THE PROJECTED ECOLOGICAL IMPACT OF THE KUSILE ASH DISPOSAL FACILITY ON BAT SPECIES RICHNESS AND POPULATIONS VIGOUR (Report version 2 dated 1 May 2013)

by

I.L. RAUTENBACH Ph.D., Pr. Sci. Nat. # **400300/05**

Commissioned by
Zitholele Consulting
P.O. Box 6002
Hafway House 1685
Tel. 011 20072060
Fax 086 6746121
E-mail mail@zitholele.co.za
http://www.zitholele.co.za

On behalf of ESKOM Holdings SOC Limited

I.L. Rautenbach, Eco-Agent CC, PO Box 25533 Monument Park 0105. 0823351288 012 3331224 Fax 012 4602525 **May 2013**

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- hold a Ph.D. in the biological sciences, which allowed registration by SACNASP (SA Council for National Scientific Professions) as a Professional Zoologist and sanctions me to function independently as a specialist scientific consultant
- declare that as per prerequisites of the Natural Scientific Professions Act No. 27 of 2003 this project was my work from inception and reflects exclusively my observations and unbiased scientific interpretations, and executed to the best of my ability
- abide by the Code of Ethics of the SACNASP
- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate opportunities to learn through constructive criticism and debate, I reserve the right to form and hold my own opinions within the constraints of my training and experience, and therefore will not submit willingly to the interests of other parties or change my statements to appease them
- am subcontracted as a specialist consultant by Zitholele Consulting CC for the project "The Projected Ecological Impact of the Kusile Ash Disposal Facility On Bat Species Richness and Populations Vigour", as described in this report
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- have, and will not have in the future, any vested or conflicting interests in the proposed development
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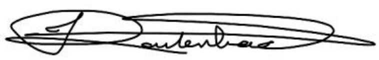

I.L. Rautenbach

ABSTRACT
It is concluded that 17 insectivorous bats occur permanently or infrequently within a radius of 20 kilometres of the Kusile plant. Some of these species are common; others are ranked as Red Data species. Fruit bats are naturally absent. The new ash disposal facility will disrupt the *status quo* in an area within a radius of 20km from the Kusile plant.

Areas A Big, G1 and G2 are almost totally devoted to maize production and fail to excite ecologically. They are also closest to the Kusile plant, a setup which is economically favourable.

Scenario 1 (Area A; 1472 hectares) is therefore favoured herein for establishing an ash disposal facility. The 1857 ha of Scenario 4 (Areas G1 and G2) would be a second choice. It is proposed that Area B is not selected because of its high agricultural potential and Area C for its high ecological value. An adjunct consideration is that ESKOM has already invested vast sums in constructing four high tension power lines, and if possible excluding Area C from consideration will result in considerable savings. Although Area F is tilled it is argued that it should be saved because of the neighbouring dams and endorheic pan. Comparative weighted post-mitigated assessments following 18 January and 19 March workshops echo these observations.

Within the strict constraints of this report, only the bulk of the ash disposal facility should be evaluated. In terms of its physical nature, 1300 - 2000 hectares of primary producers or planted fields will be permanently destroyed, and the 90 meters height of the dump will deprive aerial insects and hawking bats of airspace. Relatively speaking this will be of no consequence.

However, linked secondary and tertiary side effects must inevitably be considered, namely ash as sources of environmental poisoning. A secondary effect could be the toxic substances leached and percolated from the bottom ash stored in the prerequisite disposal facility, and a tertiary effect might? be toxic elements in nano-configuration which are not removed by scrubbers from flue emissions. This need to be confirmed by waste and air quality specialists. Should there be no environmental poisoning in any form, no reason for concern exists.

A poisoned environment will have a detrimental effect on ecological functions of the area, leading to reduction or demise of critical elements such as trophic levels or minimum population densities. The extent of such responses depends on the presence/absence of pollution and its rate of accumulation.

The effect of environmental poisoning will be more profound to species residing at the apex of the food triangle, such as insectivorous bats.

At a secondary and tertiary level of ecological concern it is not clear whether the escape of poisonous substances from bottom and fly ash into the environment and ultimate dissemination by waterways can be contained and to what extent. If gradual poisoning is a fact, it cannot be condoned.

Following the NEMA Regulations, the Wilge River and its tributaries are collectively red-flagged as a decidedly No-Go system, i.e. must be protected from pollution. The ecological integrity of the Wilge River, tributaries, drainage lines, dams and riparian zones is legallt non-negotiable. It is clear that irrespective of the selected site for an ash disposal facility there will be an unavoidable loss of wetlands, which is important to hawking bats but in this instance -not of survival importance.

Since bats are sensitive indicator species, it is suggested that two bat surveys are conducted annually during summer to monitor for abnormal population deviations which will signal ecological distress.

1. ASSIGNMENT – Eco-Agent Protocol

The soon-to-be-completed Kusile Power Station will be, next to Medupi, the largest and most modern coal-burning power generating plant in Southern Africa. The facility will require 1300 – 2000 hectares to dispose ash to a height of 90 meters over the 60 years operational lifespan of the facility.

Zitholele Consultants commissioned this appraisal of bat species richness and population dynamics at the six Scenarios proposed for the Kusile Ash Disposal facility. The quality of bat habitats was assessed. The likely impact of the ash disposal facility on bats and their life-support systems were then discussed. The risk of consequences of environmental poisoning is explored and taken into account in proposing site selection. This assignment is in accordance with the 2010 EIA Regulations (No. R. 543-546, Department of Environmental Affairs and Tourism, 18 June 2010) emanating from Chapter 5 of the National Environmental Management Act, 1998 (Act No. 107 of 1998).

The assignment is interpreted as follows: Conduct a study of the bats occurring or likely to occur on or near the five proposed sites, with an emphasis on Red Data species.

1.1 Initial preparations

- Obtain and consult relevant maps, orthophotos and information on the natural and land-use environment of the concerned area.

1.2 Bat assessment

- Compile lists of the bats that can be expected in the area, through literature review.
- Identify the Red Data species that occur (or may occur) on the site.
- Assess the quantitative and qualitative condition of suitable habitat for bats deemed present, and in particular for Red Listed bats.
- Quantify comparative impact assessments at pre- and post-mitigated levels, following the Zitholele protocol.

1.3 Environmental risk

- Explain the nature of solid and flying ash, speculate on environmental impact and suggest mitigation measures.

1.4 General

- Identify and describe ecologically sensitive areas or systems.
- Map sensitive areas.
- Identify problem areas in need of special treatment or management e.g. conditions amenable to the formation of feeding patches, water pollution, and reclamation areas.
- Make recommendations on aspects that should be monitored during development.

2. RATIONALE

Environmental conservation is no longer the prerogative of vocal left-wing 1960s-style green activist NGOs. Instead it is now universally appreciated that a rapidly-growing and more demanding human population is continuing to place exponential stress on the earth's resources with irredeemable costs to ecosystems. It is also recognized that ecosystems are in fact nature's 'engine room' to manufacture fundamental live-support products for plants, animals and humans. Environmental degradation ranges from mega-problems such as global warming, demand for power, land-use practices to indiscriminate use of household chemicals.

The new conservation awareness is settling at all levels ranging from consumers, school curricula, communities to governments. This new consciousness is typified by vigorous debate and empathy, and sometimes by decisiveness (*viz*. new legislation).

In South Africa a number of acts, (viz. the Environment Conservation Act [Act 73 of 1989], the National Water Act [Act No 36 of 1998], The National Heritage Resources Act [No. 25 of 1999], The Constitution of the Republic of South Africa Act [No 108 of 1996], the National Environmental Management Act [NEMA] [Act 107 of 1998 as amended in 2010], , the National Environmental Management Biodiversity Act, [Act 10 of 2004], the National Environmental Management: Waste Act [NEM:WA] [Act 59 of 2008], and the Environmental Impact Assessment Regulations: GN R. 543-546 of 18 June 2010, as amended (Gazette No 33306 – Regulation 547)) call developers (and by implication consumers), the scientific community and conservation agencies to task to minimise environmental impact. The conduct of natural scientists is directed by the Natural Scientific Professions Act (Act 27 of 2003). Nowadays a development prerogative is to precede new constructions by a multidisciplinary environmental investigation to assess the conservation costs. This is to ensure that best conservation practices are applied during the planning, construction and operational phases of new developments.

3. SCOPE AND OBJECTIVES OF THE STUDY

- To conduct field work to a level of confidence required for decision-making;
- To submit a detailed description of the baseline receiving environment;
- To offer inputs to the trade-off assessment;
- To consider comparative impact assessments of the six alternatives defined under the chapter describing the Study Area;
- To conduct a sustainability assessment for each alternative;
- To describe different bat micro-habitats as well as the species associated with those habitats;
- To map bat sensitive areas on orthophotos for easy reference, and particular emphasis is to be placed on habitat for Red Data and endemic species;
- To describe as fully as possible the potential impacts (direct and indirect) relative to the specific developments;
- To assess and evaluate the potential impact on the bats according to the criteria that are required by the Environmental Assessment Practitioner;
- To recommend and (if need be) discuss practical mitigation measures;
- To consider and petition the need for a monitoring programme in the Environmental Management Programme phase and propose such a programme;
- To recommended management and mitigation measures in a Management Plan Format;

- To derive weighted comparative impact statements to substantiate preference for the preferred alternative as per Zitholele impact assessment methodology;
- To offer a specialist opinion on the preferred alternative; and
- To also assess the no-go alternative in terms of the NEMA Regulations.

4. BAT BIOLOGY IN CONTEXT OF THIS ASSIGNMENT

A grasp of bat biology will assist in an appreciation of species richness and resource partitioning amongst species on the Kusile terrain.

4.1 Background

Until a few decades ago very little was known about bat biology, primarily as result of their small physique, nocturnal life style and unique and reticent life styles. Bats were strong contenders as the most misunderstood animals. However, within the last 30 years advanced technologies made it possible to probe the biology of bats with equipment such as macro mist-nets, radio telemetry, bat detectors (bio-acoustics), portable bat radar units, and more recently satellite tracking. A spate of publications resulted in a number of books reviewing the extant body of knowledge, notably Hill and Smith (1984), Schrober (1994), Fenton (1992 and 1992), Kunz and Racey (1998), Fenton, (1998).
Environmentalists are now able to document and evaluate the importance of these unique creatures in ecosystems and food chains. For example, recently environmentalists and decision-makers became perturbed about insufferable barotrauma bat fatalities caused by wind turbines resulting in enormous (sometimes irreversible) ecosystem costs.

Because of their varied and complicated adaptations, bats are well suited as indicator species of the health of an ecosystem.

4.2 Evolutionary Origin

Bird speciation is much more copious than that of bats and resulted in anatomically and biologically supreme~~ly~~ adaptations to a flying life style. The origins of birds date back to the Cretaceous period (120 – 60 million years ago), *inter alia* illustrated by a fossil of a birdlike dinosaur dated 120 million years old. Because of their weight-saving porous bone structure, the early evolution of birds is poorly represented by fossils. It is, however, clear that by the emergence of the first bats in the fossil history, birds have established themselves as a successful and diversified group of warm-blooded, bipedal, egg-laying, feathered group (Class Aves) of creatures supremely capable of flight. Since their origin, birds were diurnal and occupied all daytime niches available to flying vertebrates.

The fossil records of bats extend back to the early Eocene (ca. 60 million years ago) in Africa, North and South America, Asia and Europe. By 35 million years ago the Megachiroptera (fruit bats) and Microchiroptera (insectivorous bats) have already diverged, and possessed both primitive and present-day advanced characteristics. However, the original newly evolved flying creatures could not compete for diurnal niches with the well-established birds and had to develop alternative survival strategies, notably switching to a nocturnal lifestyle and "seeing in the dark with their ears", i.e. echolocation.

4.3 Zoogeography

Bats are, next to rodents, the most widespread and numerous assemblage of mammals (Order Chiroptera) in the world as well as in Southern Africa (about 20% of local mammal species are bats). In the world 1200 species and in the Subcontinent 80 species (Bronner *et al*. 2003; Taylor et al., 2012) have been described to science. However, there is a species richness cline from west to east, and from south to north towards the tropics (Rautenbach, 1978). Another cline in bat diversity is an altitudinal one effective in the central and eastern regions of South Africa. Higher altitudes result in a climatic regime which enforces a Highveld grassland biome with a concomitant reduced number of bat niches. Fundamentally there is a close correlation between ecological complexities offering a concomitant higher number of bat niches; in other words, the riparian forests cutting through savannahs in the subtropics and tropics harbour more species than the central Highveld grasslands and especially the coastal areas of the Western Cape.

4.4 Niche Occupation:

Although bats have eyesight comparable to humans, this was from inception insufficient for a nocturnal and flying lifestyle. However, the plethora of niches available for flying creatures were so lucrative, that bats evolved new features to capitalize on these opportunities during night such as extremely flexible wings, enlarged eyes and fruit tree clambering abilities in fruit bats, and particularly a highly advanced echolocation ability in Microchiropteran bats. Minor anatomical adaptations catered for the occupation of specific niches such as extraordinary robust dentition adapted to deal with the tough exoskeletons of beetles, enlarged ears to maximise reception of attenuated reflected echolocation calls, etc. (*viz*. Stoffberg *et al*., 2011).

4.5 Echolocation Characteristics

A plethora of niches closely related to an aerial life-style exist, and encompass airspace partition, diet, refuge and breeding opportunities. By the time bats evolved as possible contenders for these opportunities by day, all niches were successfully occupied by birds. However, all "flying" niches utilized by birds by day, were vacant by night. Bats responded to this incentive by evolving two strategies, namely improved night-sight in the case of fruit bats (Megachiroptera) (see Frontispiece), and highly sophisticated echolocation abilities by the greatest majority of bats (Microchiroptera, i.e. insectivorous bats) (Adams et al., 2012). Echolocation by bats is often equated to "seeing with their ears".

Echolocating bats produce a staccato of short-duration ultra sounds in their voice boxes which are projected forward through their open mouths into air space, and waves reflecting from solid objects as small as insects are received by the ears and interpreted by the brain to calculate the trajectories of both bat and the solid object in space. This information is used to avoid solid obstacles (natural clutter such as branches) or catch prey such as flying insects. This ability has been found to be more than 95% successful in bats hunting prey as small as midgets swarming around lights.

Echolocation ultrasound varies from ca. 20 kHz (at higher dB values) such as in the case of free-tailed bats (Molossidae) to >120 kHz (at low dB values) in the case of Southern African whispering bats (Rhinolophidae, Hipposideridae and Nycteridae). Bats characteristically emitting at lower frequencies cope with lower resolution but at longer distances up to 30 meters. Conversely, whispering bats enjoy a high resolution able to detect a small insect sitting on a branch, but at the distance of < 3 meters (Aldridge et al., 1987).

Echolocation characteristics are largely species specific (Taylor, 1999; Stoffberg et al., 2011), and modern bio-acoustic equipment and software can identify bats from their echolocation calls. (See for instance Avisoft website http://www.avisoft.com/).
It should be obvious that differing echolocation abilities alone enable a bat species assemblage to specialize and thus largely avoid resource competition (*viz*. Jacobs and Barclay, 2009).

4.6 Wing structure

Birds have rigid wings, which is the result of some forelimb elements (viz. fingers) which became lost and others having been fused to yield a feathered limb capable of fast and sustained flight. In bats no forelimb element became lost or fused, and in most cases fingers became elongated and support a double-layer of flexible skin reaching to the body and even to the back limbs to form a large wing (See frontispiece). The aspect ratio of a bat wing can be infinitely altered by minute movements of individual fingers, resulting in exceptionally acrobatic flight. So, although bats cannot fly the distances that migrating birds can, they can outmanoeuvre birds. This is a great advantage to bats hawking for circling insects.

Furthermore, the wing-loading of bats differ greatly (Aldridge et al., 1987). On the one hand free-tailed bats have narrow and elongated wings resulting in high wing loading indices. These bats fly at high speeds in open airspace since they do not have great flight manoeuvrability, and require roosts from where they can free-fall for at least a meter in order to gain enough airspeed to become fully airborne. These are the group of bats that are characterized by echolocation features of ca. 20-40kHz which allow them to detect larger prey at larger distances and which permit them sufficient time to adjust their trajectories to intercept their quarries.

On the other side of the gradient are the wings of horseshoe bats (*Rhinolophus*). The wings are broad and wide as result of elongated finger elements and a wing membrane of maximum size extended to the flanks and interfemoral membrane. The wing loading of these bats is low and slight movements of the fingers allow a great dexterity allowing horseshoe bats to navigate dense natural clutter. This type of wing configuration is closely related to a high frequency of >100 kHz. This combination of low wing loading, deftness and high ultrasonic resolution allow these bats to hunt insects in and amongst canopies and understories safe from competition from molossid and vespertilionid bats. Vespertilionids have in-between wing constructions, flight nimbleness and ultrasonic frequencies allowing them to feed for prey in air spaces such as below or above canopies of larger trees.

4.7 Food and feeding strategies

Fruit bats do not hibernate, echolocate or have a complex reproduction strategy. They fly from fruit tree to fruit tree, and to compensate for a lack of a sophisticated system to “see” with their ears, they clamber around in fruiting trees rather like primates. Colonies of fruit bats migrate locally to find fruiting trees and often roost in sheltered areas in a nearby tree. Mega bats digest and excrete a fruit meal within 45 minutes to allow for more nightly food intake. By exploring for fruiting trees, epauletted fruit bats expanded their lowveld distributional range to Pretoria where there is an abundance of fruit in gardens; suburban Pretoria is of course nowadays an extensive artificial forest allowing fruit bats into an area where they could not exist in historical times. In natural settings, Southern African fruit bats are more common in riparian forests where they are partial to figs growing year-round on a number of *Ficus* species.

Insectivorous bats have two main strategies for catching prey. The first is hawking for prey, i.e. continuous flight in search of prey and consuming victims in flight. Bats with acute echolocation and auditory abilities often hang in so-called night roosts (strategically located near a source of terrestrial insects, like under the roof of a veranda). These bats use their highly-developed sense of hearing to sense a moving terrestrial insect, then switch on the echolocation to determine its exact location, swoop down to execute the kill and then return to the night roost to consume the spoil and wait for the next insect to make a move. The majority of micro bats are insectivorous, but some specialise on larger beetles with tough exoskeletons (viz. house bats), others prefer moths (viz. whispering bats), and smaller species feed on small soft-bodied insects, *inter alia* mosquitoes. Some micro bats even prey on vertebrates, such as *Nycteris grandis* feeding on fish and frogs (Fenton et al., 1993). The notorious vampire bats of South America also belong to the Microchiropetera but has adapted to an exclusive diet of blood.

4.8 Roosts

Roosts are of survival importance to all bat species, particularly to avoid predation and the detrimental effect of extreme climatic extremes (Fenton et al., 1986). Roost prerequisites vary between and within species. All whispering bats (Rhinolophidae, Nycteridae and Hipposideridae) as well as some Vespertilionidae species (viz. *Miniopterus* spp) are collectively so-called cave bats. The cool, moist and dark interiors of deep caves, rock overhangs, crevices, deep aardvark burrows and manmade structures such as mine adits, abandoned buildings and bridge tunnels are of survival importance to these bats. Free-tailed (Mollossidae) bats prefer narrow crevices with entrances >1 meter above ground to allow sufficient airspace in which emerging bats can free-fall to gain air speed to become airborne. Vespertilionid bats are more catholic in their roost selection, which can vary from rolled-up banana leaves, amongst palm fronds, under loose bark, cracked dry tree limbs and even under roofs. Domestic roosting opportunities allowed some bat species to expand population numbers, and it is suspected even distributional ranges. Colony numbers of the little free-tailed bat (*Chaerephon pumila*) can attain pestilence levels in some houses in the lowveld and along the KwaZulu-Natal coast.

4.9 Energy budgets

Flying is the most costly mode of passage in the animal world, and micro- and macro bats can easily expend more energy than what they gain in prey captures or ripe fruit. That is why bats are often seen to gorge themselves on insect concentrations around lights or on swarms rising over water or swamps at dusk (collectively termed ‘feeding patches’). It has been calculated that bats can nightly consume insects as much as 80% of their body mass; that is especially the case during spring when foetuses are growing fast, or the 2 weeks weaning period of pups during mid-summer, or autumn when bats need to accumulate fat reserves to overwinter.

Bats are known to commute as much as 5km (Fenton *et al*., 1985) to >15km (McDonald et al., 1990) to feeding areas, and the costs of such travelling need to be offset with energy gain in the form of food.

It stands to reason that if no lucrative feeding patches or at least random distribution of aerial insects are available within a reasonable commuting distance to allow energy gains over expenditures, bats will be displaced or will perish.

4.10 Seasonality

It is clear that insectivorous bats experience winter as a stress period as result of a dearth of insect prey. It has been mentioned that bats enter in a feeding frenzy during autumn to build up fat reserves to sustain them during winter. Bats have evolved three main strategies to deal with this:

a. Bat species inclined to remain localised can enter torpor. Body temperatures are lowered and physiological functions are slowed over shorter periods to preserve fat reserves. Somehow bats can sense milder environmental conditions and can exit the effect off torpor to sample their air spaces for prey.
b. Bat species can enter hibernation, which is a physiological form of a deep winter sleep. This is more often the case for bats occurring in areas experiencing extreme conditions during winter, such as snow or at least lasting biting cold ambient temperatures. Hibernating bats lower all their physiological functions, such as for example one heart beat per minute, and maintain physiological functions by burning accumulated fat. For instance, Shreibers’s long-fingered bats were found to migrate from their summer breeding caves in moderate savannah regions to cold dolomite caves on the Witwatersrand to hibernate (van der Merwe, 1973).
c. Some insectivorous bats migrate to more moderate regions. For instance, at the onset of winter the Mauritian bat migrate from the Highveld to the tropics until the onset of summer in the southern regions.

4.11 Reproduction

Bats have a complex existence, and a number of environmental conditions need to be coped with. Insects are not abundant during winter, translating winter as a stress period for insectivorous bats and forcing them in an overwintering mode. Most bats no longer can reproduce like normal mammals. Following overwintering by hibernation / torpor / migration insectivorous bats do not have sufficient time during early spring to replenish body reserves to cope with the rigours of mating and pregnancies; therefore they mate during autumn when they have ample energy and fat reserves. However, since there is a direct relationship between body size and gestation period; small mammals similar in size to 6 – 30 g bats have a gestation period of 2-3 weeks. It is clear that should bats subscribe to the normal mammal pattern by mating during autumn they will give birth during an unfavourable period (winter). A special strategy to avoid energy-sapping motherhood during winter evolved.

Mega and Micro bats follow one of four strategies:

a. Fruit bats do not hibernate, neither do they migrate. They find year-round subsistence from wild fig trees who are year-round (to a greater or lesser extent) in fruit. As a consequence, fruit bats can mate during spring, and females can have a normal uninterrupted pregnancy to deliver single pups during mid-summer.
b. Some insectivorous bats mate during autumn and the sperm are stored with their heads imbedded in the uterus wall till spring, when normal fertilization and foetal development follows.
c. Some insectivorous bats mate during autumn and the eggs are fertilized and then preserved in an *in limbo* state till spring when the normal development process is commenced.
d. Some insectivorous bats mate during autumn, ova are fertilized and foetal development is commenced, and is then interrupted till spring.

4.12 Life expectancy

In mammals there is a direct relationship between body size and longevity. A mammal the size of a 6 – 10 g bat normally has a physiological life expectancy of two years; much less in a dynamic ecosystem. Micro bats, however, can attain a physiological age of 26 years (a *Rhinolophus clivosus* from a cave near Kimberley ex the Transvaal Museum bat banding programme). However, bat banding programmes at the Pafuri research centre, revealed micro bats seldom exceed two years in age (= ecological age).

4.13 Predation

Bats are subjected to predation, particularly by a number of raptors such as inter alia Wahlberg's eagles (Fenton et al., 1994), goshawks (Rautenbach *et al*., 1990) and bat hawks (Kemp et al., 1987). Small carnivores such as genets and mongooses are also opportunistic predators, especially of cave bats. The reason for cave bats hanging from ceilings is partially explained as predation avoidance behaviour. Bats show a variety of predation avoidance behaviours such as alertness (epauletted fruit colonies), roosting high up on cave walls and ceilings, roosting in deep crevices (Molossidae, some Verspertilionidae). Some species also roost in relatively inhospitable environments and commute to optimal feeding area.

5. STUDY AREA

5.1 General

The new 4800 MW Kusile Electricity Generating Plant between Bronkhorstspruit and eMalahleni (Witbank) on the N4 will be coal fired and the coal will be supplied via a conveyer belt by a new colliery near the power station. Ash will be transported over a distance of less than 15km by another conveyer belt and associated structures. Kusile is the second most advanced coal-fired power plant after the soon-to-be-completed Medupi power station in Lephalale. The Kusile power generation installation is planned to have a life expectancy of 60 years.

Generally the Kusile area is rural and devoted to agriculture, but this ambience will change when the power station will become fully operational complete with an ash disposal facility fed by a conveyer belt, and fuel fed by the opencast coal mining process.

This report focusses on the ash disposal facility plus associated amenities (conveyor, power, roads, water management, etc.) within 15 km from the Kusile power generating plant and which over a projected operational lifespan of 60 years will grow to a mound of ca. 1500 hectares and 90 meters high. Coal fly ash and bottom ash contain noxious elements, of which heavy metals are particularly harmful to the environment. It is understood that engineers will treat coal ash to qualify as non-hazardous waste, and that the ash disposal design will preclude leaching into the environment (http://www.acaa-usa.org/). These claims are contested by overviews on the World Wide Web (http://en.wikipedia.org/wiki/Fly_ash). The possibility of environmental poisoning is treated here as an environmental risk and consequently contentious. Hence monitoring environmental health using indicator bat species is proposed in this treatise.

5.2 Land use

Presently the collective land use of the proposed development sites is all agrarian in character, ranging from cattle grazing with low-key environmental impact, to monoculture (maize production) which totally transformed the historical biodiversity. Topography has been minimally altered by the construction of access roads, dam walls, contours and miscellaneous earth works.

The rural character of the area will be incrementally marred by the operation of the power station and especially by the growth of the ash disposal facility. It is impossible (and to a great extent irrelevant) to predict the detail of the effect on the environment by superimposing the future activities related to power generation.

5.3 Geographical properties

The six designated areas (reconfigured as six Scenarios) within 15km of the Kusile power plant earmarked for consideration as the prerequisite ash disposal facility fall in the Rand Highveld Grassland vegetation unit as defined by Mucina and Rutherford (2006). This floral association is considered as endangered with only 1% enjoying formal conservation *pace* an ideal of 24%. However, it should be noted that the Rand Highveld Grassland vegetation unit is already largely transformed within a radius of 15 – 20 km from the Kusile plant. The topography of the area consists of undulating plains typical of the Highveld of the interior.

The Rand Highveld Grassland vegetation unit lacks (like many other Grassland Biome units) significant stands of indigenous trees. This means that roosting opportunities for bats are arranged along a single (horizontal) plane only. In the savannah regions bat niche opportunities are arranged in horizontal and vertical (in mature trees) planes, as such offering more roosting opportunities for bats. This is another reason why bat species richness is lower in the grassland biome than in the woodlands of the savannah biome.

The study area lacks significant mountains or ridges with rock faces. Hence there are no caves, rock overhangs or crevices providing cool and moist daytime roosts for cave-dwelling bats. However, manmade structures (dark, humid and cool cellars, attics, culverts, mine adits etc.) are regularly populated by cave-dwelling bats. See Niche Occupation (Section 4.4) and Roosts (Section 4.8) above.

A major feature of the general area is the Wilge River, its tributaries and associated wetlands.

5.4 Sites identified for development

Having already rejected seven sites as ash disposal localities, six remaining areas have been identified as wholly or partial candidates; these are respectively designated as A, B, C, F, G and A_{small}. These are spatially defined by the coordinates scanned from a shape file.

Area A: 25º 57' 33.1"S; 28º 54' 22.6"E;
Area B: 25º 53' 03.8"S; 28º 48' 02.0"E

Area C: 25º 52' 33.7"S; 28º 54' 09.0"E

Area F: 25º 55' 46.1"S; 28º 52' 19.3"E

Area G: 25º 58' 55.1"S; 28º 52' 39.6"E
Area A_{small}: 25º 57' 54.7"S; 28º 52' 39.6"E

5.5 Specific study sites

In order to attain an ash disposal facility of sufficient capacity (1300ha to 2000 ha) the Areas specified above are to be considered in the following prescribed Scenarios, which are therefore treated as independent study areas. Only salient environmental characteristics as they relate to bat ecology are documented:

5.5.1 Scenario 1 (Area A), on Portions of the Farm Klipfontein 566 JR and Dwaalfontein 565 JR. 1472 Hectares. Partially overlying Areas A_{small} and F. This particular Scenario consists predominantly of cultivated and fallow maize fields. However, an important ecological feature of the site is the Holfonteinspruit. The integrity of the stream has been honoured during the agricultural phase of the site by a >32 meters wide buffer zone on either bank. In terms of bat ecology this stream and its riparian zones are ecologically important as breeding ground and habitat for invertebrates which during summer dusks would rise as swarms to form rich feeding patches for hawking bats.

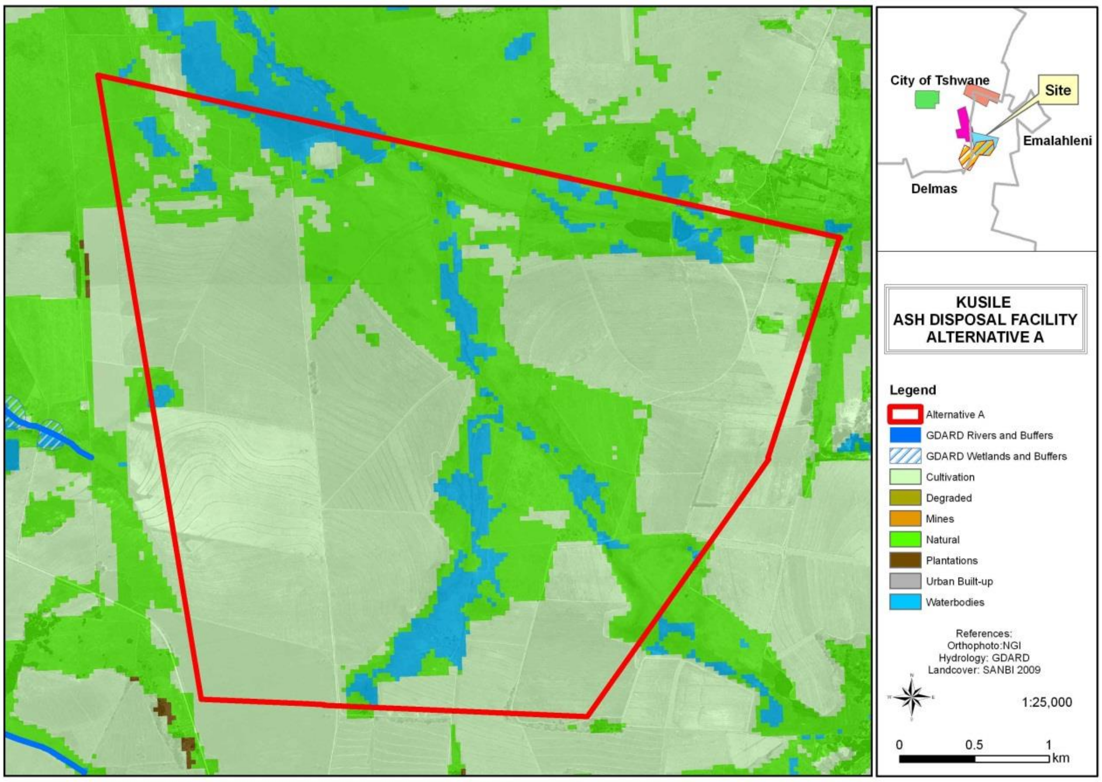

Figure 1: Orthophoto of the 1472 hectares Scenario 1 (Area A). Note the extent of the Holfonteinspruit and wetlands. GDARC Rivers and Buffers (dark blue) and Waterbodies (bright blue) mapped, are deemed as sensitive.

Figure 2: A north-easterly view over Area A as ensconced in Scenario 1, photographed from the westerly access road from waypoint 25º 57’ 52.0”S; 28º 54’

22.5”E. In the foreground regenerating grassland can be discerned, in the middle ground the Holfonteinspruit with its lush riparian zones, and in the distance the Kusile plant currently under construction.

5.5.2 Scenario 2 (Area B), on Portions of the Farms Witlklip 539 JR, Jakhalsfontein 528 JR, Nooitgedacht 525 JR and Bossemanskraal 538 JR. 1330 Hectares. This site has been subdivided into a number of smaller agricultural units ranging in size from 11 smallholdings to seven smallish farming units. The properties comprising Scenario 2 are intensively farmed and collectively have the highest agricultural production. As result of the many farming units a higher number of homesteads have been erected on or within commuting distance from the site, all of whom have a high likelihood of sheltering bat colonies during daylight in buildings and related structures. Most of the arable land has been devoted to growing maize crops, amongst others by spill point irrigation or contoured dry fields. One farmer concentrated on growing produce in a battery of tunnels. Streams have been dammed to provide water for such intensive irrigation.

Apart from the great distance to transfer ash from the power plant, is the fact that the conveyer belt will traverse the Wilge River en route to Area B (Scenario 2). This is an undesirable situation with a high risk profile.

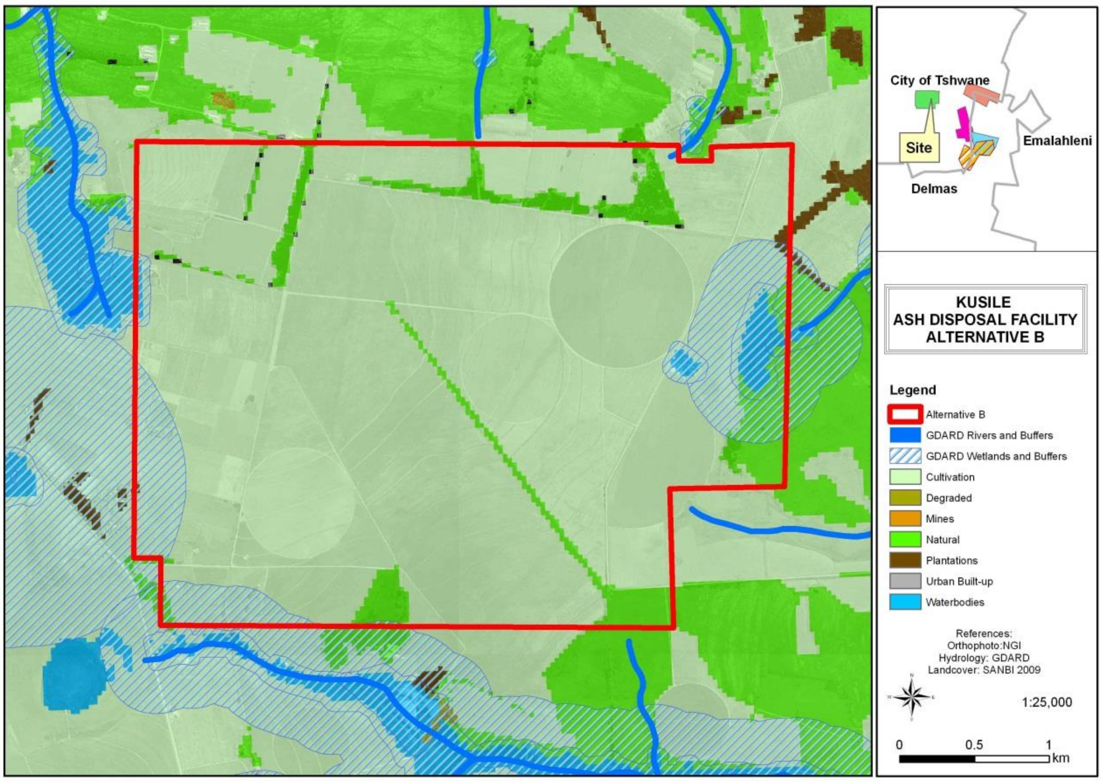

Figure 3: Orthophoto of the 1330 hectares Scenario 2 (Area B). It is clear that Area B is intensively farmed. The only wetlands are along the perimeters. GDARC Rivers and Buffers (dark blue) and Waterbodies (bright blue) mapped, are deemed as sensitive.

Figure 4: One of the dams (photographed from 25º 51’ 17.8”S; 28º 48’ 51.3”E) supplying irrigation water. Insect swarms are inclined to rise over the water during summer dusks, providing feeding patches for hawking bats. Ectothermic invertebrates require minimum thresholds of ambient temperatures and relative humidities to maintain flight, and such environmental conditions are more likely over bodies of water at dusk. Bats are prepared to commute considerable distances to feast at such lucrative sources of nourishment.

Figure 5: Another dam (also photographed from 25º 51’ 17.8”S; 28º 48’ 51.3”E) as well as the semi-aquatic vegetation along the feeder stream support insects which at dusk form aerial plankton and provide marauding bats with sustenance. Note the *Eucalyptus* tree plantation, which as an obnoxious agent detracts from the biodiversity potential of the study area. The pipes on moist surfaces provide adequate daytime roosts for cave-dwelling bats. It is predicted that the air space over this system and the one above will support high incidences of preying bats.

Figure 6. In the distance tunnels for growing speciality produce and in the foreground a recently planted maize land. From the perspective of a bat, this scenario is devoid of any life-support systems such as shelter or rising aerial plankton over the fields and tunnels.

5.5.3 **Scenario 3 (Area C), on Portions of the Farms Onverwacht 532 JR, Spitskop 533 JR, Kortfontein 530 JR and Hartbeesfontein 537 JR. 1526 Hectares**. This site is managed predominantly for grazing (former fields have been replanted with indigenous Smuts' finger grass) on its undulating grassy plains. Larger drainage lines are dammed as part of a wetland reclamation programme. As mentioned above, such bodies of water and associated wetlands support swarms of insects which during summer become airborne and attract hungry insectivorous bats. The site offer no natural or manmade roosting opportunities, hence the only bats associated with this site would be over flying bats hawking for aerial plankton during early evenings when ambient temperatures and relative humidities are high enough to allow flight in ectothermic invertebrates.

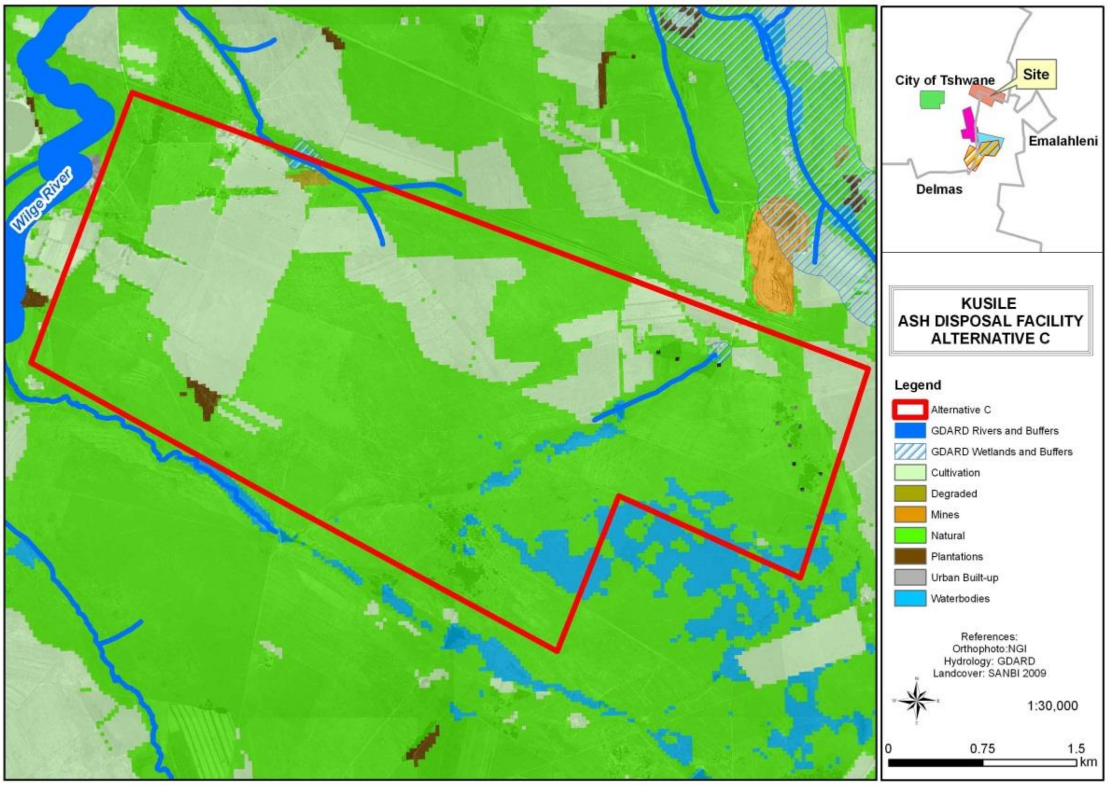

Figure 7: Orthophoto of the 1562 hectares of Scenario 3 (Area C). Note the proximity to the Wilge River, and wetlands along the south-western boundaries. Areas marked as being cultivated consist of ploughed areas planted / replanted with Smuts' grass for grazing. GDARC Rivers and Buffers (dark blue) and Waterbodies (bright blue) mapped, are deemed as sensitive.

Figure 8: One of the dams on the Area C (Scenario 3) at 25º 53’ 54.1”S; 28º 53” 57.7”E. As expounded in the legend to Figure 4, such bodies of water are more likely to retain adequate heat and relative humidity longer than landmass, which are sufficient to allow aerial plankton to remain in the air over the water during early evenings. Note the invader trees in the distance.

Figure 9: Another dam on the site (25º 53’ 20.5”S; 28º 53’ 15.7”E), fed by two drainage lines, one of which is visible to the left-top of the image. It is obvious that this site is used primarily for grazing. Bats would need to commute substantial distances from nearest daytime roosting sites to hawk for invertebrates over this pond.

Figure 10: Sacrificing the capital investment of the existing and new power lines under construction on a site earmarked for a 1500 – 2000 ha large and 90 meters high ash disposal dump, defies understanding. Photographed at 25º 53' 20.5"S; 28º 53' 15.7"E.

Figure 11: Culverts in a drainage line at 25º 52’ 54.2”S; 28º 54’ 27.6”E. Culverts such as these (and preferably larger) are often used by cave-dwelling (whispering) bats as daytime roosts, since they offer relative cool and moist interiors which are conducive to slowing physiological processes to optimize energy budgets.

Figure 12. The drainage line photographed upstream from the same position as the previous image. The wetland vegetation is considered as an excellent medium for the breeding of micro-invertebrates which often form the staple diet of smaller insectivorous bat species.

5.5.4 **Scenario 4 (Areas G & small A), Portions of Farms Klipfontein 566 JR, Dwaalfontein 565 JP and Nooitgedacht 564 JR.** This site is bilobed; the western subsection is termed small A, and the eastern lobe is termed Area G. The latter is largely superimposed by Area A which is discussed under 5.5.1 as Scenario 1. The area denoted as Scenario 4 (Areas G1 and G2) is mostly used for large-scale maize production. A monoculture such as this translates into a sterile exotic plant cover aggressively managed to lack the ability to harbour significant insect populations serving as a food stratum for insectivorous bats. The upper reaches of the Holfonteinspruit originates in the southern portion of Area s mall A, and has indigenous vegetation along its banks which presumably serves as a dispersal corridor for fauna.

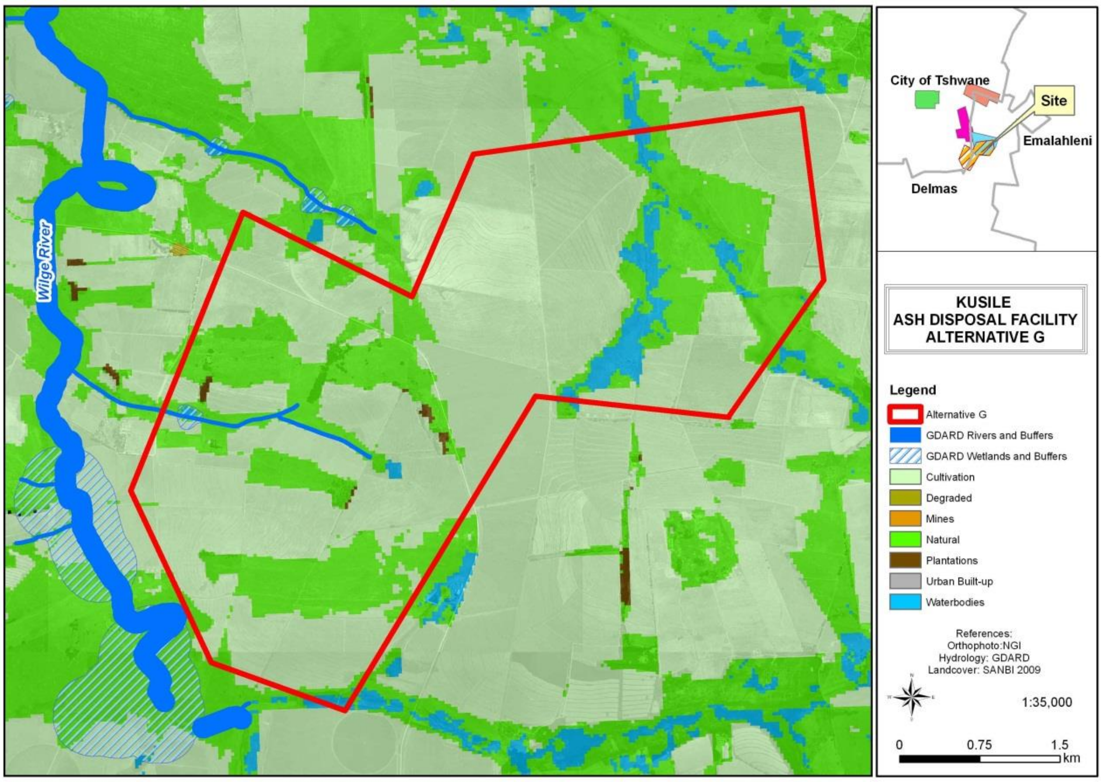

Figure 13: Orthophoto of 1857 ha Scenario 4 (Area G1 and G2). Note its proximity to the Wilge River and a wetland to its southern boundary. GDARC Rivers and Buffers (dark blue) and Waterbodies (bright blue) mapped, are deemed as sensitive.

Figure 14. A north-easterly view over Area G2 of Scenario 4 (25º 58’ 16.5”S; 28º 53; 12.8”E), with maize fields in the foreground and the Kusile plant on the horizon.

5.5.5 **Scenario 5 (Areas F and G), Portions of Farms Bossemanskraal 538 JR, Witpoort 563 JR, Klipfontein 566 JR and Dwaalfontein 565JR. 1303 Hectares.** Area F is too small to answer to the final requirements for ash disposal dumping, and thus has to be considered in tandem with either Area A, G~~1~~ or Area small A In this instance Area A and Area G are superimposed and subjected to intensive maize production. The only feature of ecological note on G1 is the upper reaches of the Holfonteinspruit and its buffer zones. Area F is also largely devoted to maize production, with small patches too rocky for ploughing and an endorheic pan (Figure 17). This area is, in terms of risk management of pollution, uncomfortably close to the Wilge River. A largish dam (Figure 16) has been built between Areas G2 and F, which probably attracts some bats from the neighbourhood to prey on rising insects at dusk.

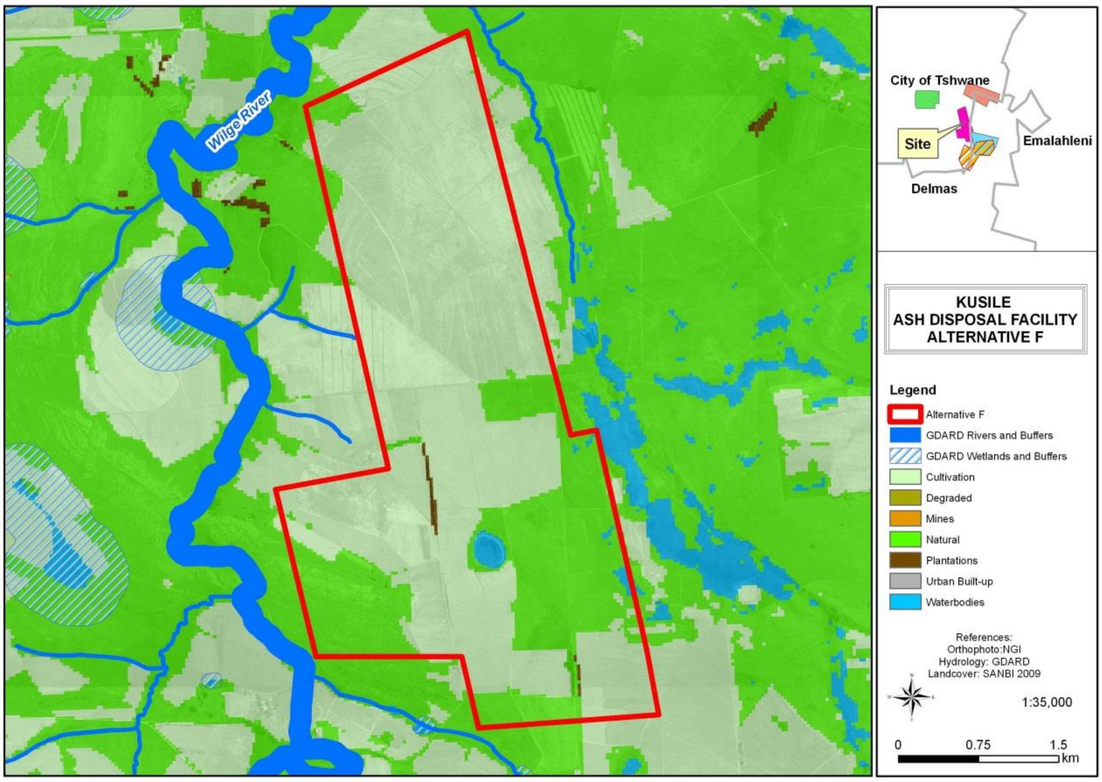

Figure 15: Orthophoto of the 1303 hectares Area F. Note its proximity to the Wilge River, the pan and the wetland outside its eastern boundary. GDARC Rivers and Buffers (dark blue) and Waterbodies (bright blue) mapped, are deemed as sensitive.

Figure 16: A dam between Areas G2 and F (at 25º 57’ 39.8”S; 28º` 52’ 43.0”E) is likely to attract hawking bats during summer evenings, but who will have to commute over Areas G2 and F *en route*. It is unlikely that bats will find lucrative hunting airspace over maize fields, unless air plankton is blown in from elsewhere.

Figure 17: An endorheic pan on Area F (25º 56' 20.0"S; 28º 52' 30.9"E). Like in the case of the dam portrayed above, it is likely that bats will find invertebrate feeding patches over the water during wind-still summer evenings. There are no natural or artificial daytime roosting sites in the immediate vicinities of the dam or the pan.

5.5.6 **Scenario 6 (Areas F and G2), Portions of Farms, Nooitgedacht 564 JR, Bossemanskraal 538 JR, Witpoort 563 JR and Dwaalfontein 565JR.** Areas F and G2 have been discussed above but in different context.

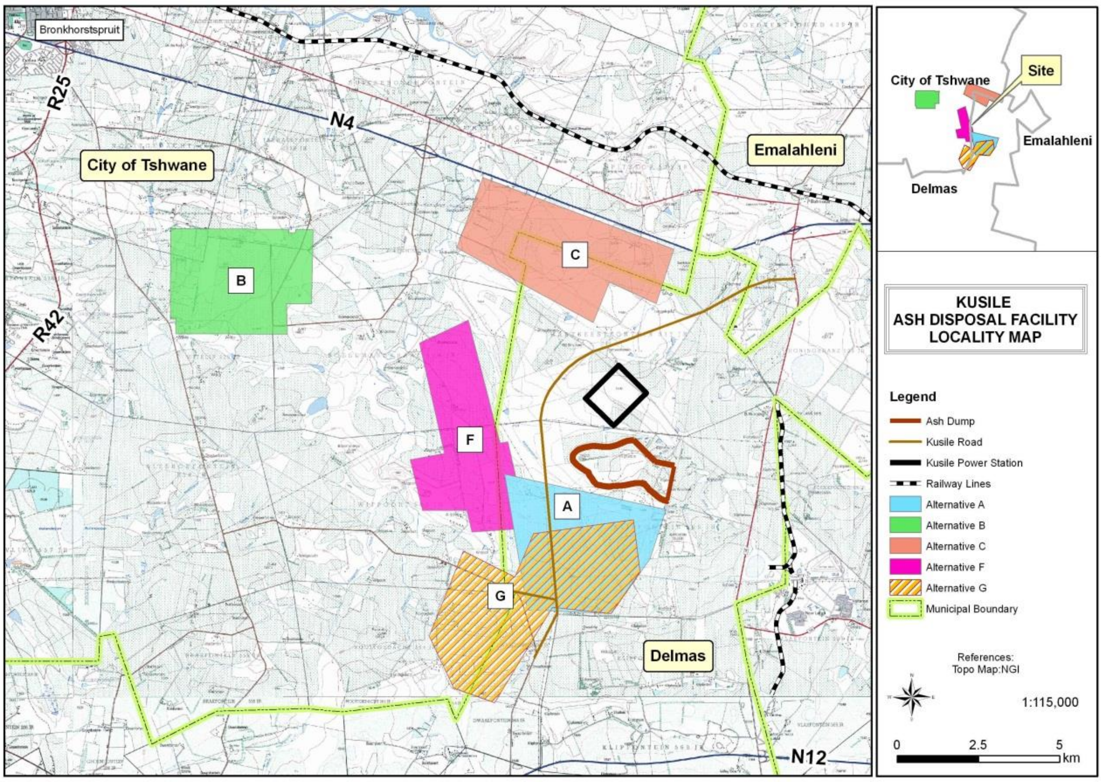

Figure 18. The relative positions of Areas A, B, C, F and G (= G1 & G2) shown on a topocadastral map.

6. METHODS

6.1 Field Survey

Site visits were conducted on 20 November 2012 and again on 3, 4, and 8 January and 12 February 2013. During these visits the observed and derived presence of bats associated with the recognized habitat types and daytime roosts on the study site, were recorded. This was done with due regard to the well recorded global distributions of Southern African bats, coupled to the qualitative and quantitative nature of recognized habitats roosts.

The 500 meters of adjoining properties was scanned for important bat habitats.

No mist netting or bio-acoustic monitoring was conducted as the terms of reference did not require such intensive work. Locals were interviewed to confirm occurrences or absences of bats.

Three criteria were used to gauge the probability of occurrence of bat species. These include known distribution ranges, habitat preferences, and the qualitative and quantitative presence of suitable habitat and particularly daytime roosts.

6.2 Desktop Survey

Specialists' meetings were held on 18th January 2013 and 19 March 2013 in order to report progress and ideally to incorporate results of related investigations. Ideally this has enhanced mutual understanding, such as the discharge of noxious flying ash too small to be filtered by flue scrubbers. More importantly, consultants were tasked to conduct comparative weighted assessments of the six scenarios.

Since bats are secretive, nocturnal, hibernators (or at least enter torpor) and/or seasonal migrators, distributional ranges and the presence of suitable habitats and appropriate daytime roosts were used to deduce the presence or absence of species based on authoritative tomes, scientific literature, field guides, atlases and data bases. This can be done with a high level of confidence irrespective of season. During the field work phase of the project, the derived list of occurrences is audited.

The probability of occurrences of bat species was based on their respective geographical distributional ranges and the suitability of on-site roost sites and habitats. In other words, *high* probability would be applicable to a species with a distributional range overlying the study site as well as the presence of prime habitat occurring on the study site. Another consideration for inclusion in this category is the inclination of a species to be common, i.e. normally occurring at high population densities (viz. house bat species, Cape serotine bat).

Medium probability pertains to a bat species with its distributional range peripherally overlapping the study site, or prerequisite habitat on the site being sub-optimal. The size of the site as it relates to its likelihood to sustain a viable breeding population, as well as its geographical isolation is also taken into consideration. Species categorized as *medium* normally do not occur at high population numbers, but cannot be deemed as rare.

A *low* probability of occurrence will mean that the species' distributional range is peripheral to the study site <u>and</u> prerequisite roost and habitat is sub-optimal. Furthermore, some bats categorized as *low* are generally deemed to be rare (viz. short-eared trident bat).

6.3 Specific Requirements

During field work the site was surveyed for Red Data species.

7. RESULTS ~ START

Acocks (1988), Mucina and Rutherford (2006), Low & Rebelo (1996), Knobel and Bredenkamp (2006), SANBI & DEAT (2009) discuss the peculiar natural plant associations of the study area in broad terms. It should be noted that botanical geographers have made immense strides in defining plant associations (particularly assemblages denoted as veld types), whereas this cannot be said of zoologists. The reason is that vertebrate distributions are not very dependent on the minutiae of plant associations. Rautenbach (1978 & 1982) found that mammal assemblages can at best be correlated with botanically defined biomes, such as those by Low and Rebelo (1996 & 1998), and latterly by Mucina and Rutherford (2006) as well Knobel and Bredenkamp (2006). Hence, although the former's work has been superseded by the work of the latter two, the definitions of biomes are similar and both remain valid for mammals and are therefore recognized as a reasonable determinant of mammal distribution.

The local occurrences of mammals (including bats) are, on the other hand, closely dependent on broadly defined habitat types, in particular terrestrial, arboreal (tree-living), rupiculous (rock-dwelling) and wetland-associated vegetation cover. It is thus possible to deduce the presence or absence of mammal species by evaluating the habitat types within the context of global distribution ranges. Sight records and information from residents or knowledgeable locals audit such deductions.

An alternative approach to understanding bat species richness is to relate it to ecological complexity, i.e. a higher number of niche opportunities.

7.1 Bat Habitat Assessment

The bat habitat in the Kusile area is assessed on an expansive basis since bats can commute over considerable distance to feeding patches (Fenton et al., 1985 and 1986). The 500 meters zones of adjoining properties are therefore automatically included in this overview since the areas and distances covered by marauding bats are known to be considerable but will vary in response to changing conditions.

Insectivorous bats have two indispensable environmental requirements, namely airspace partitions in which to hunt for invertebrate prey, and daytime refuges. From the perspective of nocturnal bat habitats and roosting opportunities by day, it is contended that all four major mammal habitats are present on the site. However, within the context of niche specialisation, these are exploited in different manners by bats than those other quadruple mammals do.

It is contended that there is a close correlation between bat species richness (and specific population densities) and the qualitative and quantitative condition of plant cover. In the tropics of the Levuvhu region of the Kruger National Park 44 bat species have been recorded (Pienaar et al., 1987; Taylor et al. et al. 2012). This is related to the ecological complexity of the system which includes warm and humid climate, savannahs, grassy plains, riverine forests with fig and other wild fruit trees, and rocky ridges containing caves. Compared to the Levuvhu system, the ecological complexity of the Kusile study sites is rated as low.

The ecological complexity of the Kusile study sites is restricted to grassy plains where invertebrates multiply and when becoming airborne during dusk they provide prey opportunities for hawking bats. However, such depauperate environmental production capacity is further impaired by large areas under cultivation which are functionally ecological sterile deserts.

There is, on the other hand, a strong propensity for invertebrates to swarm over water surfaces and swamps where humidities and temperatures remain higher than those over grassy plains. Within the framework of this report it is emphasized that wetlands (Figure 5, 12), streams (Figure 11), dams (Figure 4, 8, 9, 10, 16), pans (Figure 17) and the Wilge River (Figure 19) are of cardinal importance to the nutritive requirements of insectivorous bats and especially their energy budgets. From the perspective of insectivorous bats, but particularly from a wider ecological importance, the health of these systems is non-negotiable.

Daytime roost preferences are specific and vary greatly to include deep, moist and cool caves (and manmade cave-like structures) to narrow nooks and crannies in rocky outcrops and manmade structures, and in trees. The general Kusile study areas contain a number of buildings offering adequate roosting sites for common species such as the Cape serotine bat, African yellow house bat, greenish yellow house bat, and possibly some of the whispering bats (horseshoe bats, Egyptian slit-faced bats, Sundevall's round-leaf bats, slit-faced bats, short-eared trident bats). Culverts, drainage pipes, attics, basements and tunnels may, if present, be frequented by whispering bats. The study area lacks indigenous trees, but large exotic trees (viz. *Eucalyptus* trees) may offer specialised roosting opportunities such as for Mauritian tomb bats.

None of the areas have randjies or rocky outcrops with caves or deep crevices or overhangs in rock faces.

Figure 19: A downstream view over the Wilge River. This report maintains that the health of wetlands and water-bearing systems are ecologically of fundamental importance to bats and that the health of such systems cannot be endangered.

7.2 Environmental Risk Characteristics Unique to Ash disposal Facilities

Within the strict constraints of this report, only the bulk of the ash disposal facility should be evaluated. In terms of its physical nature, at worst 1300 - 2000 hectares of primary producers (if not maize fields) will no longer be available, and the 90 meters height of the dump will deprive aerial insects and hawking bats of airspace. Relatively speaking this will be of no consequence.

However, linked secondary and tertiary side effects must inevitably be considered, namely sources of environmental poisoning. A secondary effect will be toxic substances leached and percolated from the bottom ash stored in the prerequisite dump, and a tertiary effect will be toxic elements in nano-configuration which are not removed by scrubbers from flue emissions. Should there be no environmental poisoning in any form, no reason for concern exists.

A poisoned environment will have a detrimental effect on ecological functions, leading to reduction or demise of critical elements, such as of trophic levels or minimum breeding densities. The extent of such responses depends on the presence/absence of pollution and its rate of accumulation. Environmental poisoning can also be expected to be washed far downstream within the upper Crocodile Catchment area.

It is understood that engineering design of the dump will contain the leaching and percolation of toxic elements in solid ash deposits, but some noxious materials will become airborne and settle off-site before fresh ash is covered with a layer of benign materials. It should be emphasised that primary or secondary leaching of poisonous substances into ground and surface water will have dire consequences to the environment and human health, especially since streams will act as dispersal agents.

Minimising the possibility of leaching of deleterious substances into the Wilge River or one of its tributaries is a factor taken into consideration in this report, by favouring Areas furthest away from the river which will leave space for precautionary and emergency structures and measures.

It was understood from the specialists interactions during the 18th January meeting at the Wilge ESKOM Power Plant that not all fly ash particles will be filtered by the flue scrubbers, and nano-particles will indeed be released into the atmosphere. Some of the substances are toxic (viz. arsenic, beryllium, boron, cadmium, chromium, chromium VI, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium, along with dioxins and PAH compounds). Those present in the smoke (depending on the coal bed characteristics), will be dispersed by reigning winds and ultimately deposited on the surface. If such deposits are cumulative it can be expected to have incremental consequences for human and environmental health. It would appear that this scenario is officially accepted as inevitable.

The effect of environmental poisoning will be more profound to species residing at the apex of the food triangle, such as for insectivorous bats.

7.3 Observed and Expected Species Richness

Eighty bat species have thus far been recorded from Southern Africa (Bronner et al., 2003; Skinner et al., 2005; Taylor et al., 2012). Highest regional bat species richness (44) has been recorded from the riparian forests and savannahs in the Levuvhu tropics in the Kruger National Park, and lowest species richness (one species) along the Skeleton Coast of the Namib Desert (unpublished data ex the Transvaal Museum collection). Although untested, it appears a reasonable hypothesis that a crude relationship exists between ecological complexity and species richness.

According to such a hypothesis species richness at the Kusile terrain will be found to be >1 and <44.

A desk top study reviewing the extensive distributional data of Southern African bats, strongly suggest that 17 species can be expected to at least occasionally roost and over fly the six areas comprising the six Scenarios for the ash disposal site. Considering the extent of environmental modification (cultivation), extant bat population densities will be lower than during historical times.

The Cape serotine bat, African yellow house bat, greenish yellow house bat and the Egyptian free-tailed bat are very adaptable and thus widespread and particularly common in the Subcontinent. They are certain to be residents in the area, as such roosting in buildings and hawk for insects over water; in fact a Cape serotine bat was found impaled on a barbed wire on Area C. Harems of the seasonally migrating Mauritian tomb bat are also very likely to return during spring to regular roosts in large *Eucalyptus* trees in the vicinity, whereas flat-headed free-tailed bats with their predilection for narrow crevices are also likely to be tenants in buildings.

The local occurrence of seasonally-migrating cave-dwelling bats (Schreibers' long-fingered bat, Temminck's hairy bat, Egyptian slit-faced bat, Geoffroy's horseshoe bat, Darling's horseshoe bat, Blasius's horseshoe bat, bushveld horseshoe bat, Sundevall's roundleaf bat and short-eared trident bat) are likely given dark, moist and cool daytime roosts such as culverts, mine adits, attics, basements, abandoned buildings, aardvark burrows, etc. Given the scope of this assignment the latter cohort of species are presumed to be at least temporary residents.

Fruit bats are absent from the study area since fruiting trees are absent.

7.4 Red Listed Mammals

All Red Data species listed in Table 1 as Critically Endangered, Rare, Near Threatened or Data Deficient are discerning species and became endangered as result of the deterioration of their preferred habitats, in this case most likely roosts.

The following species are probable residents or occasional visitors: Schreibers' long-fingered bat (Near Threatened), Welwitsch's hairy bat (Near Threatened), Temminck's hairy bat (Near Threatened), Geoffroy's horseshoe bat (Near Threatened), Darling's horseshoe bat (Near Threatened), Sundevall's roundleaf bat (Data Deficient) and Short-eared trident bat (Critically Endangered).

All listed Red Data species (except the rusty pipistrelle) are cave-dwellers, seasonal migrators and hibernators. They are extremely vulnerable to disturbances during winter sleep, which is probably the major reason for their poor conservation rankings.

As a precaution, the listed Red Data species are presumed to be at least occasionally residents in the Kusile area.

No other Red Data or sensitive species are deemed present on the site, either since the site is too disturbed, falls outside the distributional ranges of some species, or does not offer suitable habitat(s).

Table 1: Mammal diversity. The species observed or deduced to occupy the site. (Systematics and taxonomy as proposed by Bronner et.al [2003] and Skinner and Chimimba [2005])

	SCIENTIFIC NAME	ENGLISH NAME
√	*Taphozous mauritianus*	Mauritian tomb bat
*	*Sauromys petrophilus*	Flat-headed free-tailed bat
√	*Tadarida aegyptiaca*	Egyptian free-tailed bat
NT?	*Miniopterus schreibersii*	Schreibers' long-fingered bat
NT?	*Pipistrellus rusticus*	Rusty pipistrelle
NT?	*Myotis welwitchii*	Welwitsch's hairy bat
NT?	*Myotis tricolor*	Temminck's hairy bat
√	*Neoromicia capensis*	Cape serotine bat
√	*Scotophilus dinganii*	African yellow house bat
√	*Scotophilus viridis*	Greenish yellow house bat
?	*Nycteris thebaica*	Egyptian slit-faced bat
NT?	*Rhinolophus clivosus*	Geoffroy's horseshoe bat
NT?	*Rhinolophus darlingi*	Darling's horseshoe bat
V?	*Rhinolophus blasii*	Blasius's horseshoe bat
?	*Rhinolophus simulator*	Bushveld horseshoe bat
?	*Hipposideros caffer*	Sundevall's roundleaf bat
CE?	*Cloeotis persivalli*	Short-eared trident bat

√ Definitely there or have a high probability to occur;
* Medium probability to occur based on ecological and distributional parameters;
? Low probability to occur based on ecological and distributional parameters.
Red Data species rankings as defined in Friedmann and Daly's S.A. Red Data Book / IUCN (World Conservation Union) (2004) are indicated in the first column: CR= Critically Endangered, En = Endangered, Vu = Vulnerable, LR/cd = Lower risk conservation dependent, LR/nt = Lower Risk near threatened, DD = Data Deficient. All other species are deemed of Least Concern.

8. FINDINGS AND POTENTIAL IMPLICATIONS

8.1 Collective Impact Assessment Summation

Seventeen bat species are residents or are seasonal / occasional visitors to the area within a radius of 15 kilometres from the Kusile plant. Given the inclination of bats to commute considerable distances during nocturnal hawking sorties, this radius must best be increased to 20 kilometres in this and future assessments.

It is concluded that the site favoured herein for the ash disposal facility will not directly impact on the 2013 *status quo* of species richness and specific population dynamics, conditional to 100% containment of chemical contamination and minimizing the destruction of existing life-support opportunities (grasslands, roosting sites). Should there be unforeseen adverse environmental effects as result of the ash disposal facility, local bats will be displaced.

It is argued that remaining indigenous grasslands within 15-20 km from the Kusile plant provide habitat, refuge and nourishment for invertebrates which, when they become airborne, provide prey subsistence for insectivorous bats higher up in the food chain. This ecological event is obviously seasonal when insect reproduction cease and bats enter torpor / hibernation.

Bodies of water and wetlands invariably support airborne insect swarms during wind-still summer dusks. The insects are recruited from wetland vegetation in riparian zones and an optimal combination of temperatures and humidities higher than airspace over landmass allow insects to remain airborne longer (Rautenbach et al., 1988). These swarms form rich feeding patches allowing hawking bats to balance their daily energy budgets and in the long term amass fat reserves to fuel winter hibernation / torpor.

Within the 20 kilometers radius from the Kusile plant the Wilge River, streams, drainage lines with aquatic vegetation and wetlands are therefore identified as ecological highly sensitive systems. Their conservation status must not be jeopardised, especially since contamination from ash solids and flying ash will be washed downstream to affect downstream systems.

A degree of resource partition is discernible at the level of resolution of this study. The listed house bats have robust dentition and jaw muscular to deal with the tough beetle exoskeletons which are normally hunted in clear airspace. The whispering bats (*Rhinolophus, Nycteris, Hipposideros*), on the other hand, are inclined to feed on smaller soft-bodies insects closer to the ground and have more petite dentition but lower wing loading indices (see 4.4 to 4.13 above).

8.1.1 Exotic plant species, declared weeds and invader plants (monocultures)

All the bats occurring in the Kusile area are native to SA and generally do not benefit from alien plants. However, infrequently some rely on exotic trees for roosts (viz. the Mauritian tomb bat). In terms of bats, mature alien trees are herein weighed as of neutral importance and reducing aliens will have no direct effect on bats (indirectly alien vegetation is known to have secondary detrimental effects on the natural environment, but this aspect falls outside the scope of this report).

From a global conservation perspective, reducing the alien trees and plants will be advantageous, especially in an area with a high mammal species richness profile. However, it should be kept in mind that alien invaders are robust plants with variable habitat requirements, and it is quite likely that some aliens will strengthen their hold on the system (viz. lantana), especially if the ecosystem is further disturbed. —If exotics happen to be high consumers of water (viz. wattles) it will be even more detrimental to the streams and wetlands.

8.1.2 Minimizing loss of ecological sensitive and important indigenous vegetation units.

This report suggests that the ecologically most transformed Scenario be favoured for development in order to maintain the conservation of remaining natural systems on least transformed land.

8.1.3 Loss of ecosystem function (e.g. reduction in water quality, soil pollution)

Solid coal ash contains arsenic, mercury, lead, and over a dozen other heavy metals, many of them toxic. And disposal of growing mounds of coal ash is creating grave risks to human health (http://www.psr.org/environment-and-health/code-black/coal-ash-toxic-and-leaking.html). In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In the US, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled, often used to supplement Portland cement in concrete production (http://en.wikipedia.org/wiki/Fly_ash).

Clearly seepage from the disposal facility o~~f~~r from the flue scrubbers will result in environmental contamination and concomitant loss of ecological function, particular water-borne systems. Bats are sensitive indicators of environmental health. Although it is assumed that whichever possible measures will be taken to prevent any form of seepage / leakage, this report is sensitive of the siting of the ash dump. It is also proposed that annual monitoring of bat numbers and activity be conducted, and that warning signs be followed up by more detailed studies.

8.1.4 Loss of bat habitat

In order to perpetuate the welfare of remaining natural habitats, this treatise favours maize fields to be sacrificed as an ash disposal facility. This would greatly increase the probabilities that bats, their roosts and habitats retain their *status quo*.

8.1.5 Loss/displacement of threatened or protected fauna

The following summation accounts for toxic material to escape into the environment where it accumulates and damage the life-support facilities of bats. This will result in the partial or entire loss or displacement of populations.

8.1.6 No-Go (Sensitive) Areas

Following the NEMA Regulations, the Wilge River and its tributaries are collectively red-flagged as a decidedly No-Go system, i.e. must be protected from pollution. The Wilge River, tributaries and wetlands (as sensitive areas) are clearly marked in Figures 1, 3, 7, 13 and 15. From these it is clear that irrespective of the selected site for an ash disposal facility, there will be a loss of wetlands.

Table 2: Summation Table for a worst-case scenario should the environment become~~s~~ contaminated.

	High	Medium	Low
Extent / Spatial Scale of Impacts		X (District)	
Intensity / Severity of Impacts	X (Eventual demise of bats from the district)		
Duration of Impacts	X (Permanent)		
Magnitude and Significance of Impacts	X (Ecological disfuntionality)		

8.2 Impact Assessment Ratings for Individual Areas

Strictly speaking the term "impact" is in this instance a misnomer. The impact of the ash disposal facility will be total on the selected Area (Scenario). What is actually quantitatively assessed is the importance of the total loss of remaining bat habitats and roosts on each Area. However, for the sake of uniformity the term "rating" will be used.

It is assumed that there will be no seepage with consequent ground water and surface water pollution. Such an event is therefore not considered in any of the criteria.

Impact	**Significance**	**Spatial Scale**	**Temporal Scale**	**Probability**	**Ratings**
	Very low	Study area	Permanent	Will occur	
Area A	1	2	5	5	2.7

SIGNIFICANCE CRITERION IS RATED AS 1 (*PACE* 0) TO ALLOW FOR THE HOLFONTEINSPRUIT, WHICH IS REGARDED AS A DISPERSAL CORRIDOR AND SUPPORT INSECT CONCENTRATIONS.

Degree of certainty for the assessment for Area A is rated as Probable.

Impact	**Significance**	**Spatial Scale**	**Temporal Scale**	**Probability**	**Ratings**
	Low	Study area	Permanent	Will occur	
Area B	2	2	5	5	3.0

THE SIGNIFICANCE CRITERION OF AREA B IS RATED HIGHER THAN AREA A BECAUSE OF MANMADE STRUCTURES PROVIDING ROOSTING OPPORTUNITIES, AND ESTABLISHED DAMS WITH SIGNIFICANT RIPARIAN VEGETATION ATTRACTING INSECT PLANKTON.

Degree of certainty for the assessment for Area B is rated as Probable.

Impact	**Significance**	**Spatial Scale**	**Temporal Scale**	**Probability**	**Ratings**
	Moderate	Study area	Permanent	Will occur	
Area C	3	2	5	5	3.3

THE SIGNIFICANCE CRITERION OF AREA C IS RATED HIGHEST BECAUSE OF THE UNDEVELOPED AND PLANTED GRASSLANDS OF THE SITE AND SEVERAL DAMS, SEEPAGE LINES AND WETLANDS ATTRACTING INVERTEBRATE AT DUSK.

Degree of certainty for the assessment for Area C is rated as Probable.

Impact	**Significance**	**Spatial Scale**	**Temporal Scale**	**Probability**	**Ratings**
	Very low	Study area	Permanent	Will occur	
Area F	1	2	5	5	2.7

THE SIGNIFICANCE CRITERION FOR AREA F IS RATED AS 1 (*PACE* 0) TO ALLOW FOR TWO DAMS AND AN ENDORHEIC PAN JUST OUTSIDE THE BORDERS OF THE AREA.

Degree of certaint~~l~~y for the assessment for Area F is rated as Probable.

Impact	Significance	Spatial Scale	Temporal Scale	Probability	Ratings
	Very low	Study area	Permanent	Will occur	
Area G1 & G2	1	2	5	5	2.7

THE SIGNIFICANCE CRITERION FOR AREA G IS RATED AS 1 (*PACE* 0) TO ALLOW FOR TWO DAMS AND AN ENDORHEIC JUST OUTSIDE THE BORDERS OF THE AREA.

Degree of certaint~~l~~y for the assessment for Area G (G1, G2) is rated as Probable.

In the above quantitative ratings, the significance criterion is the only variable. The spatial scale, temporal scale and probability criteria are rated as similar for all five areas.

The impact assessment for the various Scenarios are combinations of the ratings for Areas A, G1, G2 and F.

8.3 Weighted Comparative Assessment matrices

During the workshops of 18 January and 19 March 2013 a multivariate quantitative evaluation methodology was developed which incorporated all disciplines and compared such combined weighted values of the six scenarios plus the ‘No-Go’ areas with each other. The purpose was to define a Scenario which would cause the minimum overall damage. These evaluations have been done separately by specialists and submitted to Zitholele for integration.

9. LIMITATIONS, ASSUMPTIONS AND GAPS IN INFORMATION

All Eco-Agent CC field staff is professionally certified, is aptly qualified and has extensive field experience to conduct surveys such as this. They also have access to a wealth of appropriate information imbedded in a number of sources such as data bases, literature sources and scientific collections. In this instance the author conducted pioneer research and field work on Southern African bats, and has published widely with internationally-acclaimed bat ecologists. Eco-Agent specialists are thus confident that their baseline data are sufficiently accurate to support their conclusions and suggested mitigation measures.

Even though every care is taken to ensure the accuracy of this report, environmental assessment studies are limited in scope, time and budget. Discussions and proposed mitigations are to some extent made on reasonable and informed assumptions built on *bone fide* information sources, as well as deductive reasoning. Deriving a 100% factual report based on field collecting and observations can only be done over several years and seasons to account for fluctuating environmental conditions and migrations. Since environmental impact studies deal with dynamic natural systems additional information may come to light at a later stage. Eco-Agent CC can thus not accept responsibility for conclusions and mitigation measures made in good faith based on own databases or on the information provided at the time of the directive. This report should therefore be viewed and acted upon with these limitations in mind.

10. RECOMMENDED MITIGATION MEASURES

In view of the massive capital investment in the Kusile project, one of the Areas identified as potential ash disposal sites shall have to be selected. A process of elimination is followed here, with due regard to the derived impact assessment rating:

10.1 Site Selection

It is suggested that:

- Area C (Scenario 3) has the highest impact rating (3.3) for bats, which justifies its exclusion from any form of development. The fundamental reason for its high impact rating is that it consists of natural and planted grasslands used for grazing. As such it has a nature conservation profile of note. It also has a number of dams and drainage lines with wetland vegetation important in supporting breeding and swarming insect populations serving as a prey stratum to insectivorous bats. In terms of minimising pollution risk, it must be pointed out Area C is situated close to the Wilge River (Figure 7). Three existing high tension power lines and a fourth under construction traverse Area C, and it seems wasteful to now negate this investment to consider Area C as ash disposal facility. Area C is also a considerable distance from the Kusile plant, which like Area B also has inflated cost implications.
- Area B (Scenario 2) has the second highest impact rating (3.0), which also warrants its exclusion as a development candidate. It is furthermore advised that it is not selected since the consensus seems to be that it has a high agricultural potential. Area B is important to bats since it has a number of *in situ* and nearby structures serving as daytime roosts, and a number of water surfaces attracting insect swarms as feeding patches. It is also a considerable distance away from the Kusile plant, which has inflated cost implications. Selecting this site will also mean that the ash conveyer belt and accompanying infrastructure will cross the Wilge River, which implies a high risk profile for a 'No-Go' area.
- Area F (Part of Scenario 5) is ranked of lower importance than Area B (i.e. agricultural hub) and of lesser importance than area C (ecologically important to bats). However, it has some nearby dams and an endorheic pan which are deemed important to bats. It is also situated near the Wilge River (Figure 15), which may have implications for managing risk of environmental contamination.
- Areas A (Configuration 1, Figure 1) G1, and G2 (Figure 13) fail to excite ecologically. These sites are mostly tilled for maize production, as result of which insect plankton is not produced by the exotic monoculture. They are furthermore as close as possible to the Kusile furnaces which optimise operational costs and land-use appropriated to conveyer belts and other infrastructures. However, the Holfonteinspruit is a notable ecological component, and if Scenario 1 consisting of Area A is to be sacrificed, the Holfonteinspruit shall have to be redirected.

10.2 Ecological Poisoning

It is of cardinal importance to circumvent ecological poisoning by avoiding toxin seepage from the dump or deposition of heavy materials from flying ash.

10.3 Monitoring Environmental Health

Because of their precarious lifestyles, bats are excellent indicator species of environmental health. It is thus suggested that a bat specialist is appointed to twice a year monitor bat species richness and population densities using state-of-the-art bat detectors. Such monitoring should be conducted during October (prior to birth of pups), and during February (when young of the year have reached maturity). Should population declines deviate significantly from the mean, the reason should be investigated.

10.4 Mitigation Measures

The ash disposal facility contains elements of risk to bat populations in the area. It is suggested that risk is counter-balanced by creating new roosting opportunities by constructing new buildings in such a manner that roofs offer roosting opportunities, erecting bat hotels, arrange culvert elements to simulate caves in moist areas, avoid grazing at or near wetlands and riparian zones, keep dams with their riparian vegetation in good repair.

10.5 Enticing Bats Away From Risk Areas

Invertebrates are attracted to bright lights, and bats prey on such rich feeding patches. This phenomenon can be deployed to entice bats away from ecologically precarious areas.

11. CONCLUSIONS

It is concluded that 17 insectivorous bats occur permanently or infrequently within a radius of 20 kilometres of the Kusile plant. This species richness is commensurate with ecological complexity along an eastern – western Subcontinental axis. Some of these species are common; others are ranked as Red Data species. The new ash disposal facility will disrupt the *status quo* in an area within a radius of 20km from the Kusile plant. Such developments with supporting infrastructure may affect life opportunities of bat populations and in extreme cases displace bats. Fruit bats are naturally absent.

Areas A, G1 and G2 are almost totally devoted to maize production and fail to excite ecologically. They are also closest to Kusile plant, which is economically favourable.

Scenario 1 (Area A; 1472 hectares) is therefore favoured herein for establishing an ash disposal facility. The 1857 ha of Scenario 4 (Areas G1 and G2) would be a second choice. It is proposed that Area B is not selected because of its high agricultural potential, Area C for its high ecological value, and although Area F is tilled it is argued that it should be saved because of the neighbouring dams and endorheic pan.

This report considers the effect of the ash disposal site at three levels. The first is the mere physical properties of a 1300 – 2000 hectares ash disposal facility of 90 meters height, depriving aerial insects and hawking airspace for bats. This is of little consequence and can be off-set. The physical effect of the ash disposal facility can be mitigated by provided artificial roosting sites such as making structural alterations to new buildings, erecting bat hotels, and construct artificial caves by extending culverts under roads. Bats can also be enticed away from ecologically precarious areas.

At a secondary and tertiary level it is not clear whether the escape of poisonous substances from bottom and fly ash into the environment, accumulate and ultimate disseminated by waterways can be contained and to what extent. If this is a *fait accompli*, it cannot be condoned.

The ecological integrity of the Wilge River, tributaries, drainage lines, dams and riparian zones is *de jure* non-negotiable. Since bats are sensitive indicator species, it is suggested that two bat surveys are conducted annually during summer to monitor for abnormal population deviations.

12. ENVIRONMENTAL IMPACT STATEMENT

See Annexure A.

During the meeting of 19 March 2013 the specialist team concluded that Area A best answers to the requirements for the ash disposal facility with the least of environmental damage. The above presentation contributed to the group sentiment, which is based on a multivariate analysis of weighted values for each of the various development sites under contention by all participating specialists.

It must be emphasized that the maize fields are in terms of ecology in fact an established two-dimensional sterile environment; most of *in situ* ecological damage was done formerly by agriculture. It should thus be clear that the proposed development has little connotations in terms of environmental conservation, given effective management of noxious substances.

Impact ratings for all subcomponents of all four impacts consistently fall within the Moderate-High Impact Risk Class (3.1 – 4.0). The derived ratings are deemed as unnecessary high, but are an artefact of inevitably having to assign maximum scores for temporal and probability ratings.

It is therefore contended that ecological damage as it pertains to resident bats will remain stable at an Impact Risk rating of 3.7 during all four phases of the project as of early in the Construction Phase.

13. ENVIRONMENTAL MANAGEMENT PLANNING

See Annexure B.

See Section 10 in the main report, which elucidates the entries in the Table in Annexure B.

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APPENDIX A: *RESUMè -*

IGNATIUS LOURENS RAUTENBACH Ph.D., Prof. Nat. Sci.
Independent Environmental Consultant – MAMMALOGY.

Identity Number	421201 5012 00 5
Gender	Male
Date of Birth	1 December 1942
Nationality	South African
Home Languages	Bilingual (English & Afrikaans)
Postal Address	45 Helgaard Street, Kilner Park, Pretoria, RSA 0186. Tel no +27 12 3334112, Cell +27 082 3351288. E-mail naasrauten@mweb.co.za
Former Position	Retired Director: Planning, Northern Flagship Institute
Present Position	Consultant – Specialist, Environmental Impact Assessments (Applied research), Photographing microstock for four agencies
Qualifications	**B.Sc**. (UP), **T.H.E.D** (Pta TTC), **M.Sc.** (UP), **Ph.D**. (Un. Natal)
Professional Honours	1. Professional Natural Scientist (Zoology) – S.A Council for Natural Scientific Professions, Registration # 400300/05 2. Fellow of the Photographic Society of South Africa 3. Master photographer at club level

Notable Research Contribution	In-depth survey of the Mammals of the Transvaal. "1982. 211pp. Ecoplan Monograph 1".
Notable Literary Contribution	Rautenbach, Naas & Annalene Rautenbach. 2008. *Photography for Focused Beginners.* 302pp with 250 images. Green Door Studio, Pretoria.
Formal Courses Attended	Computer Literacy, Project Management, Contract Design, Senior Management

Employment history

May 2001 - Present Self-employed, collaborator with Eco-Agent CC Ecological Consultants as well as Galago Environmental [environmental impact assessments], technical writing, and photography

April 1999 - August 2001 Director: Planning, Northern Flagship Institution

Jan 1991 - April 1999 Executive Director, Transvaal Museum

July 1967 - Dec 1990 Curator (in charge) of the Division of Mammalogy, Transvaal Museum. Promoted to Principal Scientist rank as of June 1985

March - June 1967 Research student at the Mammal Research Institute of the Zoology Department, University of Pretoria

July 1966, Nov l966 - Febr 1967 Member of the Smithsonian Institution's field teams collectively partaking in the 'African Mammal Project'

1966: Part-time research assistant to Prof. J. Meester, University of Pretoria

1962 - 1965 Temporary assistant during University holidays in the Nematology laboratories, Agricultural Technical Services

1991 - 2002 Founder member and non-executive director of the Board of Trustees of the Museum Park Section 21 Company

1993 - 2001 Founder member and Trustee of the privatised Museums Pension Fund

1997 - 2001 Non-executive director of the Tswaing Section 21 Company

Professional Achievements

Managed a research institute of 125 members of staff. Solicited numerous grants totalling ≥ R1 000 000. Initiated and overseen building programmes of R30 million at the Transvaal Museum. Conceptualised and managed 12 display programmes.

Research: Author and co-author of 85 scientific publications re mammalogy in peer reviewed subject journals, 18 popular articles, 10 books, and >400 contractual EIA research reports. Extensive field work and laboratory experience in Africa, Europe, USA, Alaska, Brazil and Mexico. B -rated by FRD as scientist of international status 1983 – 1995.

Public Recognition:

Public speaking *inter alia* Enrichment Lecturer on board the 6* *SS Silver Wind*, radio talks, TV appearances.

Hobbies

Technical writing, photography, field logistics, biological observations, wood working, cooking, designs.

Personal Evaluation

I am goal-orientated, expecting fellow workers and associates to share this trait. I am an extrovert, sensitive to amicable interpersonal relations. I have a wide interest span ranging from zoological consulting, photography, cooking, sport, news, gardening and out of necessity, DIY. To compensate for my less than perfect memory, I lead a structured and organised life to deal with the detail of a variety of interests. Often to the chagrin to people close to me, I have an inclination to "Think Out of the Box".