Project done on Behalf of

Zitholele Consulting

Qualitative Noise Impact Evaluation for the Continuous Disposal of Ash at the Camden Power Station

Report No.: 12ZIT11

Revision 0

Date: 19 March 2013

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Report Details

Reference	12ZIT11
Status	Revision 0
Report Title	Qualitative Noise Impact Evaluation for the Continuous Disposal of Ash at the Camden Power Station
Date	19 March 2013
Client	Zitholele Consulting
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Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
dB	Decibels
Hz	Hertz
SANS	South African National Standards
Zitholele	Zitholele Consulting
Δ	The increase in noise level

Note: All acoustic terminology are discussed in more detail in Section 2.1

Qualitative Noise Impact Evaluation for the Continuous Disposal of Ash at the Camden Power Station

1 Introduction

Camden Power Station, a coal fired power station outside Ermelo in Mpumalanga, is part of Eskom's power generation fleet. Camden Power Station currently disposes of burnt boiler ash with a process called 'wet ashing' which involves disposal of ash by pumping the ash as slurry through a pipeline to the ash facility. Some of the dry ash is also transported to the ash facility with a conveyor belt.

Recent studies have revealed that the current ash disposal facility will not be able to accommodate all the ash to be generated during the remaining operational life of the Camden Power Station. It was determined that the station would require an additional ash disposal facility by 2014. The new ash disposal site will need to cater for an estimated 12.86 million m^3 of ash up to 2023, plus 5 years contingency up to 2028.

Airshed Planning Professionals (Pty) Ltd was appointed by Zitholele Consulting (Zitholele) to qualitatively evaluate the potential for noise impacts on the surrounding environment from proposed construction, operational and closure operations.

2 Approach to the Study

2.1 Noise Defined

As background to the qualitative noise impact evaluation, the reader should take note of some definitions and conventions used in the measurement, calculation and assessment of environmental noise.

Noise is generally defined as unwanted sound transmitted through a compressible medium such as air. Sound in turn, is defined as any pressure variation that the ear can detect. Human response to noise is complex and highly variable as it is subjective rather than objective.

Noise is reported in decibels (dB). "dB" is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure. The relationship between sound pressure and sound pressure level is illustrated in Equation 1:

$$L_p = 20 \cdot \log_{10}\left(\frac{p}{p_{ref}}\right)$$

Equation 1

Where:

$\boldsymbol{L_p}$ *is the sound pressure level in dB;*

$\boldsymbol{p}$ *is the actual sound pressure in Pa; and*

$\boldsymbol{p_{ref}}$ *is the reference sound pressure (p_{ref} in air is 20 µPa)*

2.1.1 Perception of Sound

Sound has already been defined as any pressure variation that can be detected by the human ear. The number of pressure variations per second is referred to as the frequency of sound and is measured in hertz (Hz). The hearing of a young, healthy person ranges between 20 Hz and 20 000 Hz (20 kHz).

In terms of sound pressure level, audible sound ranges from the threshold of hearing at 0 dB to the pain threshold of 130 dB and above. Even though an increase in sound pressure level of 6 dB represents a doubling in sound pressure, an increase of 8 to 10 dB is required before the sound subjectively appears to be significantly louder. Similarly, the smallest perceptible change is about 1 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

2.1.2 Frequency Weighting

As human hearing is not equally sensitive to all frequencies, a 'filter' has been developed to simulate human hearing. The 'A-weighting' filter simulates the human hearing characteristic, which is less sensitive to sounds at low frequencies than at high frequencies. "dBA" is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities, that have the same units (in this case sound pressure) that has been A-weighted.

2.1.3 Adding Sound Pressure Levels

Since sound pressure levels are logarithmic values, the sound pressure levels as a result of two or more sources cannot just simply be added together. To obtain the combined sound pressure level of a combination of sources such as those at an industrial plant, individual sound pressure levels must be converted to their linear values and added using Equation 2.

$$L_{p\_combined} = 10 \cdot \log\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}} + 10^{\frac{L_{p3}}{10}} + \cdots 10^{\frac{L_{pi}}{10}}\right)$$

Equation 2

This implies that if the difference between the sound pressure levels of two sources is nil the combined sound pressure level is 3 dB more than the sound pressure level of one source alone. Similarly, if the difference between the sound pressure levels of two sources is more than 10 dB, the contribution of the quietest source can be disregarded (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

2.1.4 Environmental Noise Propagation

Many factors affect the propagation of noise from source to receiver. The most important of these are:

- The type of source and its sound power;
- The distance between the source and the receiver;
- The extent of atmospheric absorption (attenuation);
- Wind speed and direction;
- Temperature and temperature gradient;
- Obstacles such as barriers or buildings between the source and receiver;
- Ground absorption;
- Reflections;
- Humidity; and
- Precipitation

To arrive at a representative result from either measurement or calculation, all these factors must be taken into account (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

2.1.5 Environmental Noise Indices

In assessing environmental noise either by measurement or calculation, reference is generally made to the following indices:

- **L_{PA}** – The A-weighted instantaneous sound pressure level.
- **L_{Aeq} (T)** – The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured). The International Finance Corporation (IFC) provides guidance with respect to L_{Aeq} (1 hour), the A-weighted equivalent sound pressure level, averaged over 1 hour.
- **L_{AIeq} (T)** – The A-weighted impulse corrected equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured).
- **L_{AZeq} (T)** – The un-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured).
- **L_{A90}** – The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of

what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels.

- **L_{A10}** – The A-weighted 10% statistical noise level, i.e. the noise level that is exceeded during 10% of the measurement period.
- **L_{Amax}** – The maximum level generated from a single noise event.
- **$L_{Req,d}$** – The equivalent continuous A-weighted sound pressure level (L_{Aeq} (T)) during the day (06:00 – 22:00), plus specified adjustments for tonal character, impulsiveness of the sound and the time of day.
- **$L_{Req,n}$** – The equivalent continuous A-weighted sound pressure level (L_{Aeq} (T)) during the night (22:00 – 06:00), plus specified adjustments for tonal character, impulsiveness of the sound and the time of day.
- **L_{Rdn}** – The equivalent continuous A-weighted sound pressure level (L_{Aeq} (T)) during a reference time interval of 24 hours plus specified adjustments for tonal character, impulsiveness of the sound and the time of day.

2.2 Methodology

The project has the potential to cause environmental noise impacts. The main objective of the qualitative noise impact evaluation is to describe potential impacts from the proposed Project on the surrounding environment. Based on the overall objective the following were included in the study:

- A review of local and international legislation and (or) guidelines pertaining to environmental noise impacts.
- A qualitative assessment of existing environmental noise levels vicinity of the project and nearby residences.
- A discussion on the atmospheric and physical environment and its effect on noise propagation.
- The identification of sources of environmental noise associated with the construction, operational and closure phases of the Project.
- The evaluation of potential noise impacts.
- A review of mitigation measures pertaining to environmental noise management.
- The compilation of a qualitative noise impact evaluation report.

3 Assumptions and Limitations

It should be noted that the evaluation did not include the quantification of impacts and that findings are based on the specialist’s experience and findings of similar projects. This report serves as a specialist opinion. Findings should be confirmed with measurements.

4 Legislative Context

Prior to discussing the impact the proposed Project may have on the surrounding area, reference needs to be made to the environmental regulations governing the impact of such operations i.e. ambient noise level guidelines.

Environmental noise is regulated under Chapter 4, 'Air Quality Management Measures', of the National Environmental Management Air Quality Act (NEMAQA) (Act no. 39 of 2004). Under the 'Control of Noise' the Act states that:

1) The Minister may prescribe essential national standards
   a. For the control of noise, either general or by specified machinery or activities or in specified places or areas; or
   b. For determining
      i. A definition of noise; and
      ii. The maximum levels of noise.
2) When controlling noise the provincial and local spheres of government are bound by any prescribed national standards.

To date, such standards have not been published under the Act. It is however anticipated that when published, these standards will make extensive reference to the South African Bureau of Standards' (SABS) South African National Standards (SANS) 10103 of 2008, 'The measurement and Rating of Noise with Respect to Annoyance and Speech Communication'.

SANS 10103 (2008) provides typical noise rating values that should not be exceeded outdoors in the different districts given in the 1st column of Table 1. Outdoor ambient noise exceeding these levels will be considered to be annoying to the community (SANS 10103, 2008).

In addition to the noise level guidelines outlined in Table 1, reference is also made to noise guidelines for estimating community response to an increase in the general ambient noise level caused by intruding noise (SANS 10103, 2008). Community response to an increase of Δ in noise level, is summarised in Table 2.

The categories of community response overlap because the response of a community does not occur as a stepwise function, but rather as a gradual change. It should be noted that environmental noise impacts are focussed on the annoyance caused from a human perspective.

Table 1: Typical rating levels for noise in districts

Equivalent continuous rating level ($L_{Req,T}$) for noise, dBA (SANS 10103, 2008)			
Type of District	**Day/night $L_{R,dn}$**	**Daytime $L_{Req,d}$**	**Night-time $L_{Req,n}$**
Rural districts	45	45	35
Suburban districts with little road traffic	50	50	40
Urban districts	55	55	45
Urban districts with one or more of the following: workshops; business premises; and main roads	60	60	50
Central business districts	65	65	55
Industrial districts	70	70	60

Table 2: Categories of community or group response

Δ - Increase in Noise Level	**Estimated Community Response (SANS 10103, 2008)**
Δ = 0 dBA	There will be no community reaction.
0 ≤ Δ ≤ 5 dBA	There will be 'little' reaction with 'sporadic complaints'. For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. Δ = 3 dBA is, therefore, a useful significance indicator for a noise impact.
5 ≤ Δ ≤ 15 dBA	There will be a 'medium' reaction with 'widespread complaints'. Δ = 10 dBA is subjectively perceived as a doubling in the loudness of the noise.
10 ≤ Δ ≤ 20 dBA	There will be a 'strong' reaction with 'threats of community action'.
15 dBA ≤ Δ	There will be a 'very strong' reaction with 'vigorous community action'.

5 The Effected Noise Environment

5.1 Locality and Distance to Communities

It is understood that two locations are considered for the proposed ash dam. The first site lies approximately 200 m north of the existing ash dam (Figure 1). At this location the ash dam will have 154 ha footprint area. Camden town lies directly east of this site. The closest residences in Camden lie approximately 400 m from the eastern corner of the proposed ash dam. A farmstead, located approximately 1 km west of the proposed as dam was also identified from Google Earth imagery.

The second alternative, referred to as Site 3, consists of two ash dams (Site 3 A and B) and is located south of the existing ash dam. Farmsteads or residences, identified from Google Earth imagery include buildings located approximately 2 km west of Site 3A and 2.3 km south-east of Site 3A and Site 3B. Camden town lies approximately 3 km north-east of Site 3.

5.2 Atmospheric Absorption and Meteorology

Atmospheric absorption and meteorological conditions have already been mentioned with regards to its role in the propagation on noise from source to receiver (Section 2.1.4). Meteorological parameters affecting the propagation of noise, when calculated using the Concawe method, include wind speed, wind direction, temperature, relative humidity, air pressure, solar radiation and cloud cover.

Average day and night-time wind speed, wind direction, temperature, relative humidity, pressure and solar radiation as calculated from Eskom Camden data for 2010 to 2012 are provided in Table 3.

It is well known that wind speed increases with altitude. This results in the ‘bending’ of the path of sound to ‘focus’ it on the downwind side and creating a ‘shadow’ on the upwind side of the source. Depending on the wind speed, the downwind level may increase by a few dB but the upwind level can drop by more than 20 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

Wind roses indicating prevailing wind directions in the area during the day and night are provided in Figure 3. Wind roses represent wind frequencies for the 16 cardinal wind directions. Frequencies are indicated by the length of the shaft when compared to the circles drawn to represent a frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies with high and low winds occurring for each wind vector. The frequencies of calms, defined as periods for which wind speeds are below 1 m/s, are also indicated.

The average day-time wind field is characterised by frequent strong winds (more than 5 m/s) from the east, east-south-east and westerly. During nigh-time the wind field is dominated by moderate winds from the north-north-west. It should be noted that at wind speeds of more than 5 m/s ambient noise levels are mostly dominated wind generated noise.

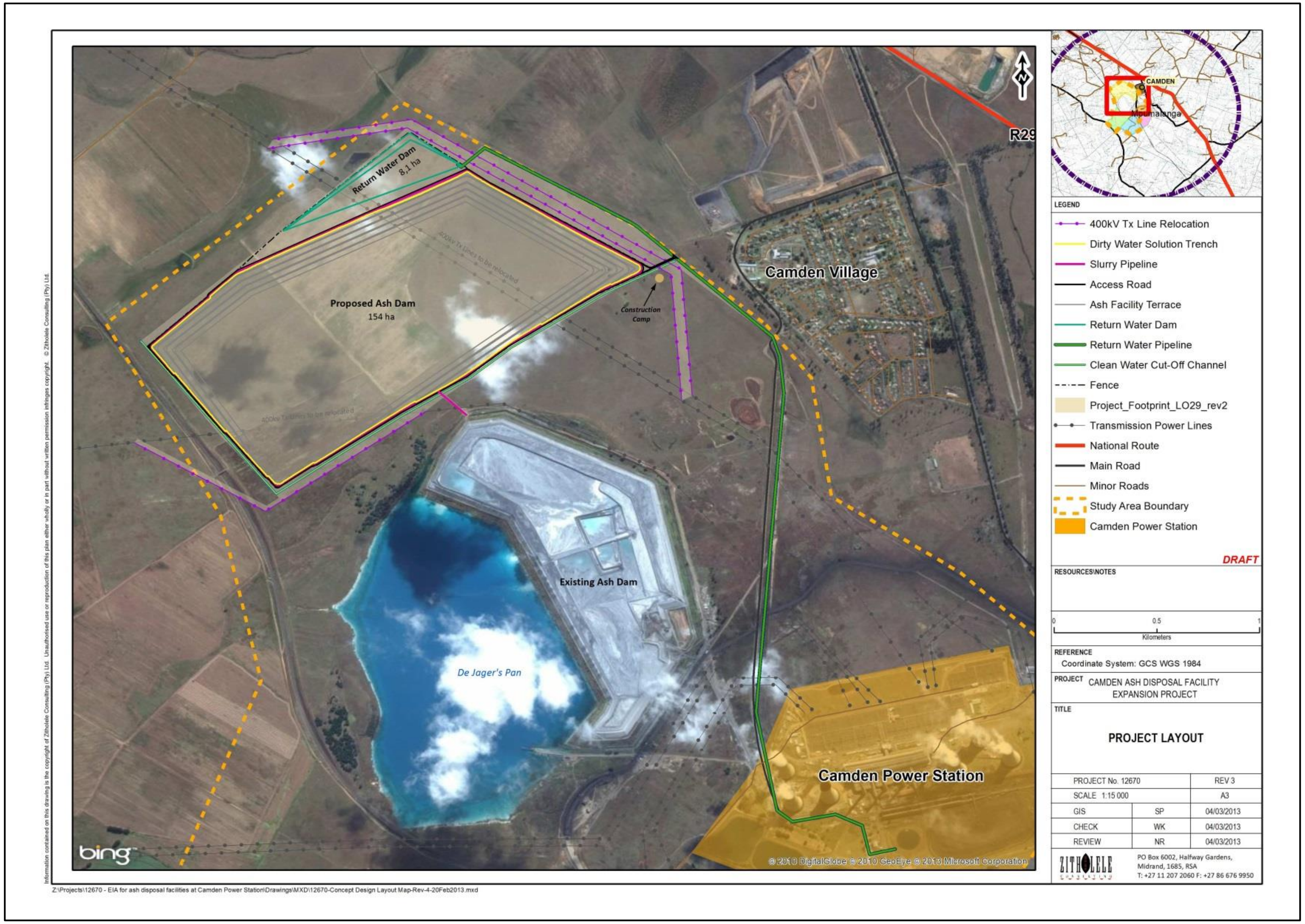

Figure 1: Proposed 154 ha footprint ash dam

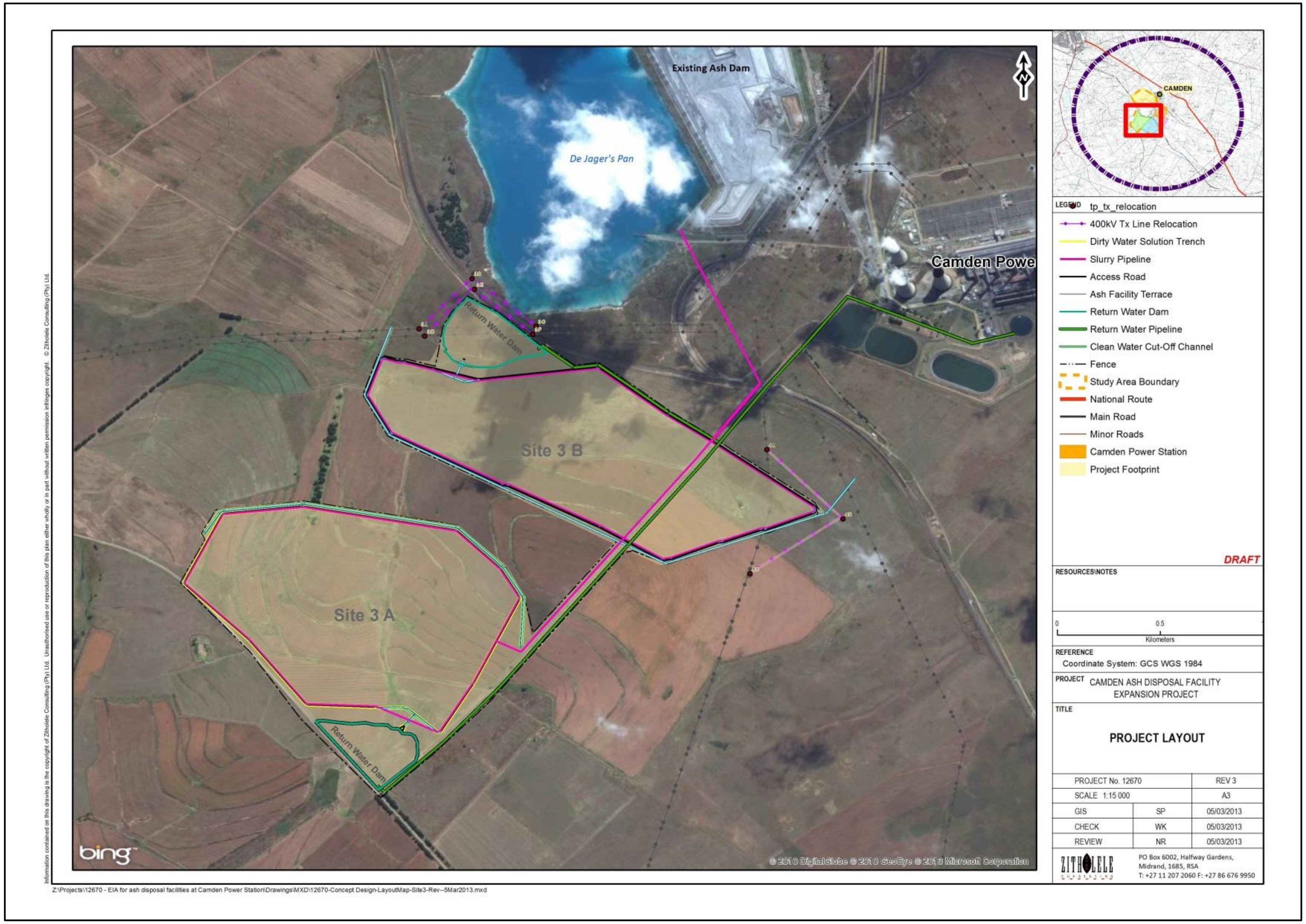

Figure 2: Proposed Site 3 ash dams

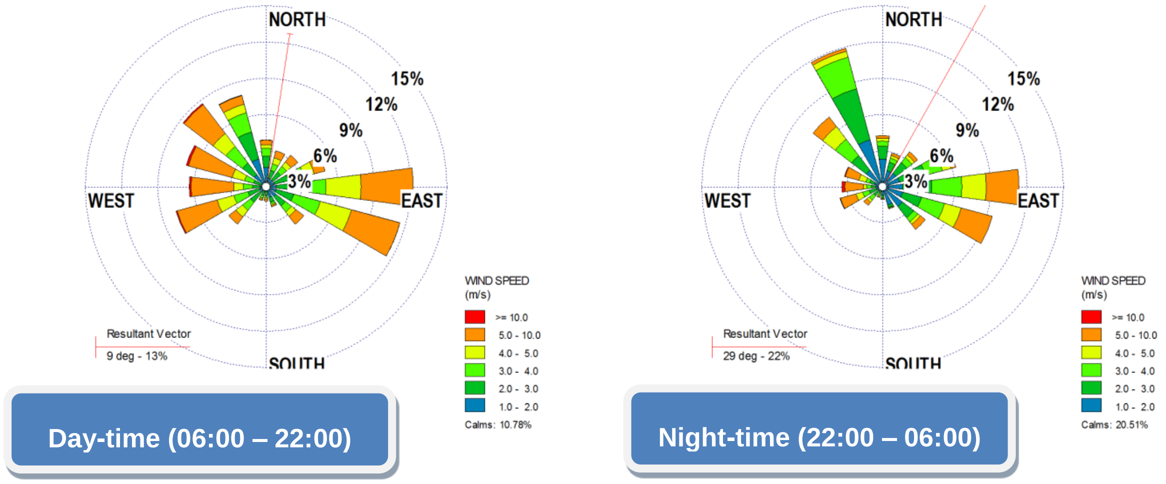

Figure 3: Day and night-time wind roses generated from Eskom Camden data (2010 to 2012)

Temperature gradients in the atmosphere create effects that are uniform in all directions from a source. On a sunny day with no wind, temperature decreases with altitude and creates a 'shadowing' effect for sounds. On a clear night, temperatures may increase with altitude thereby 'focusing' sound on the ground surface. Noise impacts are therefore generally more significant during the night.

Table 3: Average meteorological data obtained from Eskom Camden data (2010 to 2012)

Meteorological Parameter	Day-time (06:00 – 22:00)	Night-time (22:00 – 06:00)
Average wind speed (m/s)	3.7	2.6
Average temperature (°C)	16.4	10.5
Air pressure (kPa)	86.5	86.5

5.3 Terrain, Ground Absorption and Reflection

Noise reduction caused by a barrier (natural terrain or installed acoustic barrier) feature depends on two factors namely the path difference of the sound wave as it travels over the barrier compared with direct transmission to the receiver and the frequency content of the noise. Low frequency noise is difficult to reduce with barriers (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). There are no natural noise barriers between the proposed ash dam sites and noise sensitive receptors.

Sound reflected by the ground interferes with the directly propagated sound. The effect of the ground is different for acoustically hard (e.g., concrete or water), soft (e.g., grass, trees or vegetation) and mixed surfaces. Ground attenuation is often calculated in frequency bands to take into account the frequency content of the noise source and the type of ground between the source and the receiver barriers (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Ground cover consists of grass and other vegetation and is considered acoustically soft i.e. conducive to noise attenuation.

5.4 Baseline Noise Levels

It is important to note that the increase in ambient noise level as a result of the introduction of an industrial/mining noise source into the environment depends largely on existing noise levels in the project area. Higher ambient noise levels will result in the less noticeable noise impacts. The opposite also holds true. Increases in noise will be more noticeable in areas with low ambient noise levels. In the absence of site specific baseline noise data, reference is made to SANS 10103 and reported noise levels in districts.

The following can be considered as representative baseline noise levels at noise sensitive areas:

- Farmsteads and remote areas:
  - Day-time noise level – 45 to 50 dBA
  - Night-time noise level – 35 to 40 dBA
- Camden town:
  - Day-time noise level – 50 to 55 dBA
  - Night-time noise level – 40 to 45 dBA

6 Qualitative Impact Evaluation

Noise will be generated during the construction, operation and closure phases of the Project. Potential sources of noise and likely noise impact areas are discussed in this section.

6.1 Construction and Closure Phases

The extent and character of construction and closure phase noise will be highly variable as different activities with different equipment will take place at different times, over different periods, in different combinations, in different sequences and on different parts of the construction site.

Noise sources will include the bulk earthworks and the use of diesel mobile equipment. Reverse warning signals, implemented for safety reasons often result in annoyance, especially during night-time. The transport of construction/closure staff will add traffic related noise.

Construction/closure phase noise from the 1st site will most likely result in increased noise levels at Camden when construction/closure and rehabilitation activities are located at the eastern extent of the site. Considering a background day-time noise level of 50 to 55 dBA at Camden, the increase in ambient noise level is likely to be less than 3 dBA i.e. 'little' reaction with 'sporadic complaints' can be expected. Should construction/closure and rehabilitation activities continue into the night, the increase in noise level may be 5 to 10 dBA due to lower baseline night-time noise levels of 40 to 45 dBA. In increase of 5 to 10 dBA may result in 'little' to 'medium' reaction with 'sporadic' to 'widespread' complaints.

In the absence of noise sensitive receptors closer than 500 m from Site 3, nuisance noise impacts should be less significant than at Site 1. The affected noise impact area around Site 3 will however be slightly larger than for Site 1, especially to the west where baseline noise levels are expected to range between 45 to 50 dBA during the day and 35 to 40 during the night. As for Site 1, night-time noise impacts will be most significant.

6.2 Operational Phase

The operational phase noise impacts are expected to be as a result of the following sources of noise:

- Conveyor noise, mostly from stackers, idlers and drive units.
- Occasional (less than one vehicle per hour) light and medium duty vehicle traffic for ash dam inspection, maintenance and management.

Noise impacts associated with the operational phase is expected to be less significant than during the construction/closure and rehabilitation phases, especially when conveyor idlers, stacker pulleys and moving parts etc. is well maintained.

The increase in day time noise levels at noise sensitive receptors near Site 1 and 3 is expected to be less than 3 dBA. For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable.

During the night, the increase in noise level above the baseline will most likely be less than 5 dBA i.e. little reaction with 'sporadic' complaints can be expected.

7 Management, Mitigation and Recommendations

7.1 Mitigation

Although generally considered low, noise impacts may result in annoyance, especially during the night and specifically during the construction/closure and rehabilitation phases. The management and mitigations measures referred to in this Section should be considered to minimise potential noise impacts from the various project phases.

7.1.1 Good Engineering Practice

For general construction, operational and decommissioning activities the following good engineering practice should be applied:

- All diesel powered equipment must be regularly maintained and kept at a high level of maintenance. This must particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment must serve as trigger for withdrawing it for maintenance.
- All mechanical and electrical equipment i.e. drive units, idlers, pulleys etc. must be regularly maintained and kept at a high level of maintenance. This must particularly include the regular inspection and, if necessary, replacement of noisy elements. Any change in the noise emission characteristics of equipment must serve as trigger for withdrawing it for maintenance.
- To minimise noise generation, vendors can be required to guarantee optimised equipment design noise levels.
- During the planning and design stages of the project, possibly related noise aspects should always be kept in mind. The enclosure of major sources of noise, such as compressor or pump systems, must be included in the design process, since they represent basic good engineering practice.
- All vibrating equipment must be installed on vibration isolating mountings.
- By enclosing the tipper discharge and lowering the conveyor drop height, noise emissions may be reduced. Mechanical and electrical design also influences the amount of noise from stacking and reclaiming operations.
- Re-locate noise sources to less sensitive areas to take advantage of distance and shielding.
- Site permanent facilities away from community areas if possible.
- Develop a mechanism to monitor noise levels, record and respond to complaints and mitigate impacts.

7.1.2 Operational Hours

It is recommended that, as far is as practicable, noise generating activities such as maintenance and construction, be limited to day-time hours (considered to be between 06:00 and 22:00) since noise impacts are most significant during the night.

7.1.3 Noise Management Zone

It is recommended that a noise management zone of be considered around the operations. This area should corresponds to the area over which noise levels may result in annoyance i.e. complaints and occasional community action. Complaints and noise levels in this area should be recorded and monitored and results communicated to interested and affected parties.

7.2 Noise Monitoring

It is recommended that, should the project continue, ambient noise measurements be conducted prior to construction as well as during the construction, operational and closure phases to assess and confirm the impact area. Specific attention should be paid to noise levels at Camden and other noise sensitive areas.

The frequency of noise monitoring as well as the parameters that should be determined are summarised in Table 4.

In addition to the measurement of sound pressure levels, the 3rd octave band frequency spectra should also be recorded. Frequency spectrum data can provide useful insight into the nature of recorded sound pressure levels and assist with distinguishing between potential sources of noise that contribute to noise levels at a certain location. Source noise measurements could be conducted to confirm equipment manufacturer sound power data and assumed sound power data used in the current study.

Table 4: Proposed monitoring plan

Proposed Monitoring Plan	
Parameters to be Measured	**Frequency**
L_{Aeq}(1 hour) between 06:00 and 22:00	One campaign prior to the construction phase One campaign during the construction/closure phase One campaign per year of operation
L_{Aeq}(1 hour) between 22:00 and 06:00	One campaign prior to the construction phase (if applicable) One campaign during the construction/closure phase (if applicable) One campaign per year of operation
3rd Octave band frequency spectrum	During every campaign

8 Conclusions

Airshed was appointed by Zitholele to undertake a qualitative noise impact evaluation for the continuous disposal of ash at the Camden Power Station.

The main findings of the noise impact evaluation are as follows:

- The closest noise sensitive receptors are residents of Camden, approximately 400 m from the eastern corner of Site 1. Farmsteads are located approximately 2 km west of Site 3A and 2.3 km south-east of Site 3A and Site 3B
- Ground cover in the study area is considered 'acoustically soft' i.e. conducive to noise attenuation.
- The prevailing wind field indicate that day-time noise impacts will most likely be most significant to east and west; and night-time impacts to the south-southeast.
- An increase of 5 dB in ambient noise level is considered the indicator of noise impacts. This is the level at which 'little' community reaction with 'sporadic' complaints can be expected.
- The following baseline day and night-time noise levels are expected to prevail:
    - Camden:
        - Day-time noise level – 50 to 55 dBA
        - Night-time noise level – 40 to 45 dBA
    - Rural/Remote Areas:
        - Day-time noise level – 45 to 50 dBA
        - Night-time noise level – 35 to 40 dBA
- Although the difference between noise impacts from Site 1 and 3 is not considered significant, the following was found:
    - Due to lower baseline noise levels the impact area round Site 3 will be slightly larger than around Site 1.
    - For both Site 1 and 3, night time impacts will be more significant.
    - If unmitigated 'medium' community reaction with 'widespread' complaints may be expected, specifically during the night.
    - If mitigated 'little community reaction with 'sporadic' complaints may be expected, again during the night. The increase in day time noise levels will most likely not be noticeable at Camden and surrounding farmsteads.

9 References

Brüel & Kjær Sound & Vibration Measurement A/S, 2000. *www.bksv.com.* [Online] Available at: http://www.bksv.com
[Accessed 14 October 2011].

SANS 10103, 2008. *The Measurement and Rating of Noise and Speech Communication.* Pretoria: Standards South Africa.