ANNEXURE A
Site Selection Report

SITE SELECTION REPORT

ENVIRONMENTAL IMPACT ASSESSMENT: PROPOSED COAL FIRED POWER STATION & ASSOCIATED INFRASTRUCTURE IN THE WITBANK GEOGRAPHICAL AREA

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1 INTRODUCTION

Ninham Shand was appointed by Eskom to undertake an Environmental Impact Assessment (EIA) for a proposed new coal-fired power station in the Witbank geographical area. In order to ensure that the EIA has a defendable and accountable point of departure, it was decided that Ninham Shand should also undertake a site screening and selection process to select suitable site alternatives to be further investigated in the EIA process. This document reports on the site selection process and is provided as an annexure to the Scoping Report for the project in question.

Contextualising the study in terms of national energy planning, the desirability of coal-fired generation technology and the identification of geographical regions within which such power stations could be located is provided in Section 1.2 (Policy Framework) of the Scoping Report.

This document describes the process of identifying potential sites within the Witbank geographical region and the subsequent screening of those sites to allow the two most suitable to be carried forward into the EIA process *per se*.

2 IDENTIFICATION OF POTENTIAL SITES

The identification of the Witbank geographical region for the siting of a proposed new coal-fired power station had been largely informed at a strategic level by the occurrence of coal resources to supply such a power station. From a technical and economic perspective, it is optimal to locate coal-fired power stations as close as possible to the coal source. The coal resource identified for this project is centred approximately on the site of the decommissioned and dismantled Wilge power station adjacent to the R545 road some 25 km south-west of Witbank.

The identification of potential sites was undertaken collaboratively by Ninham Shand and their air quality specialist sub-consultant, together with the responsible Eskom personnel. The study area had been defined as encompassing a 30 km radius from the centre of the coal resource. While this is not optimal, it does take into consideration technical, economic and environmental aspects associated with the siting of the power station. Three other primary criteria were overlain on the study area, namely:

- the delineation of the spatial extent of the coal field[1];
- the delineation of areas where the ambient air quality is poor[2]; and
- the delineation of 10 km radii around concentrations of human settlement[3] or exclusion zones.

The purpose of this exercise was to exclude those areas in the study area where locating a coal-fired power station would not be acceptable because of these constraints. See Figures 1 to 3 for graphic representations of the application of the above three criteria.

[1] The proposed power station should be located "off coal", i.e. it should not foreclose access to underneath coal resources.
[2] I.e. where the United Kingdom SO_2 standards are exceeded.
[3] I.e. where population densities of >500/km^2 are found.

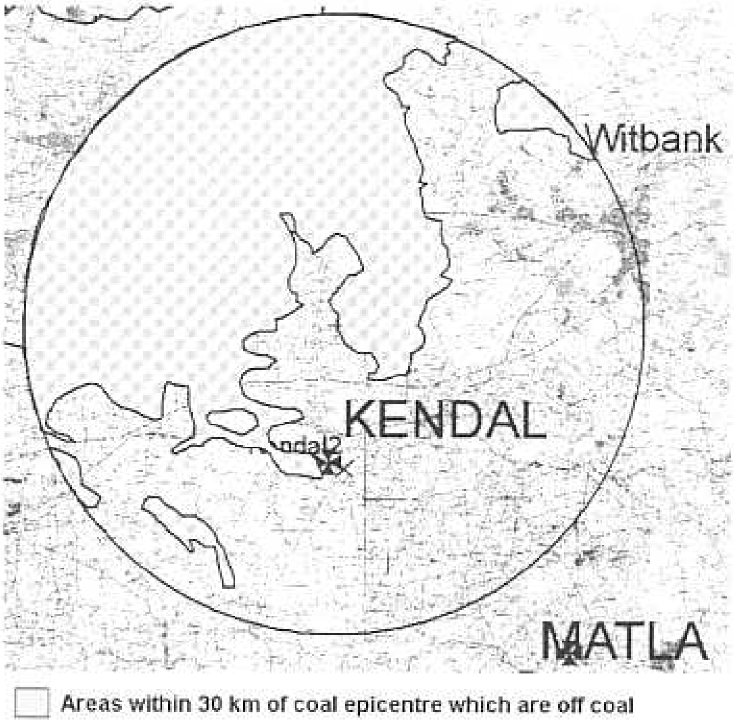


Figure 1: Areas within the 30km radius that are off coal

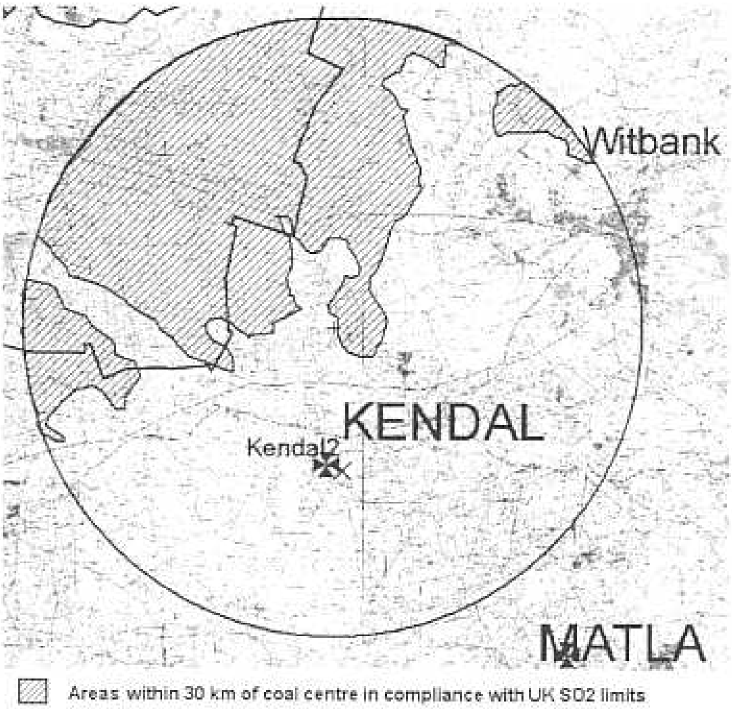


Figure 2: Areas where ambient air quality meets UK SO_2 standards

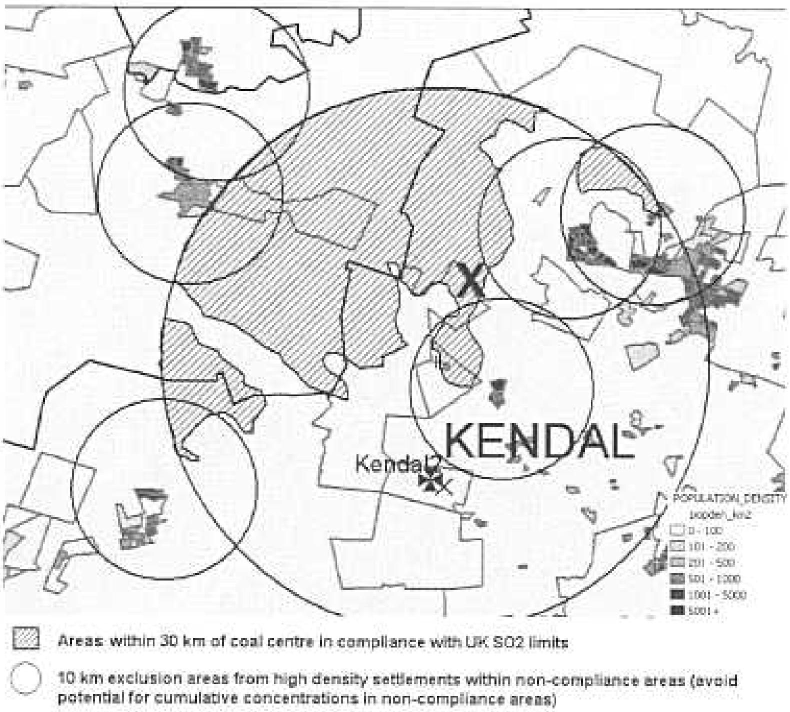


Figure 3: Areas of exclusion (10 km radii) around human settlements

A workshop was held on 3 July 2006, during which the exclusion zones within the study area were confirmed and an array of nine possible sites were identified within the remaining zones. The identification of the nine potential sites was informed by the following requirements:

- to minimise intersection with major utility corridors or other infrastructure;
- to avoid major drainage lines, uneven topography or other significant natural features;
- to identify contiguous areas of 2 500 ha[4]; and
- to use cadastral boundaries to define the potential sites.

Figure 4 presents a graphic representation of the nine potential sites that emerged from the identification of possible sites in the study area. It should be noted that a site within the exclusion zone, *viz.* Site 8, was included in the array of identified sites. This was motivated by the principle that, provided that there was no threat to human health and that no additional air pollution resulted, locating a power station in an area of poor air quality may be preferable to increasing the level of pollution in presently less polluted areas.

3 SCREENING OF POTENTIAL SITES

The screening of the potential sites was informed by means of aerial and ground inspections, followed by a workshop during which a multi-criteria decision analysis tool was applied. These

[4] A nominal area of 2 500 ha is required, within which the various elements of a typical coal-fired power station would be arranged. The actual footprint of the various elements would be less than this, probably in the order of 1 000 ha.

tasks occurred on 10 and 11 July 2006 respectively, and involved Ninham Shand and the appropriate specialist sub-consultants[5], together with the responsible Eskom personnel[6].

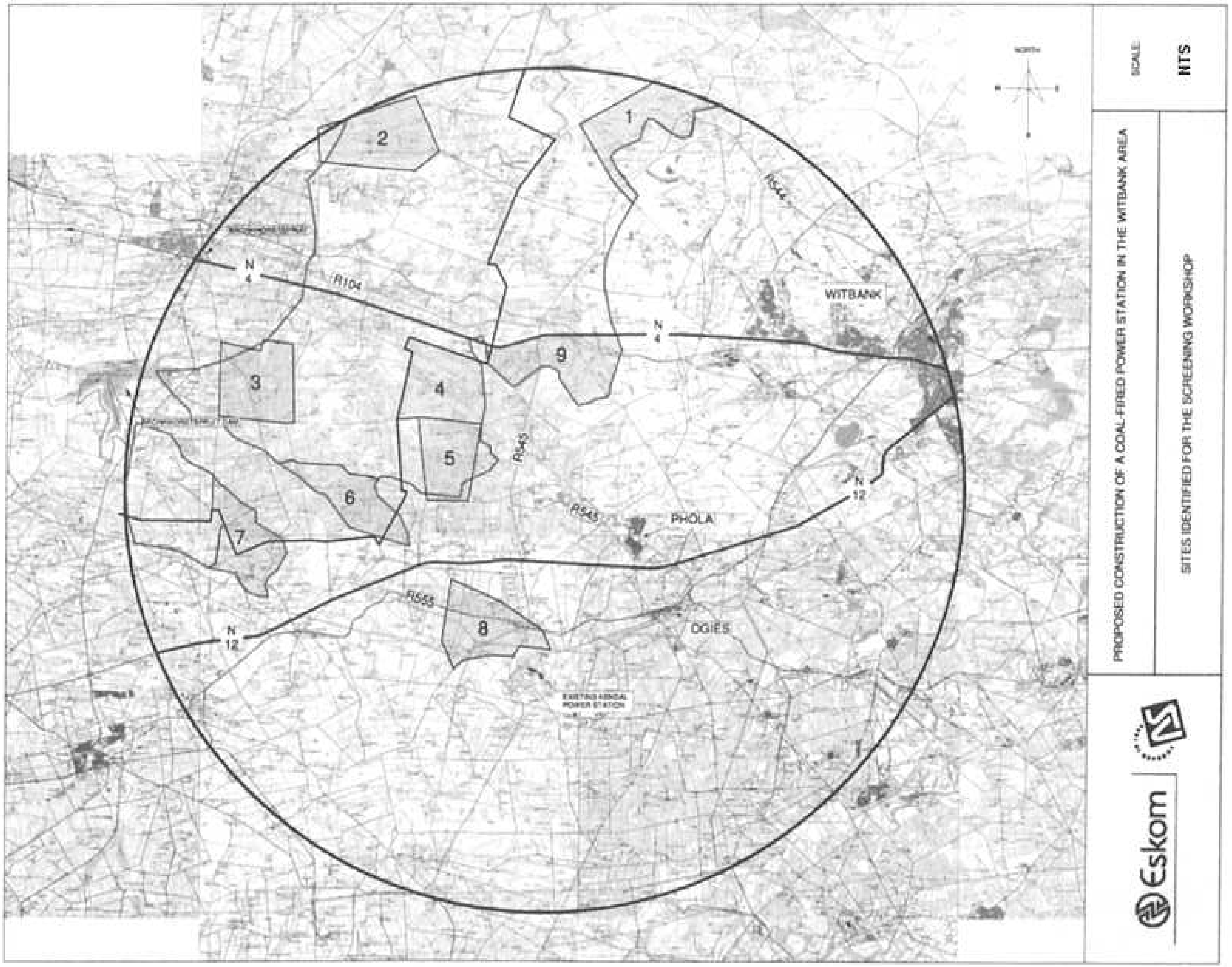
3.1 SITE INSPECTIONS

Team members were provided with briefing documentation, which included copies of Figure 4, and after a discussion on the expected deliverables, site inspections were carried out. These were initially from the air and then followed by physically visiting each site.

The most important outcome of the site inspections was that Site 1 should be abandoned. This was collectively agreed upon, for reasons of its similarity with Site 2, awkwardness of its shape and the challenges posed by existing infrastructure. It was clear that if a site in the northern quadrant were to be pursued, Site 2 would be preferable. Thus 8 potential sites were used in the analysis model.

[5] Mike Luger ~ EIA project director; Brett Lawson ~ EIA project manager; Yvonne Scorgie ~ air quality; Mader vd Berg ~ visual impact; Johan Rall ~ aquatic ecology; Johann du Preez ~ terrestrial ecology; Mark Stewart ~ geohydrology; Johnny van Schalkwyk ~ heritage impact; Elena Broughton ~ socio-economics; Judy Johnston ~ spatial planning; Andries Jordaan ~ agricultural potential.

[6] Tobile Bokwe ~ environmental (project manager); Nico Gewers ~ environmental; Kuben Nair ~ environmental; Suren Rajaruthnam ~ technical (client office manager); Bruce Stroud ~ project development engineering consultant; Alwyn vd Merwe ~ water; Johan Dempers ~ coal; Tyrone Singleton ~ air quality.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PROPOSED CONSTRUCTION OF A COAL-FIRED POWER STATION IN THE WITBANK AREA
SITES IDENTIFIED FOR THE SCREENING WORKSHOP
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Observations from the site inspections were elicited from the various team members and were recorded for reference in the site screening workshop.

3.2 SITE SCREENING WORKSHOP

3.2.1 Methodology

The site screening workshop took the form of a multi-criteria decision analysis tool application. Specifically, this comprised the application of a pairwise comparison model[7] to screen the potential sites. This is a structured approach to using sets of pairwise comparisons to rate an array of alternatives in terms of several defined criteria. The pairwise ranking process is also used to assign weights to each of the criteria (weighting is necessary as some criteria are more important than others). The process followed to determine the relative preference rating of the alternatives comprises three main steps, as follows:

- the relative priority (or weighting) of the individual criterion is determined;
- an original analytical hierarchy process decision matrix is calculated for each criterion (i.e. for each criterion, each site is assessed and scored in relation to each other site); and
- the synthesis of the decision matrices into an ideal mode decision matrix, that results in the final priorities.

The ideal mode decision matrix is then normalised, to express the ranking in numbers that are easily comparable to each other, and presented as a graph to provide a visual representation of the ranking of the sites.

The model is thus used to determine the relative importance or ranking of alternatives rather than their absolute importance or ranking, and is useful for engineers and scientists who often have to base decisions on incomplete information rather than empirically quantifiable information. Accordingly, the method is suitable for the screening of the array of potential site alternatives identified earlier, in order to focus the remainder of the study on the more favourable alternatives.

3.2.2 Description of screening criteria

The following criteria were used for the screening of the eight potential site alternatives:

[7] Saaty. T.L. (1980) *The Analytical Hierarchy Process.* McGraw-Hill International, New York, NY, USA.

Table 1: Criteria used in the screening of candidate sites

	Criterion	Explanation
1	Operational logistics	The risk to the reliability of supply increases with the distance that coal has to be transported. The capital cost of a power station is relatively small in relation to the overall operational cost, and accordingly, operational logistical factors would have a significant cost impact on the production of electricity. All sites were ranked against each other in relation to their distance from the coal resource, taking note of the rail, road, pipeline and transmission line infrastructure.
2	Landuse	Factors considered: Agriculture ~ intensive/ extensive/ irrigation. Tourism potential ~ guest farms/ game farms etc. Future development opportunities ~ residential/ tourism. Infrastructure ~ roads/ railway lines/ other utilities etc.
3	Geology/ Geomorphology	Factors considered: Risk of long term contamination of water resources. Preliminary resource evaluation. Geology ~ Stable geology, number and types of underlying structures/ Rock outcrops and terrain/ Clay rich soils can impact on geotech and possible perched aquifers. Topography ~ Requires flat, slight gradient on site for water management/ Site limitations due to drainage (1:50 / 1:100 flood line restrictions). Resource Vulnerability ~ Shallow aquifers with good groundwater potential are less suitable/ Perennial surface water higher impact than non-perennial rivers due to ecology.
4	Ecology	Considered areas of important indigenous terrestrial, aquatic and wetland flora and fauna.
5	Local air quality (uncontrolled[8])	Considered the proximity and vulnerability of communities at risk from elevated levels of air emissions.
6	Socio-economics	Factors considered: Administrative boundaries/ Job creation & displacement/ Tourism/ Safety & security/ Heritage resources/ Aesthetics/ Social services

3.2.3 Description of the rating scale

Table 2 shows the rating scale utilised to score the various sites in terms of each of the six criteria, as well as to score the relative weighting of the criteria.

[8] Uncontrolled refers to the scenario where no air pollution abatement technologies are implemented.

Table 2: Analytical hierarchy process rating scale

RATING SCALE TABLE	
Rating (R)	**Description of Relative Rating**
1	Equal
3	Weak preference
5	Essential or strong preference
7	Demonstrated preference
9	Absolute preference
2, 4, 6, 8	Intermediate values
Reciprocals of the above	If for criterion x, option A has a rating of one of the above when compared to option B (R_{XAB}), then option B has the reciprocal or inverse rating when compared to option A (R_{XBA}) e.g. if for a given criterion, option A is scored 5 relative to option B, then option B automatically scores 1/5 in relation to option A.

When applying the above rating scale, the workshop participants had to consider whether a site was better or worse than the site it was being compared to in respect of the criterion under consideration. This would then indicate whether the relative rating should be an integer value (when it is better) or a fraction value (when it is worse), using the principle of reciprocal rating as per the scale. The significance or severity of this preference is then expressed through the application of the numerical values in the scale, unless it is equal in which case a rating of 1 was used.

3.2.4 Results of site screening

The pairwise ranking undertaken by the workshop participants who, as indicated above, comprised both technical and environmental specialists, resulted in the criteria ranking tables presented in Tables 2 to 7. Note that CR represents the consistency ratio, which indicates the level of reliability in the outcome of the assigning of rankings per criterion. A CR of <10% is regarded as acceptable.

Table 3: Relative ranking of sites with respect to **Operation Logistics**

	Site 9	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	
Site 9	1	7	7	1/3	1/3	4	7	3	**0.176**
Site 2	1/7	1	1	1/7	1/7	1/5	1/3	1/7	**0.022**
Site 3	1/7	1	1	1/7	1/7	1/5	1	1/5	**0.026**
Site 4	3	7	7	1	1/2	5	7	3	**0.251**
Site 5	3	7	7	2	1	5	7	3	**0.299**
Site 6	1/4	5	5	1/5	1/5	1	4	1/3	**0.071**
Site 7	1/7	3	1	1/7	1/7	1/4	1	1/7	**0.030**
Site 8	1/3	7	5	1/3	1/3	3	7	1	**0.124**
								CR	7.76%

Table 4: Relative ranking of sites with respect to **Land use**

	Site 9	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
Site 9	1	5	5	1	1	3	5	1	0.212
Site 2	1/5	1	1/2	1/5	1/5	1/5	1	1/5	0.034
Site 3	1/5	2	1	1/5	1/5	1/3	1/3	1/5	0.037
Site 4	1	5	5	1	1	1	4	1	0.179
Site 5	1	5	5	1	1	1	5	1	0.184
Site 6	1/3	5	3	1	1	1	1	1	0.123
Site 7	1/5	1	3	1/4	1/5	1	1	1/3	0.057
Site 8	1	5	5	1	1	1	3	1	0.173
								CR	3.03%

Table 5: Relative ranking of sites with respect to **Geology/ geomorphology**

	Site 9	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
Site 9	1	1/3	1/2	1/3	1/3	1	1/2	1/5	0.046
Site 2	3	1	2	1/3	1/3	2	2	1/5	0.094
Site 3	2	1/2	1	1/3	1/3	1/2	2	1/5	0.063
Site 4	3	3	3	1	2	3	3	1	0.221
Site 5	3	3	3	1/2	1	3	3	1/3	0.162
Site 6	1	1/2	2	1/3	1/3	1	2	1/3	0.074
Site 7	2	1/2	1/2	1/3	1/3	1/2	1	1/3	0.057
Site 8	5	5	5	1	3	3	3	1	0.282
								CR	4.69%

Table 6: Relative ranking of sites with respect to **Ecology**

	Site 9	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
Site 9	1	2	1	1/3	1/2	1	1/2	1/3	0.070
Site 2	1/2	1	1/2	1/5	1/3	1/3	1/4	1/7	0.035
Site 3	1	2	1	1/3	1/2	1/2	1/2	1/5	0.060
Site 4	3	5	3	1	2	3	2	1/2	0.202
Site 5	2	3	2	1/2	1	2	2	1/3	0.130
Site 6	1	3	2	1/3	1/2	1	1/2	1/5	0.075
Site 7	2	4	2	1/2	1/2	2	1	1/3	0.113
Site 8	3	7	5	2	3	5	3	1	0.315
								CR	1.83%

Table 7: Relative ranking of sites with respect to **Local air quality (uncontrolled)**

	Site 9	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
Site 9	1	1/3	1/7	1/5	1/5	1/9	1/7	1/3	0.020
Site 2	3	1	1/5	1/3	1/3	1/7	1/5	1	0.039
Site 3	7	5	1	3	3	1/3	1	5	0.186
Site 4	5	3	1/3	1	1	1/5	1/3	3	0.085
Site 5	5	3	1/3	1	1	1/5	1/3	3	0.085
Site 6	9	7	3	5	5	1	3	7	0.359
Site 7	7	5	1	3	3	1/3	1	5	0.186
Site 8	3	1	1/5	1/3	1/3	1/7	1/5	1	0.039
								CR	3.46%

Table 8: Relative ranking of sites with respect to **Socio-economics**

	Site 9	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
Site 9	1	1/3	1	1/5	1/5	1/3	1/3	1/5	0.036
Site 2	3	1	1	1/5	1/5	1/3	1/3	1/2	0.052
Site 3	1	1	1	1/5	1/5	1/4	1/4	1/4	0.039
Site 4	5	5	5	1	1	3	3	2	0.258
Site 5	5	5	5	1	1	2	3	2	0.245
Site 6	3	3	4	1/3	1/2	1	1	1	0.123
Site 7	3	3	4	1/3	1/3	1	1	1	0.117
Site 8	5	2	4	1/2	1/2	1	1	1	0.131
								CR	1.97%

After undertaking the pairwise ranking described above, workshop participants then assigned relative weights to each of the six criteria, in order to rank the potential sites. The weightings were debated and agreed upon by the workshop participants. Table 8 indicates the weightings assigned to each of the six criteria, in the column titled "priority vector". The column entitled "priority vector" indicates the final weighting (rounded to nearest whole number) for each criterion.

Table 9: Weighting assigned to the criteria

CRITERIA	Operational logistics	Landuse	Geology/ geomorphology	Ecology	Local air quality (uncontrolled)	Socio-economics	Priority Vector
Operational logistics	1	5	6	3	1/7	3	20%
Landuse	1/5	1	1/2	1/4	1/9	1/3	3%
Geology/ geomorphology	1/6	2	1	1/2	1/9	1/3	5%
Ecology	1/3	4	2	1	1/5	1	10%
Local air quality (uncontrolled)	7	9	9	5	1	5	53%
Socio-economics	1/3	3	3	1	1/5	1	10%
						CR	9.63%

Criteria 1 to 3, which are the technical/ cost criteria, were assigned a total of 28% of the weighting, while the more 'environmental' criteria accounted for the remaining 72% of the weighting. This is an indication that environmental issues, i.e. biophysical and social issues, were the dominant force behind the screening of sites.

The workshop ranking and weighting exercise resulted in the following hierarchy (most preferred to least preferred):

- Site 6
- Site 4
- Site 5
- Site 7
- Site 8
- Site 3
- Site 9
- Site 2

Refer to Figure 5 below for the final ranking (known as the "Final Priority") results. This represents the outcome of the screening process. Given that Sites 4 and 5 are fairly similar and immediately adjacent, it was decided to incorporate them into a single site, resulting in Sites (4+5) and Site 6 being taken forward into the EIA.

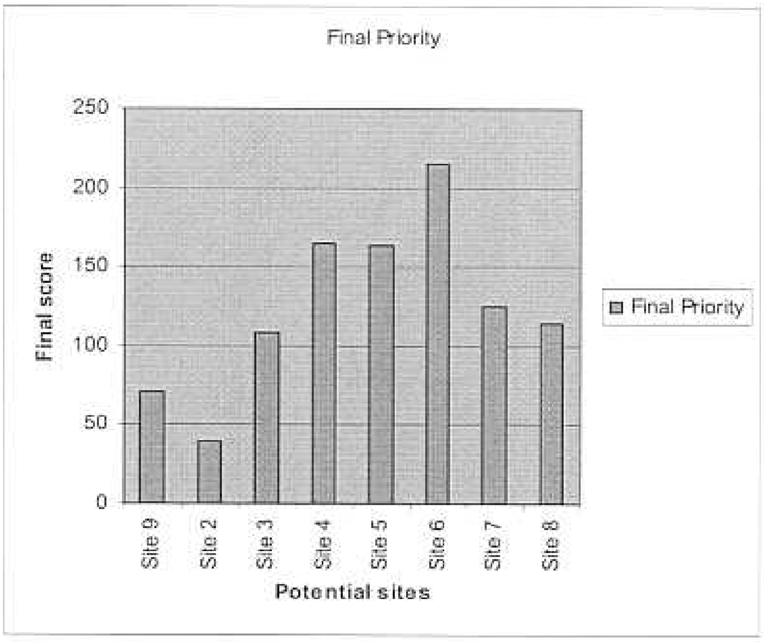

Figure 5: Final priority of sites generated by the application of the pairwise ranking model

3.2.5 Sensitivity analysis

In order to test how sensitive the model is to the criteria weightings, a sensitivity analysis was undertaken and five alternative weighting scenarios were created and compared to the workshop weighting scenario. The purpose of this was to determine whether different weightings would significantly alter the outcomes of the site screening process and thereby validating the results.

The first scenario is the one of equal weighting, where the weighting was equally shared across all criteria i.e. each criteria weighted at 16.67%. Figure 6 below shows how the relative ranking of sites changes between the workshop weighting and an equal weighting scenario. Sites 4 and 5 remain the most favourable, while Site 8 overtakes Site 6 as the third contender. However, the overall picture remains essentially the same, with the top four sites still being relatively better than the remaining sites.

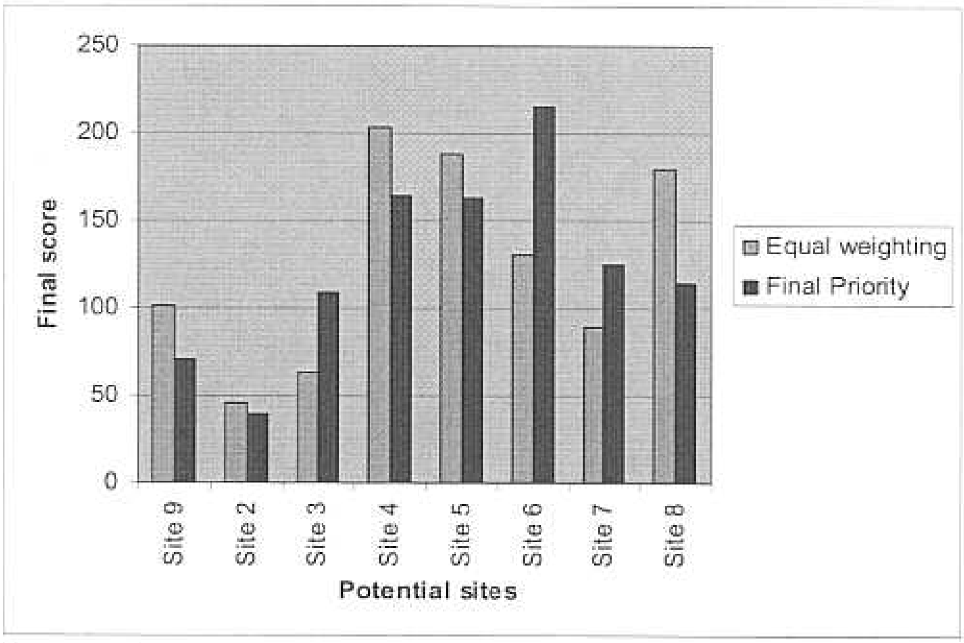

Figure 6: Sensitivity analysis 1, comparing the Final Priority to a scenario where all criteria are given equal weight

The second scenario tested was the 'green' or environmental scenario, where the cost criteria (criteria 1 to 3) were zero weighted, and the weighting equally distributed between the environmental criteria, i.e. criteria 4 to 6. Once again, while there is a shift in the relative ranking of the eight sites in comparison to the workshop weightings, the same three sites still emerge as the preferred sites. See Figure 7.

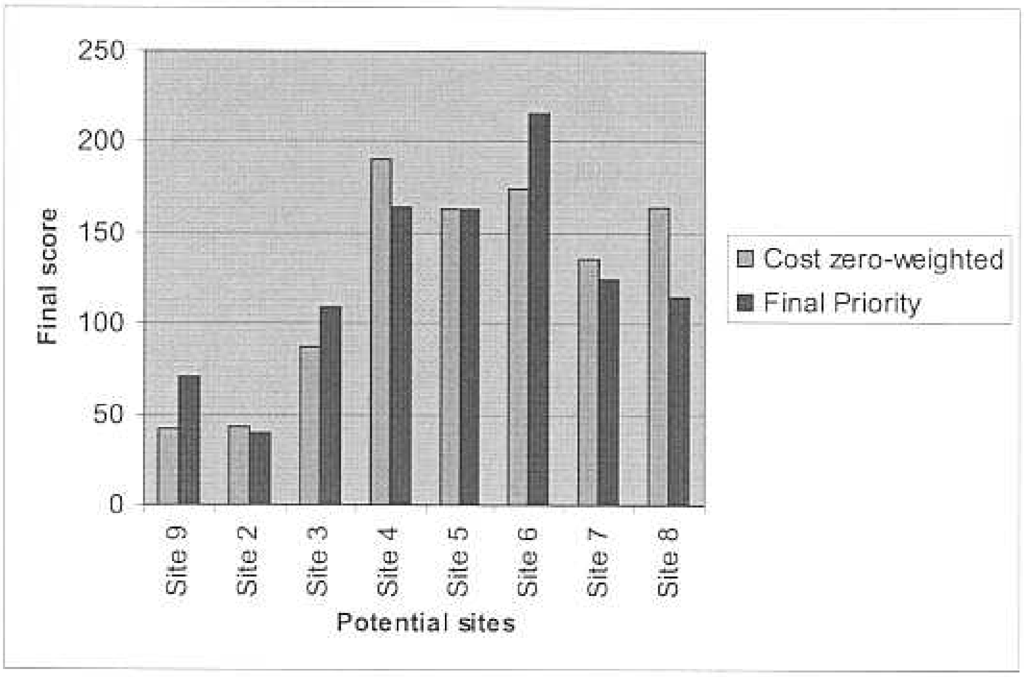

Figure 7: Sensitivity analysis 2, comparing the Final Priority to a scenario where all cost criteria are zero-weighted

The third scenario tested gave weight to the social criteria only, i.e. criteria 2, 5 and 6. This would be the situation if biophysical and technical criteria were to be ignored. The same three sites, *viz.* Sites 4, 5 and 6, still emerge as the preferred sites. See Figure 8.

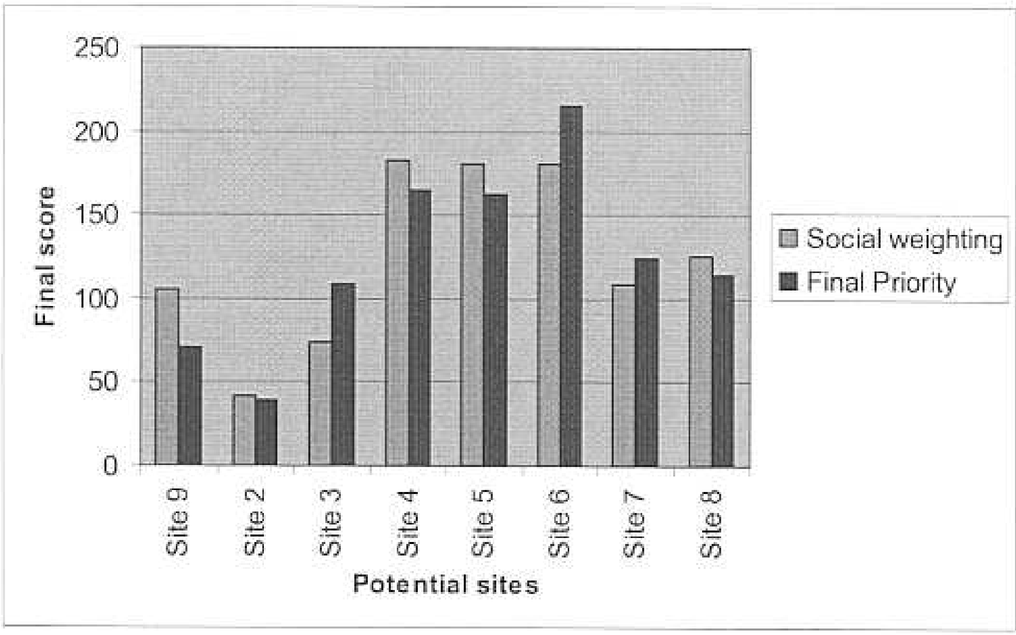

Figure 8: Sensitivity analysis 3, comparing the Final Priority to a scenario where only social criteria are given weight

The fourth scenario tested gave weight to the technical criteria only, i.e. criteria 1, 2 and 3. This would be the situation should biophysical and social criteria be ignored. Site 6 reduces significantly in this case and the sites nearest to the coalfield, i.e. Sites 8 and 9, understandably gain prominence. Nevertheless, Sites 4 and 5 remain the leading contenders. See Figure 9.

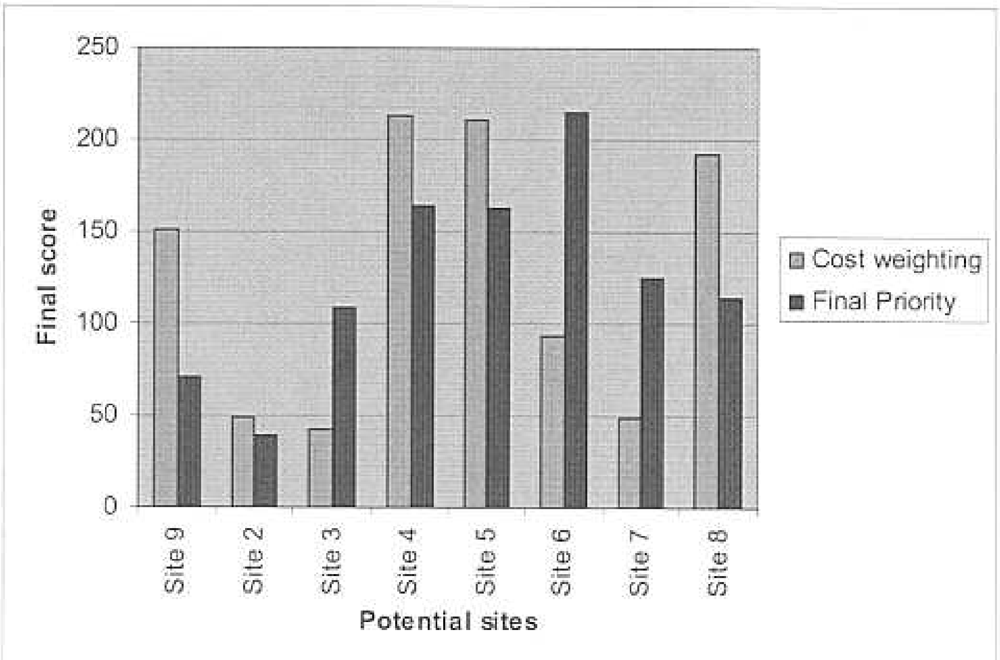

Figure 9: Sensitivity analysis 4, comparing the Final Priority to a scenario where only cost criteria are given weight

The fifth scenario tested was where the local air quality weighting and rating, as per the analytical hierarchy process decision matrix, was amended to reflect a situation where controls (air pollution abatement technology) are installed. The air quality specialist was of the opinion that the weighting could be reduced by 30%, i.e. from 53% in the overall weighting reflected in Section 3.2.4 above, to 37% as a result of emission controls such as flue gas desulphurisation being installed. In this scenario, Sites 4 and 5 remain the most preferable sites but Site 2 emerges as a contender. This is explained by Site 2 being well within an area where ambient air quality is acceptable under the South African air quality standards and hence, with the inclusion of emission controls, would have the least air quality impacts relative to the other sites. See Figure 10.

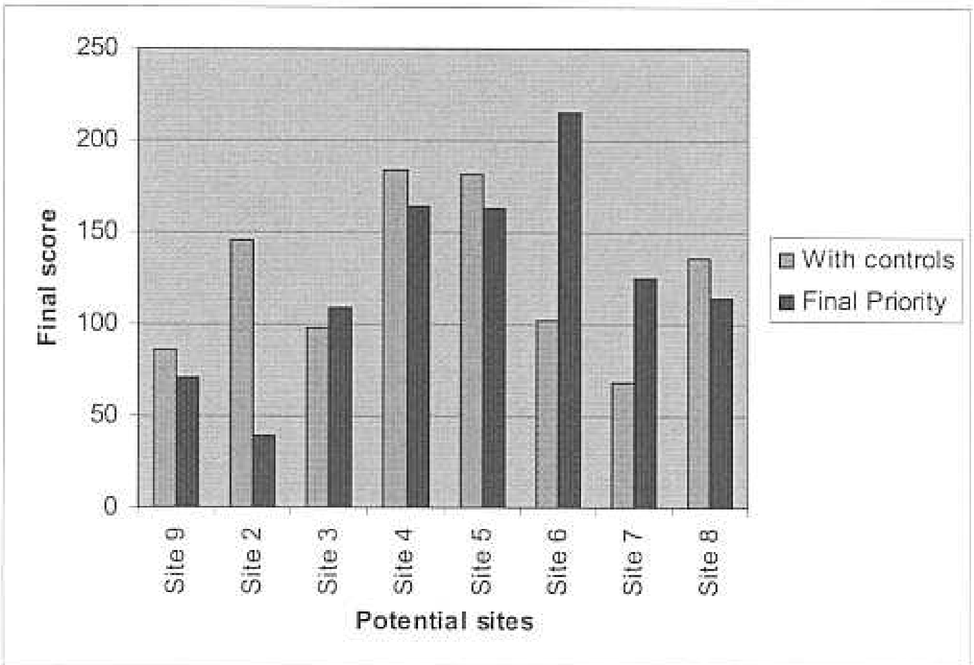

Figure 10: Sensitivity analysis 5, comparing the Final Priority to a scenario where air emission controls are implemented

From the sensitivity analyses, it can be concluded that irrespective of the weightings assigned to the six criteria, Sites 4 and 5 consistently emerge as preferable to the other potential sites investigated, and that Site 6 would on balance be the third option.

4 CONCLUSION

Based on the application of the site identification and screening methodologies described above, it is believed that carrying Sites 4, 5 and 6 forward into the EIA *per se* is a valid conclusion to the site selection process for the proposed coal-fired power station in the Witbank area. On reflection, it was also suggested that Sites 4 and 5 could be grouped as a single site. Their rankings have proved to be consistently very similar and since the sites are contiguous, specialist studies could be carried out more efficiently. Also, wider options are available insofar as the placement of the individual components of a coal-fired power station and its associated infrastructure are concerned.

In summary, it is thus recommended that two sites are investigated further in this EIA, namely Sites 4/ 5 and Site 6. For ease of reference these are to be referred to as Site X and Site Y respectively in subsequent documentation.