
Executive Summary

Introduction

The Botswana Power Corporation (BPC), through a 20 % equity contribution to a Special Purpose Company (SPC) that is being established, intends to construct a new coal-fired power station (Morupule B Power Station) adjacent to the existing Morupule Power Station. 80% of the contribution to the SPC will be through debt finance from local and international project financiers.

The proposed 600 MW Morupule B Power Station will be wholly-owned by the SPC and is scheduled to be ready for commercial operation by 2010.

To reduce dependency on imported power, BPC initiated the Morupule B Power Station Project, a feasibility study for which was commissioned in 2003. The study consisted of a number of components including a scoping-level environmental investigation, a coal resource determination study and a water resource assessment. The feasibility study was completed in 2004 and it confirmed that the construction of the proposed Morupule B power station would be feasible.

The Environmental Impact Assessment Act, 2005 (Act 6 of 2005, the EIAA) requires the environmental impact of all activities identified in terms of Section 3 (Screening) of the EIAA to be fully considered and authorisation for the activity obtained prior to the commencement of the activity. The proposed development requires an Environmental and Social Impact Assessment (ESIA) to be undertaken in line with the provisions of the EIAA as well as taking due cognisance of the World Bank Group requirements and the Equator Principles.

An ESIA typically comprises two phases, namely a preliminary assessment or Scoping Phase and a detailed Impact Assessment Phase. The Scoping Phase identifies issues and concerns related to the project. The Scoping Phase for the proposed Morupule B Power Station development was completed in 2004.

The detailed Impact Assessment Phase comprises specialist studies to assess specific issues and concerns. Ecosurv (Pty) Ltd (Ecosurv) in association with GIBB Botswana (Pty) Ltd (GIBB Botswana) have been appointed by BPC to undertake the ESIA required for the project. This document constitutes the EIS¹ for the project. The EIS has been compiled in compliance with section 10 of the EIAA.

Project location

The proposed Morupule B Power Station is to be situated adjacent to the existing Morupule Power Station, which lies approximately 280 km north of Gaborone. Palapye is the nearest village, situated approximately 5 km to the east of the power station. The main road between Palapye and Serowe (A14) lies south of the proposed site. Serowe is situated approximately 30 km west of the site and is the administrative centre of the Central District.

¹ The EIS is referred to throughout this report as the Environmental and Social Impact Assessment (ESIA)

Both the existing Morupule Power Station site and the proposed site for the Morupule B Power Station are within the ownership of the Bamangwato Tribal Authority which is leased to BPC with the future demarcated land portion for the proposed Morupule B Power Station. The proposed site is 476 ha in extent according to the survey record. A railway servitude of 18 ha is registered across the site.

Planning and legislative context

A list of the relevant acts, policies and plans relevant to the proposed project is provided hereunder:

- Central District Development Plan 6;
- Palapye Planning Area Development Plan;
- National Development Plan;
- National Water Master Plan;
- National Energy Policy;
- Botswana Strategy for Waste Management;
- International Commitments Influencing Local Planning;
- International Finance Corporation/World Bank Group Requirements;
- Botswana Biodiversity Strategy and Action Plan;
- The Tribal Land Act of 1970 (As amended in 1993 and 1999);
- The Acquisition of Property Act of 1955;
- The Factories Act of
- The Water Act of 1968;
- The Atmosphere Pollution (Prevention) Act of 1971;
- The Public Health Act of 1981;
- The Monument and Relics Act of 2001;
- The Waste Management Act of 1998;
- The Town and Country Planning Act of 1980;
- The Agricultural Resources Conservation Act of 1974;
- The Forest Act of 1968;
- The Herbage Preservation (Prevention of Fires) Act of 1978;
- The Mines and Minerals Act (As amended in 1999);
- The Mines, Quarries, Works Machinery Act of 1978;

- The Environmental Impact Assessment Act of 2005; and
- The Land Control Act of 1975.

Development plan description

Existing Morupule Power Station

The existing Morupule Power Station is a thermal power plant which combusts coal to produce heat energy, which is used to convert water into steam. The steam is used to drive the steam turbines, which then generate the electricity.

Coal is supplied to the plant via a conveyor belt from the Morupule Colliery. Coal is delivered directly to the boiler bunkers and on to a temporary (live) stockpile for reclamation at a later stage. The coal from the temporary stockpile is collected by a loader and delivered to a reclaim hopper, for forwarding to the boiler bunkers.

This temporary stockpile provides the buffer in case of variation in supply from the mine and boiler consumption requirements.

The Morupule Power Station consumes in the order of 560 000 – 630 000 tons of coal per annum depending on the availability of the plant. Each boiler, when operating at full capacity, consumes approximately 20 tons of coal per hour. The furnaces at this station are of a balanced pressure type. The steam is delivered at the turbine stop valve at 86 bar and approximately 510 °C.

The steam drives the turbine blades that are connected to the turbine shaft, which in turn is connected to an alternator rotor. The alternator rotor acts as a large electro-magnet which generates a magnetic field that in turn induces electricity. The electricity is then supplied to the national electricity grid. The facility employs approximately 375 staff.

The electricity grid in Botswana consists of a network of power lines ranging from 11 kV to 400 kV. At present, power from the existing Morupule Power Station is transmitted via 33 kV and 220 kV power lines. A single 400 kV power line from the Matimba Power Station in South Africa feeds into the Botswana electricity network at the Phokoje Substation. 66 kV and 33 kV power lines are used to distribute power to individual homes. A 102 km 400 kV transmission power line for the Morupule B Power Station will be constructed as a separate project. An EIA for this power line is currently being undertaken.

Project need and desirability

The primary motivation for the proposed Morupule B Power Station is the need for Botswana to reduce its dependency on imported power from neighbouring countries. The importance of this need is reflected in the BPC financial results for the year ending March 2006², in which the utility reported a loss as opposed to the forecasted profit which it intended to achieve. BPC's annual report for 2006 identifies the increased cost of imported power as one of the main reasons for not achieving the forecasted profitability targets for the year. Imported power accounts for 30 % of BPC's annual expenditure.

² This is the latest annual report available

The shortage of generation capacity in the Southern African region as a whole is expected to result in a significant increase in electricity costs throughout the region. Capital expenditure on a new power generation facility within Botswana has been identified as a more cost-effective option for Botswana than the continued reliance on imported power.

The strategic importance of a secure, reliable electricity supply to the economic growth of a country is a further critical factor motivating the need for the Morupule B Power Station. Countries throughout the world recognise the importance of a level of self-sufficiency especially when it comes to electricity supply so that political and social instability in one country does not result in a disruption to an electricity supply in another country. Equally important is the need for sufficient electricity supply to be vested in the interests of the state. Special Purpose Companies (SPC) are an important vehicle in the development of the electricity generation mix within a country but it is agreed internationally that sufficient supply capacity must remain in the ownership of the state.

Proposed Morupule B Power Station

The proposed Morupule B Power Station will make use of different technology but the manner in which electricity will be generated (thermal generation) is essentially the same as for the existing Morupule Power Station. The Morupule B Power Station is proposed to be constructed in two phases. Phase I involves the proposed construction of a 600 MW power plant consisting of 4x150 MW units. Phase II seeks to double the installed generating capacity to 1200 MW. This ESIA is only based on the proposed Phase I development.

The Morupule B Power Station will be an independent power station with no shared facilities with the existing power station. Detail design of the plant has not been completed and it will be influenced in part by the findings of this EIA. The general technical specifications of the plant are however envisaged to consist of the following main components and equipment:

- Boiler plant;
- Turbine-generator;
- Condenser and feedwater system;
- Closed circuit cooling water system;
- Water supply and treatment system;
- Wastewater treatment system;
- Coal handling system;
- Limestone handling system;
- Ash handling system;
- General mechanical systems;
- Electrical equipment;
- Control and instrumentation system;
- Service installations; and
- Civil works.

BPC has recommended either a Coal-Fired Circulating Fluidised Bed Combustion (CFBC) boiler or a Pulverised Coal (PC) boiler but taking due regard of the World Bank Group environmental guidelines. Raw or process water will be sourced from the wellfield currently under investigation in proximity to the Paje Wellfield.

It is estimated that approximately 2 million m³ of raw water will be required for the existing Morupule Power Station and the proposed Morupule B Power Station. The raw water will be supplied to the power plant via a pipeline, which will be designed and constructed as a separate project.

The proposed coal handling system consists of two conveyor belts which will transport the coal approximately 2.5 km from the Morupule Colliery to the Morupule B Power Station. The coal will be crushed, screened and placed in hoppers at the Morupule Colliery, ready for transfer via the conveyor system. Coal received at the power plant will be screened and if necessary crushed prior to storage in coal bunkers. Screening and crushing of coal to the required <6 mm size will be undertaken. The current agreements in place with the Morupule Colliery indicate that coal must be <31 mm in size. Excess coal will be transported via belt conveyor to a stockpile area, which will serve as an emergency coal supply when the supply from the Morupule Colliery is problematic.

Limestone injection into the CFBC boiler is proposed in order to reduce SO_x emissions. Limestone will be delivered to site via rail, after which it will be unloaded into hoppers from where it will be fed into screens for separating limestone into the required size.

Ash is produced from the CFBC boiler during the combustion process and is removed as bed or bottom ash and fly ash. Once the coal has been combusted, the bottom ash/coarse ash from the boiler will be collected and then cooled in the ash cooler. A positive pressure conveying system will then transport the dry bed ash to a bed ash silo. The fly ash from the bagfilters will be pneumatically collected in fly ash hoppers prior to delivery to a fly ash silo.

Dry fly ash will be unloaded from the silos into trucks through paddle/rotary type feeders. On an annual basis, approximately 35 000 tons of ash is provided to the cement industry in this way from the existing Morupule Power Station. Water will be used to condition the ash prior to unloading into open trucks in order to suppress the dust emissions during this process.

Fly ash, which cannot be disposed of in a dry form through use in other industries will be mixed with the neutralised/raw water from the ash water tank and pumped to a new ash pond via two new pipelines. Bed ash is likely to be transported by truck to the new ash pond.

The ash pond will be based on a compartmentalised design. In the much-larger first compartment (settling pond), coarse ash will settle. The water with fine ash will flow into the smaller second compartment (stilling pond) where the fine ash will settle. Water from the stilling pond is proposed to be collected in a collecting well from where it will flow by gravity to a recovery water sump situated in close proximity to the ash pond. Treatment of the water through chemical dosing will take place at the recovery water sump prior to delivery of the water to a clarifloculator for the removal of suspended particulates. The water from this process will flow via gravity into an underground clear water tank from where it will be pumped to the ash water tank for reuse. The ash pond will be lined with a Low Density Poly Ethylene (LDPE) liner.

Construction of the Morupule B Power Station is scheduled to commence in 2008. A period of commissioning of the power station will precede the operational phase, which is scheduled for October 2010.

Biophysical environmental setting

Geology and soils

The geology of the area where the proposed Morupule B Power Station is to be constructed consists of shales and mudstones of the Lotsane Formation overlain by relatively thin (10 m - 20 m) Kalahari Beds. Beneath the Lotsane Formation are the fractured quartzites of the Tswapong Formation, which outcrop as the western escarpment of the Tswapong Hills some 20 km to the southeast of the site. The soils of the study area are characterised by their orange colour and fine grain size, and their sandy silt loam texture. Soils from this area are aeolian (wind-blown), and have been derived from the weathering of the Ntane Sandstone Formation, which outcrops along the Serowe escarpment.

Topography and landform

The proposed development site is at an elevation of approximately 950 metres above mean sea-level (mamsl). The land to the northwest of the site (e.g. the rocky country around Serowe) rises to an elevation of 1100 mamsl. In general there is a gentle gradient falling away to the southeast of the site. The site lies within the Lotsane River Catchment. This is a major ephemeral river in the area. This catchment is slightly hilly, but predominantly undulating. There are a few topographical features in the area that attain elevations of approximately 100 m above the surrounding countryside. These features include the Tswapong hills, which lie about 10 km to the southeast and the two small "koppies", to the north of the site. The rocky outcrops are situated on the Morupule Colliery property.

Surface water environment

The Lotsane River is the closest river to the proposed power station, situated approximately 3.7 km to the south east while the Morupule River is about 5 km west. The Lotsane River forms part of the Limpopo River basin and flows into the Limpopo River on the Botswana and South African border.

Groundwater environment

Underlying the majority of the site and the surrounding area is unsaturated Kalahari Beds (> 15 m of aeolian sand, sandstone, duricrusts and gravel), located above the Lotsane Formation (shale and mudstones). Below this formation is the Palapye fractured quartzitic aquifer. From a hydrogeological viewpoint, the Kalahari Beds immediately below the proposed development site can be considered to be a very minor aquifer.

The hydrogeological report indicated that a groundwater mound has developed beneath the present ash lagoon site due to seepage from the lagoon. This seepage has caused a rise in groundwater contours immediately below the site of around 3.5 m over the last ten years. This has the potential to cause the movement of contaminants away from the ash lagoon towards the southeast. The mound of water however does not appear to have moved significantly off site and the relatively small degree of rise (average 35 cm a year) shows that movement of groundwater is slow in both the saturated and unsaturated aquifer zones.

Monitoring of groundwater quality is undertaken by BPC through a network of monitoring boreholes. The hydrogeological specialist study compared the latest Annual Groundwater Monitoring Audit Report (2005/2006) results from the site with the Botswana Bureau of Standards Water Quality Guidelines for Acceptable Drinking Water (BOS 32:2000).

The results of this comparison indicate that the highest average concentration of sulphate, ammonia and iron in the water currently exceeds the BOS 32:2000 maximum limits for acceptable water for these parameters.

The existing power plant does not appear to have significantly impacted on the water resources in the area albeit for a rise in sulphate concentrations. The hydrogeological specialist study indicated that the proposed site, based on soil types, strata and depth to unsaturated zone, has a moderate aquifer vulnerability setting.

Ecology

Two vegetation types have been identified in the study area namely *Burkea/Ochna* Savannah and *Acacia erioloba* Savannah. *Burkea/Ochna* Savannah is associated with deep well-drained ferralitic sandy soils, and is characterised by *Colophospermum mopane* species. *Acacia erioloba* Savannah is characterised by *Acacia erioloba*, *Terminalia sericea*, and *Lonchocarpus nelsii* species. Both these vegetation types are savannah type systems and occur in the areas south of the Makgadikgadi.

Although the site of the proposed power station and slurry dams has low plant species diversity, the Tswapong hills area, which is located to the east outside of the study area, has been highlighted as being host to important species.

The Tswapong hills are host to large breeding populations of Palaearctic migrants and are thus given the status of being an Important Bird Area (IBA)³. Of the species occurring in the Tswapong hills, the Cape Vulture, *Gyps coprotheres*, is a species of global conservation concern.

Climate

Semi-arid conditions with cool dry winters and warm, wetter summers characterise the climate of the study area. Rainfall data from the power station from 1989-2006 indicates a mean annual precipitation of 371 mm with the majority of rainfall received between November and March. The dominant winds occur from a north easterly direction with an average wind speed of 3 m/s. Strong winds exceeding 5 m/s occur at a frequency of 41%. Temperature maximums in the study area generally occur during the October-March months, with June and July months experiencing the lowest temperatures. Only small inter-annual variations in temperature ranges occur. The average annual maximum temperature is between 28 °C and 30 °C and the average minimum temperature is between 14 °C and 16 °C. Potential evapotranspiration is in the order of 900-1500 mm/year, which is three to four times the average annual rainfall

Air quality

The baseline ambient air quality of the local airshed was simulated through dispersion modelling because there is insufficient on-site data available for the criteria pollutants of concern. The main sources contributing to the ambient air quality within the vicinity of the proposed Morupule B Power Station are the current Morupule Power Station and the Morupule Coal Mine. The other main sources, i.e. Matimba and Matimba B Power Stations are considered to be too far away to have a significant influence on the background concentrations at the Morupule Power Plant. The predicted baseline SO₂, NO₂ and PM10 baseline concentrations due to the existing Morupule Power Plant is summarised in **Table 8**.

³ Important Bird Areas have no national legal status

Table 8: Predicted SO₂, NO₂ and PM₁₀ baseline concentrations due to the Morupule Power Plant (exceedances of air quality guidelines are highlighted)

Averaging Period	Standard/ Guideline ($\mu\text{g}/\text{m}^3$)	MAX GLC		PALAPYE		SEROWE	
		Max Conc ($\mu\text{g}/\text{m}^3$)	Fraction of GL	Max Conc ($\mu\text{g}/\text{m}^3$)	Fraction of GL	Max Conc ($\mu\text{g}/\text{m}^3$)	Fraction of GL
Sulphur Dioxide (SO₂)							
Highest hourly	350(d)	4683.6	13.4	690.0	2.0	43.0	0.1
Highest 24-hour average	300(a)	557.9	1.9	70.0	0.2	7.4	0.02
	150(b)		3.7		0.5		0.05
	50(c)		11.2		1.4		0.15
Annual average	80(a)(b)	155.2	1.9	3.5	0.0	0.9	0.01
	30(c)		5.2		0.1		0.02
Nitrogen Dioxide (NO₂)							
Highest hourly	400(a)	164.0	0.4	25.0	0.1	1.9	0.005
	200(c)		0.8		0.1		0.01
Highest 24-hour average	150(b)	19.6	0.1	2.6	0.02	0.3	0.002
Annual average	100(a)(b)	5.5	0.1	0.1	0.001	0.04	0.0004
	40(c)		0.1		0.003		0.001
Particulates (PM₁₀)							
Highest 24-hour average	150(b)	366.6	2.4	3.4	0.02	1.2	0.008
	100(c)		3.7		0.03		0.012
Annual average	200(a)	189.2	0.9	0.2	0.001	0.1	0.001
	50(b)(c)		3.8		0.004		0.002

Notes:

- (a) Botswana guideline (90% of observed to be less than 300 $\mu\text{g}/\text{m}^3$)
- (b) World Bank (WBG) Thermal Power Guidelines
- (c) World Health Organisation (WHO) Interim Target-2 (IT-2)
- (d) European Community (EC) hourly standard

Abbreviations:

- GLC – ground level concentration (this is the maximum concentration)
- GL – Guideline
- Max Conc – Maximum Concentration

Sulphur dioxide

The maximum predicted ground level concentrations are predicted to occur approximately 800 m west of the existing Morupule Power Station. These concentrations currently exceed the relevant Botswana and World Bank Group (WBG) limits for highest hourly, daily average and annual average intervals (**Appendix 4.4**).

The guidelines for highest daily averages as provided by Botswana and the WBG were not exceeded at Palapye. Annual average concentrations at Palapye and Serowe do not exceed any of the guidelines. Highest hourly predicted SO₂ concentrations exceeded the European Community (EC) standard at Palapye and the WHO Interim Target (IT)-2 guideline over a 24-hour average.

The allowable frequency of exceedance according to the EC hourly standard of 350 µg/m³ is 24 hours per calendar year. Based on the predicted hourly concentrations at Palapye, the 350 µg/m³ limit will be exceeded for 7 hours in the calendar year, thus within the EC limit in this regard.

At Serowe, none of the ambient air quality guidelines or standards was exceeded for any of the averaging periods.

Nitrogen dioxide

The maximum ground level concentration was predicted to occur approximately 769 m to the west of the power station (**Appendix 4.4**). The maximum ground level concentration for highest hourly averages was predicted to comply with the Botswana, WBG and WHO guidelines. Highest daily and annual average predictions were also well within the respective guidelines. All predicted NO₂ ground level concentrations were low and well within the respective guidelines at Palapye and Serowe.

Particulate matter (10 micron)

The maximum ground level concentration for highest hourly averages was predicted to occur within a 500 m radius of the power station (**Appendix 4.4**). Predicted ground level concentrations of PM₁₀ considered all the sources at the Morupule Power Station including stacks, vehicle entrainment on roads, wind blown dust from the coal storage piles and the ash lagoon and materials handling operations.

Maximum ground level concentrations were predicted to exceed the daily and annual guidelines as reflected by the WBG and WHO (**Appendix 4.4**). Predicted emissions are at the limit of the Botswana annual average guideline.

At Palapye and Serowe, the predicted PM₁₀ concentrations were low and well within the respective guidelines for highest daily and annual averages.

The quantitative assessment of ambient air quality indicated above is conservative in that the hourly and daily averaging periods contain only the maximum predicted ground level concentrations, for those averaging periods, over the entire period for which simulations were undertaken (**Appendix 4.4**). It is therefore possible that even though a high hourly or daily average concentration is predicted to occur at certain locations, that this may only be true for one hour or one day during the year.

Greenhouse gas production

The Morupule Power Station greenhouse gas contribution may be placed within the context of national greenhouse gas emissions by making reference to the greenhouse gas emissions inventory included in the National Communication to the United Nations Framework Convention on Climate Change (UNFCCC, 2002).

The Air Quality Impact Report compiled by Airshed Planning Professionals in 2004 indicated that the current Morupule Power Station contributed approximately 32.6%, 0.3% and 0.01% of the country's total CO₂, NO₂ and CH₄ emissions respectively.

Botswana's current CO₂ emissions have been calculated at approximately two tons of CO₂ emissions per person per year (**Appendix 4.3**). This figure excludes the carbon cost of imported electrical power but includes present coal production and use, all fuels, gas and firewood. The average figure for CO₂ emissions per person per year for middle-income countries is 3.8 tons.

Noise

The general procedure used to determine the noise impact was guided by the requirements of the Code of Practice SANS 10328:2003: *Methods for Environmental Noise Impact Assessments*. The noise impact criteria used specifically take into account those as specified in SANS 10103:2004, *The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and Speech Communication*.

Measurements and auditory observations were taken at nine monitoring sites during the noise impact investigation in order to establish the ambient noise conditions of the study area (**Table 9**). These were taken at appropriate sites at varying distances from the power station site.

Table 9: Current noise levels in the Morupule Power Station study area.

Noise Sensitive Site*	Period	Maximum Allowable Noise Level (dBA)		Measured Noise Level (Year 2007) (dBA)
		WHO & WB	SANS 10103	
Site 1: Colliery Village (Suburban Residential)	Day	55	50	47.5
	Night	45	40	39.2
Site 2: Colliery Village (Suburban Residential)	Day	55	50	39.8
	Night	45	40	28.8
Site 3: Kgaswe School (Educational)	Day	55	50	57.9
	Night	Not Applicable	Not Applicable	49.3
Site 4: Settlement (Rural Residential)	Day	55	45	45.5
	Night	45	35	30.8
Site 5: Palapye (Urban Residential)	Day	55	55	62.4
	Night	45	45	46.2
Site 6: Palapye (Urban Residential)	Day	55	55	56.8
	Night	45	45	51.0

* Sites 4a, 7 and 8 are omitted as no night-time measurements were taken at these locations

The background noise levels in the study area indicate the following (**Appendix 4.7**):

- Noise levels in Palapye Village are high and are typical of an urban complex;
- The existing noise climate alongside the main roads in Palapye is degraded with regard to the SANS urban residential living standards, that is noise exceeds the SANS standards particularly at night. In general the daytime conditions are within the SANS noise standards;
- The areas outside Palapye and remote from the main roads and the power station/colliery are very quiet and reflect a rural character;
- The existing noise climate alongside Road A14 outside Palapye Village is degraded with regard to the SANS rural residential living standards;
- The impact of the power station on noise sensitive sites in the surrounding area is minor. Noise levels from the existing power station exceed 35dBA (the SANS maximum allowable night-time level for rural residential use) up to a distance of about 2500 metres from the facility. The Colliery Village and the settlement ("Molapo wa Dipitse") lie outside this zone and are thus not impacted by the power station noise. These residential areas are also not adversely impacted by traffic noise from Road A14. The old housing that was used during the construction of the existing power station, adjacent to the Kgaswe Primary School, lies within this zone but noise levels at this site are more severely affected by the Road A14 traffic noise. The power station will be heard late at night when traffic volumes are low;
- Noise levels from traffic on Road A14 at the Kgaswe Primary School are slightly higher than desirable for an educational environment. The maximum daytime noise level measured in the vicinity of the school was 76.6dBA whilst the average daytime noise level was 57.9dBA. Noise from vehicles passing over the speed control humps on the power station access road just to the west of the school is a significant noise nuisance factor. Noise from the power station does not have a significant impact on the activities at the Kgaswe Primary School; and
- The overall impact of the noise from the coal trains on noise sensitive sites in the area is not significant. There is a minor nuisance effect at the school from the warning horn sounding when the train approaches the level crossing with the power station access road.

Socio-economic environmental setting

Land use

Within the surrounding area there are a number of land use practices. These include:

- Arable agriculture;
- Livestock production;
- Urban development (mainly housing); and
- Land developed for mining and power production.

The most viable and commonly practised land use in the area is communal grazing livestock. According to the Central District Planning Study Document (1992), over 65% of land is used for livestock grazing. Within the 10 km radius of the proposed development about 68 % of the land is available for traditional livestock production (made up of agricultural lands, Department of Agriculture artificial insemination camps and free range) with an additional 8 % fenced for commercial livestock production.

Two Artificial Insemination (AI) camps belonging to the Ministry of Agriculture (MOA), called Leupala and Moupule are located within 10 km of the site. Livestock carrying capacities are presently 7 ha/Large Stock Unit (LSU).

Dry land farming is seen to be a common land use practice in the area with this practice accounting for approximately 11 % of the total area within the district (Central District Planning Study, 1992).

The main crops grown in the Palapye area are sorghum, maize, cowpeas, millet, and melons. Arable agricultural production is low but it remains an important part of the rural economy.

Heritage aspects

Surveys of the eastern parts of Botswana have identified sites ranging from the early Stone Age through to the Late Stone Age, to the Iron Age and the historic period. In other words, there are signs of human activity in the eastern parts of Botswana from as early as two million years ago until historic times. Stone Age research in this area has been limited and this is evident from the National Museum site register whereby very few sites have been recorded. A review of the relevant records pertaining to the general study area at the Botswana National Museum indicated that 17 sites have been recorded in the 27-C1-map sheet. These were mostly sites of Stone Age, Iron Age and historic period with the Toutswe culture mostly represented in the Iron Age. The archaeological survey undertaken confirmed that none of these sites are located on the proposed development site.

Population

Central District has a population of about 501 381. The majority of the population (153 035) are concentrated in the Serowe–Palapye sub district. The sub district covers an area of 30 925 km² with a population density of 5 persons/km².

Employment

Employment opportunities in the area are linked to variety of economic activities, which include agriculture (arable and pastoral), mining, industrial and commercial, manufacturing, and construction. The location of the Morupule coal mine and the BPC Power Station has boosted employment opportunities in the Palapye area where unemployment has been known to be high.

Health

Health data (HIV/AIDS and Sexually Transmitted Infections) prevalence in Palapye is high and at present increasing.

Services

Education

The literacy rate for Central District was in the region of 62% during the 2001 census. There are nine government-owned primary schools and one privately owned school in Palapye. Preschools are also available throughout the village. There are three junior secondary and one senior secondary school in the village. There is also a vocational training centre, and informal education centre.

Health

The delivery of health services in Palapye is provided through a primary hospital and four clinics. The primary hospital falls under the Ministry of Health while clinics are coordinated by the Ministry of Local Government. There are also specialised centres such as anti-retroviral drugs distribution centres to address the high HIV/AIDS rate in Botswana. There are also a number of private medical practitioners in the village.

Housing

Housing structures in Palapye as well as most villages in Central District are predominantly modern structures with tin roofing. However, there are still traditional housing structures made from mud and grass thatch scattered throughout the village.

Social amenities

Palapye is serviced by one police station and there are plans to build a bigger one due to the rapid growth of the village. Water supply is from the national supply, community standpipes and private connections. There are three cemeteries, but only one of these is in use.

Transport and communication

The A1 trunk road (Francistown–Gaborone) links the south and the north parts of the country. There is also the B14 road, which links Central and Ngamiland Districts. The village is also serviced by an airstrip for small aircraft. Telecommunications in the area are served by Botswana Telecommunications Corporation (BTC) and cellular phone service providers. Botswana Post provides postal services.

Electricity supply

Palapye benefits from the location being close to Morupule Power Station. The village is connected to the national supply grid through one substation. However, there is another under construction as residents have been complaining about frequent power surges and outages. Main consumers of electricity are the commercial industrial establishments.

Stakeholder engagement process

The SEP for the Impact Assessment Phase commenced in August 2007 with the publication of an advertisement in English and Setswana announcing the project. The first advertisement was placed on 3 August 2007 and the second advertisement was placed on 30 August 2007 (**Appendix 5.3**). An opportunity to attend the scheduled public meeting regarding the project was included in the advertisements. A Background Information Document (BID), and comments sheet was made available to all I&APs (**Appendix 5.4 and Appendix 5.5**). It was presented in both Setswana and English.

A public meeting was held at Palapye main Kgotla on 4 September 2007. The meeting was announced through the advertisements placed in local newspapers. The public meeting was conducted in Setswana as all the participants could speak and understand the language. The meeting was attended by 31 people including the consultations team and representatives from BPC.

A meeting with key local and central government officers was convened in Palapye on 4 September 2007. The meeting was arranged through the assistance of the Central District Assistant Council Secretary responsible for the Serowe-Palapye Sub-District.

The consultations team undertook consultations in the following lands areas within 10 km of the proposed power station site:

Morupule;
Mantshadidi;
Mmalenakana;
Dikabeana; and
Molapowadipitse.

Meetings were held with focus groups that comprised of local farmers. A summary of the comments received during the Impact Assessment Phase consultation process were as follows:

Public, farmers and livestock owners meetings

The town leadership and the community generally welcomed the project;
Preference should be given to local people for non-skilled and semi-skilled labour requirements and the hiring should be done in a transparent manner such use of the Kgotla;
Some of the residents mentioned that increased power generation may lead to lower power costs and this will encourage the nation to divert from the use of other natural resources. This was pointed out as a worthwhile venture as it would reduce pressure on other natural resources especially firewood;
Residents also pointed out that there were frequent power outages in their area, and hoped that increased power generation would help ease the problem; and
Increased probability of illegal occupiers of land who will come in as job seekers.

Business community

Short-term increase in population in the area may lead to increase in sales and revenue; and
The contractor should source some of the materials and services locally.

Key government officers

Construction phase might exert pressure on existing social amenities such as schools and clinics available in the town.

The proposed project was generally welcomed and viewed as a good investment for the country. All the consulted stakeholders concurred with the results of the Scoping Phase that was undertaken in 2004. Consequent to this, no new issues were identified during consultations.

Specialist studies key findings

Social impact assessment

- All of the key interest groups interviewed, namely the local authorities, farmers and businesses all indicated that they did not experience any major problems with the operations of the existing power station and mine. In addition they all indicated that the proposed power station would benefit both Botswana and the town of Palapye. The benefits to Botswana were linked to improved power generation reliability and energy security. The benefits to the town of Palapye were linked to the creation of local employment and business opportunities during both the construction and operational phase;
- Concerns were raised by the representatives from local government regarding the potential pressure that the increased number of employees and job seekers would have on existing services, such as housing and medical facilities. However, the social specialist felt that these issues could be effectively managed through the implementation of mitigation measures;
- A number of potential negative impacts during the construction phase were also identified, specifically the influx of construction workers and job seekers, impact of heavy vehicles (noise, dust and safety impacts), stock theft and increased risk of veld fires. However, each of these issues can be effectively mitigated by the implementation of an Environmental Management Plan during the construction phase;
- The findings of the study also indicate that the project will create a number of opportunities for local businesses during both the construction and operational phase of the project. These represent positive impacts;
- Based on the findings of the Social Impact Assessment it is recommended that Phase 1 of the Morupule B Power Station proceed. In order to enhance the local employment and business opportunities the mitigation measures listed in the report should be implemented; and
- The mitigation measures listed in the report to address the potential negative impacts during the construction phase, specifically the impact of heavy vehicles (noise, dust and safety impacts), stock theft and increased risk of veld fires, should also be implemented.

Noise impact assessment

A summary of the predicted noise levels compared with relevant noise limits is provided in **Table 16**. The assessment of the predicted noise impact during the construction phase indicated the following:

- Source noise levels from many of the construction activities will be high. Noise levels from all work areas will vary constantly and in many instances significantly over short periods during any day working period;
- Working on a worst-case scenario basis, it was estimated that the ambient noise level from general construction should not exceed 35dBA at the nearest noise sensitive receptor (namely the Kgaswe Primary School that is offset by about 1350 metres from the construction). This level is within the noise limits prescribed by the World Bank Group;
- As the daily volume of construction generated traffic will be relatively small in comparison with the existing daily traffic on the external main road system, the noise impact from this additional traffic on the surrounding areas was assessed to be insignificant; and

- For all construction work, the construction workers working with or in close proximity to equipment will be exposed to high levels of noise.

With respect to the operational phase, the noise specialist indicated the following:

- The noise from the individual power stations at any point within the area of influence of both power stations will be enhanced as a result of the cumulative noise impact from both power stations. The maximum increase will be 3dBA. This noise enhancement will be experienced mainly in the area between the power stations;
- Noise levels near to the main roads will remain high and will continue to increase as traffic volumes increase;
- The residences on the western edge of Palapye (*urban residential*) lie well outside the power station's 45dBA+ impact zone and thus will not be negatively affected;
- The Colliery Village (*suburban residential*) lies well outside the power station's 40dBA+ zone and thus will not be negatively affected;
- The "Molapu Wapitsi" settlement (*rural residential*) lies well outside the power station's 35dBA+ zone and thus will not be negatively affected. No other settlements are potentially affected;
- Night-time noise levels in the "contractor's" village are already degraded from road traffic noise and the anticipated increase from the planned power station will be minor;
- The noise assessment indicates that the current ambient noise levels at the school are between 41dBA and 46dBA. With the Morupule B Power Station, noise levels at the school are conservatively predicted to increase to between 45dBA and 50dBA. The WBG limit for educational land use is 55dBA. The specialist concluded that the noise from the proposed power station will not significantly worsen the noise climate at the Kgaswe Primary School;
- Noise impact from ancillary works and equipment (such as the conveyor belts) will in general be low and localised. The drive houses for the conveyor belt system, however, will be sites of high noise levels; and
- The volume of traffic generated by the operations at the proposed power station will only marginally increase the ambient noise levels along the road corridor between the power stations and Palapye.

The impact of noise as a result of the proposed development was assessed to be of low significance both before and after the implementation of suggested mitigation measures.

Ecosurv in association with GIBB Botswana for Botswana Power Corporation

Table 16: Comparison of predicted noise levels against the World Bank Group limits

Noise Sensitive Site	Period	Maximum Allowable Noise Level (dBA)		Measured Noise Level (Year 2007) (dBA)	Calculated Noise Level from Noise Source Component Indicated (Year 2012) (dBA)			Cumulative Noise Level with and without New Power Station (NPS) (dBA)		Increase in Noise Level (Δ) due to New Power Station (dBA) $(\Delta = \Sigma_2 - \Sigma_1)$
		WHO & WB	SANS 10103		Existing Power Station (a)	Road Traffic Noise (b)	New Power Station (c)	Without NPS ($\Sigma_1 = a+b$)	With NPS ($\Sigma_2 = a+b+c$)	
Site 1: Colliery Village (Suburban Residential)	Day	55	50	47.5	33.2	39.6	35.0	40.5	41.6	+1.1
	Night	45	40	39.2	33.2	33.5	35.0	36.4	38.7	+2.3
Site 2: Colliery Village (Suburban Residential)	Day	55	50	39.8	33.4	39.8	35.0	40.7	41.7	+1.0
	Night	45	40	28.8	33.4	33.8	35.0	36.6	38.9	+2.3
Site 3: Kgaswe School (Educational)	Day	55	50	57.9	44.5	55.6	46.7	55.9	56.4	+0.5
	Night	na	na	49.3	44.5	49.6	46.7	50.8	52.2	+1.4
Site 4: Settlement (Rural Residential)	Day	55	45	45.5	26.0	40.3	30.5	40.5	40.9	+0.4
	Night	45	35	30.8	26.0	34.2	30.5	34.8	36.2	+1.4
Site 5: Palapye (Urban Residential)	Day	55	55	62.4	24.1	61.6	32.8	61.6	61.6	0
	Night	45	45	46.2	24.1	55.5	32.8	55.5	55.5	0
Site 6: Palapye (Urban Residential)	Day	55	55	56.8	23.0	54.2	31.1	54.2	54.2	0
	Night	45	45	51.0	23.0	48.2	31.1	48.2	48.3	+0.1

Note: The Cumulative Noise Level (Σ) is obtained by summing the relevant component noise levels logarithmically.

Ecology and land use

The ecological and land use study noted that there are few ecological issues relating to the proposed development of the power station. No post-mitigation impacts of high or medium significance were noted for the construction phase of the development. The following operational phase post-mitigation impacts were assessed to be of high significance:

- Groundwater depletion and drawdown; and
- Botswana's per capita contribution to global warming.

In terms of the latter, it has been calculated that with Phase I of the Morupule B Power Station, Botswana's per capita CO₂ emissions will increase to 8.7 tons, which is slightly above the world average (**Appendix 4.3**). If the proposed Mmamabula Power Station and Phase II of the Morupule B Power Station proceed, this would result in a per capita CO₂ emission level for Botswana of nearly 17 tons. On a per capita basis, this would make Botswana the highest CO₂ producing country in Africa and one of the highest in the world.

The following post-mitigation impacts were assessed to be of medium significance:

- Loss of Cape Vultures due to electrocution if additional power lines are required. This impact should be considered during the transmission power line EIA;
- Human health impacts as a result of predicted daily average SO₂ emissions at a concentration which exceeds relevant local and international emission limits; and
- Night-time noise impact to 16 households within 2.2 km of the power station.

The latter impact is based on the findings of the noise impact specialist (**Appendix 4.7**). These households are currently exposed to an ambient noise level of between 35.2 dBA (2500 m from the site) and 38.2 dBA (2000 m from the site). With the Morupule B Power Station, the predicted noise profile at this distance is expected to increase to between 39.1 dBA (2500 m from the site) – 41.9 dBA (2000 m from the site). This is an approximate increase in noise of between 3.7 dBA and 3.9 dBA. Appendix A of the noise impact assessment indicates that an increase in noise of 3 dBA is just detectable. The suburban residential standard for the night-time period is 40 dBA.

Air quality

Table 17 summarises the predicted emissions concentrations of the Morupule B Power Station.

Table 17: Predicted SO₂, NO₂ and PM10 future concentrations due to the Morupule and Morupule B Power Plants (exceedances of air quality guidelines are highlighted)

Averaging Period	Stack Height	Standard/ Guideline (µg/m ³)	MAX GLC		PALAPYE		SEROWE	
			Max Conc (µg/m ³)	Fraction of GL	Max Conc (µg/m ³)	Fraction of GL	Max Conc (µg/m ³)	Fraction of GL
Sulphur Dioxide (SO₂)								
Highest hourly	150 m	350(d)	4,707.03	13.45	950.00	2.71	98.00	0.28
	200 m		4,706.55	13.45	940.00	2.69	91.00	0.26
	300 m		4,683.60	13.38	937.00	2.68	76.00	0.22
Highest 24-hour average	150 m	300(a)	581.36	1.94	95.00	0.32	16.50	0.06
		150(b)		3.88		0.63		0.11
		50(c)		11.63		1.90		0.33
	200 m	300(a)	577.88	1.93	89.00	0.30	14.70	0.05
		150(b)		3.85		0.59		0.10
		50(c)		11.56		1.78		0.29
	300 m	300(a)	559.26	1.86	82.00	0.27	12.50	0.04
		150(b)		3.75		0.55		0.08
		50(c)		11.19		1.64		0.25
Annual average	150 m	80(a)(b)	189.16	2.36	6.30	0.08	2.40	0.03
		30(c)		6.31		0.21		0.08
	200 m	80(a)(b)	181.68	2.27	5.90	0.07	2.30	0.03
		30(c)		6.06		0.20		0.08
	300 m	80(a)(b)	169.06	2.11	5.30	0.07	2.20	0.03
		30(c)		5.64		0.18		0.07
Nitrogen Dioxide (NO₂)								
Highest hourly	400(a)	164.90	0.41	34.00	0.09	3.90	0.01	
	200(b)(c)		0.82		0.17		0.02	
Highest 24-hour average	150(b)	20.59	0.14	3.50	0.02	0.72	0.005	
Annual average	100(a)	6.74	0.07	0.23	0.002	0.10	0.001	
	40(b)(c)		0.17		0.01		0.003	
Particulates (PM10)								
Highest 24-hour average	150(b)	2,377.30	15.85	23.00	0.33	7.80	0.05	
	100(c)		23.77		0.23		0.08	
Annual average	200(a)	1,232.13	6.16	1.80	0.29	0.62	0.003	
	50(b)(c)		24.64		0.04		0.01	
Notes: (a) Botswana guideline (90% of observed to be less than 300 µg/m ³) (b) World Bank (WBG) Thermal Power Guidelines (c) World Health Organisation (WHO) Interim Target-2 (IT-2) (a) European Community (EC) hourly standard								
Abbreviations: GLC – ground level concentration (this is the maximum concentration) GL – Guideline Max Conc – Maximum Concentration								

Sulphur dioxide

- The highest predicted ground level concentrations exceeded all the relevant guidelines and standards for hourly, daily and annual averaging periods. This was based on a design stack height of 150 m. The maximum ground level concentration predicted was very close to the existing Morupule Power Station impacting approximately 800 m to the west;

- The zone of exceedance for highest hourly predictions (EC standard) covered a radius of approximately 10 km around the power plant site. The number of hours exceeding the EC hourly standard of $350 \mu\text{g}/\text{m}^3$ at Palapye was 13 based on the 150 m stack but reduced to 10 with the 200 m stack and with the 300 m stack down to 6. The EC allows 24 hours of exceedance;
- The Botswana and WBG guideline for highest daily average and annual average at Palapye and Serowe were not predicted to be exceeded. The hourly average EC standard and highest daily WHO IT-2 guideline was exceeded at Palapye;;
- The zone of exceedance for highest hourly predictions (EC standard) covered a radius of approximately 10 km around the power plant site;
- Over an annual average, only the maximum ground level concentrations exceeded the relevant guidelines. This was predicted to be right at the plant, less than 1 km from the source. With an increase in stack height to 200 m a reduction of 6 % would be achieved at Palapye and at 300 m the overall improvement will be 16 %;
- Highest daily averaged SO_2 concentrations exceeded the critical level for agricultural crops, forest trees and natural vegetation ($79 \mu\text{g}/\text{m}^3$) both on-site and at Palapye and surrounding areas. No reports regarding the impact of SO_2 emissions on agricultural crops or natural vegetation were noted during stakeholder consultation or within the social impact assessment report;
- Predicted annual averaged SO_2 concentrations were well within the EC and United Kingdom limit value ($20 \mu\text{g}/\text{m}^3$) for the protection of ecosystems;
- The Morupule B Power Station has a relatively small contribution to the high SO_2 concentrations (**Table 18**);
- With the increase in stack heights to 200 m and 300 m, very little difference was noted in the cumulative (i.e. including the existing Morupule Power Station) maximum predicted ground level concentrations. The predicted ground level concentrations at Palapye reduced by 1% between the 150 m stack and the 200 m stack and by a further 0.4% when increased to 300 m. The incremental impacts from the three stack heights did however indicate a significant reduction between 200 m and 300 m. The predicted maximum concentrations from the proposed Morupule B Power Station in isolation were $1315 \mu\text{g}/\text{m}^3$ at 150 m, $978 \mu\text{g}/\text{m}^3$ at 200 m and $740 \mu\text{g}/\text{m}^3$ at 300 m. Thus a reduction in ground level concentrations of 26% will be achieved by increasing the stack height from 150 m to 200 m and a further 24% reduction by increasing it to 300 m. With the background concentrations included (i.e. Morupule Power Station) the reduction is less noticeable.

Table 18: Comparison of predicted baseline air quality with predicted air quality after the development of the Morupule B Power Station

Averaging period	Max GLC*	Max GLC*	Percentage difference
	($\mu\text{g}/\text{m}^3$) Without Morupule B (baseline)	($\mu\text{g}/\text{m}^3$) With Morupule B	
<i>Sulphur dioxide</i>			
Highest hourly	4,683.6	4,707.0	0.5
Highest daily	557.9	581.4	4.2
Annual average	155.2	189.2	21.9
<i>Nitrogen dioxide</i>			
Highest hourly	164.0	164.90	0.6
Highest daily	19.6	20.6	5.1
Annual average	5.5	6.7	21.8
<i>Particulate matter (PM10)</i>			
Highest daily	366.6	2,377.30	548.5
Annual average	189.2	1,232.13	551.2

* Ground-level concentration

Nitrogen dioxide

- A maximum hourly ground level concentration of $165 \mu\text{g}/\text{m}^3$ was predicted for operations from the Morupule B Power Plant and Morupule Power Plant. This concentration did not exceed the WBG, WHO or Botswana limits;
- Highest daily averaged and annual averaged NO_2 concentrations complied with WBG, WHO and Botswana limits;
- The predicted ground level NO_2 concentrations were well below the European Union (EU) vegetation protection limits and thus no negative impacts on vegetation is expected; and
- The predicted increase in NO_2 emissions as a result of the Morupule B Power Station is relatively small (**Table 18**).

Particulate matter (PM10)

Predicted ground level concentrations of PM10 included all sources at Morupule, i.e. stacks, vehicle entrainment on roads, wind blown dust from the storage piles and ash dumps and materials handling operations. The findings were as follows:

- PM10 concentrations exceeded the referenced daily and annual guidelines (i.e. Botswana, WBG and WHO) for the maximum ground level concentration. Due to the low level of release of the main particulates sources (i.e. materials handling, wind blown dust and vehicle entrainment), the maximum predicted impact was expected to be within close proximity of the plant;
- The area exceeding the WBG limits for highest daily PM10 concentrations extended for approximately 2.5 km from the site. The exceedance of the annual average Botswana guidelines is within an area of a few hundred meters from the source and a radius of approximately 1 km when compared to the WBG and WHO annual guidelines;
- Predicted highest daily averaged and annual averaged PM10 concentrations at Palapye and Serowe complied with all the emission limits; and
- Current on-site concentration of particulate emissions was predicted to increase by more than 500% as a result of the Morupule B Power Station project. This predicted increase is predominantly as a result of an assumption used in the air quality assessment that road infrastructure for the new power station will be unpaved, which will not be the case (**Table 18**).

It is important to note that the input data used in the air quality impact assessment was based on the proposed design specification requiring that the emissions limits from the proposed plant would be at the emission limits of the World Bank Group. Actual emissions are likely to however be well below these limits and the findings of the air quality impact assessment can thus be considered to be conservative.

Hydrogeology

- The study revealed that the soils and aquifer immediately around the existing and proposed power station location are considered to be of moderate vulnerability;
- The existing power plant does not appear to have significantly impacted on the water resources in the area albeit for a rise in sulphate concentrations;
- The increased amount of coal storage, chemical storage and the amount of burnt coal ash to be disposed of are the activities which are likely to have the most potential for consequent impact;
- The possibility of the spread of contaminants by rainfall from the smoke produced by coal burning was reviewed by a desktop study of other power stations worldwide. It seems unlikely that the new development will have a significant effect on the water environment;
- The residual impact to groundwater and surface water resources were assessed to be of low significance; and
- The specialist concluded that the proposed new power station is unlikely to pose a significant pollutant risk to groundwater.

Archaeology

A team of four people surveyed the proposed Morupule B Power Plant site on foot with the aid of maps, aerial photographs and a GPS to mark and record anything that could bear archaeological significance. Surface surveying was done in transects covering a total width of 150 meters. Interviews from previous research conducted in the same area were also utilised.

The specialist concluded that there was nothing of archaeological importance in the proposed development area. The absence of archaeological material on the surface of the area however does not rule-out the probability of encountering materials during the course of project activities as the sands may cover some artifacts. Archaeological monitoring will need to be instituted during site clearance to ensure that any archaeologically significant materials are reported to the Botswana National Museum. This is especially important for the area currently covered in rubble, which due to the rubble, has not been surveyed by the archaeological specialist.

Impact assessment results

The significant environmental impacts identified in the Scoping Phase as well as newly identified possible impacts have been assessed through the various specialist studies. **Table 19** summarises the results of the impact assessment. The significance of the residual impact (impact after mitigation) for most impacts was assessed to be of low significance.

Table 19: Summary of potential environmental impacts

POTENTIAL <i>CONSTRUCTION</i> PHASE IMPACTS	RESIDUAL IMPACT SIGNIFICANCE
Biophysical impacts	
Impact of emissions to air on human health, fauna and flora	Low
Loss of vegetation and habitat	Low
Loss of grazing due to man-made fires	Low
Disturbance of wildlife	Low
Impact of spillages of chemicals, petrochemicals and hydrocarbons on water resources	Low
Erosion and sedimentation	Low
Litter	Low
Security	Low
Traffic	Low
Socio- cultural/ socio-economic impacts	
Loss of arable lands and grazing during site establishment	Low
Social behaviour and human health	Low
Aesthetics/Visual	Low
Safety	Low
Impact on social fabric of town	Medium / Medium (+)
Impact on employment / temporary employment opportunities	High (+)
Archaeological impacts	Low
Noise impact during construction	Low
Impact on business opportunities	High (+)
Impact on Serowe Landfill	Low

POTENTIAL OPERATIONAL PHASE IMPACTS	RESIDUAL IMPACT SIGNIFICANCE
Biophysical impacts	
Groundwater depletion and drawdown	High
Habitat loss from coal dust dispersal	Low
Impact of high SO ₂ levels on agriculture	Low
Impact of high SO ₂ levels on sensitive habitats	Low
Impact of NO ₂ emissions on human health	Low
Impact of PM ₁₀ emissions on human health	Low
Human health impacts from SO ₂ emissions	High
Impact of ash waste stream on soil and groundwater	Low
Impact of water reuse	Medium (+)
Impact of coal storage on soil and groundwater	Low
Global warming	High
Socio-cultural/ socio-economic impacts	
Impact on visual "sense of place"	Low
Impact of increased emissions on surrounding land use and planning	Medium
Impact on Botswana's energy supply	High (+)
Manpower needs/ job creation	Medium (+)
Impact on business opportunities	High (+)
Impact of Morupule B on power tariffs	Medium
Noise impact on surrounding communities	Low

POTENTIAL DECOMMISSIONING PHASE IMPACTS	RESIDUAL IMPACT SIGNIFICANCE
Biophysical impacts	
Ash dam and material storage areas	Low
Waste disposal	Low
Traffic	Low
Air quality	Medium (+)
Use of water resources	Medium (+)
Fauna and flora	Low (+)
Socio-cultural/ socio-economic impacts	
Land use	Low (+)
Noise impacts	Low /Low (+)
Impact on local economy	Low
Social behaviour and human health	Low
Safety	Low

Assessment of alternatives

Alternatives within the EIA process are regarded as different means of meeting the general purpose and requirements of the originally proposed activity. To ensure that the assessment of alternatives is meaningful, the alternatives proposed must be feasible and have the same principle purpose as the originally proposed activity.

The following broad categories of alternatives were considered:

Site alternatives

The main factors influencing the location of a coal-fired power plant is proximity to a coal resource of suitable quality and an appropriate water supply. Other important factors that influence location include availability of land, environmental suitability, proximity to the market and availability of infrastructure such as roads, railways and telecommunications.

Establishment of the power station at any other location in Botswana would require significant additional infrastructure to be constructed such as roads, rail and the establishment of a new coalmine. Notwithstanding the financial cost associated with this additional infrastructure, the impact to the environment would be significantly greater than the proposed expansion of an existing footprint.

Technology alternatives

The various technologies available differ markedly in their generation costs, performance and utilisation characteristics, suitability for the national context and state of commercial development.

The choice of electricity generation technology is multi-faceted and complex and must be conducted within the context of relevant national and international policies, legal requirements and the specific daily, weekly and seasonal variation in demand for electricity.

Both renewable and non-renewable technologies fall into one of the following categories:

- Base-load electricity generation technology; or
- Peaking electricity generation technology.

Base-load electricity generation technologies refer to power stations which are designed specifically to generate electricity continuously over all hours of the day.

In contrast, peaking electricity generation technologies are designed to only generate electricity during periods of high demand for electricity, normally on weekdays from 07:00 to 09:00 and 18:00 to 20:00.

The electricity demand pattern in Botswana requires that a base-load generation technology be considered because a peaking electricity generation technology will only limit the extent to which imported power will be needed at certain times of the day. Although this will assist in reducing reliance on imported power, it will not enable BPC to replace the current 70 % reliance on imported power with local generation capability, which is a key strategic objective of this project. Renewable energy technologies such as solar thermal generation and wind energy are peaking generation technologies as they rely on natural conditions which do not exist on a 24-hour basis. This factor reduces the number of possible generation technology alternatives to the following base-load generation options:

- Bio-energy technologies;
- Hydro-electric technologies;
- Gas turbine technologies;
- Nuclear technologies; and
- Coal-fired technologies.

Of these, the only feasible option for a base-load technology is a coal-fired plant. A number of alternatives exist for the specific design technology of the coal-fired plant.

Operational alternatives

Peaking electricity generation technologies are only operated at a certain time of the day, typically when electricity demand is the highest. Given Botswana's need for base-load electricity generation capacity, the Morupule B Power Station must be able to generate electricity throughout the day. No feasible operational alternatives to that proposed are thus identified.

Design alternatives

The proposed Morupule B Power Station intends to make use of either the CFBC boiler design or the Pulverised Coal (PC) boiler design. The CFBC design is an advanced coal-utilisation technology which has the following benefits⁴ over conventional thermal power plants:

- Wide range of fuel adaptability which allows for the use of low grade coal, biomass and waste tyres;
- Decreased emissions of NO_x and SO_x;
- High combustion efficiency; and
- Space saving and improved maintenance ability.

A summary of PC technology with Selective Catalytic Reduction (SCR) for removal of NO_x and Flue Gas Desulphurisation (FGD) for removal of SO_x compared with CFBC technology is provided in **Table 21**.

Table 21: Comparison between PC and CFBC boiler designs. Source: Alstom (2006).

Design technology	SO ₂ capture mg/Nm ³	Ca/S	NO _x emissions mg/Nm ³	Operation and Maintenance Costs
CFBC	> 95%	1,0 – 2,5	150-250	Medium
PC with SCR and FGD	> 95%	1,0	50-100	High

Selecting between PC and CFBC boiler designs is a complex decision and environmental performance is only one criterion which should influence this decision. The results in the table above suggest that the CFBC boiler design is able to achieve a similar environmental performance with respect to gaseous emissions to PC technology with SCR and FGD at a lower operating cost.

The no-project alternative

The no-project alternative implies that BPC continues to import power from neighbouring countries. The benefits of this alternative are that most of the negative impacts associated with the proposed development option will be prevented. Notwithstanding the significant job creation potential and positive opportunities for local business, the largest cost of not proceeding with the project is that the positive impacts of the development option on Botswana's energy supply will not be realised.

⁴ New Energy and Industrial Technology Development Organisation (2006)

Conclusions

This ESIA has been compiled in accordance with Section 10 of the EIA Act and with due consideration of international best practice including the requirements of the World Bank Group. The biophysical, socio-economic and socio-cultural impacts of the development have been assessed and mitigation measures for all identified impacts have been proposed. The main conclusions from the ESIA are summarised below:

1. The specialist studies in hydrogeology, social impact, archaeology and noise did not identify any negative impacts of high or medium significance which could not be satisfactorily mitigated through the implementation of the ESMP;
2. The stakeholder engagement process indicated that the proposed project was generally welcomed by stakeholders and viewed as a good investment for the country;
3. The per capita carbon emission rate for Botswana, based on findings within the ecological and land use specialist study, was identified as an impact of high significance. The findings indicate that with Phase I of the Morupule B Power Station, Botswana's per capita CO₂ emissions will increase to 8.7 tons per year, which is slightly above the world average. This impact must however be considered with due regard to Botswana's status as a developing nation as well as its relatively low population density. The impact is identified within this report because of the importance of global warming and its agreed contribution to global climate change. The impact is a socio-political impact, rather than a social or ecological impact;
4. The impact of SO₂ concentrations on human health was considered to be of high significance. SO₂ concentrations which exceed the Botswana and World Bank Group ambient air quality limits are predicted to occur with the highest ground level concentration predicted to be at approximately 800 m west of the existing Morupule Power Station. The Botswana and WBG guidelines for ambient SO₂ concentrations at Palapye and Serowe were not predicted to be exceeded;
5. Given the three stack height scenarios modelled (i.e. 150 m, 200 m and 300 m) it can be concluded that an increase in stack height will not result in significant changes to predicted SO₂ ground level concentrations. This is due to the elevated background SO₂ concentrations. For this reason, increasing the proposed Morupule B Power Station stack height beyond 150 m is considered to have an insignificant impact on emission reduction at ground level. However, in isolation from the existing Morupule Power Station emissions, a 200 m stack height is predicted to result in a 26 % decrease in maximum ground level SO₂ concentrations. It is concluded that both the 200 m and 300 m stack height options for the Morupule B Power Station will have a significant positive impact on ambient emission concentrations but only once the existing Morupule Power Station has been decommissioned or if emissions are reduced from the latter;
6. Predicted NO₂ concentrations complied with all relevant emission limits;
7. PM10 emissions are predicted to increase significantly as a result of the Morupule B Power Station, predominantly as a result of the assumption that road infrastructure will be unpaved which is not to be the case. These emissions are considered to be near-field to the source and can be effectively mitigated through the implementation of the ESMP and through paving of the road infrastructure;

8. The assessment of alternatives to the proposed development option concluded that the development of the proposed Morupule B Power Station, with the recommended mitigation measures, is considered to be the preferred alternative. It is recognised that the Morupule B Power Station will have an impact on the environment, however the impact of not proceeding with the development is considered to be of greater significance.

Recommendations

Recommendations by various parties including stakeholders, the EIA project team and the various specialists have been summarised in the text below. Where possible, all recommendations have been incorporated into specific mitigation measures within the ESMP.

1. The proposed Morupule B Power Plant should be designed to be in compliance with the World Bank Group emission limits for new thermal power plants⁵;
2. Rehabilitation and mitigation of fugitive dust emissions must be continuous throughout the life of the project in order to result in the minimal effort to apply final rehabilitation strategies. The following mitigation measures are recommended for PM10 control:
 - 2.1 Chemical suppressants should be applied to unpaved roads and access roads to control emissions from vehicle entrainment on unpaved roads. For unpaved haul roads on the plant site it is recommended that dustfall in the immediate vicinity of the road perimeter be less than 1,200 mg/m²/day;
 - 2.2 The vegetation cover on the walls of the ash dump should be such to ensure at least 80% control efficiency for the walls. The surface areas should be kept wet. Dustfall immediately downwind of the site must be limited to <1 200 mg/m²/day;
 - 2.3 Topsoil piles and the storage pile for overburden materials should be vegetated completely to ensure as little as wind disturbance of these areas as possible; and
 - 2.4 Based on the increase in particulate emissions due to the proposed operations, it is recommended that a dust fallout network be designed for the site in accordance with the specifications in the ESMP.
3. Flue Gas Desulphurisation (FGD) as a control option for SO₂ emissions should be considered for the new power plant if the PC boiler design is selected;
4. Given that the existing power plant contributes up to 74% to the predicted SO₂ concentrations, it is recommended that additional studies be commissioned by BPC to investigate the feasibility of installing pollution abatement equipment for SO₂ emissions at the existing Morupule Power Station;
5. The impact of SO₂ emissions on vegetation indigenous to Botswana is unknown. Monitoring of vegetation downwind of the power plant is recommended so that any impacts can be identified and mitigated;
6. Although a stack height of 150 m would meet the relevant air quality emission limits, it is recommended that the stack height of the Morupule B Power Station be at least

⁵ Note: The World Bank emissions limits fully comply to the national limits.

- 200 m high to take into consideration future developments such as more stringent air quality limits and the possible development of Phase II of the Morupule B Power Station;
7. An online stack monitor must be implemented at the boiler stack to measure SO₂ and NO_x emissions;
 8. Isokinetic stack sampling should be conducted at all the remaining point sources at least once a year. This is to ensure that the dust collectors are working according to design specifications;
 9. A new ambient air quality monitoring station inclusive of a meteorological station must be installed at the Morupule B Power Station. It is recommended that this ambient station is calibrated at least once every six months to ensure accurate and continuous data capturing;
 10. Archaeological monitoring must be undertaken during site clearance especially in the area of the rubble dumps and the developer must immediately inform the Botswana National Museum should they encounter anything of archaeological significance;
 11. As part of the monitoring programme, a brief survey for rare and endangered plants in the area exposed to SO₂ levels in excess of the national air quality objectives should be undertaken after the rainy season;
 12. The Land Board and land use planners must be made aware of the power station impact zones in terms of air quality. This will allow for suitable land allocation and planning;
 13. The ash dam and all coal storage areas should have an enclosed drainage system to facilitate the reuse of the water;
 14. The drainage of surface water off site in the case of high intensity rainfall should be addressed in the design of the new power plant. It is recommended that all surface water and roof and car park run off be collected for reuse on the site. The retention of stormwater on site will remove the pathway for contaminants off site and the stored water can be reused back in the plant;
 15. Storage of hydrocarbons and chemicals will require proper spillage and leakage protection. Bunds and the use of leakage detectors are considered vital for such storage areas (tanks, etc);
 16. Additional monitoring boreholes to the four boreholes currently on site may need to be drilled to monitor any potential deterioration in groundwater quality. These should encircle the site both upstream and downstream of the site;
 17. Once the final design details of the planned power station are known, the parameters, which directly affect the calculations made in the noise impact study, should be checked and validated. If necessary, the calculations should be redone and the noise impact checked;
 18. Various measures to reduce the potential noise impact from the planned power station are possible and should be incorporated into the design of the plant. The noise mitigating measures will need to be designed and/or checked by an acoustical engineer in order to optimise the design parameters and ensure that the cost/benefit of the measure is optimised;

19. At commissioning, the noise footprint of the planned power station should be established by measurement in accordance with the relevant standards, namely SANS ISO 8297:1994 and SANS 10103. The character of the noise (qualitative aspect) should also be checked to ascertain whether there is any nuisance factor associated with the operation;
20. A closure plan and social development programme must be developed from mid-life of the Morupule B Power Station and annually updated by the Morupule B Power Station plant owner;
21. A database of local firms that qualify as potential service providers for post EPC tender award services (construction companies, catering companies, waste collection companies etc) should be developed. These companies should be notified of and invited to bid for project related work;
22. Where necessary, firms should be assisted and or capacitated to enable them to fill in and submit the required tender forms and fulfil contracts for post EPC tender award services;
23. The local chamber of business and hospitality industry should identify strategies aimed at maximizing the potential benefits associated with the Project;
24. Where necessary an induction programme for construction workers should be initiated prior to the commencement of the construction phase;
25. A formal structure (e.g. liaison committee) should be set up between contractors and the local authorities and adjacent landowners to ensure cordial relations and to address conflicts that may arise;
26. Farmers must be compensated in full for any stock losses and or damage to farm infrastructure that can be positively linked to construction workers. If the formal structure referred to above deems it necessary, this should be contained in an agreement of good conduct to be signed between BPC and all adjacent landowners;
27. Appropriate and adequate social amenities must be provided for the construction workers at the camp;
28. An HIV and AIDS awareness programme for construction workers must be implemented;
29. Where local skills and expertise are not available BPC should, where possible, employ Botswana nationals as opposed to expatriates. Local labour must be utilised as far as possible during the construction, operational and decommissioning phases of the development; and
30. The impacts associated with the groundwater investigations, transmission power line, coalmine expansion and water supply pipeline will have a cumulative impact, the significance of which is unknown at this stage. Authorities and stakeholders must be provided with an indication of the significance of these cumulative impacts within each of the individual EIAs.