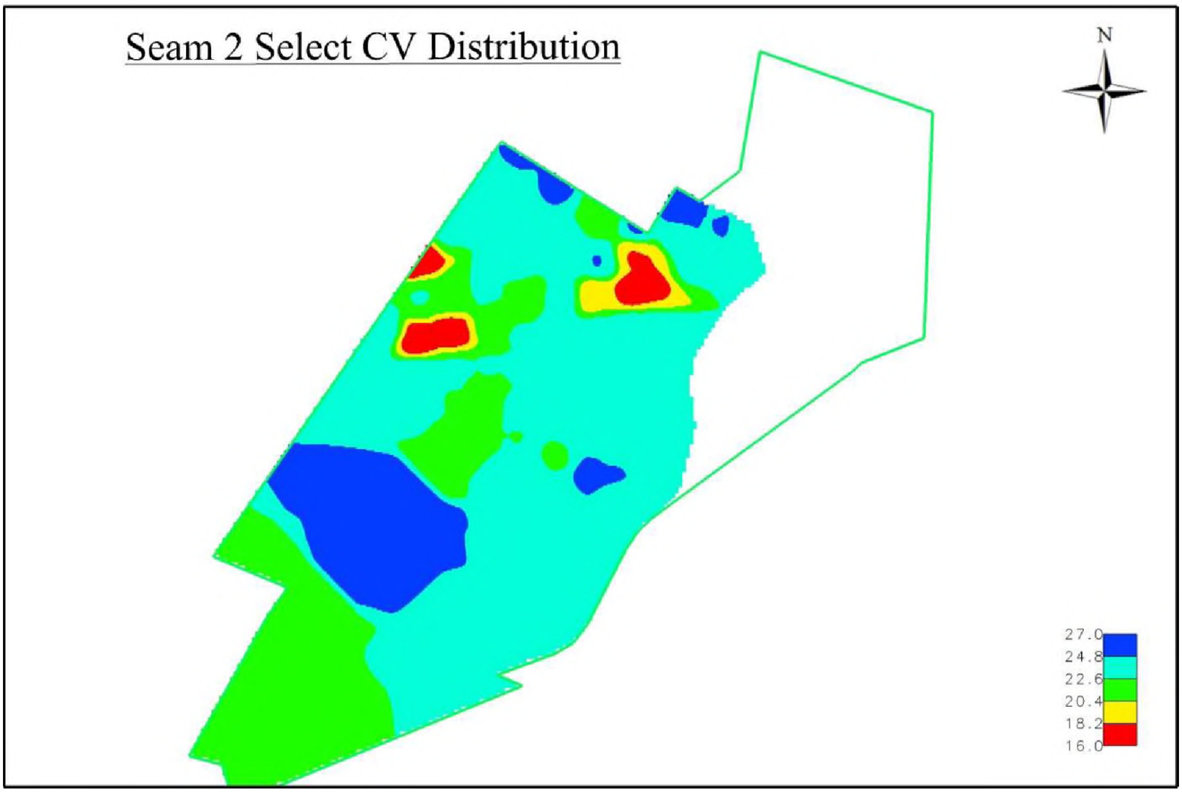


Figure 32. Seam 2 Select Calorific Value distribution map.

4.2.3 Resource classification

Only boreholes with both seam thickness and quality data were used to define coal resources. For the purpose of the classification, the resource area was subdivided into northern and southern areas on the basis of the density of available boreholes. The northern area, which has thicker coal seams at relatively shallow depths, was drilled at an average borehole spacing of 250 m, well within the recommended minimum of 350 m borehole spacing to confirm physical continuity and coal quality continuity for a Measured coal resource. Borehole coverage in the southern area, where the coal seams are thinner and deeper, is at an average spacing of 500 m and greater, which is not adequate to achieve a Measured category resource. The location of the coal resources according to classification categories Measured, Indicated and Inferred is presented in Figure 33.

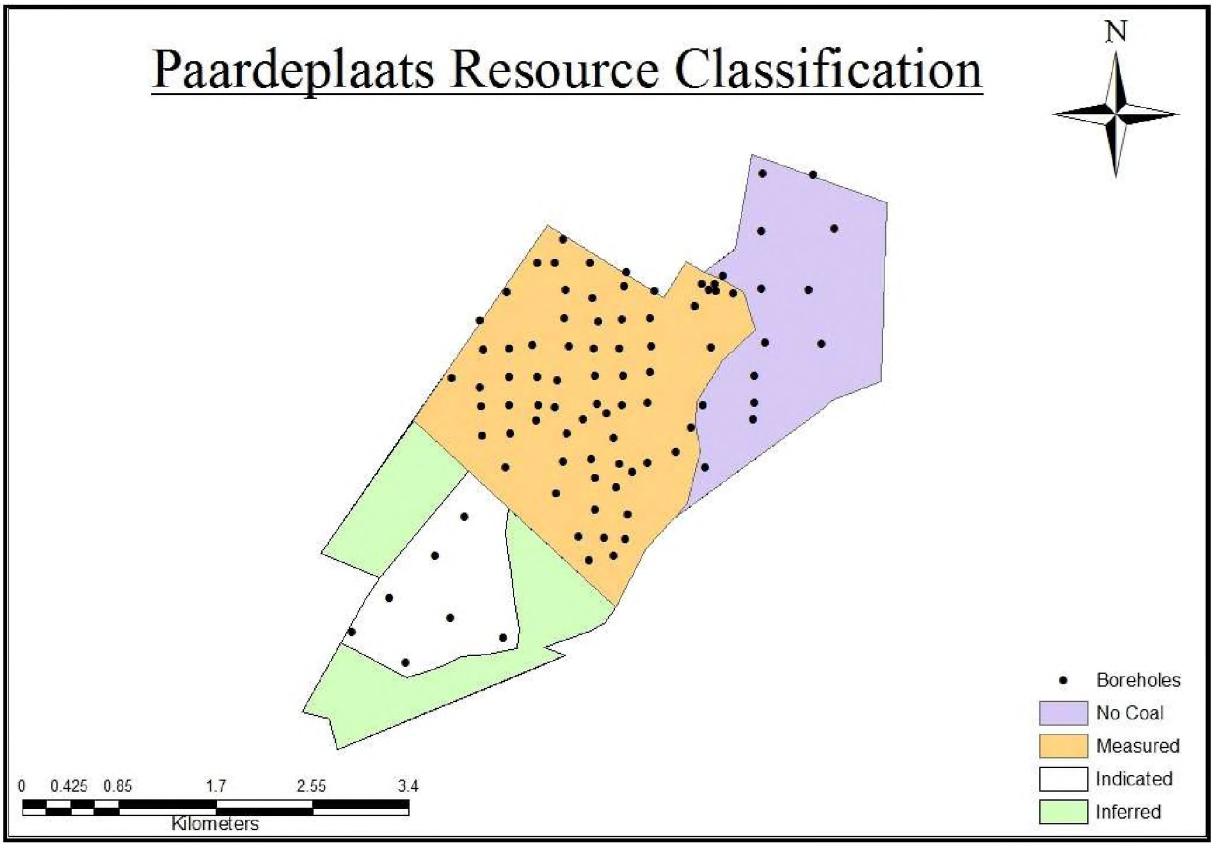


Figure 33. Coal Resource classification status map.

4.3 Coal resource statement

The coal resource statement is a product of the resource estimation exercise, which entails all the data collection, processing and validation techniques already described, and it provides an estimated tonnage and classification of the in situ coal resources and coal qualities (Table 12). The modelled raw density was used to calculate tonnage from the estimated volume. The coal resources are reported according to the following categories as defined by SANS 10320:2004:-

- Gross Tonnes In Situ (GTIS), which are defined as tonnage and coal quality, at specified moisture content, contained in the full coal seam above the minimum thickness cut-off and relevant coal quality cut-off parameters.
- Total Tonnes In Situ (TTIS), which are defined as tonnage and coal quality, at specified moisture content, contained in the full seam above the minimum thickness cut-off and quality cut-off parameters, after application of geological losses to GTIS.

- Mineable Tonnes In Situ (MTIS), which are defined as tonnage and coal quality, at a specified moisture content, contained in the coal seams, or sections of the seams, which are proposed to be mined at the theoretical mining height, excluding dilution and contamination material, with a specific mining method and after the relevant minimum and maximum mineable thickness cut-off and relevant coal quality cut-off parameters have been applied.

The following cut-offs were applied to the Coal Resources:

- The coal resources are limited to the boundaries of the prospecting area.
- The north eastern portion where there are no coal occurrences is excluded.
- Seam 1 is excluded because of insufficient seam thickness and quality data.
- Raw ash of 50% and above
- A minimum seam thickness of 0.5 meter
- Coal resources above the limit of weathering (LOW) horizon are excluded.
- Geological losses of 5%, 10% and 20% are applied to Measured, Indicated and Inferred Coal Resources, respectively, prior to the reporting of TTIS. These losses account for any geological features, such as dykes and sills, localised thinning of the coal seam, weathering, etc., that were not identified during exploration, but can have a negative impact on the coal resources.

Table 12: Coal Resource Statement

Resource Category	Seam	Seam Thickness (m)	Coal Area	Coal Volume	GTIS (Mt)	Geol. Loss (%)	TTIS (Mt)	Inherent Moisture (%)	Ash (%)	Volatile Matter (%)	Calorific Value (Mj/Kg)	Total Sulphur (%)	Relative Density (g/cm³)
Measured	S5	0.76	215,053	164,417	0.3	5%	0.3	3.05	32.6	22.62	19.61	1.18	1.73
	S4UU	0.92	2,868,203	2,643,553	4.5	5%	4.3	3.29	33.29	20.74	18.8	1.18	1.72
	S4U	1.37	4,441,713	6,080,878	10.7	5%	10.2	3.41	36.22	20.01	17.26	1.03	1.76
	S4L	0.74	1,877,960	1,384,300	2.3	5%	2.2	3.37	30.54	22.13	19.45	1.06	1.68
	S3	0.78	2,465,604	1,930,918	3.2	5%	3.0	3.38	29.34	22.41	20.7	1.13	1.64
	S2UU	0.94	1,215,298	1,144,144	2.1	5%	2.0	3.25	40.22	18.51	15.31	0.54	1.82
	S2U	1.57	4,406,705	6,914,717	11.8	5%	11.2	3.43	31.06	20.6	19.02	0.91	1.71
	S2S	2.99	4,920,581	14,715,374	23.5	5%	22.4	3.63	22.47	22.52	22.65	1.05	1.6
	S2L	1.07	1,561,633	1,663,613	2.8	5%	2.6	3.43	30.48	20.16	19.83	0.61	1.67
	Subtotal / Ave.	**1.53**	**23,972,750**	**36,641,914**	**61.2**	**5%**	**58.2**	**3.48**	**29.01**	**21.32**	**20.11**	**1.00**	**1.67**
Indicated	S5	0.56	209,468	117,464	0.2	10%	0.2	3.12	32.72	21.19	19.78	1.98	1.68
	S4U	0.93	1,071,102	999,571	1.6	10%	1.4	2.92	23.79	22.81	22.69	1.89	1.59
	S4L	0.82	720,946	588,712	1.0	10%	0.9	3.47	39.12	19.91	16.82	0.79	1.76
	S3	0.88	1,458,149	1,277,220	2.0	10%	1.8	3.24	25.72	23.45	22.17	1.25	1.58
	S2U	0.68	170,076	114,903	0.2	10%	0.2	3.33	27.79	21.24	21.19	0.78	1.63
	S2S	1.19	1,511,297	1,796,460	2.8	10%	2.5	3.52	21.27	22.84	23.42	1.08	1.56
	S2L	1.01	478,338	482,071	0.8	10%	0.7	3.29	26.85	26.2	20.64	1.35	1.64
	Subtotal / Ave.	**0.96**	**5,619,376**	**5,376,401**	**8.6**	**10%**	**7.8**	**3.30**	**25.83**	**22.86**	**21.81**	**1.27**	**1.61**
Inferred	S5	0.61	501,875	308,158	0.5	20%	0.4	3.42	32.9	21.48	19.76	2.19	1.68
	S4UU	0.72	310,625	225,174	0.4	20%	0.3	3.25	33.66	19.16	18.72	0.86	1.71
	S4U	1.03	1,621,250	1,668,016	2.7	20%	2.2	3.51	26.45	22.43	21.48	1.37	1.63
	S4L	0.78	643,750	503,060	0.9	20%	0.7	3.29	35.91	19.79	17.49	0.6	1.73
	S3	0.91	1,876,875	1,700,253	2.7	20%	2.2	3.10	25.95	23.1	22.08	1.11	1.59
	S2UU	0.77	157,500	120,693	0.2	20%	0.2	3.15	37.61	17.17	16.88	1.15	1.78
	S2U	0.83	1,031,875	852,616	1.5	20%	1.2	3.59	35.33	19.88	18.4	0.94	1.72
	S2S	1.47	2,038,125	2,995,278	4.7	20%	3.8	3.23	21.76	22.63	23.22	1.16	1.57
	S2L	0.8	729,375	586,953	1.0	20%	0.8	3.61	29.85	23.19	19.79	0.91	1.66
	Subtotal / Ave.	**1.01**	**8,911,250**	**8,960,201**	**14.6**	**20%**	**11.6**	**3.33**	**27.11**	**22.06**	**21.29**	**1.15**	**1.63**
	Grand Total / Ave.	**1.32**	**38,503,376**	**50,978,516**	**84.4**	**8.0%**	**77.6**	**3.44**	**28.36**	**21.60**	**20.49**	**1.05**	**1.66**

5. COAL RESERVES

A coal reserve is that part of the coal seam that will be mined, either the full seam or a selected part of the seam, and is based on an evaluation that demonstrates that extraction of a coal resource is justified at the time of the valuation and that an economic mine plan has been defined (SANS 10320:2004).

5.1 Coal resource conversion to reserves

The conversion of coal resources to coal reserves as defined by the SAMREC Code is shown in Figure 34. The SAMREC Code makes reference to SANS 10320:2004 for the definition of the relevant terms and the methods used in the evaluation of coal deposits.

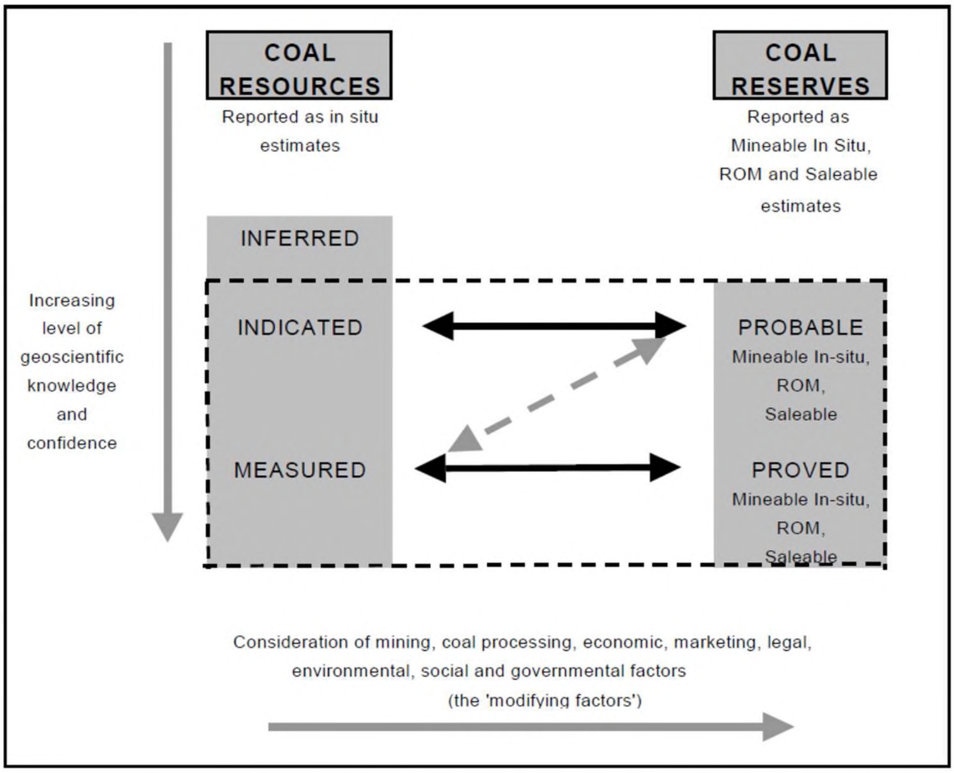


Figure 34. Relationship between Coal Resources and Coal Reserves (SAMREC Code)

The area with Probable coal reserves (Indicated coal resources) (Figure 33) is flanked by sizeable areas with Inferred coal resources, resulting in a limited confidence level. Owing to the limited confidence level, only Measured coal resources were converted to Proved coal reserves. The reserve areas and thickness for the respective seams are presented in Figure 35 to Figure 40.

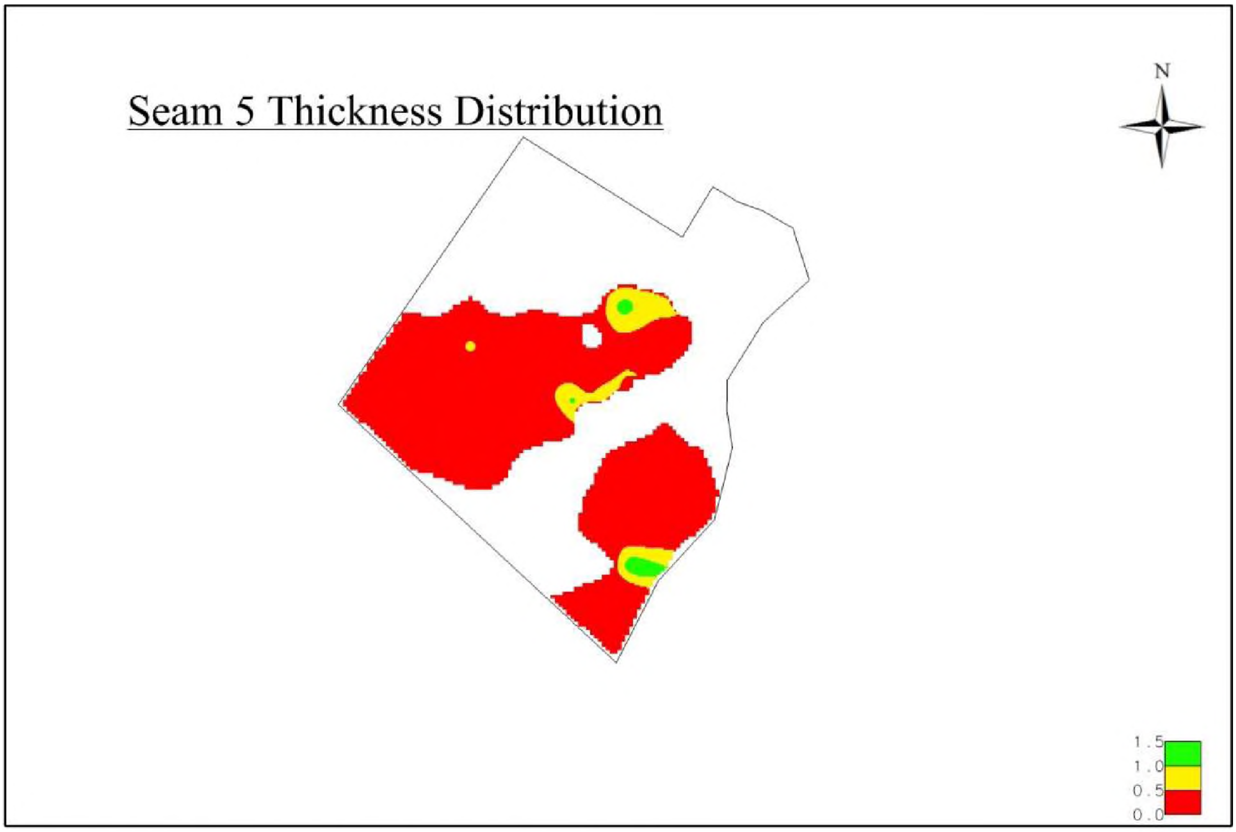


Figure 35. Seam 5 reserve area and thickness.

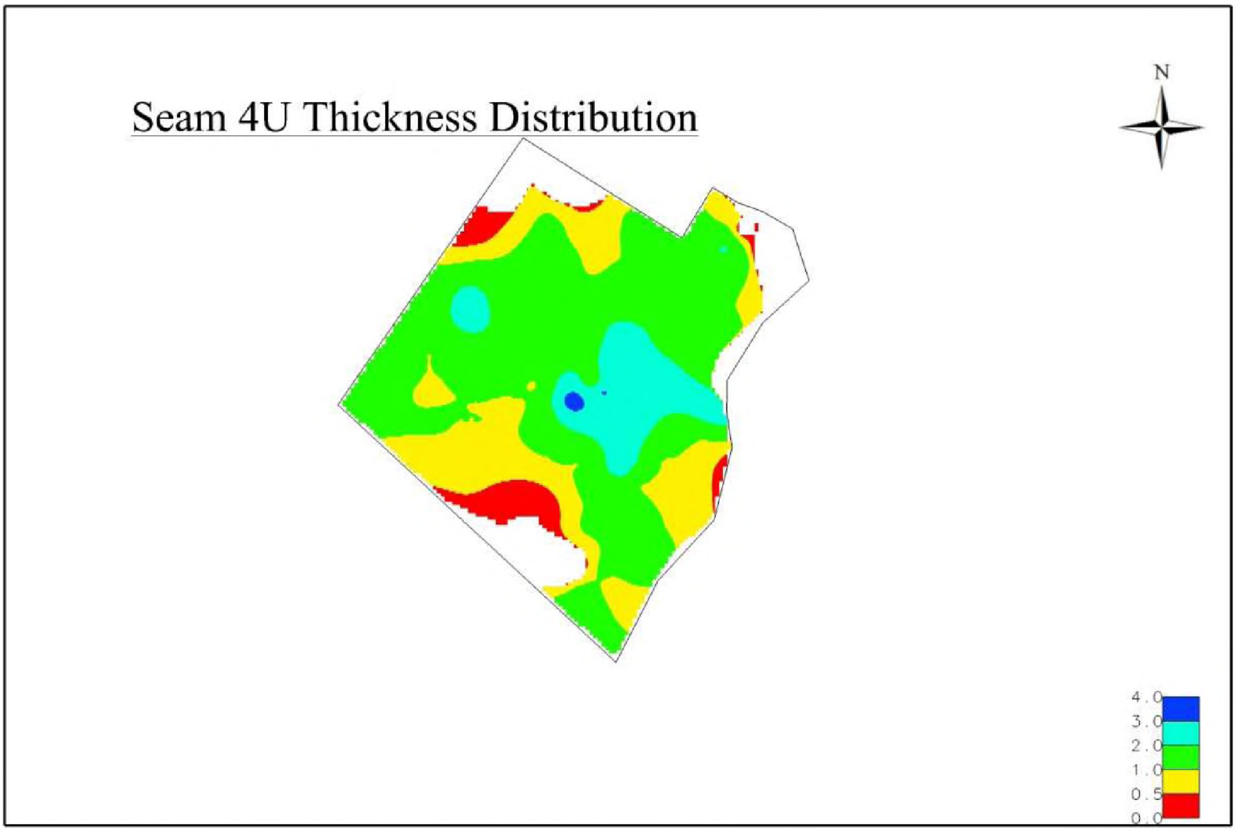


Figure 36. Seam 4 Upper reserve area and thickness.

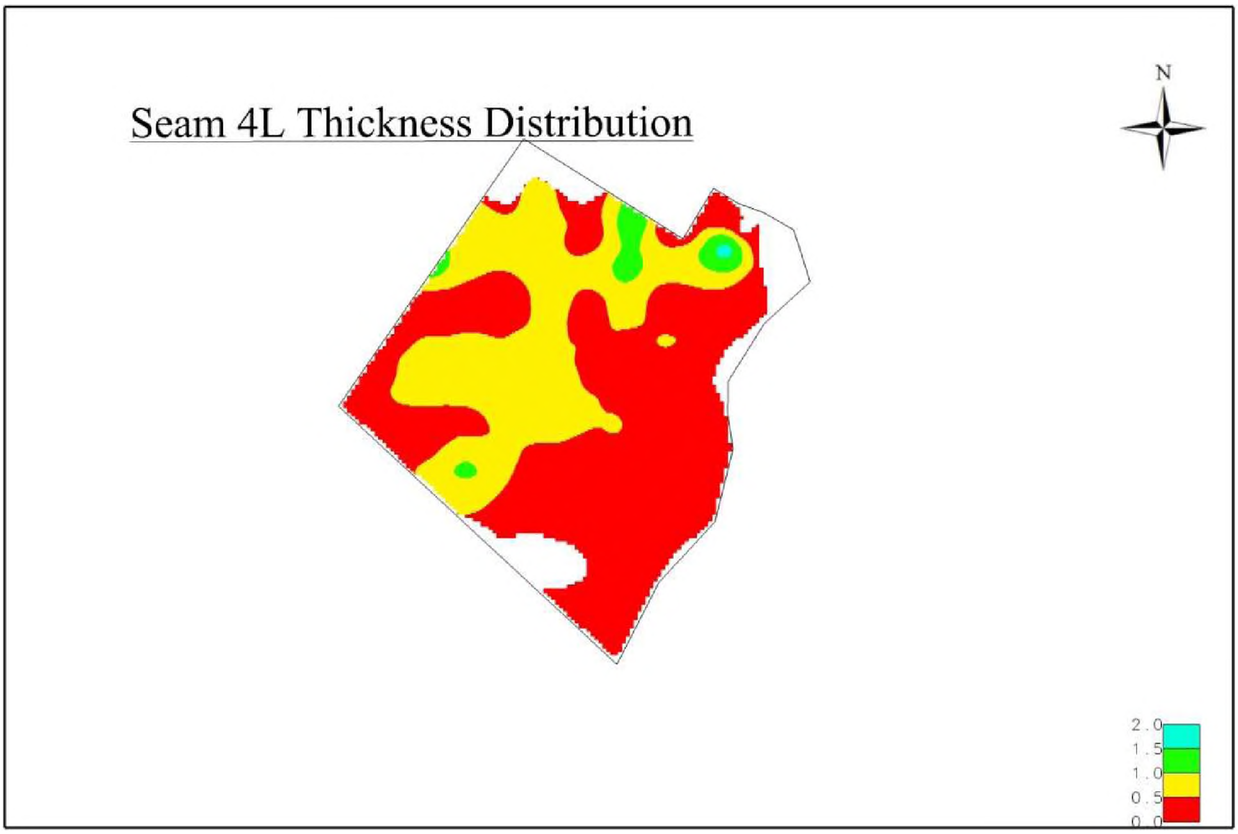


Figure 37. Seam 4 Lower reserve area and thickness.

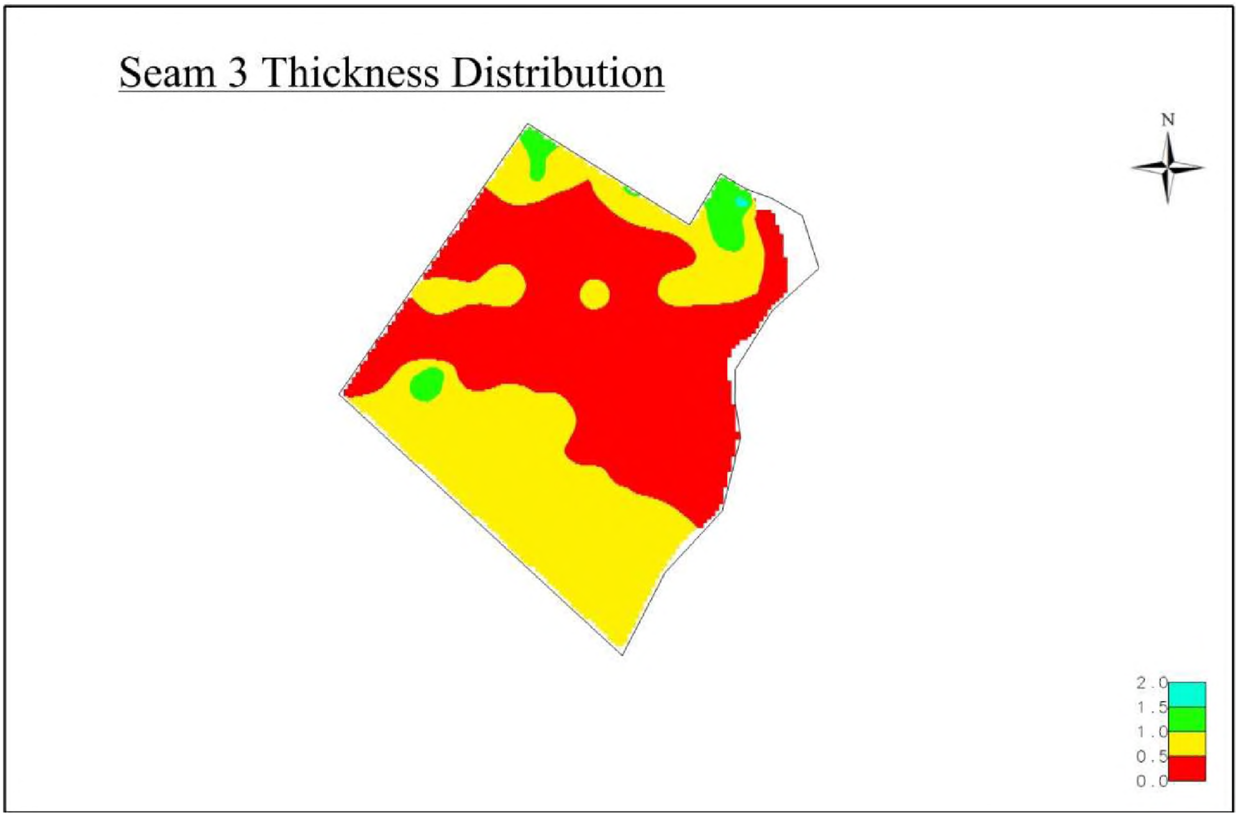


Figure 38. Seam 3 reserve area and thickness.

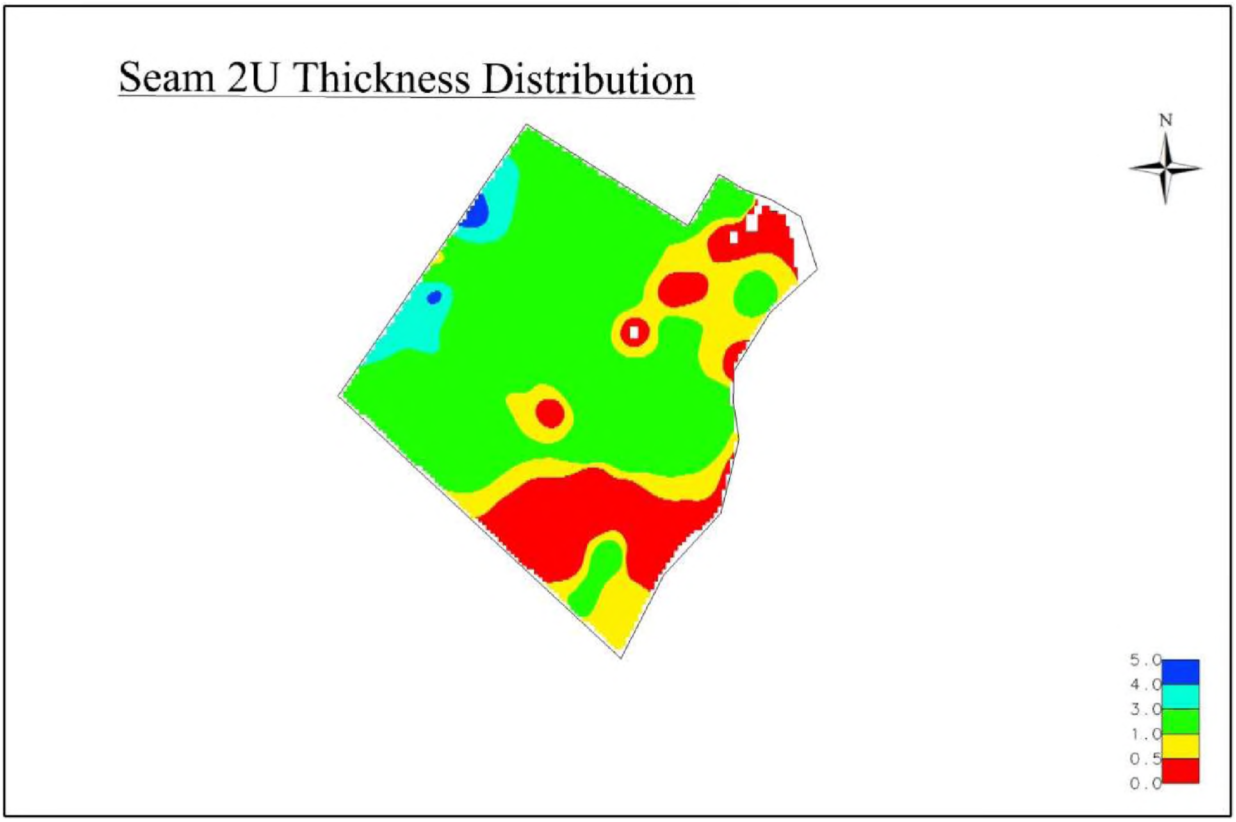


Figure 39. Seam 2 Upper reserve area and thickness.

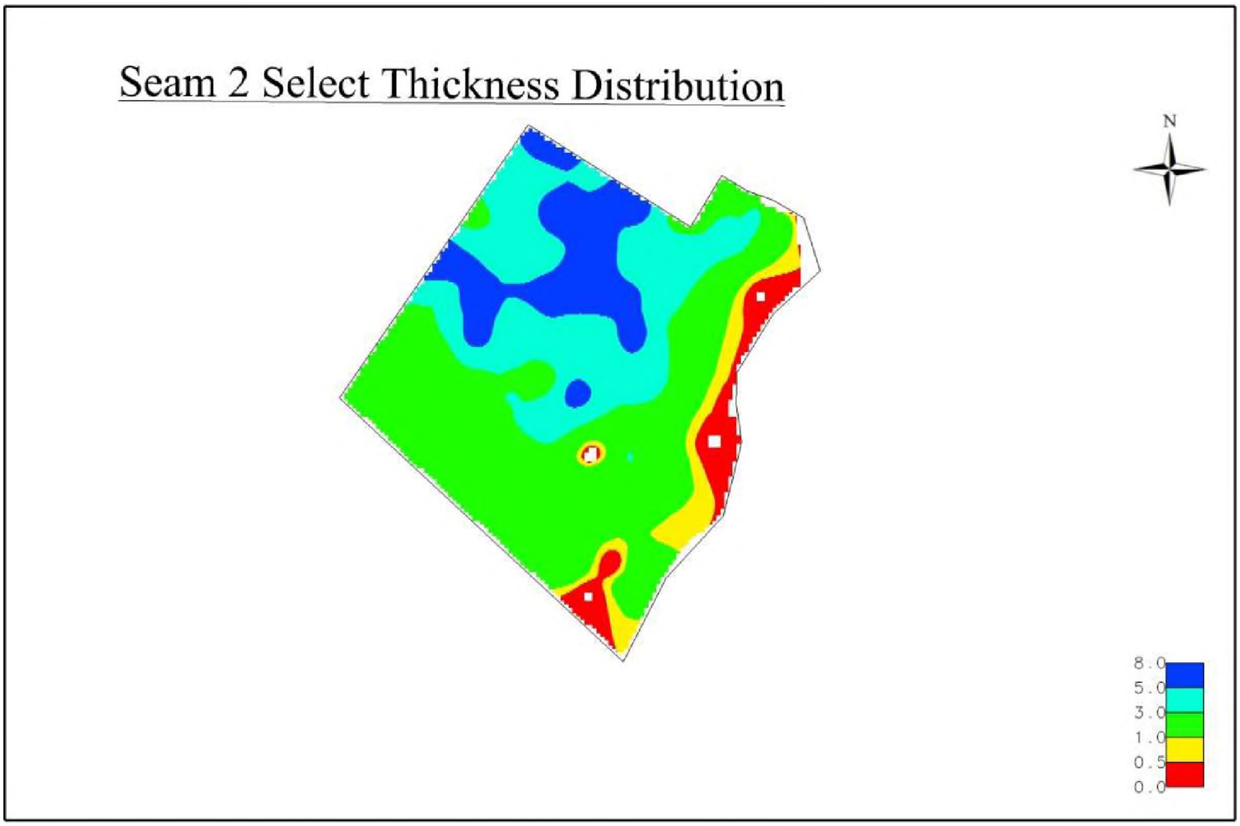


Figure 40. Seam 2 Select reserve area and thickness.

5.2 Modifying Factors

The modifying factors applied are based on the assumption that the coal deposit, once developed into an operating colliery, would be exploited similarly to the adjacent Glisa Colliery. The mining method at Glisa Colliery is surface strip mining, which involves the selective extraction of overburden, interburden and the coal seam(s). Run of Mine (RoM) coal is beneficiated via a combination of a dense medium processing plant and two dry crushing and screening plants. The saleable product is sold domestically to Eskom.

A reserve evaluation is beyond the intent of this study, and was thus not done. The modifying factors applied are either assumed, or based on known coal mining industry averages. A summary of the modifying factors is presented in **Table 13**.

Table 13: Summary of modifying factors

Coal Resource cut-offs	As per Coal Resource Statement
Mining	
Mining extraction factor	95%
Surface moisture	3%
Contamination	5%
Mining loss factor	5%
Coal Processing	
DMS plant yield cut-off	40%
DMS plant efficiency factor	85%
Crush and screen plant efficiency factor	98%
Product quality (CV)	22.5 Mj/Kg & 21.5 Mj/Kg
Market	
22.5 Mj/Kg & 21.5 Mj/Kg	Eskom
Costs	
RoM and processing	R200/t
Revenue	
Eskom	R250/t
Others	All regulatory requirements satisfied and licences granted

5.3 Coal reserve statement

All coal resource areas considered for conversion to reserves are within acceptable strip ratio, and thus TTIS equals MTIS. Contamination impacts on the overall yield and not the saleable product qualities. Reported coal reserves (RoM) are inclusive of contamination. The Coal Reserve statement is presented in Table 14.

Table 14: Coal Reserve Statement

Reserve Category	Seam	MTIS (Mt)	Mining Extraction Factor (%)	Contamination (%)	Surface Moisture (%)	Mining Loss Factor (%)	RoM (Mt)	Practical Yield (%)	22.5 Mj/Kg saleable product (Mt)	21.5 Mj/Kg saleable product (Mt)	Yield (%)	Inherent Moisture (%)	Ash (%)	Volatile Matter (%)	Calorific Value (Mj/Kg)	Total Sulphur (%)
Proved	S5	0.3	95	5	3	5	0.3	56	0.0	0.1	66	2.96	28.94	25.46	21.51	1.01
	S4UU	4.3	95	5	3	5	4.2	65	0.0	2.8	77	3.78	25.31	22.07	21.74	0.6
	S4U	10.2	95	5	3	5	9.9	52	0.0	5.1	61	3.90	23.76	22.69	21.76	0.41
	S4L	2.2	95	5	3	5	2.2	62	0.0	1.3	73	3.78	24.67	23.32	21.69	0.38
	S3	3.0	95	5	3	5	2.9	77	0.0	2.2	90	3.76	25.36	22.14	21.76	0.46
	S2U	11.2	95	5	3	5	10.9	74	0.0	8.1	87	3.99	24.08	20.74	21.66	0.25
	S2S	22.4	95	5	3	5	21.8	98	21.4	0.0	98	3.63	22.47	22.52	22.65	1.05
	S2L	2.6	95	5	3	5	2.6	72	0.0	1.9	85	3.92	24.89	20.51	21.72	0.25
	Total / Ave.	**58.2**	**95**	**5**	**3**	**5**	**54.8**	**78**	**21.4**	**21.6**	**85**	**3.76**	**23.46**	**22.10**	**22.18**	**0.71**

6. ECONOMIC EVALUATION

The economic environment of the project can be evaluated by looking at, (a) the South African coal market, in terms of producers and consumers of South African coal and size of the market, (b) the current state of the South African coal market in terms of supply and demand, and (c) global and domestic coal prices.

6.1 The South African Coal Market Environment

The South African coal market environment can be profiled by looking at the producers, consumers and size of the market in terms of annual tonnes produced and monetary value of sales.

6.1.1 Size of the South African Coal Market

a) South Africa's position in the Global Coal Market

While South Africa is a significant participant in global coal markets, it is not the biggest: China, the USA and India are much larger producers and consumers of coal; Australia, Indonesia, Russia and Colombia are larger exporters of coal (Eberhard, 2011). In 2013, South Africa ranked 5th in the world in terms of coal reserves, 7th in terms of coal production, 5th in terms of both exports and consumption (DMR, 2015). The position of South Africa in relation to other countries is shown in Table 15.

Table 15: World Coal Reserves, Production, Exports and Consumption

COUNTRY	RESERVES			PRODUCTION			EXPORTS			CONSUMPTION		
	Mt	%	Rank	Mt	%	Rank	Mt	%	Rank	Mt	%	Rank
Australia	76,400	8.2	4	459.3	5.9	5	336.3	25.2	2	121.3	1.5	7
Canada	6,582	0.7	11	68.9	0.9	11	36.3	2.7	7	40.9	0.5	11
China	114,500	12.3	3	3,560.7	45.5	1	7.3	0.5	-	3,880.6	49.3	1
Colombia	6,746	0.7	10	85.4	1.1	10	74.3	5.6	6	7.1	0.1	12
India	60,600	6.5	6	612.8	7.8	3	1.5	0.1	-	791.2	10	3
Indonesia	28,017	3.0	9	488.6	6.2	4	426.1	32	1	62.5	0.8	10
Kazakhstan	33,600	3.6	8	119.9	1.5	9	32.7	2.5	8	87.5	1.1	8
Poland	5,465	0.6	12	142.8	1.8	8	11.1	0.8	-	144.5	1.8	6
Russia	157,010	16.9	2	347.2	4.4	6	140.8	10.6	3	234.8	3	4
South Africa	66,700	7.2	5	256.3	3.3	7	74.6	5.6	5	183.9	2.3	5
Ukraine	33,873	3.6	7	65.8	0.8	12	5.6	0.4	-	75.9	1	9
USA	237,295	25.6	1	904.0	11.6	2	106.7	8	4	842.9	10.7	2
Other	101,287	10.9	-	711.1	9.1	-	80	6	-	1,402.6	17.8	-
Total	**928,075**	**100**	-	**7,822.8**	**100**		**1,333.3**	**100**		**7,875.7**	**100**	

(Source: DMR, 2015)

b) South Africa's coal production

South Africa produced 252 Mt of saleable coal in 2015, after a peak of 261 Mt in 2014; South Africa's coal production from 1915 to 2015 is shown in Figure 41.

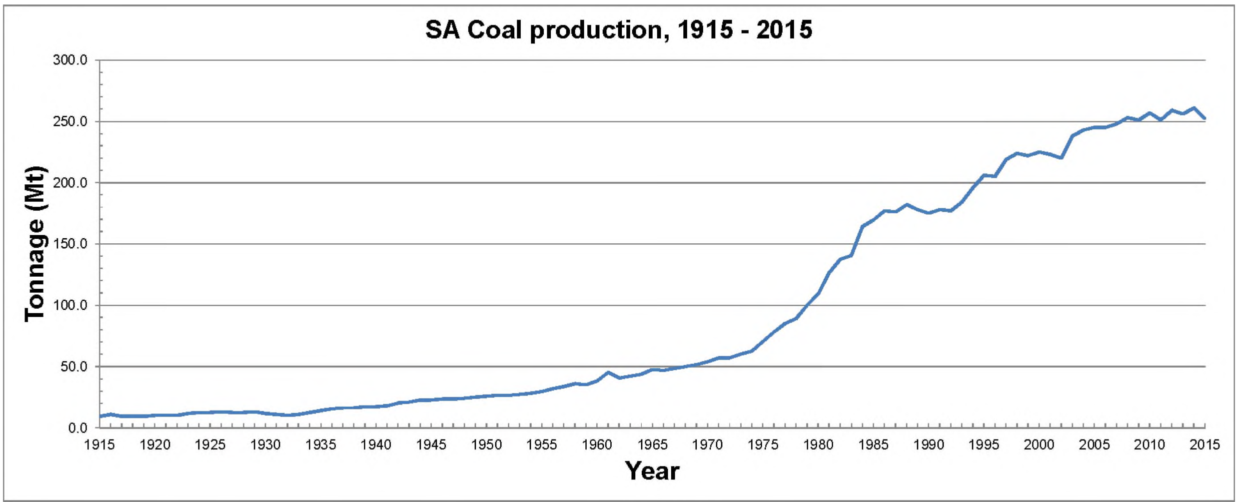


Figure 41. South Africa's coal production from 1915 to 2015 (Source: Leger, 1991; Stats SA, 2012; DMR, 2016).

Prior to the 1970's coal production was relatively stagnant primarily due to relatively low levels of mechanisation and extraction rates in a low coal price environment with limited growth in demand. Leger (1991) noted that rising inflation in the late 1960's resulted in reduced profitability, and as a consequence of declining profits there was little significant investment in new collieries.

In responding to declining profits, mine owners through the Transvaal Coal Owners Association (TCOA) addressed the low coal prices by firstly, challenging the domestic price controls which were introduced from 1951 onwards; and secondly by introducing different coal products in the market, with differential selling prices. Prior to 1972 there were only two grades of coal, high and low with a price difference of five cents per tonne; in 1972 four grades of coal from A (high grade) to D (low grade) were introduced, with a graded differential of 22.5 cents per tonne between top and bottom qualities (Leger, 1991).

The oil crisis of 1973-4 contributed to South Africa's increased coal production, with the higher export prices incentivising investments in new collieries. The drive to meet export demand saw improved extraction rates due to improved levels of mechanisation and new mining technologies. Increase in electricity demand in South Africa post 1994 stimulated a further growth in the country's coal production.

c) Monetary value of South Africa's coal sales

The tonnage and monetary value of domestic and export sales between 2000 and 2014 is shown in **Error! Reference source not found.**. Export sales were one third the size of domestic sales by tonnage, but had a higher monetary value than domestic sales. The higher value of the export sales is due to the better quality of the export product and the ZAR/US Dollar exchange rate.

Table 16: South Africa's Sales of Saleable coal, 2000 - 2014

YEAR	DOMESTIC SALES MASS Mt	DOMESTIC SALES Value (FOR) R'000	DOMESTIC SALES R/t	EXPORT SALES MASS Mt	EXPORT SALES Value (FOB) R'000	EXPORT SALES R/t
2000	154.6	8 772 310	57	69.9	9 234 328	160
2001	152.2	9 564 521	63	69.2	11 185 460	245
2002	157.6	11 773 123	75	69.2	16 956 659	280
2003	168.0	13 212 837	79	71.5	19 366 998	189
2004	178.3	13 606 151	76	67.9	13 490 623	213
2005	173.4	14 878 140	86	71.4	14 472 904	296
2006	177.0	16 245 861	92	68.7	21 155 176	316
2007	182.8	19 718 642	108	67.7	21 745 322	361
2008	197.0	30 104 161	153	60.6	44 706 204	737
2009	184.7	34 463 054	187	60.5	30 934 920	512
2010	186.4	33 702 229	181	66.8	37 477 184	561
2011	177.9	37 253 525	210	68.8	50 548 678	735
2012	185.7	43 921 277	237	76.0	52 226 904	687
2013	183.4	49 447 281	270	73.2	50 911 117	696
2014	183.0	54 924 215	300	75.4	50 881 592	675
TOTAL / AVERAGE	**2 642**	**391 587 327**	**145**	**1037**	**445 294 069**	**444**

(Source: DMR, 2012, 2015, 2016).

6.1.2 Producers in the South African Coal Market

The structure of the producer market consists of five big companies (the Majors), which produce over 80% of saleable coal; with the remainder coming from a spread of smaller companies (the Juniors). In 2013, the Majors namely, Anglo Coal, Glencore Xstrata, Exxaro, Sasol and BHP Billiton Coal South Africa (BECSA) produced 84% of South Africa's saleable coal, and the Juniors, the balance of 16% (see Figure 42.)

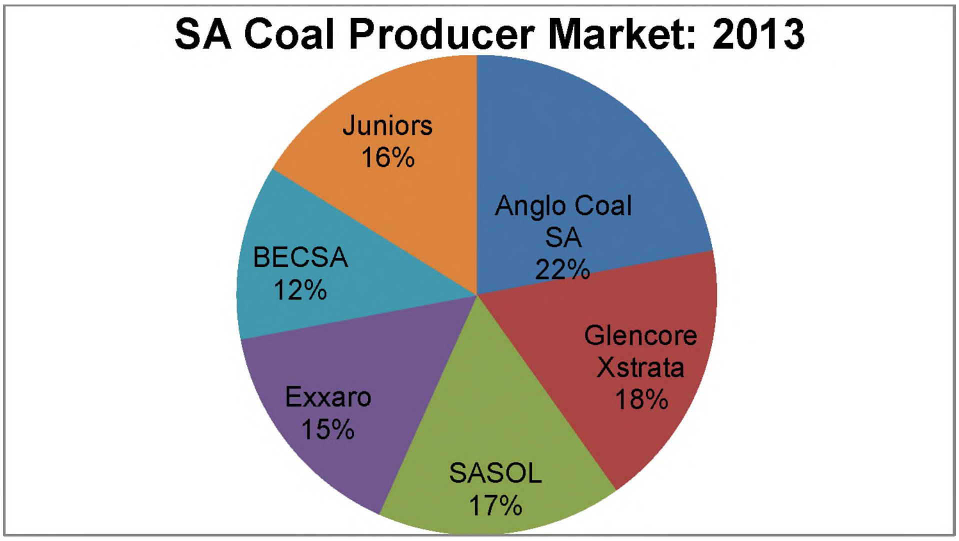


Figure 42. South Africa's producer market, 2013 (DMR, 2015).

6.1.3 Consumers in the South African Coal Market

The consumer market as shown in **Figure 43** below is dominated by Eskom, 46% in 2013 followed by exports at 29%, Sasol Synfuels at 15%, merchants & domestic at 4%, metallurgical at 2%, industries at 2% and other consumers at 2% (DMR, SAMI 2013 – 2014).

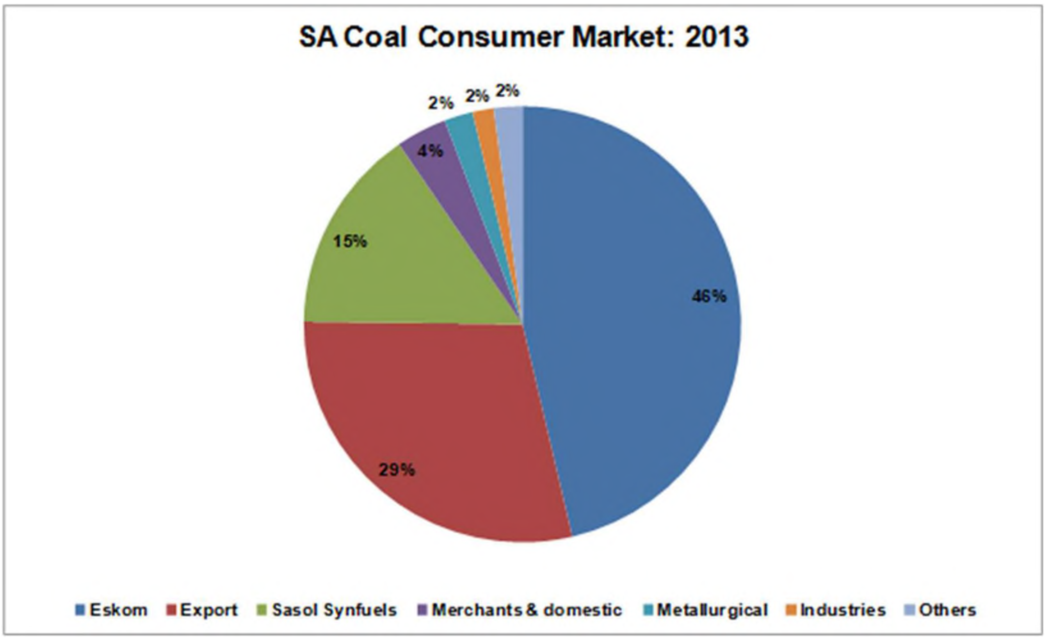


Figure 43. Consumers of South Africa's coal, 2013 (DMR, 2015).

The domestic consumption in 2013 accounted for 71% of that year's production; the remaining 29% was exported. The split between domestic consumption and exports has relatively been consistent, at an average ratio of 5:2 over the past two decades (see Figure 44).

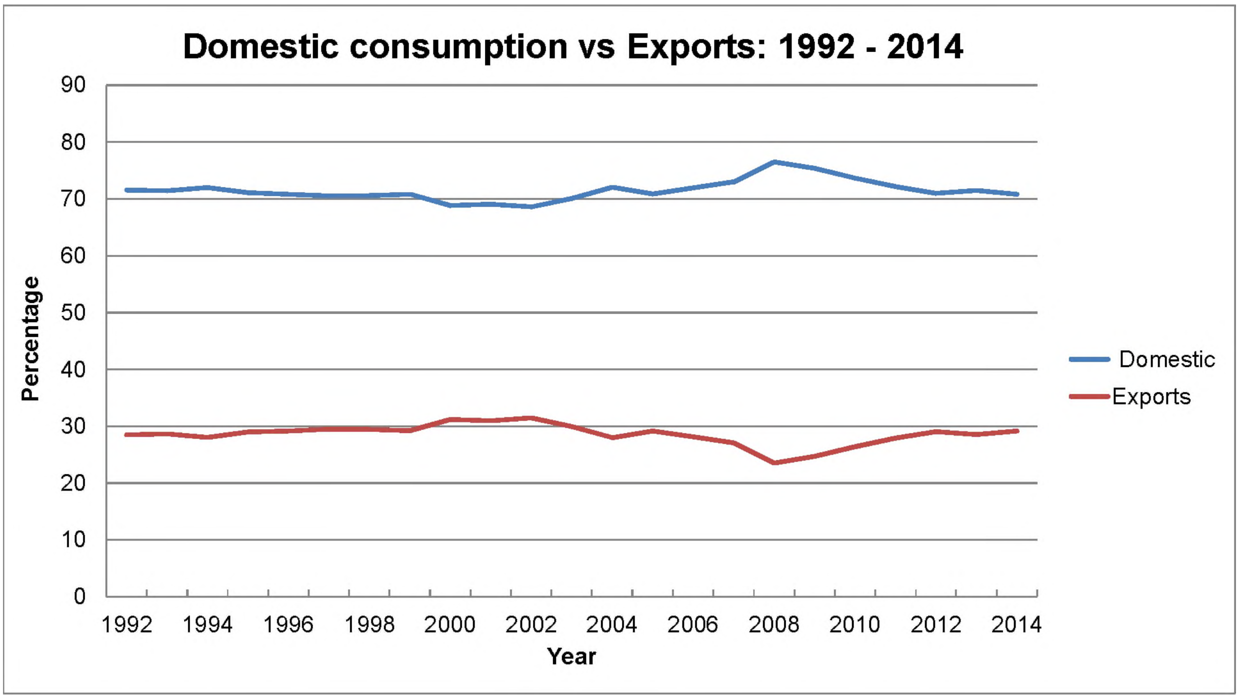


Figure 44. Domestic consumption vs exports (DoE, 2009 and DMR, 2016).

Because Sasol Synfuels procures its coal feedstock mainly in-house from Sasol Mining, it can, for the purpose of identifying possible markets for an independent coal supplier, be considered a closed market. If Sasol is excluded, Eskom and the export market account for almost 90% of South African coal consumption, and the two are explored briefly in this section.

a) Eskom

Eskom is a government owned entity that was established in 1923 by the South African government as the Electricity Supply Commission in terms of the Electricity Act. One of Eskom's mandates is to provide sustainable electricity to grow the economy and improve the quality of life of people in South Africa and the region

(Eskom, 2014). To achieve its regional mandate, Eskom participates in the Southern African Power Pool (SAPP), wherein Eskom imports electricity from Namibia, Lesotho and Mozambique, and also sells electricity to Namibia, Botswana, Zimbabwe, Mozambique, Swaziland and Zambia on either firm or unfirm contracts. The main objective of the SAPP programme is for the participating countries to support each other in meeting their electricity needs.

Table 17: Eskom's coal-fired power stations and their generating capacities (MW).

Power station	Location	MW	Year Commissioned	Principal coal supplier
Arnot	Middelburg	2 232	1971	Exxaro
Camden	Ermelo	1 450	1967	Various
Duvha	Witbank	3 450	1980	South 32
Grootvlei	Balfour	1 960	1969	Various
Hendrina	Hendrina	1 865	1971	South 32
Kendal	Witbank	3 840	1988	South 32
Komati	Middelburg	1 000	1961	Various
Kriel	Bethal	2 850	1976	Anglo Coal
Lethabo	Sasolburg	3 558	1986	Anglo Coal
Majuba	Volksrust	3 843	1996	Various
Matimba	Lephalale	3 690	1987	Exxaro
Matla	Kriel	3 450	1979	Exxaro
Tutuka	Standerton	3 510	1985	Anglo Coal

Eskom operates twenty seven power stations with a total nominal capacity of 41,995 Mega Watts (MW); thirteen coal-fired power stations contribute 85 percent of Eskom's generating capacity (Table 17). With its power stations and vast network of power lines and substations, Eskom generates and distributes 95 percent of electricity used in South Africa, and about 40 percent of the African continent.

In the past decade Eskom has used between 65 and 70 percent of the coal sold domestically. When excluding Sasol, Eskom's consumption in 2013 amounted to 83 percent of domestic sales. Eskom's coal burn, the amount of coal that Eskom burns to generate electricity, increased from 57 Mt in 1982 to 130 Mt in 2014, an increase of 128 percent (Figure 45). The increase in coal burn is directly related to the new power stations that were commissioned after 1982 coupled to the post 1994 electricity demand surge.

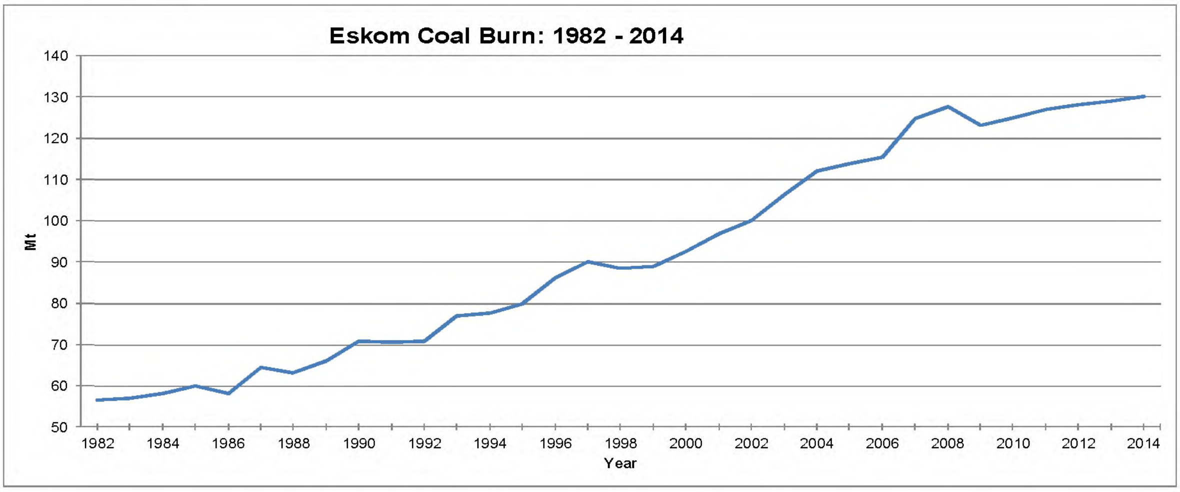


Figure 45. Eskom's coal burn from 1982 to 2014 (Eberhard, 2011 and Eskom, 2014).

b) The export market

South Africa is conveniently positioned between the Atlantic and Pacific coal markets, and its low cost producer status enables it to export competitively to either Europe or the East (Eberhard, 2011). South Africa has been exporting coal for a considerable period of time, and the amounts exported have been influenced by either government policy or the actual demand. Eberhard (2011) noted that until the 1940s, between a sixth and a third of annual coal tonnage was exported, but it dropped to around 2% of production between 1950 and 1970 as government imposed restrictions on exports.

The expansion of South Africa's coal exports was catalysed by a contract signed in 1971 between the Transvaal Coal Owners Association (TCOA) and seven Japanese steel mills for 27 Mt of blended coking coal (Eberhard, 2011). In 1977, after the opening of the Richards Bay Coal Terminal (RBCT) in 1976 with a capacity of 12 Mtpa, South Africa's coal exports exceeded the 10 Mt mark. South Africa's coal exports between 1992 and 2014 are shown in Figure 46.

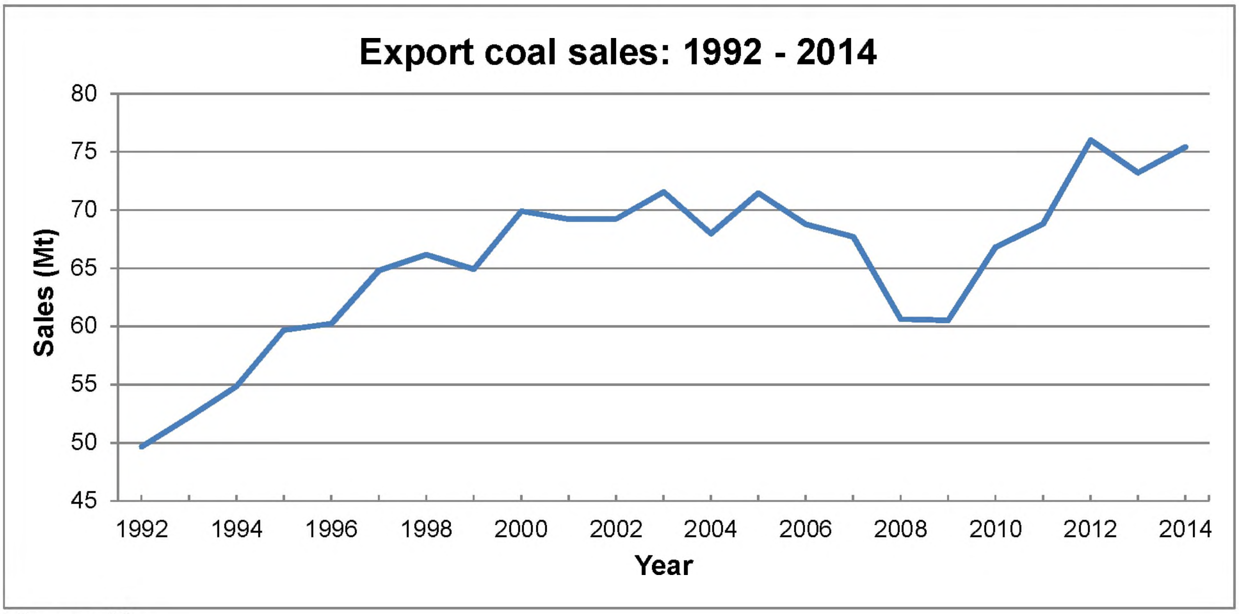


Figure 46

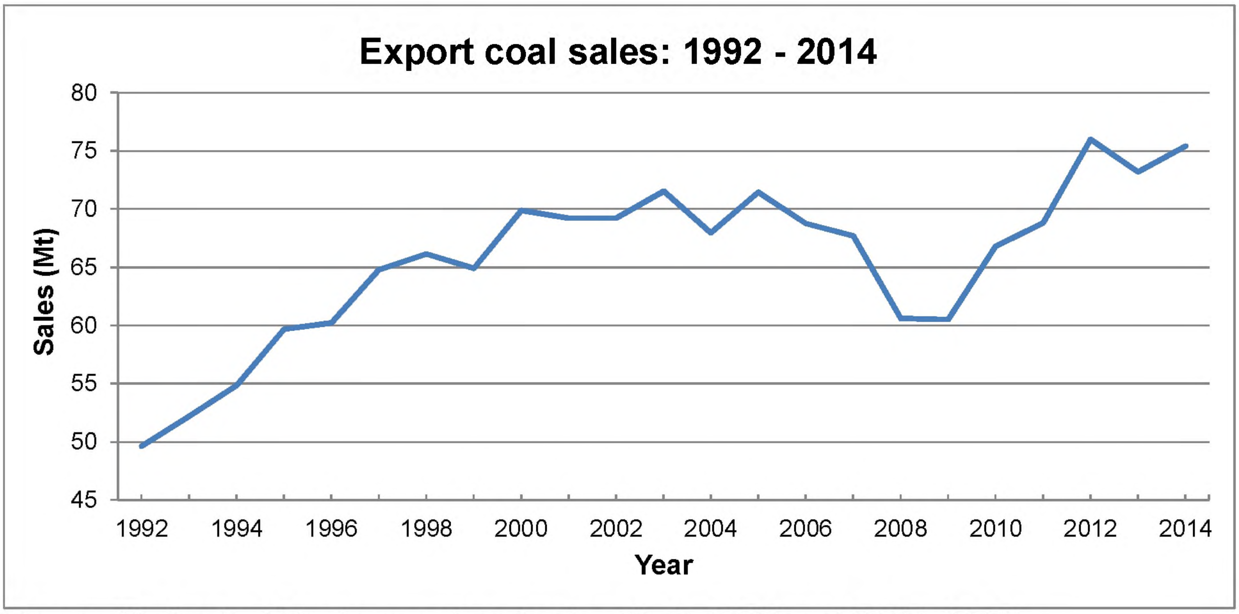


Figure 46. South Africa's export coal sales (DoE, 2009 and DMR, 2016).

South Africa's coal exports in 2013 went to Europe, Asia, Middle East, Americas and Africa (Figure 47). The Europe region traditionally accounted for most of South Africa's exports, but in the last 5 years or so, the Asia region has taken the lead. This has been due to reducing demand in Europe coupled with declining coal qualities, and at the same times the Asia region, particularly India, has better appetite for the lower quality coal.

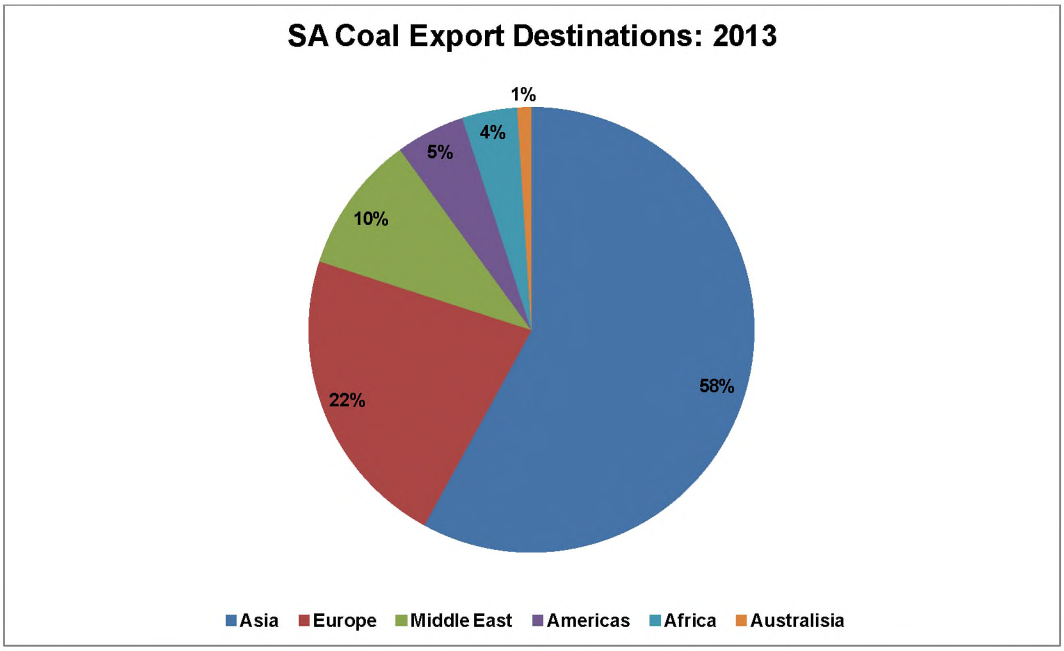


Figure 47. Destinations of South Africa's coal exports, (DMR, 2015)

Given that the export market is the second biggest market for South Africa's coal behind Eskom, it is worth noting the individual countries that receive the bulk of South Africa's exports. In 2013 ten countries accounted for 85% of South Africa's exports (Table 18).

Table 18: Top 10 importers of South Africa's coal, 2013

COUNTRY	SA COAL EXPORTS		
	Mt	%	Rank
India	21.57	28.9	1
China	13.25	17.8	2
Netherlands	7.12	9.5	3
Taiwan - Province of China	5.74	7.7	4
Israel	2.98	4.0	5
Portugal	2.79	3.7	6
Guyana	2.53	3.4	7
Turkey	2.51	3.4	8
United Arab Emirates	2.44	3.3	9
Italy	2.21	3.0	10
Other	11.46	15.4	-
Total	**74.6**	**100**	

Source: DMR, 2015

6.2 Current state of South Africa's coal market: Supply and demand

Most global coal demand is currently satisfied using local supply; 86% of the global supply was consumed locally inside the country of production (Wood Mackenzie, 2014). South Africa is one of those countries where local supply has always been more than adequate to meet local demand. For the major coal producing countries, there will be no shortage of coal in the future although there will be a need to increase exports to meet growing Asian demand (Wood Mackenzie, 2014).

South Africa's coal supply is demand driven, primarily from Eskom for electricity generation followed by the export market and thirdly by Sasol for synthetic fuel generation. Two new coal-fired power stations, Medupi and Kusile are currently in the construction phase. Eskom's dominant position as electricity supplier is unlikely to change due to prevailing government legislation, and its heavy reliance on coal will remain unchanged for the foreseeable future due to the competitiveness of coal when considering other alternatives. Eskom's actual coal burn from 2008 – 2014 and forecast coal burn from 2015 – 2040 are shown in Figure 48.

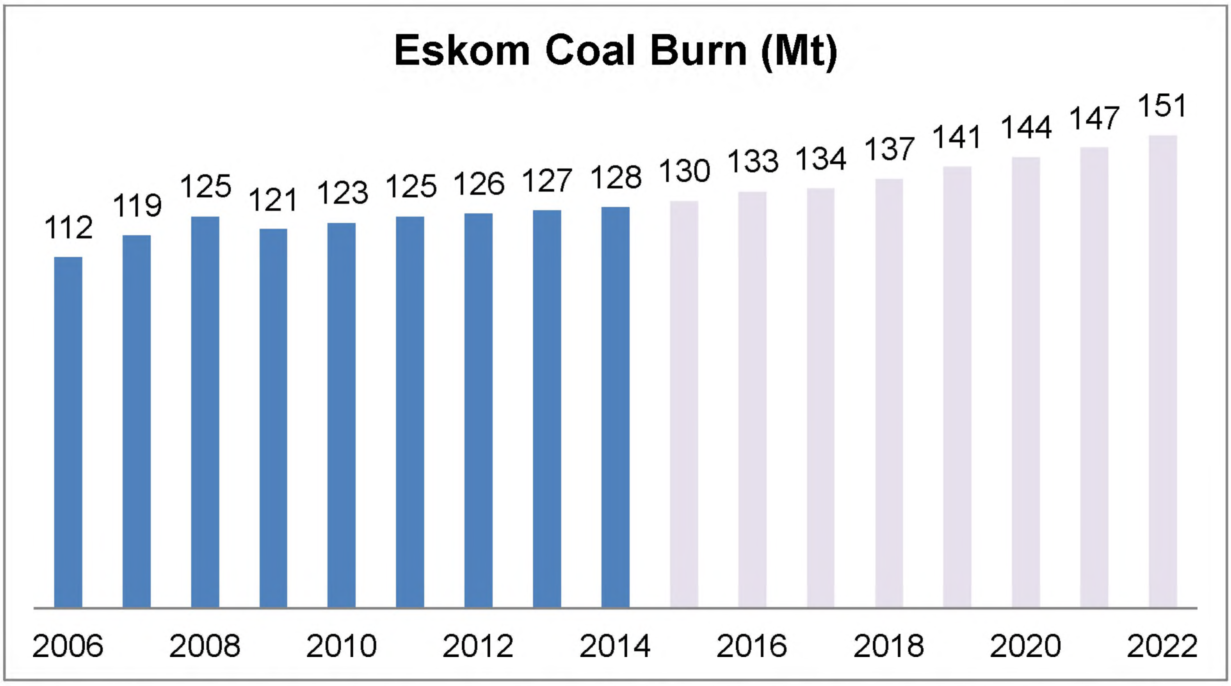


Figure 48. Eskom's coal burn, actuals for 2006 to 2014; forecast for 2015 to 2022

Eskom's coal burn is set to increase gradually over the next two to three decades as it continues to run its fleet of coal-fired power stations. The overwhelming majority of Eskom's coal-fired power stations are in Mpumalanga Province, and this bodes well for coal projects in the Mpumalanga coalfields as it allows for better access to the market. Eskom's coal-fired power stations have a life of 50 years to 60 years, and the South African Coal Road Map (SACRM) technical report (2013) shows a set of power stations that will be decommissioned from 2022 to 2029, 2030 to 2040, and those that will still be operational beyond 2040. The SACRM (2013) also forecasts the Waterberg to be the locality of most coal-fired power stations beyond 2040.

South Africa is ranked 5th in the list of coal exporting countries, and coal exports contribute significantly to the country's foreign earnings. The export market is traditionally attractive due to its higher prices, and for the same reason, it remains an attractive option to those with the means of exporting. The Richards Bay Coal Terminal (RBCT) has capacity to export 91 Mt per annum, but due to railway constraints, the highest that has been exported is 76 Mt, achieved in 2012. The demand for seaborne thermal coal in Asia will grow by 1 Bt from 2014 – 2035 to reach 2 Bt, and as the developed western economies in Europe and the Americas back away from coal consumption, Asia will increasingly be the main destination for global coal exports (Figure 49) (Wood Mackenzie, 2014).

South Africa's remaining recoverable coal reserves are estimated at 55 Bt and the Mpumalanga province coalfields account for 51% of these. There are therefore sufficient coal reserves for the foreseeable future to meet Eskom's coal requirements. The country's coal resource base is even more extensive at 121 Bt, and with future technological advances and increases in coal prices, the coal reserve base should be expanded. With the forecasted growth of coal demand in the Pacific markets, the export market remains attractive, even more so when the prices are high.

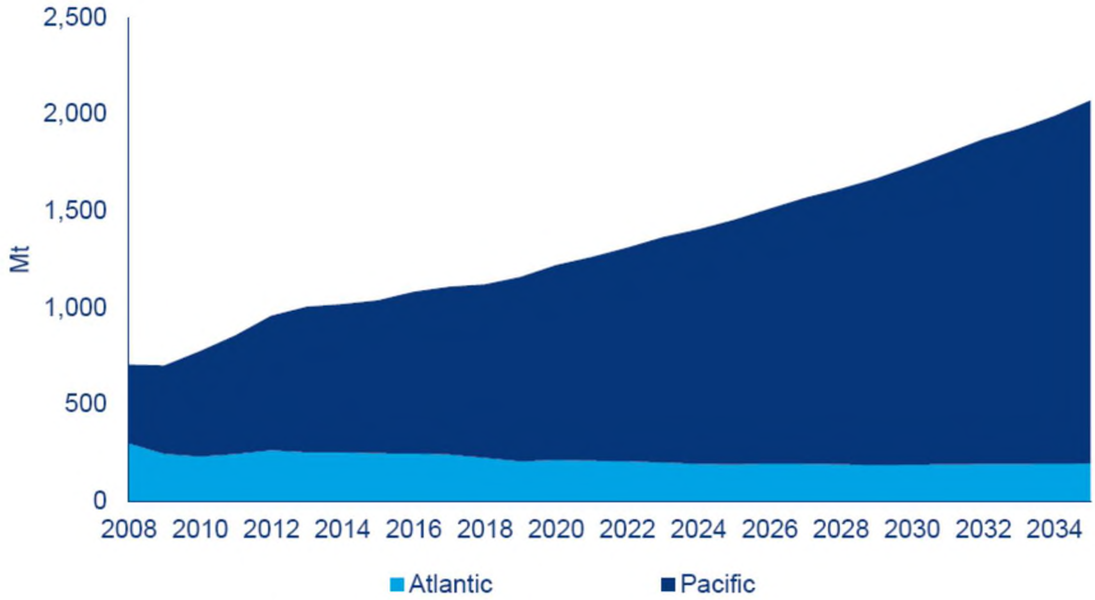


Figure 49. Share of global coal exports between Atlantic & Pacific markets (Wood Mackenzie, 2014).

South Africa's thermal coal exports will begin to grow in the mid-2020s, reaching 108 Mt in 2035, mainly to India and Malaysia (Figure 50) (Wood Mackenzie, 2014).

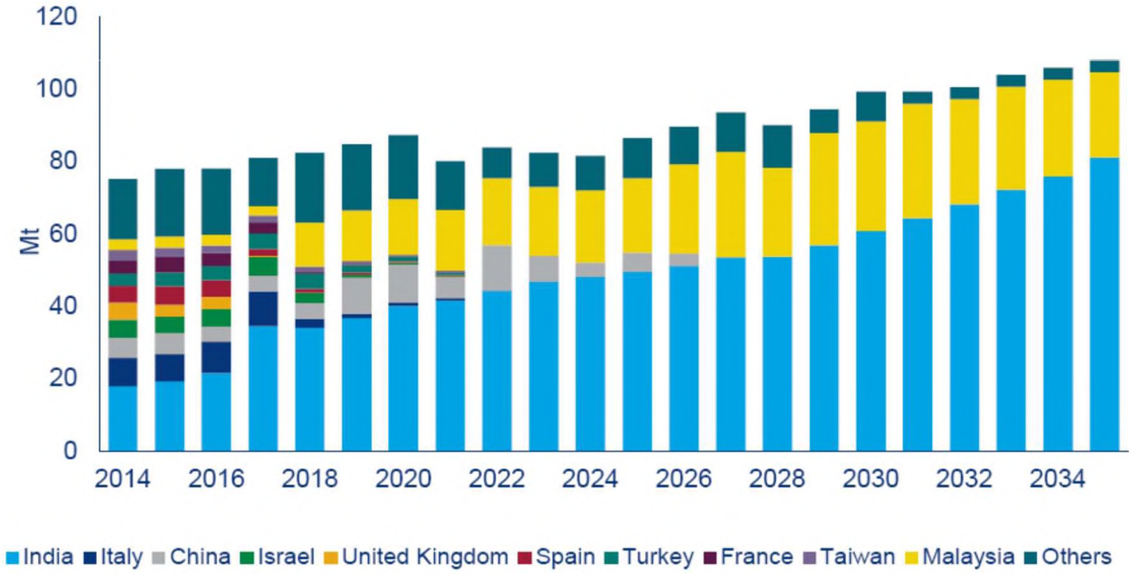


Figure 50. Destination of South Africa's seaborne thermal coal exports (Wood Mackenzie, 2014).

Traditionally South Africa's exports were high quality coal to the European market. The depletion of high quality coal reserves coupled with the decline of the European market would have signalled a decline in the country's export potential, but the emergence of the Asian market, particularly India with its better appetite for lower quality coal, has meant that South Africa can maintain and grow its export potential.

The amount of coal that South Africa sends to the export market might change from time to time due to government regulations. Between 1950 and 1970 South Africa exported around 2% of production as government imposed restrictions on exports. Current developments suggest that government might in one form or the other impose restrictions on coal exports in the near future.

Eskom, in its 2014 integrated report remarked as follows, "securing coal is a growing challenge as Eskom's coal-fired power stations require a continuous supply of acceptable quality coal at fair prices. Eskom has to compete with international buyers of South Africa's coal reserves, which has a negative effect on the coal price." In promoting national energy security, Eskom has lobbied parliament to approve legislation that might have the effect of declaring coal as a strategic resource. Eskom believes that given the importance of coal to the country, state intervention is required to ensure that South Africa has enough coal to meet its growing energy needs.

6.3 South African coal prices

The domestic and export prices from 2000 to 2013 are shown in
Figure **51**. It is not the intention of **Figure 51** to compare domestic and export prices, as the two are based on different product offerings, with the latter based on a better product, and also affected by foreign exchange rate.

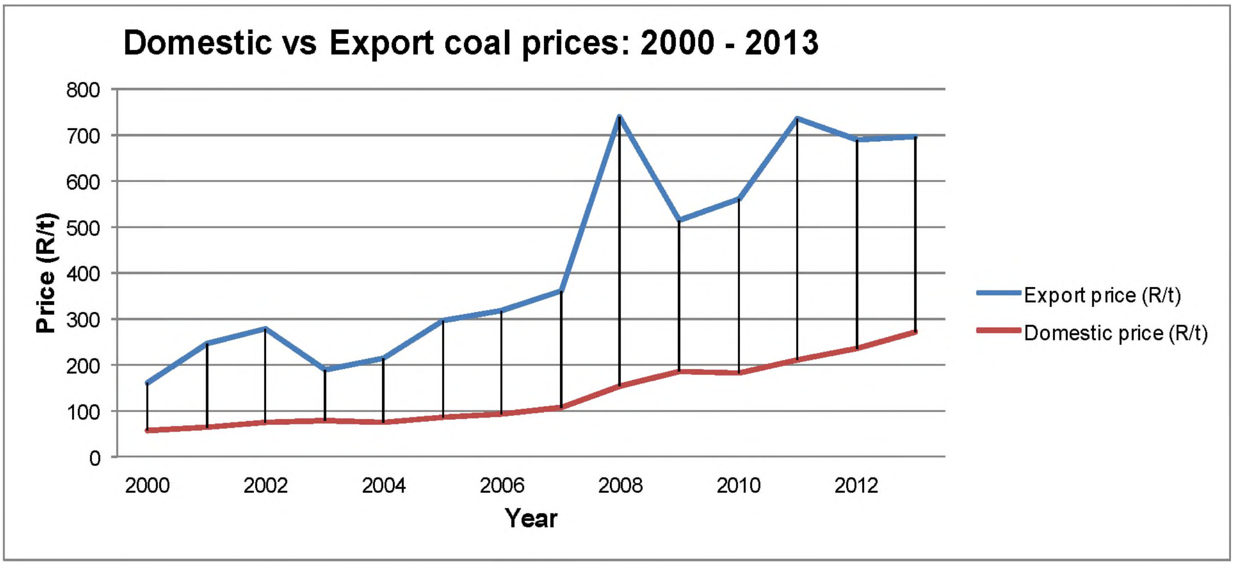


Figure 51. South Africa's coal price (DMR, 2015).

The domestic price has been stable on an upward trend, whilst the export price fluctuated but also showing an upward trend. The fluctuation of the ZAR export price is a function of both fluctuating USD export price and ZAR/USD exchange rate. The reported domestic price is an average, mainly influenced by Eskom, and even within Eskom there is a wide range in pricing offered to different suppliers based on Eskom's criteria. Current export prices (USD/t) are at multiyear lows due to enduring oversupply and intense competition for the Chinese market; the oversupply will peak in 2017 before supply and demand finally balance in 2019/2020 (Wood Mackenzie, 2014).

The USD prices for South Africa's coal exports from January 2012 to June 2014 are shown in Figure 52.

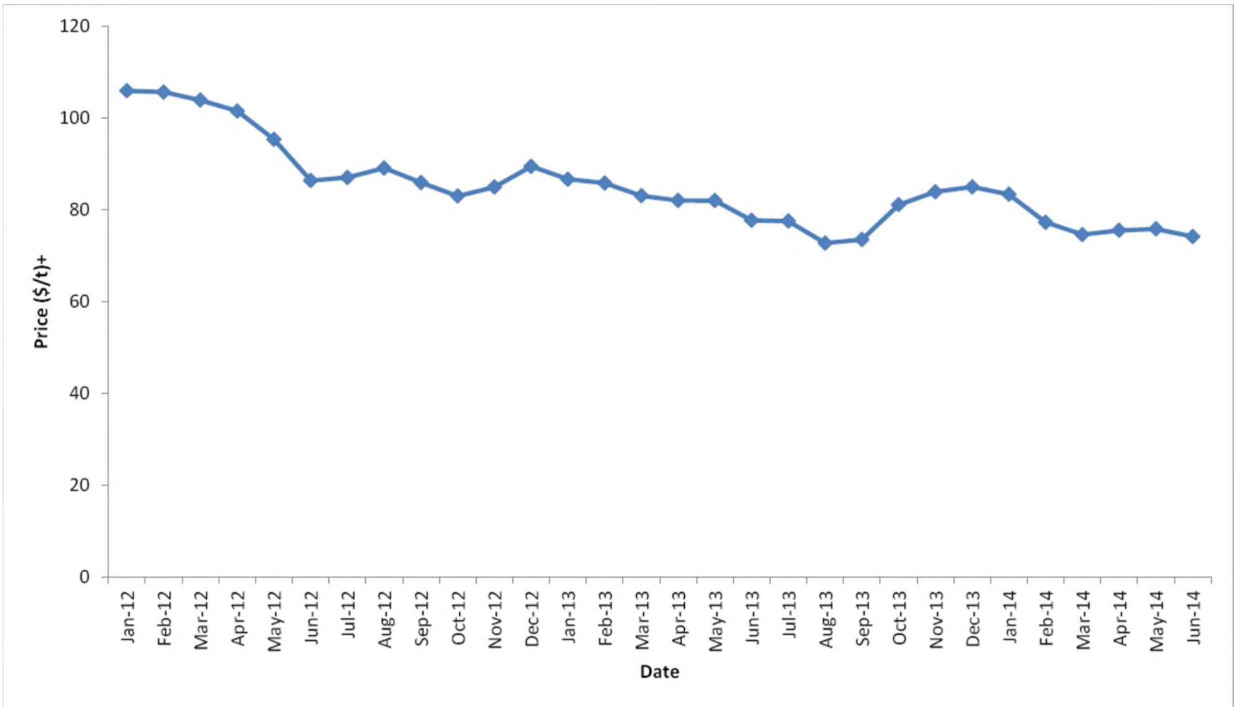


Figure 52. RBCT monthly coal prices, January 21012 – June 2014 (DMR, 2015).

Even though the USD price of export coal decreased due to the market oversupply, the ZAR price increased due to the rand weakening against the US dollar.

7. COAL ASSET VALUATION

7.1 Introduction

The South African Code for the Reporting of Mineral Asset Valuation (SAMVAL Code), sets out minimum standards and guidelines for Public Reporting of Mineral Asset Valuation in South Africa. The International Financial Reporting Standards (IFRS) defines an asset as “a resource controlled by the enterprise as a result of past events and from which future economic benefits are expected to flow to the enterprise”. Valuation is concerned with the value or worth of a Mineral Asset as opposed to evaluation in which the key objective is an economic assessment or determination of the economic merit of an Asset (SAMVAL Code).

A coal project may consist of an operating colliery or an exploration project that will or may be developed in future. There are thus two classes of coal assets for which valuations can be necessary, namely:

Coal assets considered to be an immediate investment opportunity (production phase)

Coal assets for which no immediate sale is contemplated (exploration phase)

An investor always has the option to sell an asset whether a sale is contemplated or not, and the value of any coal asset is dependent on the potential for that asset to be developed, regardless of when such an investment might take place (Torries, 1998).

Coal asset valuations can be placed in one of the following two broad classes:

- Determining value for investment purposes.
- Determining the fair market for taxation or similar purposes.

Torries (1998) defines fair market value and investment value as follows:

“Fair market value is the value a willing seller and willing buyer may place on a property, provided there are no circumstances forcing the seller to sell or the buyer to purchase”. “Investment value is the value at which the transaction would actually take place, in which case the actual investment amount may equal the fair market value or not. The difference would depend on the specific investment requirements and constraints of the investor".

7.2 Valuation Approaches

The general standard is to use more than one valuation approach in any single coal asset valuation. According to the SAMVAL Code, there are three generally accepted approaches to Mineral Asset Valuation, namely:

- **Cash Flow Approach**, which relies on the 'value-in-use' principle and requires determination of the present value of future cash flows over the useful life of the Mineral Asset.
- **Market Approach**, which relies on the principle of 'willing buyer, willing seller' and requires that the amount obtainable from the sale of the Mineral Asset is determined as if in an arm's-length transaction.
- **Cost Approach**, which relies on historical and/or future amounts spent on the Mineral Asset.

The applicability of the three valuation approaches is shown in Table 19.

Table 19: Relationship between stages of development and Valuation approaches for Mineral Properties (SAMVAL Code)

Valuation Approach	Exploration Properties	Development Properties	Production Properties	Dormant Properties		Defunct Properties
				Economically Viable	Not Viable	
Cash Flow	Not generally used	Widely used	Widely used	Widely used	Not generally used	Not generally used
Market	Widely used	Less widely used	Quite widely used	Quite widely used	Widely used	Widely used
Cost	Quite widely used	Not generally used	Not generally used	Not generally used	Less widely used	Quite widely used

The VALMIN Code, a Code prepared in Australia for the Technical Assessment and Valuation of Mineral and Petroleum Assets and Securities for Independent Expert Reports, classifies Mineral Assets as either:

- Exploration Areas
- Advanced Exploration Areas

- Pre-Development Projects
- Development Projects
- Operating Mines

The Paardeplaats project is classified as a Pre-Development Project, which according to the VALMIN Code, is defined as a property where Coal Resources have been identified and their extent estimated (possibly incompletely) but where a decision to proceed with development has not been made.

7.2.1 Valuation Approach Decision

The choice of valuation approach and methodology to use is dependent on a number of factors, such as: the purpose(s) of the valuation and for whom the valuation is to be done. The valuation is done for the purposes of appraising the value-add of all the exploration accomplishments and for decision making on developing the project into an operating mine.

The Cost Approach was chosen to appraise the value-add of all the exploration activities, and the Cash Flow Approach was chosen to provide information for investment decision making purposes.

7.2.2 Cost Approach

The Cost Approach comprises of the Historical Cost method, in which the valuation is based on past costs less any outstanding obligations and / or depletions, and the Appraised Value method, in which the valuation is based on meaningful past exploration costs plus warranted future costs, factored with premiums for remaining exploration potential and discounts for lack thereof (Moyes, 2011). A factor known as prospectivity enhancement multiplier (PEM), which is directly related to the success or failure of the exploration venture to date and to possible future success, is applied to the cost of exploration. The PEM may range from 0 to 5, but is normally from 0.5 to 3 (Moyes, 2011). The PEM Schedule for coal projects used by Venmyn Deloitte is shown in Table 20, and is adopted for this project's valuation.

Table 20: Coal Prospect Exploration Phase Classification and the Corresponding PEM (from Venmyn Deloitte, 2012)

Phase	Exploration Phase	PEM Value		Exploration Activity
		Upper	Lower	
0	Exploration Concept	0	0	Project about which nothing is known, but which has potential on a conceptual basis
1	Desktop Study	1	0	Historical and literature study, records or evidence of coal findings in the area. Historical mining data, if any.
2	Reconnaissance	1	1	Geological mapping if terrain is suitable. Palaeo topographical mapping. Historical drilling with intercept data, no laboratory analyses
3	Ground Follow-up	1	1	Detailed outcrop mapping, identification of coal hosting strata, coal seam outcrop mapping. Sampling of exposed coal seams where available. Historical drilling data with intercept and analyses, but of questionable authenticity.
4	Ground Follow-up	2	1	Ground geophysics, remote sensing techniques. Reliable historical drilling, but correlations difficult due to density of drilling.
5	First-phase Drilling	5	2	Large diameter core drilling, widely spaced grid with preliminary coal analyses. First pass tonnage estimate. Inferred coal resource.
6	Resource Drilling and Laboratory Testwork	11	5	In-fill drilling, detailed coal analysis and washability test work. Established coal qualities, market potential, detailed resource tonnage estimation, washabilities. Advanced Inferred and Indicated Coal Resource classification.
7	Historic Mining	20	11	Previous commercial production, establishing reliable and well documented quality, tonnage, washability etc. Measured Coal Resource classification
8	Reserve Classification	>20	20	Complete feasibility assessment, establish economics and design a mine of an appropriate nature. Classification of Coal Reserves.

The results of the Cost Approach valuation are shown in **Table 21**. Included in the historical costs are costs related to obtaining of the prospecting permit and exploration data acquisition expenditure and associated professional services. Moyes (2011), raised the question about the inclusion of boreholes that did not intersect coal seam(s) in the allocation of past exploration expenditure. Such boreholes helped in delineating the Coal Resource, but how do they influence the value of the remaining potential? It is the author's view that all costs related to reasonable planned and drilled boreholes should be included in the historic expenditure, but boreholes that did not intersect coal seam(s) should not be allocated the same PEM, if any, as applied to boreholes that intersected coal seam(s). In accordance with the PEM schedule in Table 20, a PEM of between 5 and 11 was chosen on the basis of the project's advanced exploration phase and future prospectivity as indicated by the Inferred and Indicated Coal Resources.

Table 21: Paardeplaats Project - Cost Approach Valuation

Project	Prospecting permit related costs (ZAR)	Exploration Data Acquisition (ZAR)	Total (ZAR)	Lower PEM	Upper PEM	Min Project Value (ZAR)	Max Project Value (ZAR)	Mean Project Value (ZAR)
Paardeplaats	1,000,000	7,072,500	8,072,500	5	11	40,362,500	88,797,500	64,580,000
Total	1,000,000	7,072,500	8,072,500	5	11	40,362,500	88,797,500	64,580,000

7.2.3 Cash Flow Approach

The Cash Flow Approach comprises of three methods, namely, Discounted Cash Flow (DCF), Tail Margin and Probability Analysis (Moyes, 2011). This valuation is based on the DCF method. The DCF method is generally accepted as the preferred method of valuation of mineral properties in the pre-feasibility study, feasibility or bankable feasibility study, or operating mines, as long as there is sufficient data to allow its reasoned application (Musingwini, 2012).

The required reasonable sufficient data includes the following:

- Annual RoM production schedule until end of life of mine (LoM).
- RoM coal qualities, coal processing plant yield and saleable product tonnage and qualities.
- Coal prices and sales costs.
- Operating costs for mining and coal processing, royalties and taxes payable.
- Capital costs.

The production schedule and expected sales revenue over the LoM are shown in Table 22.

The DCF method determines the net present value (NPV) of future cash flows that the exploration project might be expected to generate, discounted by an appropriate discount rate over the project's LoM. The discount rate used to discount the future cash flow value to present worth is usually the Asset owner's minimum internal rate of return (IRR) for the category of project under review (Musingwini, 2012). A positive NPV or an IRR greater than the discount rate are indicative of an economically viable project, and vice versa. The information used in the construction of a DCF schedule has certain levels of uncertainty, as well as the discount rate applied, and all these combined bring uncertainty to a DCF valuation. The uncertainty of the DCF valuation is mitigated by the Tail Margin and Probability Analysis methods, which were not used in this valuation.

The results of the Cash Flow Approach valuation are shown in Table 23. Mining and coal processing will be done by Contractors, hence the lower Capex expenditure, which is mainly for infrastructure, such as roads, electricity power supply, fencing, pollution control dams, etc.

Table 22: Production schedule over the Life of Mine.

Production	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Total Overburden (bcm)	**11,936,004**	**11,936,004**	**11,936,004**	**11,936,004**	**11,936,004**	**11,936,004**	**11,936,004**	**11,936,004**	**11,936,004**	**11,936,004**
Paardeplaats Colliery	11,936,004	11,936,004	11,936,004	11,936,004	11,936,004	11,936,004	11,936,004	11,936,004	11,936,004	11,936,004
Total ROM (t)	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**
Paardeplaats Colliery	5,484,000	5,484,000	5,484,000	5,484,000	5,484,000	5,484,000	5,484,000	5,484,000	5,484,000	5,484,000
Stripping Ratio	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
TOTAL PLANT ROM	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**	**5,484,000**
DMS PLANT FEED ROM	3,300,000	3,300,000	3,300,000	3,300,000	3,300,000	3,300,000	3,300,000	3,300,000	3,300,000	3,300,000
C&S PLANT FEED ROM	2,184,000	2,184,000	2,184,000	2,184,000	2,184,000	2,184,000	2,184,000	2,184,000	2,184,000	2,184,000
Saleable Product (t)	**4,285,320**	**4,285,320**	**4,285,320**	**4,285,320**	**4,285,320**	**4,285,320**	**4,285,320**	**4,285,320**	**4,285,320**	**4,285,320**
DMS PLANT	2,145,000.00	2,145,000.00	2,145,000.00	2,145,000.00	2,145,000.00	2,145,000.00	2,145,000.00	2,145,000.00	2,145,000.00	2,145,000.00
C&S PLANT	2,140,320.00	2,140,320.00	2,140,320.00	2,140,320.00	2,140,320.00	2,140,320.00	2,140,320.00	2,140,320.00	2,140,320.00	2,140,320.00
DMS Yield	**65%**	**65%**	**65%**	**65%**	**65%**	**65%**	**65%**	**65%**	**65%**	**65%**
Overall Yield	**78%**	**78%**	**78%**	**78%**	**78%**	**78%**	**78%**	**78%**	**78%**	**78%**
Sales	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016
Tonnages to Arnot PS	4,285,320.00	4,285,320.00	4,285,320.00	4,285,320.00	4,285,320	4,285,320	4,285,320	4,285,320	4,285,320	4,285,320
22.5 CV	2,140,320.00	2,140,320.00	2,140,320.00	2,140,320.00	2,140,320	2,140,320	2,140,320	2,140,320	2,140,320	2,140,320
21.5 CV	2,145,000.00	2,145,000.00	2,145,000.00	2,145,000.00	2,145,000	2,145,000	2,145,000	2,145,000	2,145,000	2,145,000
Prices										
22.5 CV	291.00	312.83	336.29	361.51	388.62	417.77	449.10	482.78	518.99	557.92
21.5 CV	256.00	275.20	295.84	318.03	341.88	367.52	395.09	424.72	456.57	490.81
Revenue										
22.5 CV	622,833,120.00	669,545,604.00	719,761,524.30	773,743,638.62	831,774,411.52	894,157,492.38	961,219,304.31	1,033,310,752.14	1,110,809,058.55	1,194,119,737.94
21.5 CV	549,120,000.00	590,304,000.00	634,576,800.00	682,170,060.00	733,332,814.50	788,332,775.59	847,457,733.76	911,017,063.79	979,343,343.57	1,052,794,094.34
Total	1,171,953,120	1,259,849,604	1,354,338,324	1,455,913,699	1,565,107,226	1,682,490,268	1,808,677,038	1,944,327,816	2,090,152,402	2,246,913,832
Eskom Distribution	85	91	98	106	114	122	131	141	152	163
Eskom Distribution	364,252,200.00	391,571,115.00	420,938,948.63	452,509,369.77	486,447,572.50	522,931,140.44	562,150,975.98	604,312,299.17	649,635,721.61	698,358,400.73
Total Revenue	1,171,953,120.00	1,259,849,604.00	1,354,338,324.30	1,455,913,698.62	1,565,107,226.02	1,682,490,267.97	1,808,677,038.07	1,944,327,815.92	2,090,152,402.12	2,246,913,832.28
Yearly escalation rate	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%

Table 23: Paardeplaats project - Cash Flow Approach Valuation

Calendar Year	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Project Year	0	1	2	3	4	5	6	7	8	9	10
Capex (ZAR m)	-250										
Total Revenue (ZAR m)	0	1 536	1 651	1 775	1 908	2 052	2 205	2 371	2 549	2 740	2 945
Production Costs (ZAR m)	0	1 045	1 123	1 207	1 298	1 395	1 500	1 612	1 733	1 863	2 003
Royalties (ZAR m)		6.8	7.0	7.6	8.1	8.8	9.4	10.1	10.9	11.7	12.6
Carbon Tax (ZAR m)		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Operating Profit (ZAR m)	-250	484	520	559	601	646	695	747	803	864	929
Sales Distribution costs (ZAR		364	392	421	453	486	523	562	604	650	698
Net Profit Before Tax (ZAR m)	-250	119	129	138	149	160	172	185	199	214	230
Tax @ 28%	0	33	36	39	42	45	48	52	56	60	64
Net Profit After Tax (ZAR m)	-250	86	93	100	107	115	124	133	143	154	166
Cashflow (ZAR m)	-250	86	93	100	107	115	124	133	143	154	166
NPV (ZAR m)	324										
IRR	39%										
Hurdle Rate	13%										

8. CONCLUSION

The Paardeplaats Project is located in a well-established coal producing region, the Witbank Coalfield, which has been studied extensively. The coal seams found in the Paardeplaats Project correlate with the recognised coal seams of the Witbank Coalfield, with all five coal seams present. Of the five seams, only four can be considered to have economic potential, namely the No. 2, No. 4, No.3 and No. 5 seams.

The exploration drilling work, in which ninety boreholes were drilled, was done in accordance to industry accepted standards to produce a coal resource statement that is compliant to the SAMREC Code. The coal resources are classified into Measured, Indicated and Inferred categories, with 73% in the Measured category, 10% in the Indicated category and 17% in the Inferred category. Further exploration drilling work is required to increase geological confidence in the areas with Indicated and Inferred coal resources. The No. 2 seam accounts for 61% of the coal resources, No. 4 seam accounts for 29%, No. 3 seam accounts for 9% and the No. 5 seam accounts for 1%.

The Measured Coal Resources were converted to Proved Coal Reserves in accordance to SAMREC Code guidelines. Mining and coal processing considerations were assumed from the adjacent Glisa Colliery, which has a similar geology to the project area. The Coal Reserves base of 54.8 Mt RoM is sufficient to support a mine with a life of 10 years at a production rate of 5.48 Mt RoM per annum. The saleable product amounts to 43.0 Mt, giving the mine a total yield of 78%.

The saleable product qualities, at a calorific value of 22.0Mj/Kg are traditionally more suited to the domestic market, in particular Eskom, than the export market. However, changes in the export market over the past 5 years or so have meant that lower quality coal, which historically was for domestic consumption, can now be exported. This is primarily because of the swing from the European market to the Asian market, with the latter having a better appetite for lower quality coal. The swing is also coupled with Europe's reduced demand for coal as fuel source, as they move to other alternative sources of energy.

South Africa's coal supply is demand driven, and the demand is primarily from Eskom (46%), export market (29%) and Sasol Synfuels (15%). The growth in Eskom's demand for coal has been significant in response to increased demand for electricity in South Africa; between 1982 and 2014 Eskom's coal demand increased by 128% from 57 Mt to 130 Mt. Eskom's demand is still expected to increase, given the construction of its two new coal-fired power stations.

South Africa's coal exports have remained flat in the last 15 years, fluctuating between 60 Mt and 75 Mt, but that was still enough to maintain the country's position in the world as an important coal exporter. The demand for seaborne thermal coal in Asia is expected to grow by 1 Bt from 2014 to 2035 to reach 2 Bt, and coal exporting countries, like South Africa, are expected to increase their exports to meet this growing demand. In this regard, South Africa's coal exports are expected to start growing in the mid-2020s to reach 108 Mt in 2035. The domestic prices have been stable on an upward trend in the last decade; the export prices have been characterised by volatility in the short term, but on an upward trend in the long term.

The future outlook on coal demand can be surmised as positive, particularly for coal projects with a medium to long term horizon, and the Paardeplaats Project falls in that category. As an established coal producing region, the Mpumalanga Province has existing road and rail infrastructure, which links the collieries to the power stations and export harbours respectively. The Paardeplaats Project is located along N4 national road and the main railway line to Maputo; it is connected to Richards Bay railway line via the town of Carolina; rail loading facilities are located 6km away at the Belfast siding station. The Mpumalanga Province is also home to 80% of Eskom's fifteen coal-fired power stations, and this bodes well for any coal mining project in the region because of close proximity to the market.

The coal producer space though dominated by five big companies is open to new projects entering the market, regardless of whether the project is owned by a Major or a Junior producer; the demand is enough for all producers to participate. This is particularly true for coal projects in Mpumalanga Province because of the established transport infrastructure and proximity to coal-fired power stations and export harbours.

The coal from the Paardeplaats Project can be sold both to Eskom and the export market. Though the export market is traditionally attractive because of its higher prices, times of market volatility have shown that it is not advisable to have maximum exposure in the export market. It is therefore advisable to supply both Eskom and the export market, with the former ensuring revenue stability at times of decreasing prices in the export market. A case in point is that current export prices are still significantly less than their historic highs, which led to some producers opting to supply Eskom instead of exporting. This resulted in the Richards Bay Coal Terminal lowering its export forecasts for 2016 and 2017 because of the lower export prices (Miningmx, 2016).

The valuation of the project using the Cost Approach revealed that the project has thus far been a worthy undertaking because of the encouraging exploration results. The Cash Flow valuation approach showed an economically viable project.

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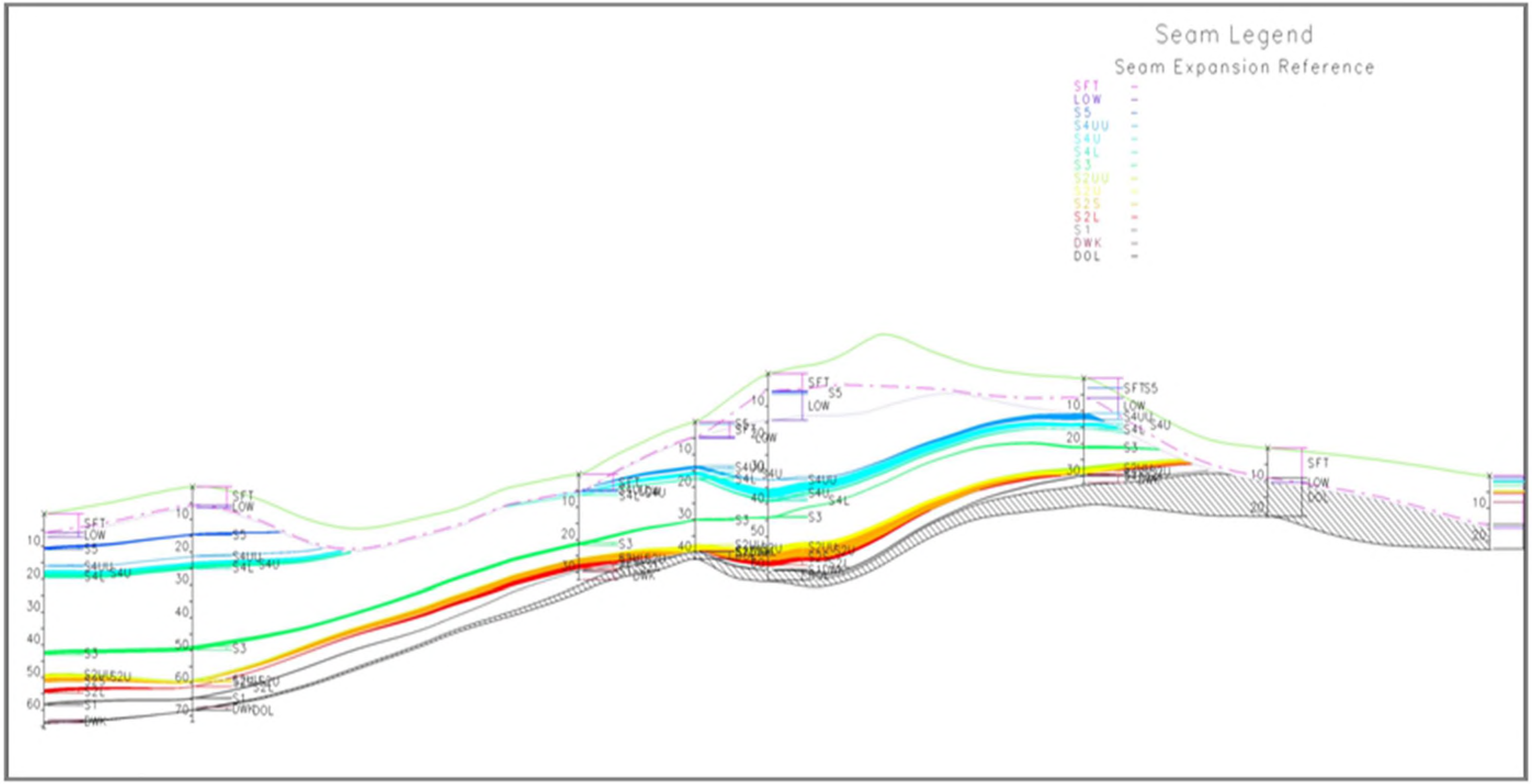
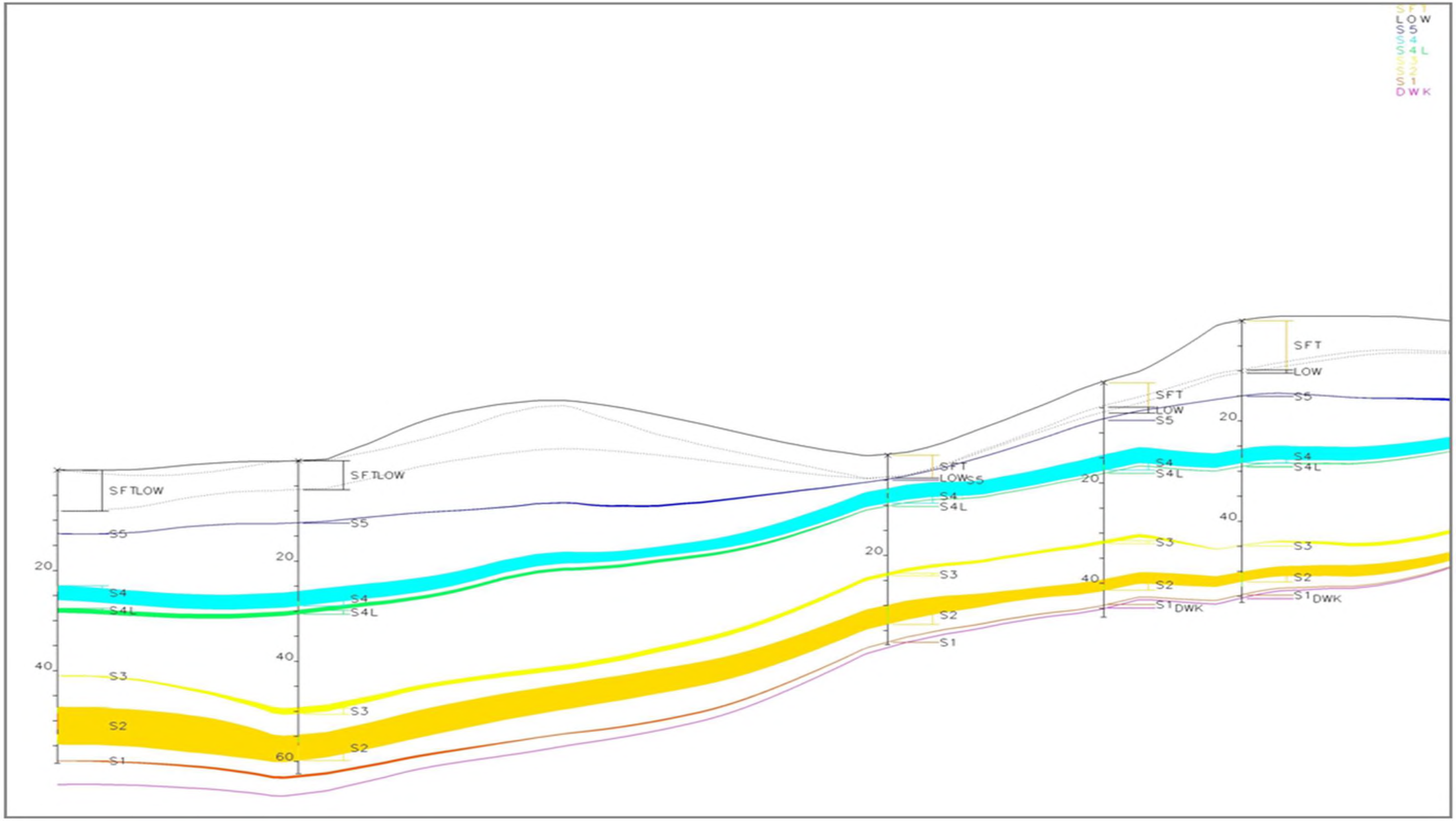
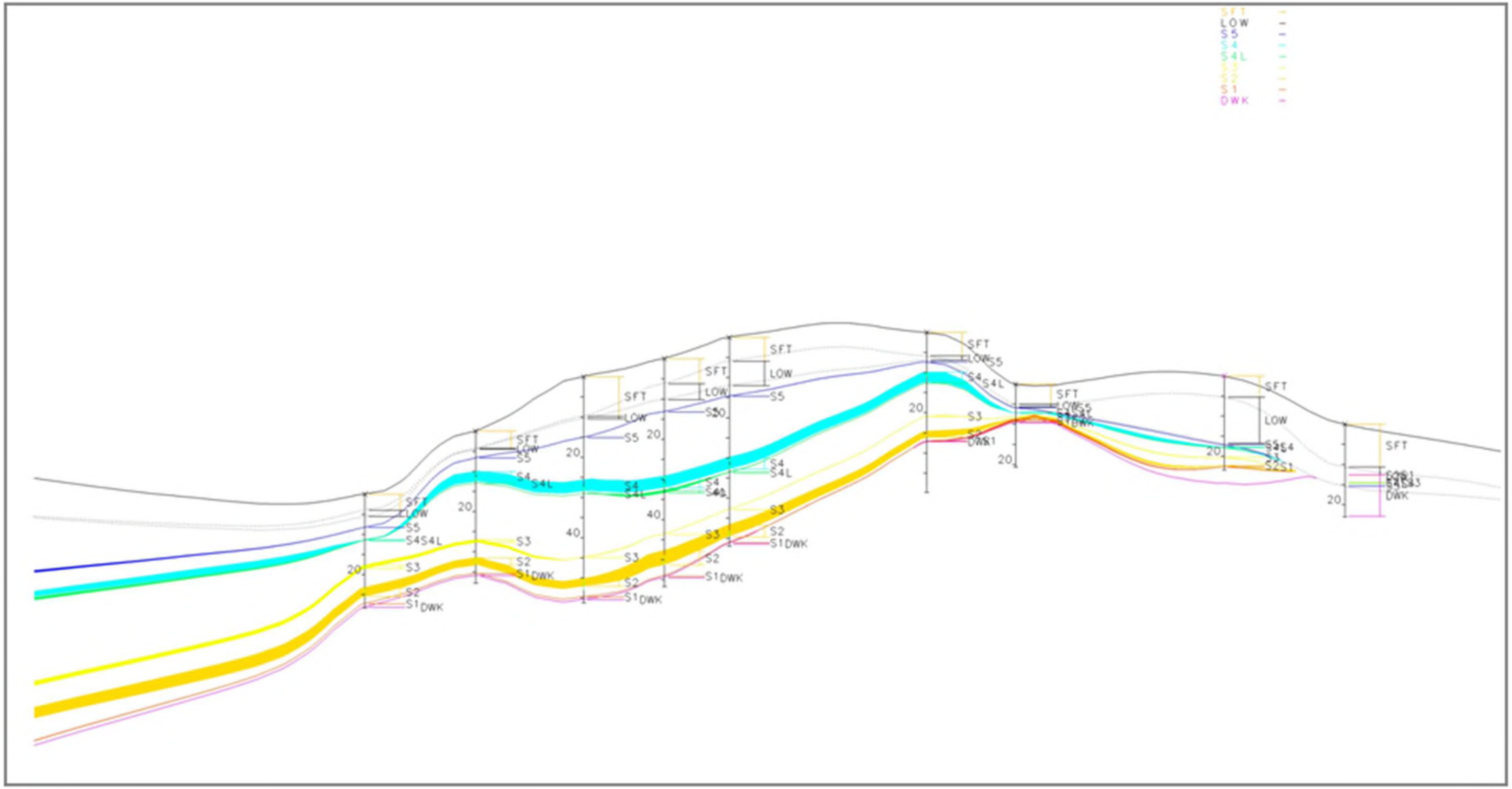
10. APPENDIX A – GEOLOGICAL CROSS SECTIONS



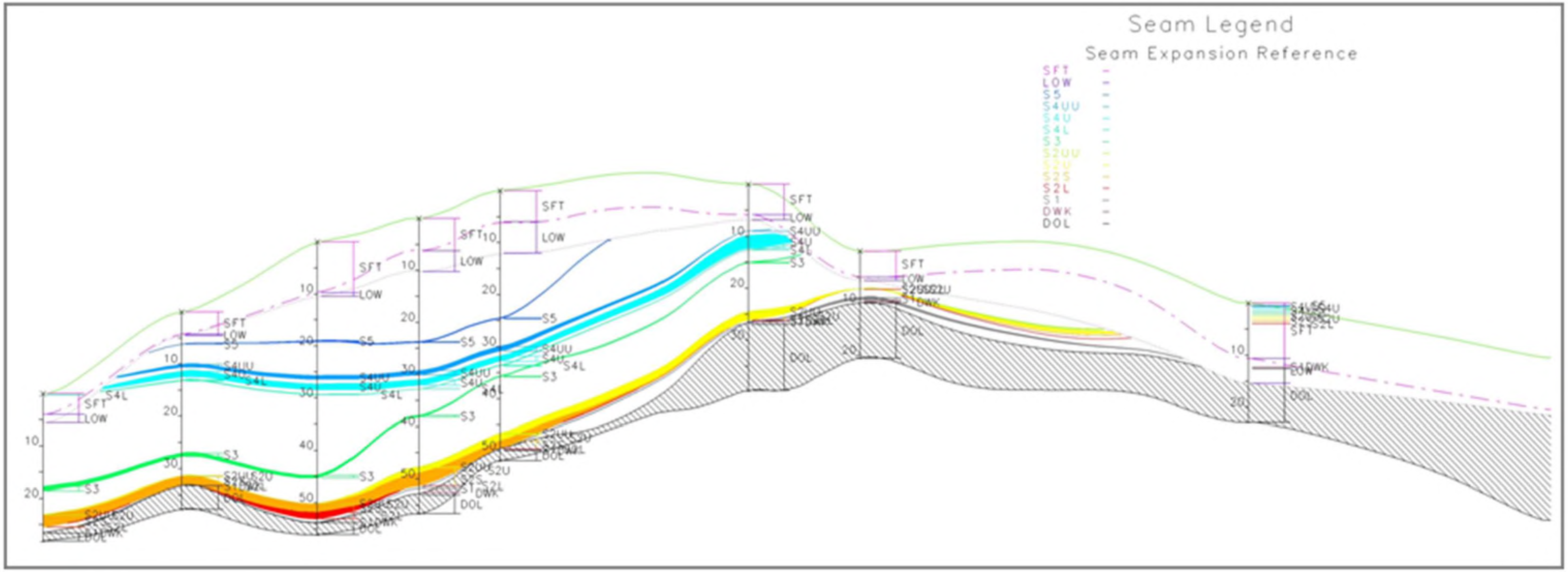
NS9 cross section



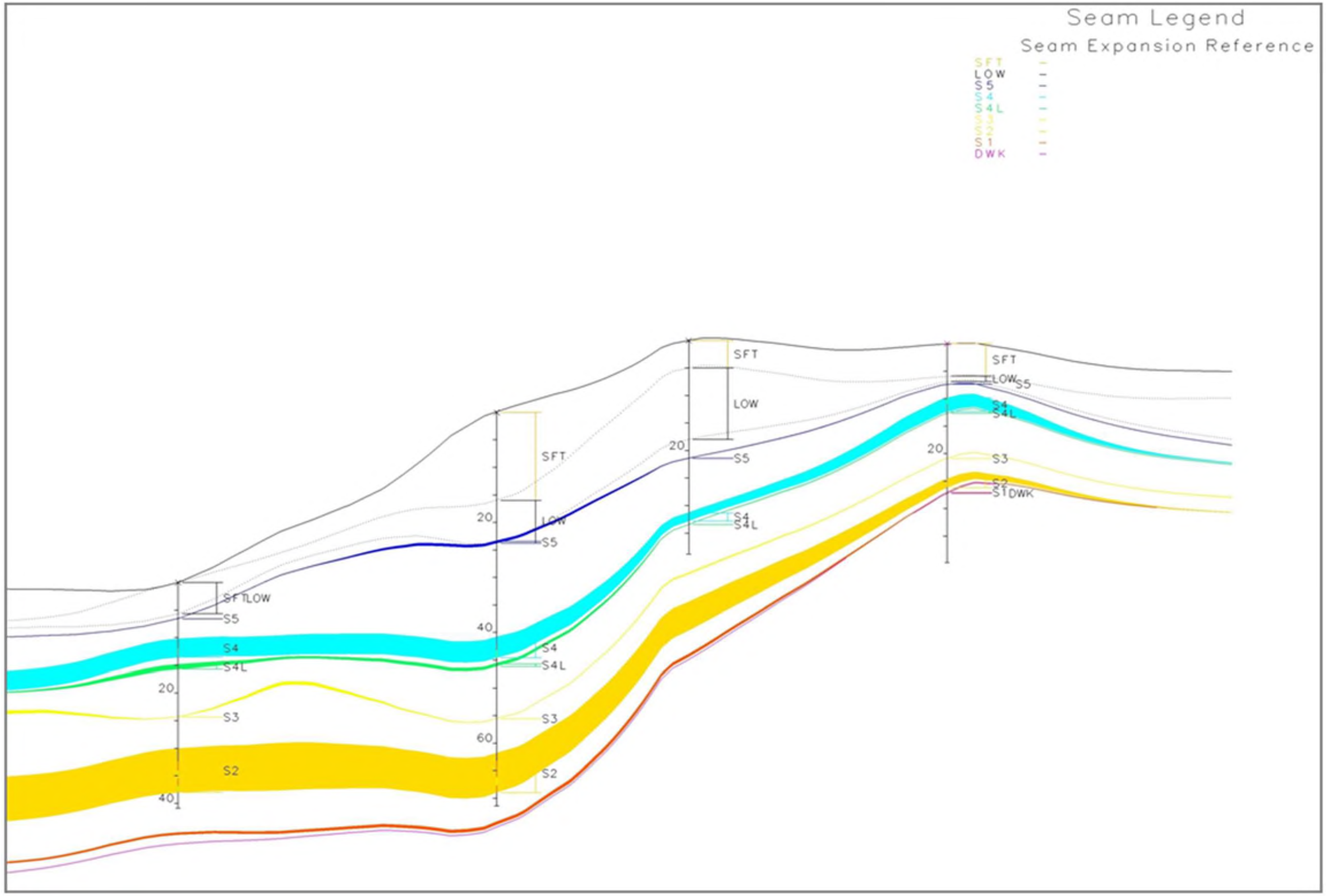
NS8 cross section



NS10 cross section

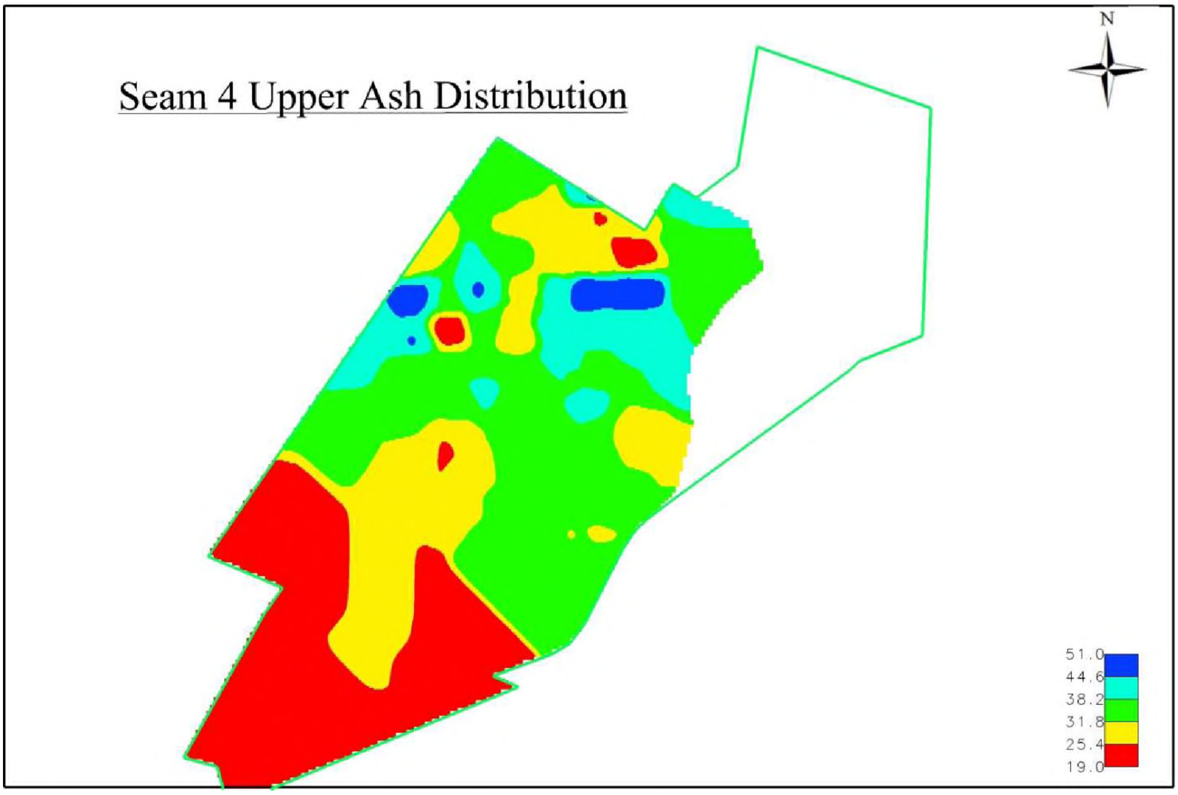


E-W 4 cross section

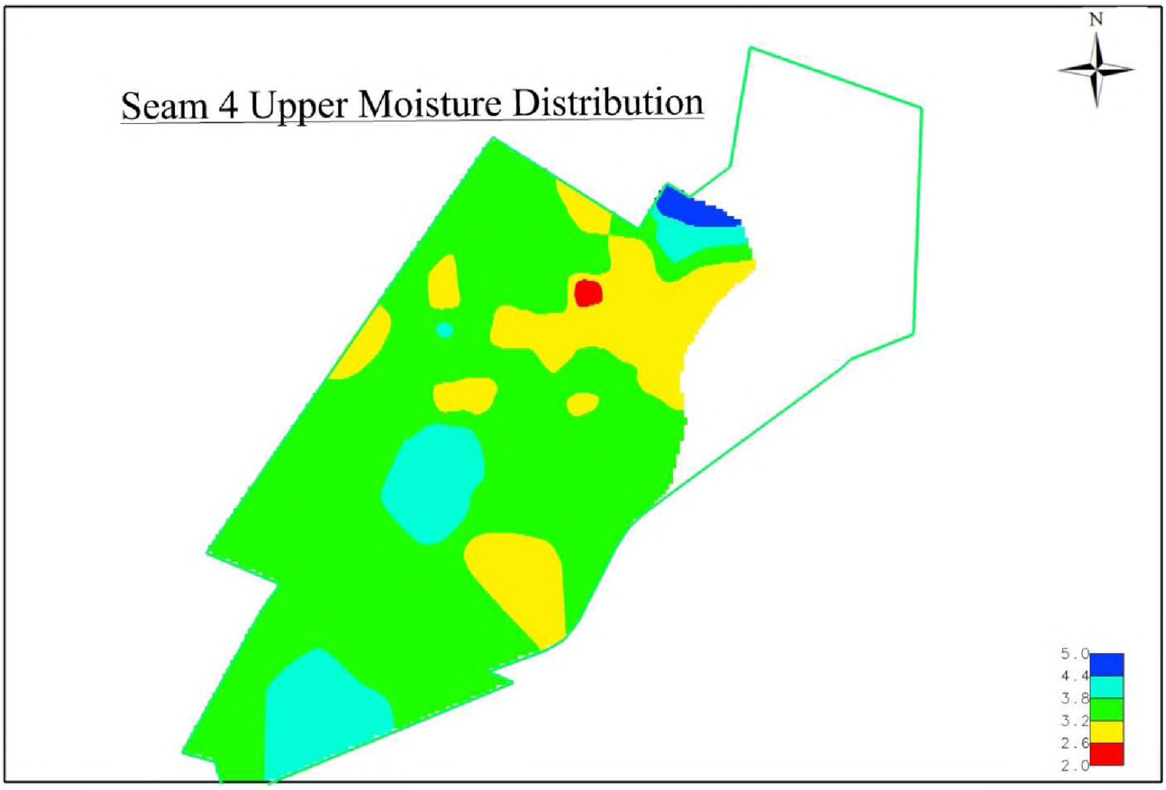


E-W 9 cross section

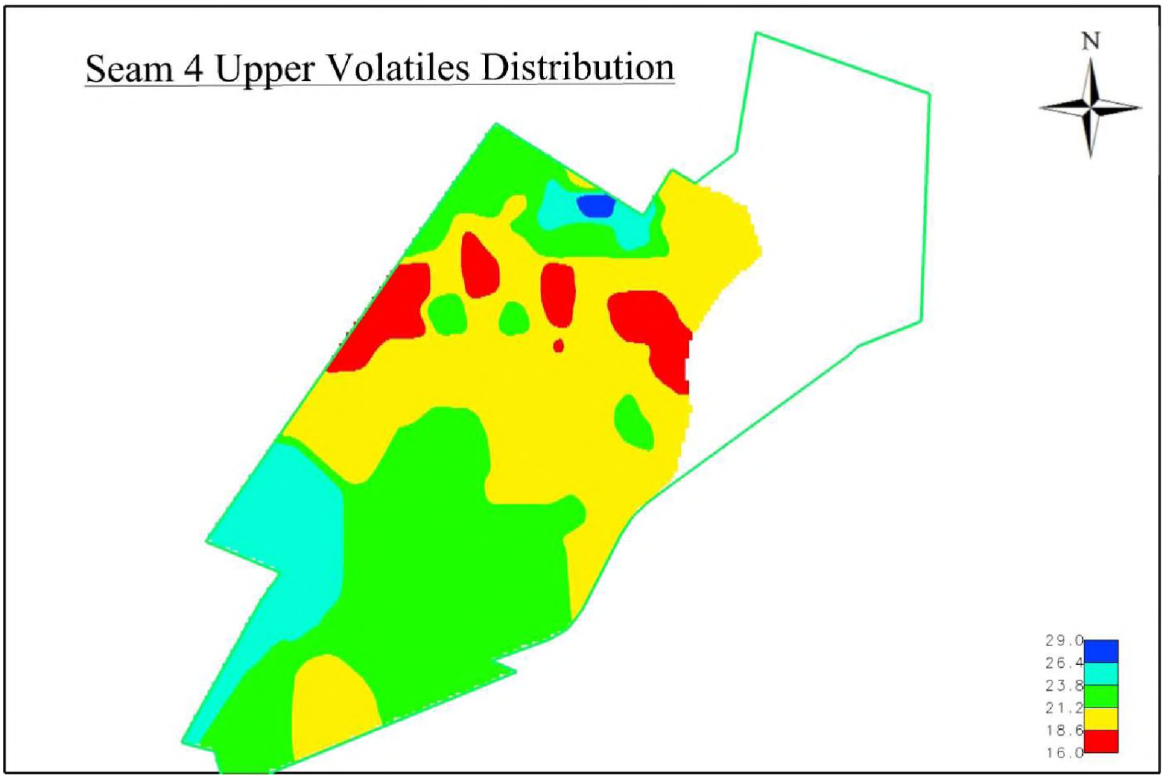
11. APPENDIX B – SEAM QUALITY DISTRIBUTION MAPS



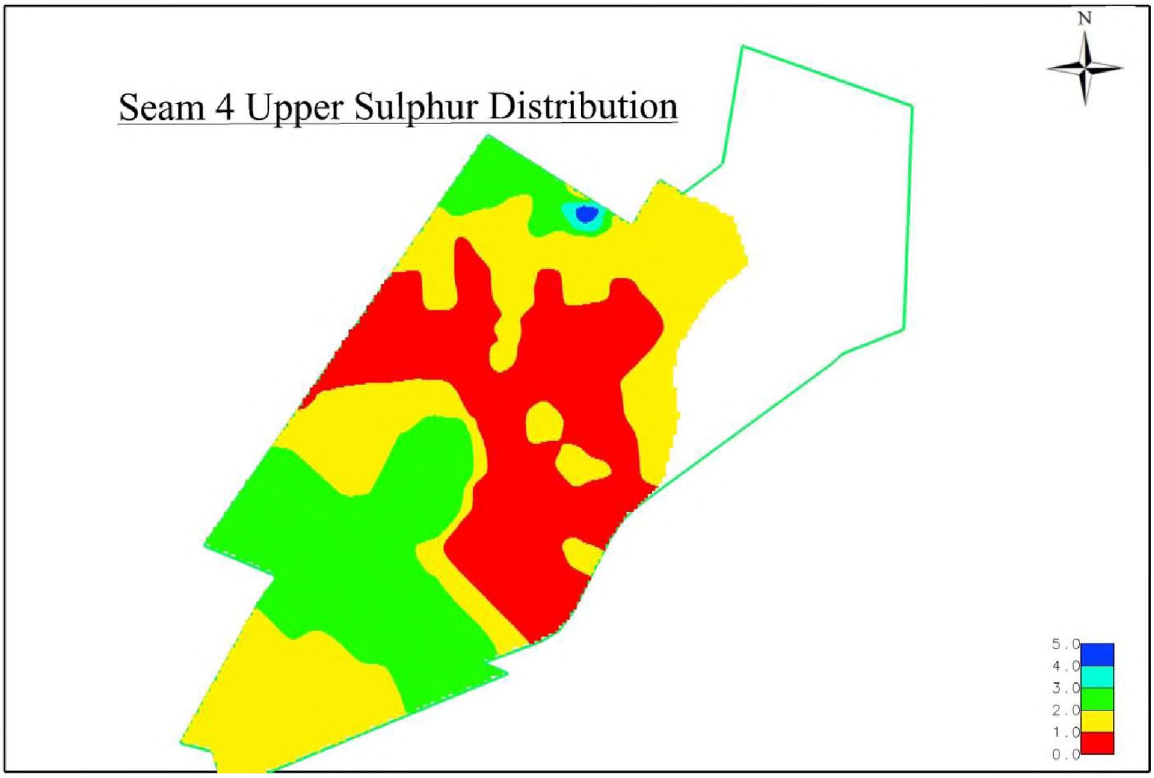
Seam 4 Upper Ash distribution map



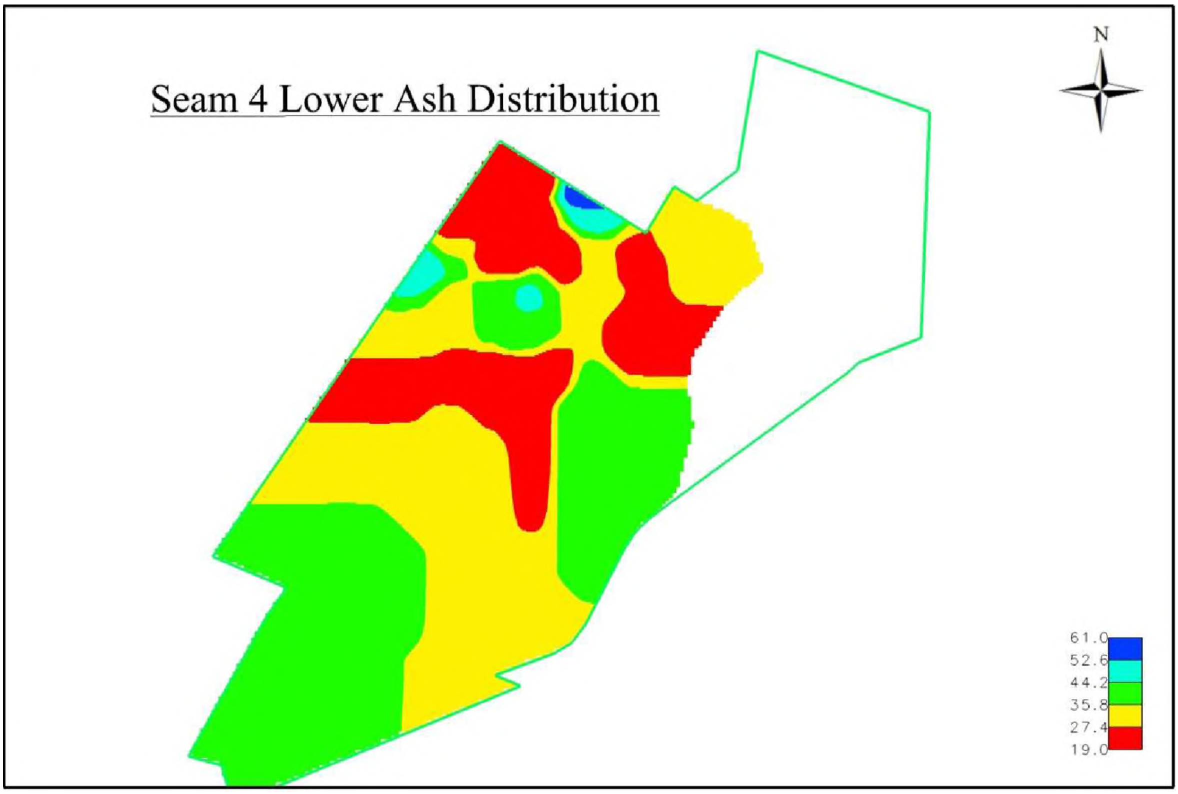
Seam 4 Upper Inherent Moisture distribution map



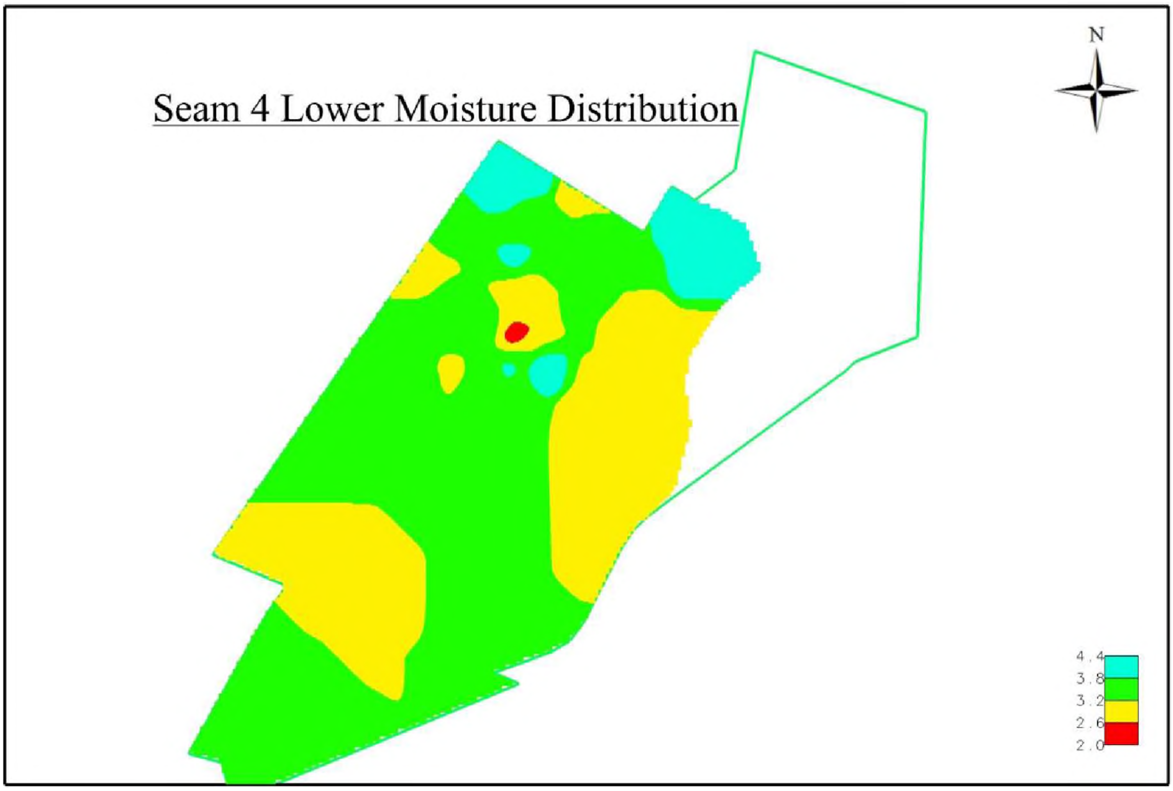
Seam 4 Upper Volatile Matter distribution map



Seam 4 Upper Sulphur distribution map



Seam 4 Lower Ash distribution map



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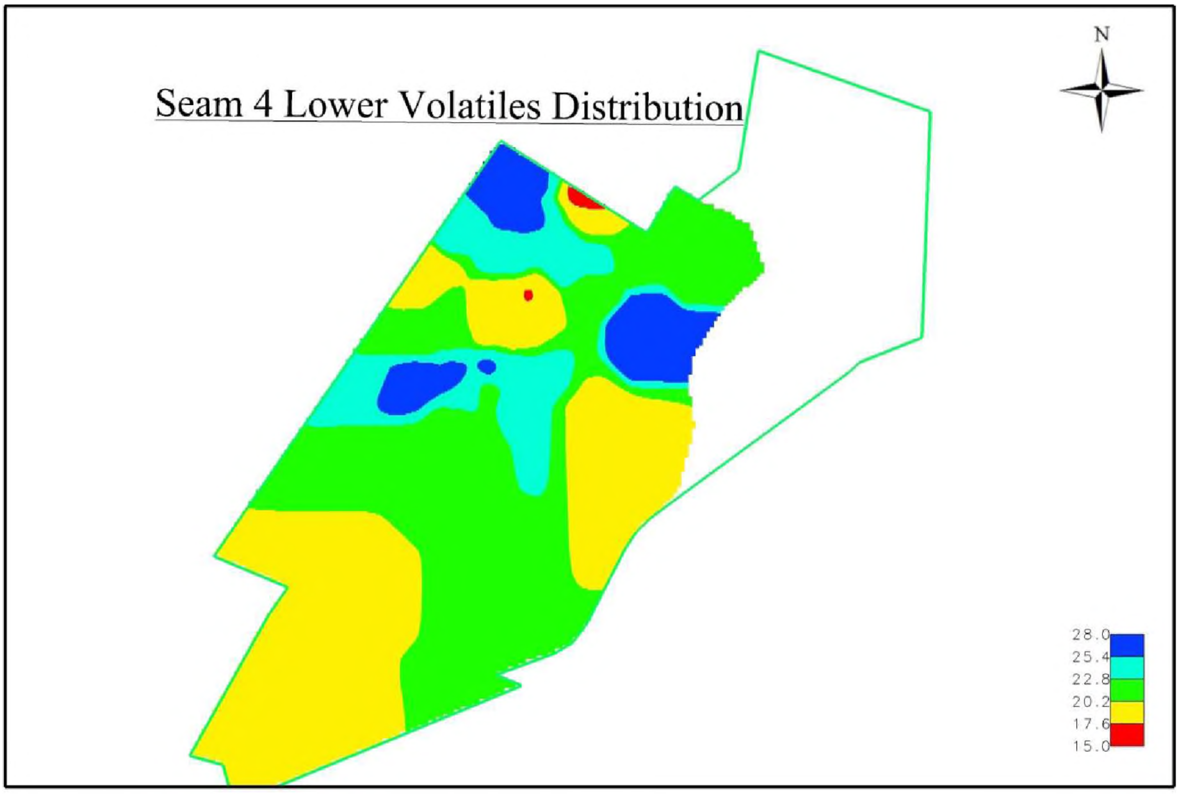
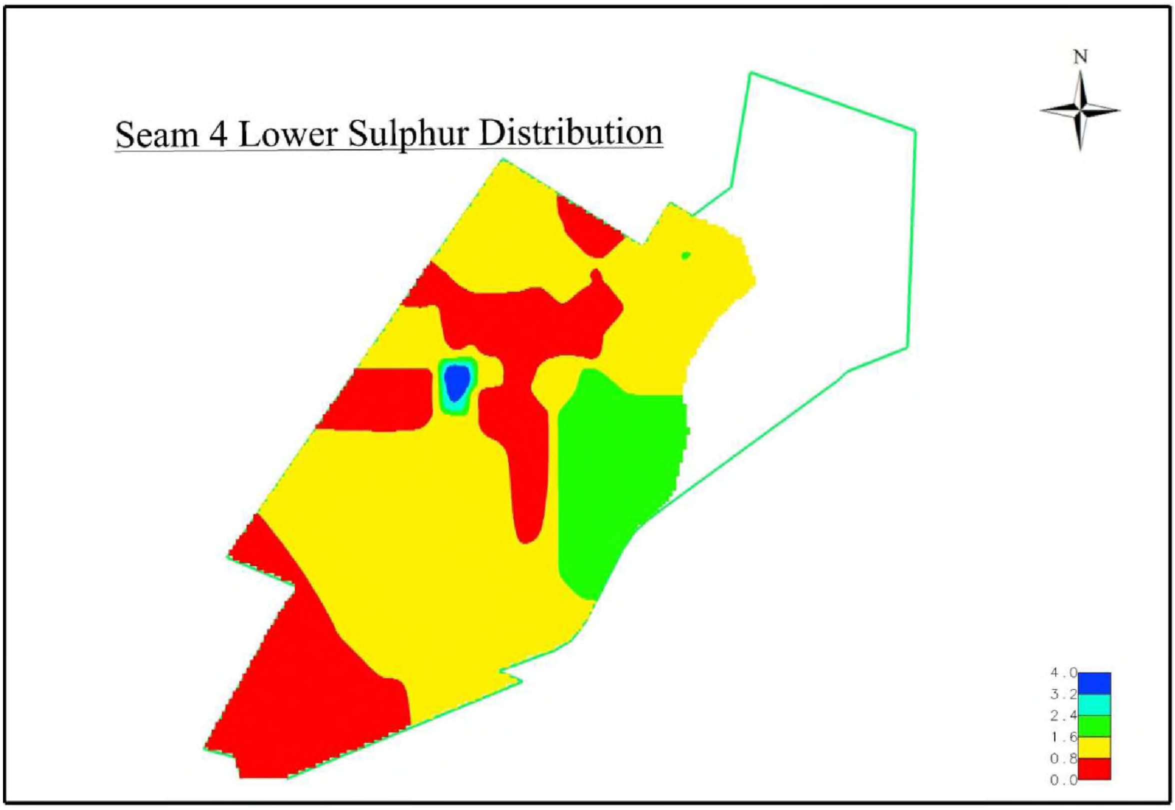
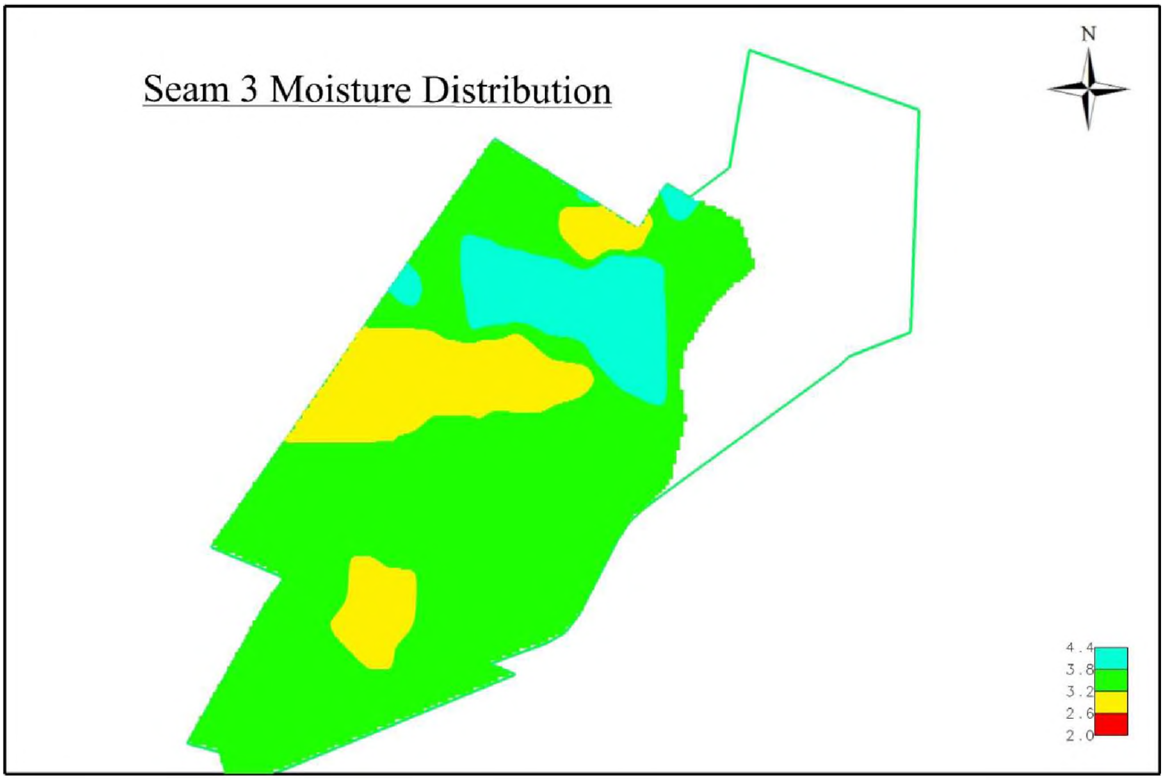


Seam 4 Lower Volatile Matter distribution map

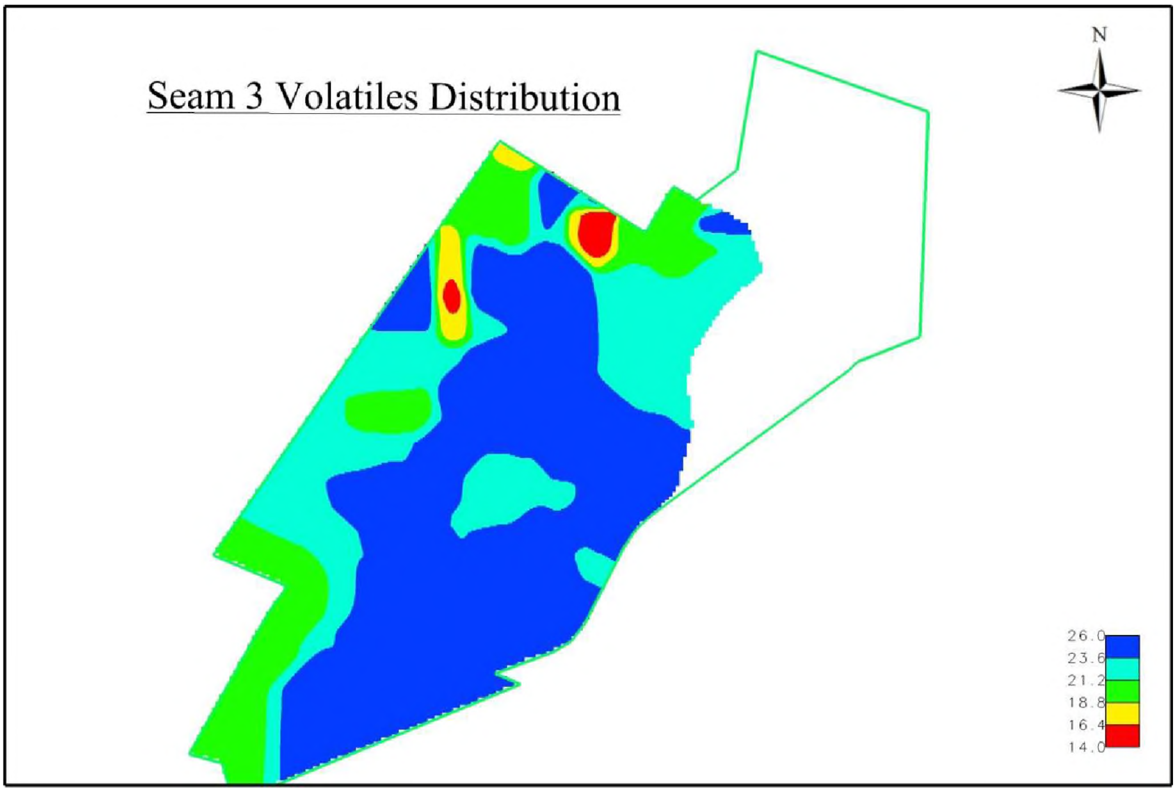


Seam 4 Lower Sulphur distribution map

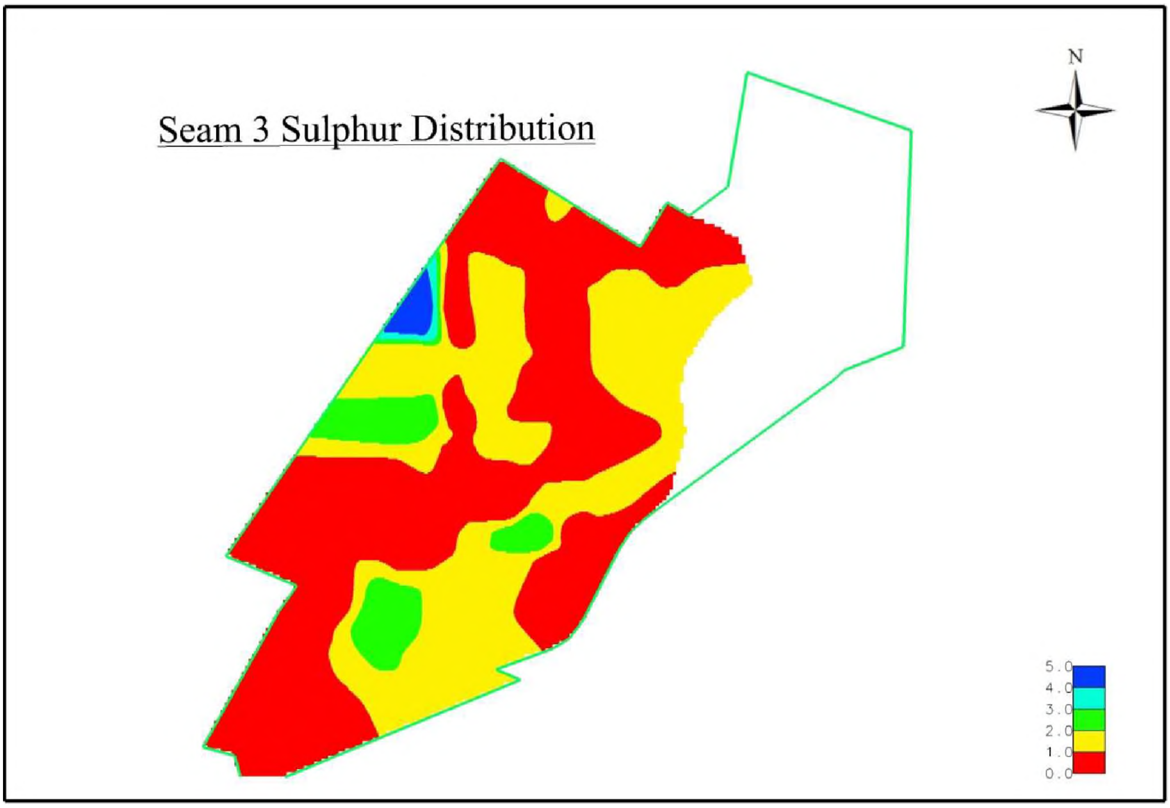
Seam 3 Ash distribution map



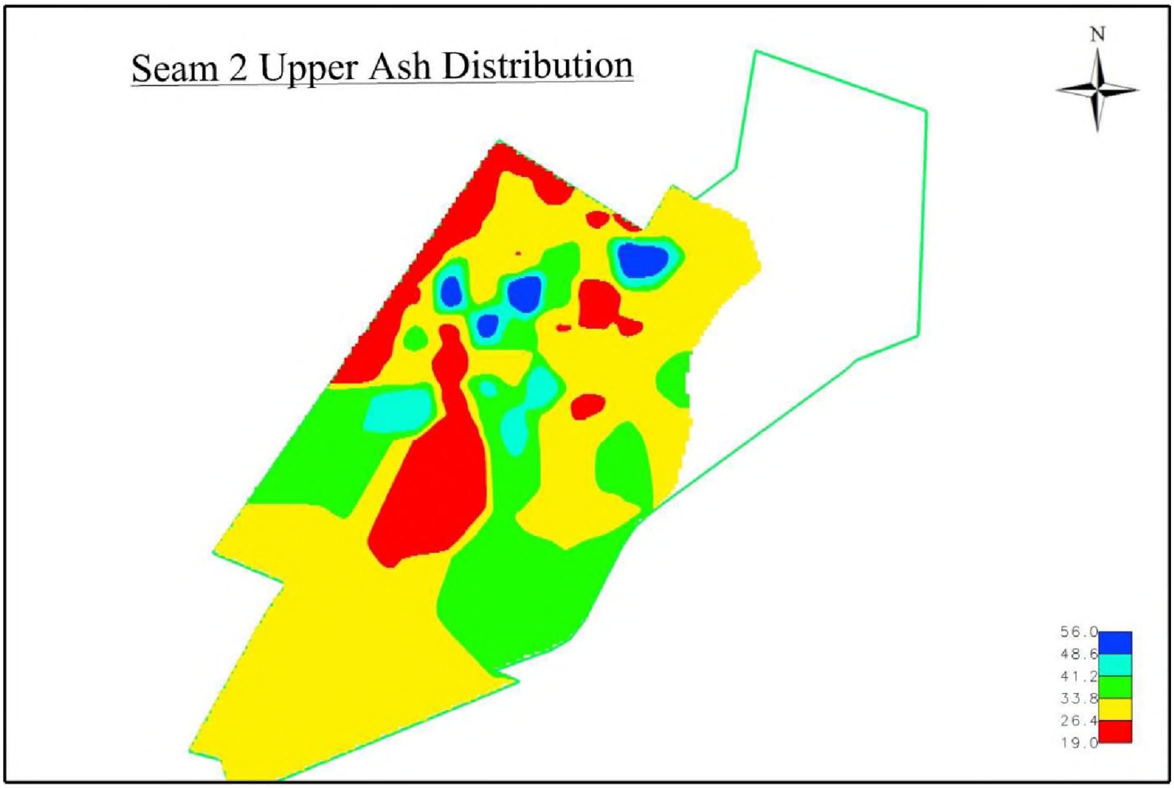
Seam 3 Inherent Moisture distribution map



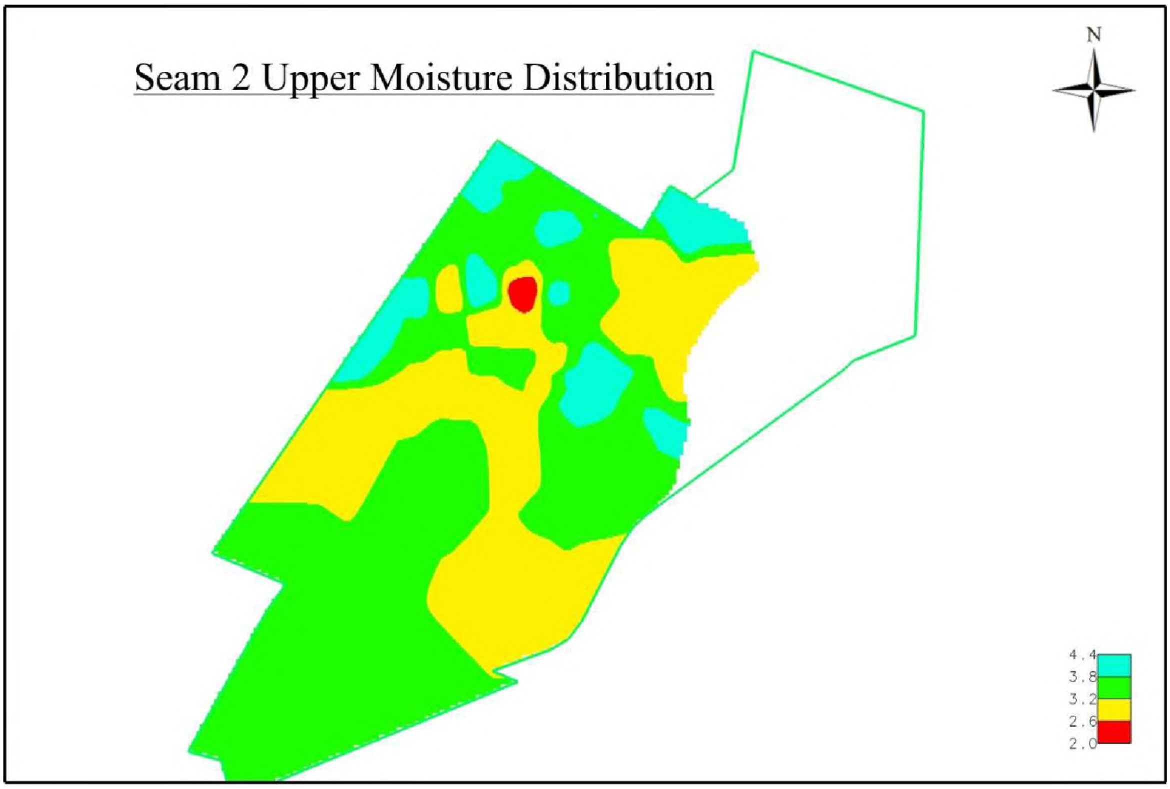
Seam 3 Volatile Matter distribution map



Seam 3 Sulphur distribution map



Seam 2 Upper Ash distribution map



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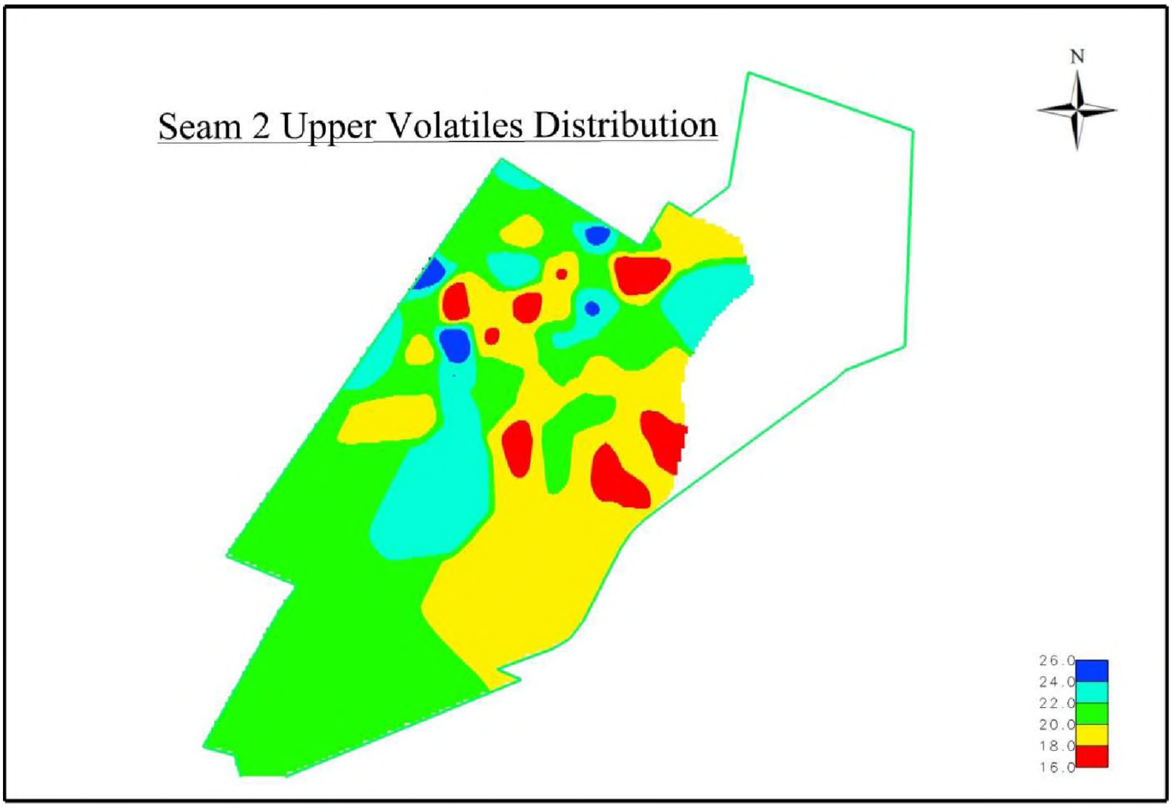

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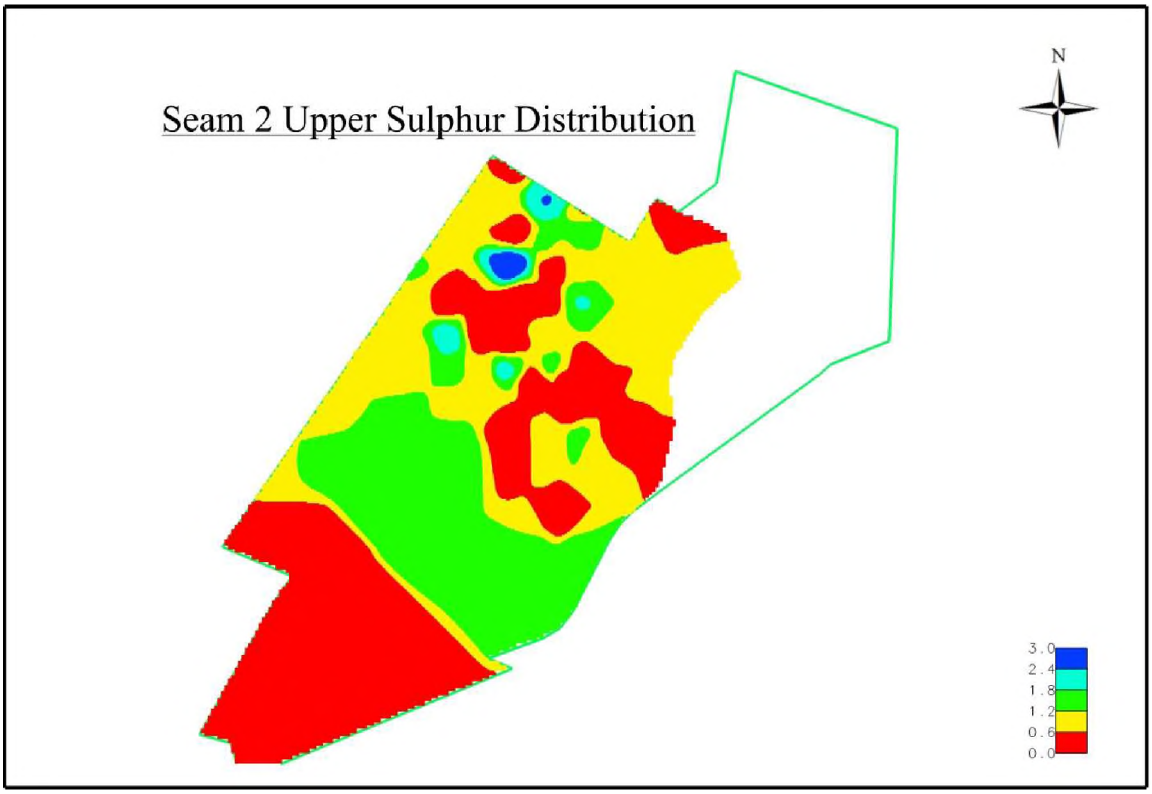

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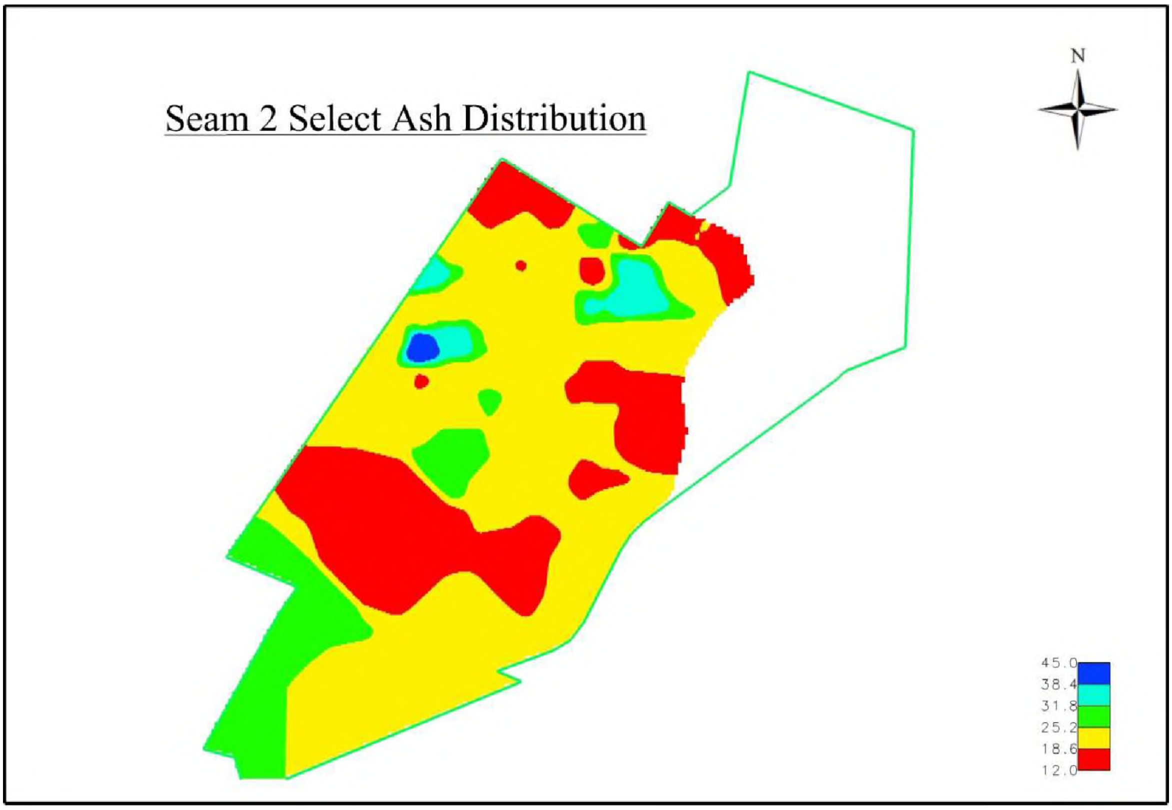

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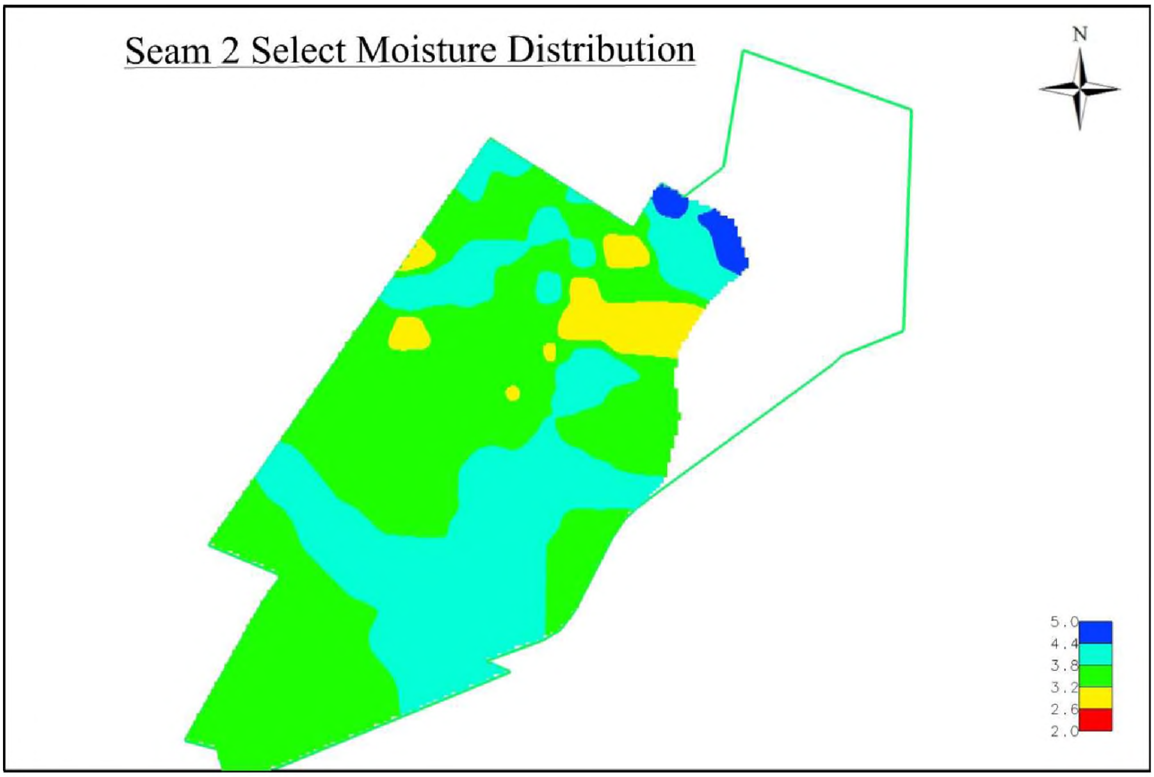

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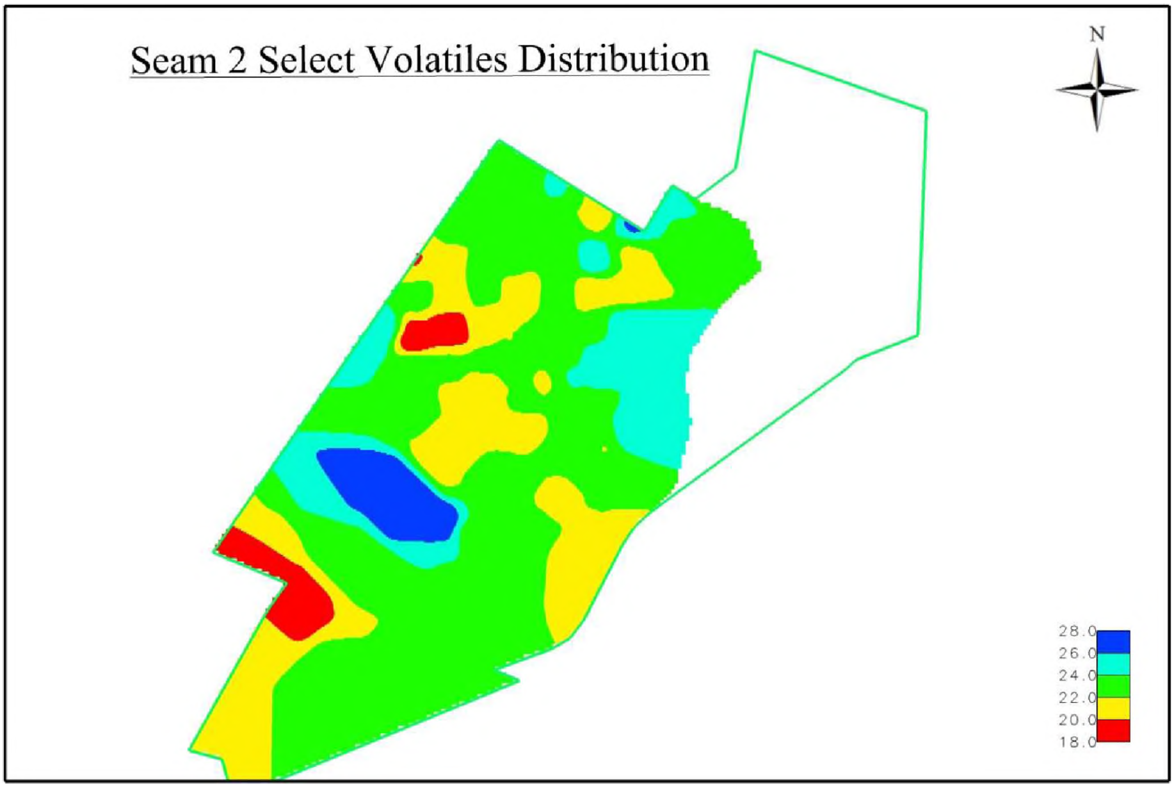

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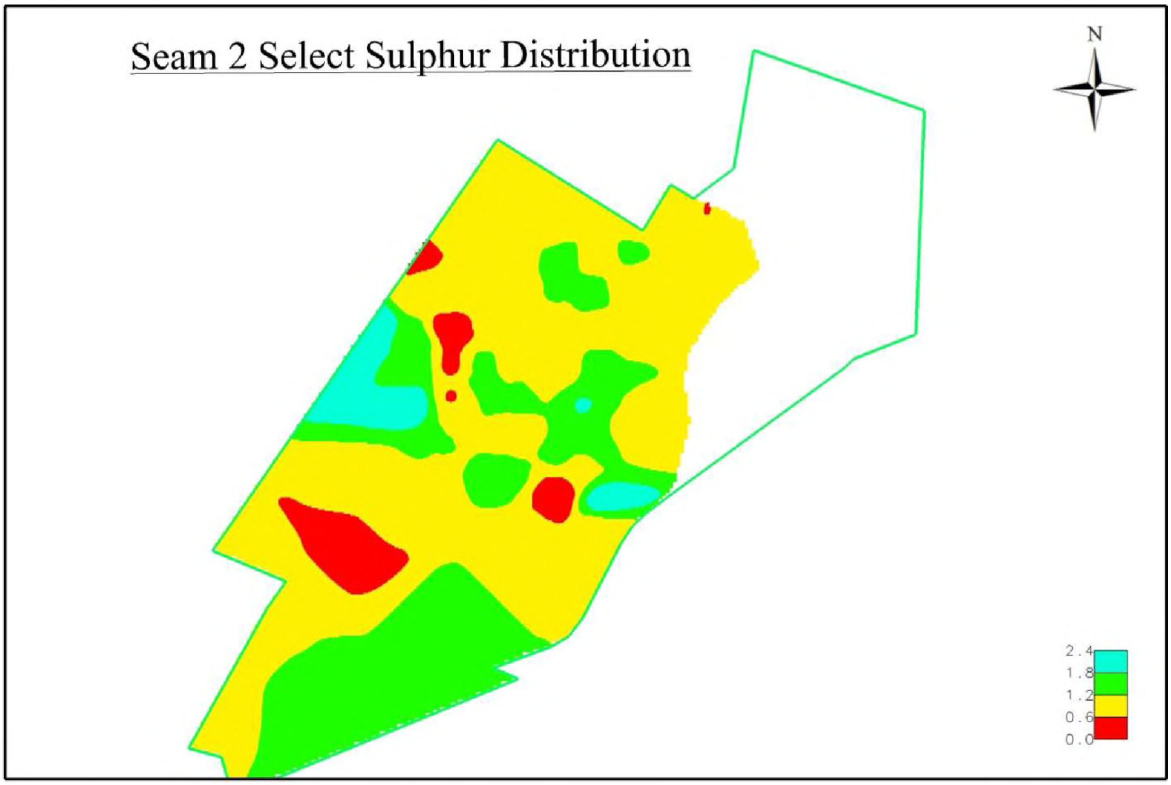

Seam 2 Select Sulphur distribution map