Scott Wilson Ltd.

AES SONEL

Kribi Power Project

Environmental and Social Impact Assessment Report, Addendum
Amendment of Gas Plant from 150MW to 216MW

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Report Control Form

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CONTENTS

Page

TABLES

FIGURES

1. INTRODUCTION

1.1 BACKGROUND

The Ministry of Environment and Protection of Nature (MEPN) formally approved the Environmental and Social Impact Assessment (ESIA) Report (Scott Wilson, October 2006) for the Kribi Power Project on 5 April 2007 (see Appendix 1). This approval was subject to minor amendments and the undertaking of an Indigenous Persons Plan (including Pygmies). An addendum to the ESIA Report was therefore produced. In addition, the addendum took into consideration the following revisions to the Plant design since the preparation of the ESIA report:

- The use of nine reciprocating engines in the place of the four gas engines assessed within the ESIA; and
- The movement of the plant site approximately 200 m to the east of the location assessed within the ESIA. This places the proposed power plant further from the road and the adjacent village of Mpolongwe.

1.2 SCOPE OF WORK

AES Sonel has commissioned Scott Wilson Ltd. to prepare an additional ESIA Addendum report to address their plan to increase the capacity of the Plant from 150 MW to 216 MW. This further upgrade is to include:

- An increase in the size of the plant and substation within the current site boundary (i.e. no requirement for additional landtake beyond original assessment); and
- An increase in plant capacity from150 MW (9 gas engines) to 216 MW (13 gas engines), each of 16.6 MW (Wartsila, unit type, 18V50 DF).

There is to be no change to the transmission line.

1.3 APPROACH

The proposed amendments relate solely to the plant. There is to be no amendment to the already assessed footprint[1], which has already been assessed (Scott Wilson, October 2006 and Scott Wilson, October 2007). The potential impacts of the proposed amendments relate to air quality and noise only, which are assessed in Section 2 and 3 of this report respectively.

With regard to terminology used in the ESIA, specific technical terms are explained in the appropriate section of the text. However, in the interests of clarity and consistency, a number of terms defined in the text are defined in Table 1, and are the same used in the original ESIA report

[1] Location and boundary.

Table 1: Kribi Power Project - ESIA Terminology	
Term	**Definition**
Site and surrounding area	
Mpolongwe site	The 16 ha search area identified for the location of the plant site (the full 16ha to be fenced).
Plant Site	The area (4 ha), which will be surrounded by internal fencing, encompassing the gas fired power plant, ancillary buildings and equipment.
Project Area	The entire area to be utilised for the project encompassing Mpolongwe Site, Transmission Line Wayleave and the Mangombe substation in Edéa.
Nature of predicted impacts	
Neutral	No overall environmental impact.
Adverse	Negative environmental impact.
Beneficial	Positive environmental impact.
Significance of predicted impacts [(1)]	
Insignificant	An impact which is either too small to be measured or, even if quantifiable, does not give rise to any material change in the environment.
Minor	An impact that is capable of causing change in the environment but does not fundamentally affect the status, potential productivity or usage of the environment.
Significant	An impact that is capable of causing sufficient change in the environment to affect the status, potential productivity or usage of the environment.
Duration of predicted impacts [1]	
Short term	An impact that persists for 15 months or less i.e. during construction period.
Medium term	An impact that persists for between 15 month and five years (i.e. during initial operations)
Long term	An impact that persists for longer than five years .

[1] The classification of an impact as temporary, short-term or long-term is purely descriptive and does not, of itself, imply a degree of significance or acceptability (thus, a temporary impact may also be a significant impact, whilst a long-term impact may be insignificant).

2. AIR QUALITY

This section discusses the current and future ambient air quality in the airshed around the proposed plant site. The potential effects on air quality are considered with regard to World Bank ambient air quality guidelines (World Bank, 1998) as this is considered most relevant to this type of development and aligns with the previous assessment undertaken. This section of the Addendum report has been updated to incorporate the changes to the plant site described above in Section 1.2.

A qualitative assessment has been made of the potential impacts of fugitive releases of dust around the proposed plant site during the construction phase of the project. Operational emissions from the power plant stacks have been modelled to evaluate the proposed stack height and determine the magnitude of the change in air quality statistics of nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and fine particulate matter (PM_{10}).

2.1 BASELINE CONDITIONS

There are no existing large-scale industrial developments or other major point sources of emissions in the vicinity of the proposed power plant. The main local sources of combustion emissions are the nearby Kribi to Edéa main road and domestic emissions from local housing. Traffic travelling along the main road is light, averaging between 400 and 450 vehicles per day (Scott Wilson, October 2006). Traffic and domestic emissions are unlikely to be significant.

Cameroon does not have a systematic network of air quality monitoring stations. As such, there are no readily available sources of baseline air quality data for the Kribi area. To resolve this problem, a diffusion tube survey was carried out at two sites adjacent to the proposed plant site to establish indicative background levels of NO_2, SO_2 and ozone (O_3). Monitoring took place between April and June 2006 (Scott Wilson, October 2006). The results of the monitoring exercise are presented in Table 2.

Table 2: Background Pollutant Concentrations (µg/m^3) (revised)

Pollutant	Site 1: Mean Background Concentration (µg/m^3)	Site 2: Mean Background Concentration (µg/m^3)	Average (µg/m^3)
NO_2	1.2	0.8	1.0
SO_2	1.4	1.5	1.5
O_3	33.8	44.1	39.0

Note: This table has been updated to include monitoring results obtained from a Scott Wilson diffusion tube monitoring survey, which were not available at the time of preparation of the original ESIA.

For evaluation purposes these concentrations are compared to the World Bank Standards, as set out in Table 3.

Table 3: World Bank Air Quality Guideline Values		
	Reference Period	**Recommended maximum ground level concentration values (µg/m³)**
NO_2	24 hour average	150
	Annual average	100
SO_2	24 hour average	150
	Annual average	80
Total Suspended Particulate	24 hour average	230
	Annual average	80
PM_{10}	24 hour average	150
	Annual average	50

The World Health Organisation (WHO) has also published air quality guidelines (WHO, 2005), listed in Table 4. Their limits, which are broadly similar to EU Limit Values, are not mandatory. The WHO guideline values have been set at a level that provides the protection of human health for all members of the public.

Table 4: WHO Air Quality Guideline Values		
	Reference Period	**Recommended maximum ground level concentration values (µg/m³)**
NO_2	1-hour average	200
	Annual average	40
SO_2	10-minute average	500
	24-hour average	125
	Annual average	50

As is shown in Table 2, background concentrations of NO_2 and SO_2 are far below both World Bank and WHO guideline values, reflecting the very low level of current emissions of these pollutants in the area around the proposed site. Background levels of ozone are typical of equatorial latitudes. The photochemistry of the region is limited by low levels of NO_2 and, as a result, minor emissions of nitric oxide would be rapidly converted to nitrogen dioxide. However, more significant emissions of nitric oxide would be converted into nitrogen dioxide as the plume disperses downwind. Measured concentrations of oxides of nitrogen would be composed of nitric oxide and nitrogen dioxide in varying proportions at any given distance from the source.

Overall, baseline air quality in the vicinity of the proposed plant site is good, although there is the possibility of deterioration within Edéa.

2.2 POTENTIAL IMPACTS

Potentially significant air quality impacts from the proposed development relate primarily to point source gaseous emissions from the power plant stacks during operations. However, short-term local impacts may arise from fugitive dust and gaseous emissions from plant and vehicles during the power plant's construction phase.

The main impacts include:

Construction

- *Exhaust fumes* from construction traffic and plant at the power plant site.
- *Dust generation* from construction activity and construction vehicle movements across unsurfaced roads and cleared site areas;

Operation

- *Power Plant Emissions* from power generation plant stacks, arising from the burning of the main fuel source (gas), and short-term stack emissions arising from the burning of back up fuels (diesel) during any shut down period of the gas supply.

Exhaust Fumes

Construction

The anticipated volume of construction traffic and plant activity will represent a large increase over current traffic movements on the Edéa / Kribi road (see Section 5.7 of the ESIA). However, the overall traffic flows on this road are relatively low. The impact of the additional construction phase vehicle emissions on air quality, taking into account the very low level of baseline air pollution, would not be significant. As such, this impact is not assessed further within the ESIA.

Operation

Traffic volumes during the operational phase are very low (see Section 5.7 of the ESIA). Therefore, no air quality impacts will arise from this source. This impact is not assessed further within the ESIA.

Dust Generation

Construction

The primary potential air quality impact arising from the construction phase is dust generated during construction activities and the movement of construction vehicles on unsurfaced areas.

Site preparation, construction works and the movement of site vehicles can generate dust emissions. Dust is particulate matter in the size range 1-75 micrometres (µm) in diameter, and is produced through the action of abrasive forces on materials. Fine particulate matter (PM_{10}) is defined as particles less than 10 µm in diameter, and is of the most concern regarding health effects. Construction dust is generally larger in diameter than 10 µm and, therefore, does not necessarily increase existing levels of PM_{10} considerably. Particles between 10 and 75 µm in diameter are not typically associated with adverse effects on human health, their main potential effects being the soiling of surfaces (soiling is the cumulative deposition of airborne particles on to a surface).

During the construction of the power plant, some activities would have the potential to generate emissions of fugitive dust. These include:

- vehicle movements on unsurfaced areas;
- land clearance to remove vegetation from construction areas and excavation;
- land levelling and grading of the site and access road route;
- the storage on site of surplus excavation materials and dusty building materials; and
- construction of site buildings and installation of plant and equipment.

During the wet season it is likely that the regular and intense rainfall in the area would significantly reduce the frequency and severity of impacts from dust generated by the works, by maintaining a high level of moisture within exposed soils and by washing deposited material from surfaces.

At the present time there are no statutory World Bank or EU standards relating to either ambient concentrations of airborne dust or to rates of surface soiling by dust particles. The emphasis of the control of construction dust should be the adoption of best practices on site. However, where mitigation measures are employed any residual dispersion of dust off-site would not have the potential to significantly impact on local residents.

Overall, the impact on local air quality due to emissions of fugitive dust from the plant site during the construction phase can be classified as adverse, short-term, and minor in magnitude.

Operation

As there will be minimal maintenance activity during the power plant's operational phase, there is little potential for the generation of fugitive dust. Such maintenance will only entail one or two vehicles movements every few months and, therefore, will not lead to significant air quality impacts arising from this source. Therefore, this impact is not assessed further within this Addendum.

Power Plant Emissions

This is purely an operational impact, as the power plant will not be functioning during the construction phase.

The main air quality impact during the operation of the proposed power plant will be emissions to air from the combustion of fuel within the gas engines. The primary fuel for the plant will be natural gas obtained from the Sanaga Sud gas field. However, there is no plan to build a gas storage facility at the proposed power plant site. Therefore, it is intended to fire the plant with diesel oil during periods when the gas supply is interrupted.

Emissions to air from the burning of natural gas and diesel will include carbon dioxide (CO_2), oxides of nitrogen (NOx), SO_2, and particulate matter, a proportion of which will be PM_{10}. The particulate matter emitted to atmosphere may include small quantities of trace metals.

There are currently no national limits for emissions from power plants in Cameroon. Therefore, emission guidelines for new thermal power plants burning fossil fuels, as detailed in the World Bank Pollution Prevention and Abatement Handbook (1998), are employed within the design of this plant. The appropriate emission standards relating to the proposed plant are detailed in Table 5.

Table 5: World Bank Emission Guidelines for New Thermal Power Plants (Engine Plants)

	Emission Guideline (mg/Nm^3)	
Fuel	Natural Gas	Diesel
Particulate Matter	50	50
SO_2	0.2 metric tonnes/day/mw or 2000 mg/Nm^3	0.2 metric tonnes/day/mw or 2000 mg/Nm^3
NO_x	2000	2000

Reference conditions: 15% O2, dry.

An assessment of the potential impacts has been undertaken through an air quality modelling exercise. This assessment is based on the revised power plant configuration consisting of thirteen Wartsila 18V50DF reciprocating engines as opposed to the originally proposed four GE Frame 6B gas engines fitted with dry low NO_x (DLN) combustors and the previous revised proposal for nine Wartsila reciprocating engines. Discharge to atmosphere from the plant occurs via thirteen stacks, one for each power unit.

Model Scenarios

The load profile for the power station in the rainy season is expected to be a base load of 40 to 50 MW, with a peak output of 216 MW lasting for 4 hours per day. However, during the dry season, when production from hydro plant is limited due to low water regulated flows, the plant is expected to run continuously at full load. The emissions from the proposed plant have therefore been modelled on a worst-case basis, with the plant assumed to be operating on natural gas at continuous 100% output.

The plant may burn diesel, typically at 30% continuous load for twenty hours per day and up to 100% output for four hours per day, for around 8 days per year. This would occur during periods of interrupted gas supply. A consideration of the possible worst-case short-term impact of operating the plant in this way has been made by modelling NO_x, SO_2 and PM_{10} emissions from the power station at 100% output when burning light fuel oil (diesel/heating oil), enabling 1-hour / 24-hour maximum NO_2, 10-minute / 24-hour maximum SO_2 and 24 hour PM_{10} concentrations to be predicted in the vicinity of the closest sensitive receptors. Long-term statistics have not been modelled, as the plant would only burn diesel fuel for short periods of time and not throughout the year.

A summary of the revised emissions modelled is provided in Table 6.

Table 6: Engine Emission Data (revised)

Scenario	100% load (natural gas)	100% load (No. 2 distillate)	Notes
Stack Internal Diameter (m)	1.6	1.6	
Exit Velocity (m/s)	25.8	30.3	Calculated, based on supplied volumetric flow rates (actual).
Stack Exit Temperature (K)	648	643	
CO emission rate (g/s)[1]	5.7	4.8	-
NO_x emission rate (g/s)[1]	11.4	69.0	Calculated as NO_2
SO_2 emission rate (g/s)[1]	0.4	10.4	
PM_{10} emission rate (g/s)[1]	0.3	1.1	As total dry particulate dust, assumed to be PM_{10}

[1] Emission rates are per engine stack; there are 13 stacks in total.

The effect of stack height on ground level concentrations of the pollutants emitted has been evaluated as part of the sensitivity analysis, by running AERMOD with stack heights of 20 (proposed stack height), 22.5, 25, 27.5 and 30 metres. Annual mean ground level concentrations are compared with the air quality guidelines in Tables 3 and 4.

The air quality impacts on the surrounding area resulting from the operation of the proposed plant, as calculated by the dispersion model, are combined with existing ambient air quality statistics and compared with the assessment criteria to establish the significance of any effects.

Hazardous Air Pollutant (HAP) Emissions

The emission of unburned hydrocarbons and NO_x may contribute to the formation of ground level O_3. Reactive plume modelling would be required to assess the impact of these pollutants in forming O_3. No such modelling has been performed as part of this assessment, as there is limited potential for the proposed plant to significantly effect local or regional ground level O_3 concentrations.

Dispersion Model Selection

The air quality impacts of the proposed power plant are best evaluated using a refined, near-field (less than 50 km from the emission source) Gaussian Plume Dispersion Model. This type of model is suited to calculating maximum ground level concentrations at receptors close to the plant boundary.

This assessment has been undertaken using the US EPA preferred model AERMOD, developed by the American Meteorological Society and U.S. Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC). AERMOD is an advanced plume model that incorporates the latest understanding of the atmospheric boundary layer, and includes the PRIME downwash algorithm for the assessment of structure effects.

In addition to AERMOD, there are two input data processors that make up the regulatory components of the modelling system. AERMET is a meteorological data pre-processor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, while AERMAP is a terrain data pre-processor that allows the incorporation of complex terrain effects within the model.

During its development, AERMOD has undergone a number of validation studies, the most recent of which were published in 2003 (USEPA). Comparisons with the previous ISC-PRIME model show similar results for most databases, with occasional notable improvements.

This assessment has used the latest version (5.9.0) of the software package ISC-AERMOD View, produced by Lakes Environmental Software.

Terrain Data

The area around the proposed plant location is gently undulating at an altitude of 10 m to 20 m above sea level. The land between the stacks and the receptors does not slope sufficiently to justify the consideration of terrain effects within the model, and for the purposes of this assessment, the terrain has been regarded as flat or simple.

Building Downwash Effects

Nearby buildings and structures have the potential to effect the dispersion of emissions from the plant stacks. As the wind blows over and around these buildings, the airflow will be disrupted and pollutants may become entrained within the eddy (cavity) near to the building or within the associated zone of turbulent air (wake), resulting in higher near-field ground level concentrations.

The engine house building on the proposed site is likely to be the most significant source of building downwash, due to its size and proximity to the power plant stacks. The dimensions of this building have been entered into the model and the BPIP-PRIME downwash model run to supply AERMOD with downwash data. Building Downwash effects have therefore been considered within the model.

Meteorological Data

Discussions were held with the UK Met Office, to establish the most representative source of meteorological data for use within the dispersion modelling assessment. Three options were considered:

- Kribi (WMO reference 64971);
- Douala (WMO 64910) 165 km to the north;
- Libreville in Gabon (WMO 64500), 230 km to the south.

All three sites are close to the coast and experience similar meteorological conditions.

Ideally, hourly sequential meteorological data is used for dispersion modelling purposes. However, in this case this has not been possible. Of the three sites considered, none collect readings on an hourly basis. Libreville data is 3-hourly, while Kribi and Douala report on a 6-hourly basis. For this reason, data from Libreville for the years 2003 to 2005 has been recommended and supplied by the UK Met Office as the most appropriate for use in dispersion modelling for this assessment. Additionally, the Libreville site has a higher data coverage rate than the other two locations.

The data was supplied in ADMS format, and was converted to SAMSON format using the built-in converter within AERMET. The data was then pre-processed in AERMET, using the input variables in Table 7.

Table 7: AERMET Input Data

Parameter	Variable
Station Location	0.50°N 9.41°W
Site Location	2.57°N 9.56°W
Upper Air Data	Upper Air Estimator within AERMET
Wind Direction Sectors	1
Surface Parameters	Albedo: 0.215 Bowen: 0.875 Surface Roughness: 1.3
Anemometer Height	10 m

Receptors

The closest sensitive receptors are located in the village of Mpolongwe, to the north and northwest of the proposed plant. With the revised plant layout, the closest existing receptors are approximately 350 m away, as opposed to 115m originally envisaged. However, these dwellings are expected to be relocated (see Section 6 of the ESIA) and have been assessed separately in the Resettlement Action Plan for the Project (Scott Wilson, October 2007). The closest receptors during plant operations would therefore be residential properties 410 m from the plant boundary, as opposed to 170 m in the original assessment.

Ground level concentrations of the pollutants modelled have been calculated using a site-centred polar grid at 10° radial increments, with 20 m distance increments from the origin up to 1 km, then 250 m increments up to 4 km and thereafter at 500 m increments up to 10 km. Grid nodes inside the plant boundary have not been modelled.

Additionally, the change in air quality statistics at selected residential properties within Mpolongwe has been considered by including their locations as discrete receptors. Each of these receptor locations represents the level of exposure that would also be experienced at other receptors in their vicinity. The closest structures to the power plant site were chosen along side other properties within the village, to ensure a worst-case scenario was established with regard to the impact of stack emissions on ground-level pollutant concentrations.

The location of each discrete receptor is illustrated in Figure 2.1, and listed in Table 8. The coordinates given are referenced to the WGS 1984 system, UTM zone 32 N. The concentration of pollutant at each receptor was modelled at a height of 1 m above ground level.

Table 8: List of Discrete Receptors (Revised)

Receptor	X Coordinate	Y Coordinate	Receptor	X Coordinate	Y Coordinate
R1	608099	334758	R6	608070	334872
R2	607992	334729	R7	608104	334921
R3	607940	334613	R8	608207	334942
R4	607946	334789	R9	607974	334439
R5	607995	334859	R10	607960	334378

The location of receptors have been revised to reflect the revised plant location

NO_X to NO_2 Conversion

NO_x emissions from the power plant will consist of both NO and NO_2. However, NO_2 is of the most concern regarding health effects. At the point of emission into the atmosphere NO will be the predominant species, around 95% of NO_x produced by combustion is NO. In rural areas, with low background levels of pollution, oxidation to NO_2 will rapidly occur in the presence of O_3.

As shown in Table 5.3.1 (Scott Wilson, October 2006), background concentrations of O_3 in the region are relatively high. It can be assumed, therefore, that the conversion of NO to NO_2 would not be O_3 limited at extended distances from the emission point. However, as the selected sensitive receptors in Mpolongwe are within 1 km of the proposed plant, an estimate of how much NO has been converted to NO_2 at these locations has been made using the NO_x to NO_2 conversion module in AERMOD. The model was setup to use the OLM (Ozone Limiting Method), the ratio of NO/NO_2 within the plant stacks was assumed as 0.95/0.05 and the ambient O_3 concentration in the atmosphere around the plant was assumed to be a constant 39 µg/m^3 (value taken from Table 2).

Sensitivity Analysis

The results of the sensitivity analysis are presented in Tables 9 to 11.

Air quality statistics have been calculated for all pollutants using meteorological measurements for three different years: 2003, 2004 and 2005. The results for NO_2 are represented in Table 9. As expected the model proved sensitive to differences in meteorological conditions, with each dataset returning different predicted pollutant concentrations than the other years. By including three years of meteorological data in the assessment it is likely that worst-case conditions for atmospheric dispersion have been considered in the assessment of mitigated impacts.

The importance of stack height has been considered for an option of 20 m for the height of release and variants of 22.5 m, 25 m, 27.5 m and 30 m (see Table 10)[2]. The diameter of the release, volumetric flow rate, velocity of release and the temperature of the exhaust gases was the same for each model run. The model predicted impacts on local air quality with a 20 m stack that would achieve World Bank criteria at all sensitive receptors. The WHO hourly standard value for NO_2 would only be achievable at the selected receptors with a stack height in excess of 30 m. However, WHO ambient air quality guidelines are not mandatory.

The model returned a proportional worsening in the effectiveness of pollutant dispersion for a lower stack. Advanced dispersion models are not designed to model the dispersion of plumes through the structure of forests and, as the forest canopy is understood to approach 20 m in height, this value has been adopted as the minimum stack height. A height of 20 m has been used for the main assessment as opposed to 22.5 m in the original assessment.

The terrain surrounding the site is largely forested by broad-leaved trees and the effect of turbulent mixing in the airflow over this surface has been represented in the assessment of impacts through the use of a surface roughness coefficient of 1.3. As there is some uncertainty as to the density and structure of the forest an alternative average surface roughness value for broad-leaved forest of 0.9 was also considered. Overall the model generally predicted (see Table 11) impacts of greater magnitude when the higher roughness coefficient of 1.3 was used.

In general, the model has demonstrated its sensitivity to model conditions and in each instance the worst-case option has been selected for use within the assessment.

[2] *Note the Stack height has been amended from the original ESIA report from 22.5 m to 20 m.*

Table 9: Effect of Meteorological Data Year on Maximum 24-hour NO_2 Concentrations (revised)

Receptor	Year		
	2003	2004	2005
R1	31.9	47.8	30.4
R2	34.7	30.8	29.0
R3	53.8	27.5	30.4
R4	27.3	33.0	27.5
R5	21.9	36.9	27.6
R6	26.5	31.1	38.0
R7	38.0	35.8	46.4
R8	58.0	47.3	41.7
R9	43.2	44.7	28.1
R10	28.5	51.9	30.9
Maximum	200.6	213.0	192.5

Table 10: Effect of Stack Height on Maximum 24-hour NO_2 Concentrations (revised)

Receptor	20 m Stack			22.5 m Stack			25 m Stack			27.5 m Stack			30 m Stack		
	2003	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**
R1	31.9	47.8	30.4	30.2	30.1	30.3	29.9	29.8	30.1	29.2	29.2	28.5	25.4	27.3	25.6
R2	34.7	30.8	29.0	31.1	24.9	28.4	29.2	24.4	27.7	27.3	23.7	24.1	25.5	23.7	23.4
R3	53.8	27.5	30.4	53.0	26.9	29.5	50.5	26.2	27.4	47.2	25.0	26.1	44.8	24.0	25.1
R4	27.3	33.0	27.5	23.1	24.1	26.5	22.5	23.3	25.1	21.7	22.4	22.6	19.4	21.3	22.5
R5	21.9	36.9	27.6	21.3	22.4	26.6	20.7	21.7	25.2	19.9	20.7	22.3	18.1	19.8	22.1
R6	26.5	31.1	38.0	25.2	27.8	35.5	23.2	25.7	32.5	20.1	25.3	30.8	18.5	23.2	23.5
R7	38.0	35.8	46.4	37.2	34.0	43.2	34.6	30.5	38.8	30.0	30.3	36.8	28.0	27.7	28.6
R8	58.0	47.3	41.7	54.4	47.5	40.3	51.1	44.4	36.0	50.2	39.5	34.5	49.9	36.9	26.7
R9	43.2	44.7	28.1	41.3	41.9	27.2	39.2	39.0	26.4	36.9	36.0	25.4	34.9	33.7	24.7
R10	28.5	51.9	30.9	27.8	50.3	30.1	27.5	48.0	29.0	26.7	45.0	27.3	25.8	43.3	25.6
Maximum	200.6	213.0	192.5	182.2	181.4	178.2	162.6	148.9	157.4	131.7	128.9	141.0	109.4	123.0	98.0

Table 11: Effect of Surface Roughness on Maximum 24-hour NO_2 Concentrations

Receptor	Surface Roughness = 0.9			Surface Roughness = 1.3		
	2003	2004	2005	2003	2004	2005
R1	30.0	37.2	29.9	31.9	47.8	30.4
R2	32.8	27.7	26.1	34.7	30.8	29.0
R3	53.4	29.6	30.3	53.8	27.5	30.4
R4	28.7	28.9	26.8	27.3	33.0	27.5
R5	26.4	26.2	26.5	21.9	36.9	27.6
R6	24.7	29.7	27.6	26.5	31.1	38.0
R7	22.8	32.1	37.6	38.0	35.8	46.4
R8	49.0	37.4	34.8	58.0	47.3	41.7
R9	36.0	26.1	28.8	43.2	44.7	28.1
R10	29.9	37.2	25.2	28.5	51.9	30.9
Maximum	187.3	197.4	178.5	200.6	213.0	192.5

Dispersion Modelling Results

The revised results of the dispersion modelling with emissions data for the power station burning natural gas are presented in Tables 12 to 14. The values in Tables 12 and 13 include the contribution from background concentrations of NO_2 and SO_2 respectively. In addition, the spatial distribution of the contribution of the plant's emissions to annual mean concentrations of each pollutant are illustrated for oxides of nitrogen in Figures 2.2 a-c, for sulphur dioxide in Figures 2.3 a-c and for fine particulate matter in Figures 2.4 a-c.

Table 12: Dispersion Modelling Results, Natural Gas Fuel, NO_2 (revised)

Receptor	1-hour average (µg/m^3)			24-hour average (µg/m^3)			Annual average (µg/m^3)		
	2003	2004	2005	2003	2004	2005	2003	2004	2005
R1	515.4	516.9	520.0	31.9	47.8	30.4	9.2	10.7	9.5
R2	455.9	433.6	504.4	34.7	30.8	29.0	7.7	7.7	8.0
R3	514.0	475.9	513.4	53.8	27.5	30.4	9.0	6.6	9.1
R4	390.5	420.1	468.8	27.3	33.0	27.5	6.9	7.6	7.5
R5	364.6	388.8	470.7	21.9	36.9	27.6	7.7	9.1	8.3
R6	365.1	510.8	444.9	26.5	31.1	38.0	10.0	11.4	9.9
R7	380.7	514.5	515.0	38.0	35.8	46.4	12.9	13.5	11.2
R8	516.2	513.7	517.4	58.0	47.3	41.7	22.9	20.2	14.9
R9	486.3	514.4	480.7	43.2	44.7	28.1	8.4	7.0	8.5
R10	480.6	514.2	513.9	28.5	51.9	30.9	7.5	6.8	7.7
WB Standard (µg/m^3)	**-**			**150**			**100**		
WHO Guideline* (µg/m^3) (not mandatory)	200			-			40		

Table 13: Dispersion Modelling Results, Natural Gas Fuel, SO_2 (revised)

Receptor	10 minute average (µg/m³)*			24-hour average (µg/m³)			Annual average (µg/m³)		
	2003	2004	2005	2003	2004	2005	2003	2004	2005
R1	27.5	28.9	31.7	2.6	3.5	2.8	1.8	1.8	1.8
R2	22.3	21.2	26.3	2.7	2.5	2.6	1.7	1.7	1.7
R3	26.2	23.2	25.7	3.4	2.4	2.5	1.8	1.7	1.8
R4	19.3	20.6	22.8	2.4	2.6	2.4	1.7	1.7	1.7
R5	18.1	19.2	23.0	2.2	2.8	2.4	1.7	1.8	1.8
R6	18.1	25.7	21.8	2.4	2.6	2.8	1.8	1.9	1.8
R7	18.8	26.7	27.1	2.8	2.8	3.1	1.9	1.9	1.9
R8	28.6	27.1	29.3	3.5	3.2	3.1	2.3	2.2	2.0
R9	23.9	26.6	23.4	3.0	3.0	2.5	1.8	1.7	1.8
R10	23.8	26.4	26.2	2.5	3.4	2.6	1.7	1.7	1.7
WB Standard (µg/m³)	**-**			**150**			**80**		
WHO Guideline (µg/m³)	500			125			50		

**Derived from 1-hour averages, correction factor of 1.3 applied.*

Table 14: Dispersion Modelling Results, Natural Gas Fuel, PM_{10} (revised)						
Receptor	24-hour average (µg/m^3)			Annual average (µg/m^3)		
	2003	2004	2005	2003	2004	2005
R1	0.9	1.5	1.0	0.2	0.3	0.2
R2	0.9	0.8	0.8	0.2	0.2	0.2
R3	1.4	0.7	0.8	0.2	0.1	0.2
R4	0.7	0.8	0.7	0.2	0.2	0.2
R5	0.6	0.9	0.7	0.2	0.2	0.2
R6	0.7	0.8	1.0	0.2	0.3	0.2
R7	1.0	1.0	1.2	0.3	0.3	0.3
R8	1.5	1.3	1.2	0.6	0.5	0.4
R9	1.1	1.2	0.7	0.2	0.2	0.2
R10	0.7	1.4	0.8	0.2	0.2	0.2
WB Standard (µg/m^3)	**150**			**50**		
WHO Guideline (µg/m^3)	-			-		

Predicted Impacts – Natural Gas Fuel

For each pollutant it is evident that the maximum impact occurs to the North East of the plant and that impacts to the west of the site are of a lower magnitude. The largest emissions for a locally important pollutant are those of oxides of nitrogen. These disperse to raise annual mean concentrations of nitrogen dioxide at discrete receptors by between 6.6 µg/m^3 and 22.9 µg/m^3 above baseline levels. This represents a range of 7% - 23% of the World Bank criteria of 100 µg/m^3 and 17% - 57% of the WHO Guideline value of 40 µg/m^3. The predicted impact on levels of fine particulate matter and sulphur dioxide at discrete receptors achieve the respective threshold values by a very large margin.

Annual mean concentrations of NO_2 in excess of the World Bank Standard are predicted to occur at or in very close proximity to the site boundary. Such impacts are not representative of the level of exposure that would be experienced at air quality sensitive receptor sites.

The magnitude of short term impacts have also been predicted at selected receptors located close to the Plant. Maximum 24-hour impacts in the range of 21.9 µg/m^3 to 58.0 µg/m^3 were predicted for NO_2. This represents between 15% and 39% of the World Bank 24-hour NO_2 Standard of 150 µg/m^3. As with annual average NO_2 impacts, 24-hour concentrations in excess of the World Bank Standard are predicted to occur at or in very close proximity to the site boundary. Such impacts are therefore not representative of the level of exposure that would be experienced at air quality sensitive receptor sites.

Predicted short-term impacts on local ambient levels of SO_2 and PM_{10} would result in concentrations that are well within respective World Bank Standards and WHO Guideline values.

The WHO hourly standard value for NO_2 was not achieved at any of the selected receptors with the chosen stack height of 20 m. However, WHO ambient air quality guidelines are not mandatory in this instance.

In reality, the impact of the plant's emissions will be less than those predicted as the values displayed are based on an assumed operating condition of 13 engines (as opposed to 4 turbines originally proposed) running continuously at maximum load. In practice, the emissions from the plant would be less than the values modelled and the impact on local air quality would in turn be smaller than those discussed above. This would also be the case in terms of the predicted maximum 1-hour concentrations of NO_2. Here it is possible that the plant would not be operating at maximum load during the periods of adverse meteorological conditions when such impacts could potentially occur.

Overall, the impact on local air quality due to emissions from the power plant, when running on natural gas fuel, can be classified as adverse, long-term, and minor in magnitude.

Predicted Short-term Impacts – Diesel Backup Fuel

The maximum predicted short-term impacts associated with burning diesel as a back-up fuel are presented in Tables 15 to 17.

Table 15: Dispersion Modelling Results, Diesel, NO_2 (Revised)

Receptor	1-hour average (µg/m^3)			24-hour average (µg/m^3)		
	2003	2004	2005	2003	2004	2005
R1	654.2	660.9	673.5	63.0	62.2	52.1
R2	621.8	613.9	639.1	68.9	56.3	51.6
R3	638.2	627.6	636.0	75.5	38.2	41.4
R4	595.0	610.4	620.1	65.5	60.3	45.3
R5	595.0	601.1	621.0	57.6	60.7	59.6
R6	594.7	634.6	611.9	69.0	62.8	64.5
R7	591.4	640.5	642.9	88.0	69.3	67.0
R8	652.1	649.6	654.4	117.2	77.6	67.0
R9	623.2	636.9	625.7	72.6	66.9	49.1
R10	632.4	634.4	636.1	68.2	69.4	46.6
WB Standard (µg/m^3)	**-**			**150**		
WHO Standard (µg/m^3)	200			-		

Table 16: Dispersion Modelling Results, Diesel, SO_2 (Revised)						
Receptor	10-minute average (µg/m³)*			24-hour average (µg/m³)		
	2003	2004	2005	2003	2004	2005
R1	657.6	684.0	734.4	30.1	35.2	33.3
R2	530.5	500.3	599.7	28.2	23.2	27.1
R3	596.5	553.1	587.4	48.5	25.1	26.8
R4	425.1	486.1	524.9	21.6	22.5	24.2
R5	425.2	449.2	527.8	20.1	23.4	24.4
R6	423.8	581.7	493.3	21.4	26.6	30.5
R7	412.2	603.8	613.9	31.9	31.8	37.9
R8	650.4	639.2	657.9	49.3	43.3	37.8
R9	537.2	592.0	547.0	37.5	36.7	25.4
R10	572.2	582.8	588.7	26.3	44.9	27.4
WB Standard (µg/m³)	**-**			**150**		
WHO Standard (µg/m³)	500			125		

**Derived from 1-hour averages, correction factor of 1.3 applied.*

Table 17: Dispersion Modelling Results, Diesel , PM_{10} (revised)			
Receptor	24-hour average (µg/m³)		
	2003	2004	2005
R1	3.0	3.6	3.4
R2	2.8	2.3	2.7
R3	5.0	2.5	2.7
R4	2.1	2.2	2.4
R5	2.0	2.3	2.4
R6	2.1	2.7	3.1
R7	3.2	3.2	3.9
R8	5.1	4.4	3.8
R9	3.8	3.7	2.5
R10	2.6	4.6	2.7
WB Standard (µg/m³)	**150**		
WHO Guideline (µg/m³)	-		

The magnitude of short-term impacts in the area around selected receptors has been determined with the plant running on diesel fuel. The maximum predicted impacts do not exceed the World Bank limit criteria for concentrations of SO_2 or PM_{10} at any of the selected receptors. The World Bank PM_{10} standard is met by a very large margin.

Maximum 10-minute impact values for SO_2 were predicted to be between 412.2 µg/m^3 and 734.4 µg/m^3, or between 85% and an exceedence of the WHO guidance concentration. Maximum 24-hour concentrations are well within the World Bank and WHO guidance values. The impact ranges by between 20.1 µg/m^3 and 49.3 µg/m^3, or between 13% and 33% of the World Bank standard.

Maximum 1-hour average impact values for NO_2 were predicted to be higher than the WHO guidance value at all selected receptors with the chosen stack height of 20 m. However, the WHO guidance value is not mandatory. The predicted 24-hr average impact concentrations are between 38.2 µg/m^3 and 117.2 µg/m^3, or between 25% and 78% of the World Bank standard.

Overall, the impact on local air quality due to emissions from the power plant, when running on diesel back-up fuel, can be classified as adverse, short-term, and minor in magnitude.

2.3 MITIGATION MEASURES

Dust Generation

Fugitive emissions of dust during the construction phase will be minimised and controlled by the implementation of an Environmental and Social Management Plan (ESMP) for the project. These mitigation measures will be incorporated into the detailed ESMP being finalised by Scott Wilson in December 2008. Mitigation measures to reduce construction dust emissions could include:

- Wherever possible materials arising from site earthworks will be stored and used within the redevelopment of the site. This will reduce the number of off-site vehicle movements required.

- Site roads and the site access route will be inspected, swept and sprayed with water as required to prevent dust causing a nuisance off site. An appropriate site speed limit will reduce dust generation from vehicles travelling over unmade surfaces.

- No mitigation measures will be required to control emissions from on site vehicles beyond accepted good practice. For example, maintaining vehicles in good working order, parking vehicles away from sensitive receptors and not running engines for longer than is necessary.

- All plant and stockpiles will be thoughtfully located, so as to minimise impacts on sensitive receptors. Where practicable to do so, storage areas should be located at least 50 m from sensitive receptors.

- The unnecessary handling of dusty materials will be avoided. During the processing of dusty materials, methods to mitigate the generation of dust emissions will be employed, such as minimising drop heights and dampening materials and surfaces with water.

- The area cleared for construction activities will be kept to a minimum, retaining ground cover where possible, including a screen of vegetation and mature trees between the power plant site and the main road and residential housing.

- Completed earthworks will be landscaped and vegetated or covered with hard standing as soon as practicable.

- A record will be kept of complaints received and actions taken.

Power Plant emissions

No specific measures are employed to limit stack emissions.

Monitoring Requirements and Protocols

Once the power plant is in operation, a monitoring programme would be implemented, based on surrogate performance measurement of combustion temperature and excess oxygen level, with the aim of achieving optimal plant performance. The aim of the programme would be to minimise emissions of particulate matter and NO_x in conjunction with maximising energy efficiency and economic operation.

In addition to the surrogate performance monitoring measures listed above, direct measurement of emissions of particulate and NO_x in flue gases would be undertaken on an annual basis. Control of sulphur oxides and heavy metals in flue gases would be best achieved through analysis of the fuel. Stack monitoring should be conducted using a recognised international standard method.

Ambient diffusion tube monitoring of nitrogen dioxide would also be undertaken within Mpolongwe for a period of one year, following commissioning of the power plant, in order to confirm that long-term levels are within the World Bank Standard. As the plant is gas-fired, the measurement of SO_2 and PM_{10} would not be required.

2.4 EVALUATION OF MITIGATED IMPACT

Dust Generation

Construction

The potential magnitude of dust impacts without mitigation is not considered within this assessment, as standard mitigation techniques for the control of dust emissions, including those identified in Section 2.3 above, will be included within the proposal's EMP.

Construction dust can only have a significant impact on sensitive receptors if it is located in fairly close proximity to the activity. The potential for dust to be transferred off site, to affect PM_{10} levels or cause a perceptible increase in soiling rates, is likely to be limited to around 100 m from a construction process such as this, which involves considerable earthworks.

There is a distance of around 410 m between the nearest residential properties and the power plant boundary. As such, the impact of dust emissions due to construction activities occurring on the power plant site would be insignificant. Earthworks associated with the installation of the access road could potentially cause a perceptible increase in surface soiling rates and PM_{10} levels at residential housing close to the access road entrance. Such impacts would be short term and minor adverse in significance.

An area of approximately 3.5 ha, between the proposed power plant site and the main road, would be cleared and used as a construction compound. The storage of loose, dusty materials and the movement of construction vehicles within this area could result in emissions of fugitive dust across the site boundary affecting the closest residential properties. The impact of such emissions would be short term and minor adverse in significance

The incorporation of effective site management procedures and mitigation measures to control dust would ensure that the impact of construction works on nearby sensitive receptors would be minimised. Episodes of enhanced dust deposition should be restricted to periods of unusually dry and windy weather, during which background levels of dust would also become elevated.

A small proportion of the dust generated by construction activities will be PM_{10}. Under normal meteorological conditions, receptors located more than 50 m from the emission source are unlikely to experience a perceptible increase in PM_{10} concentrations. It is therefore unlikely that a measurable change in PM_{10} concentrations will be observed during the construction of the power plant. The impact of PM_{10} emissions on sensitive receptors during the construction of the site access road would be adverse, short term in nature and minor in significance.

Power Plant Emissions

The principal control on operational emissions from the plant is in the form of stacks. These stacks can be of sufficient a height to facilitate adequate dispersion of the exhaust plume before the pollutants reach ground level. This assessment has been based on the assumption that all thirteen stacks would be 20 m high and it has been confirmed that this height would provide a level of protection at local air quality sensitive receptors sufficient to achieve World Bank criteria.

The sensitivity analysis also considered the impact associated with the use of higher stacks of 22.5 m, 25 m, 27.5 m and 30 m. The additional height resulted in a progressive improvement in the magnitude of impacts on ground level (z = 1 m) concentrations of NO_2. A shorter stack is not considered appropriate due to the height of the surrounding forest, as it would be likely to impair the dispersion of the emissions from the plant. An assessment of the height of the surrounding vegetation will however be undertaken to ensure the final stack height is above the upper forest canopy to ensure adequate dispersion.

Overall the impact from the operation of the plant on air quality would be adverse, long term, and minor in significance, with emissions discharged from an appropriate stack height.

Evaluation of Alternative Development Options

The zero (no project) option would remove the potentially negative impacts that may arise from the construction and operation of the project.

The main body of the original ESIA report considered the impacts on air quality when using gas engines instead of gas driven engines. The gas turbine option would require six units in place of the thirteen units considered within this Addendum, to provide the necessary output. As gas engines produce lower NO_x emissions than gas engines, impacts are predicted to be lower than the reciprocating engine plant.

2.5 CONCLUSIONS

The overall conclusion from this Addendum assessment is that the construction and operation of the Kribi 216 MW Power Plant will not result in impacts on the air quality of the project area with the potential to result in the exceedence of World Bank Air Quality Guideline Values.

During the construction phase, dust generation, particularly at the construction site compound, has the potential to cause dust impacts at adjacent properties. However, simple and effective control measures for containing and mitigating dust generation are available. In addition, any impacts will be of an infrequent and short-lived nature.

During normal operation on the natural gas fuel, the engine emissions result in ground level pollutant concentrations below the guidelines values set by the World Bank.

During times when the plant is running on the diesel fuel, emissions will be higher. However, this operation is for very short-term periods up to a maximum of approximately 8 days per year at 30% load. Short-term impacts from this temporary operation are still predicted to meet World Bank guideline criteria.

A summary of the impact evaluation is presented in Table 18.

Table 18: Summary of Impact Evaluation – Air Quality

Project Location	Phase[2]	Impact	Nature of Impact	Receptor	Nature[1]	Duration[1]	Significance[1]
Plant site	C	Dust nuisance / heath risk	Dust rise from on site activity	Local population	Adverse	Short-term	Minor
	O	Reduced local air quality	Emissions from power plant (gas)	Local population	Adverse	Long-term	Minor
	O	Reduced local air quality	Emissions from power plant (Diesel)	Local population	Adverse	Short-term	Minor
	C	Reduced local air quality	Vehicle exhaust emissions	Local population	Adverse	Short-term	Insignificant
Based on assessment criteria presented in Table 1							

3. NOISE AND VIBRATION

3.1 BASELINE CONDITIONS

The existing ambient noise levels around the site of the power station have been measured by AES Sonel, and these levels have been analysed to produce the ambient noise levels for the locations surrounding the site. The ambient noise levels were measured by Scott Wilson in April 2006 at three locations, with the noise levels found to be between 50 and 55 dB(A) (Scott Wilson, October 2006). Dominant sources during the noise monitoring were from road vehicles, the activities of the local residents, and also noise produced by local wildlife.

Noise levels were monitored during both day and night periods, with little variation found between these time periods. Using the lowest measured noise levels, the daytime L_{Aeq} is determined to be 50 dB, with the night time L_{Aeq} determined as 51 dB. However, the sources of noise change between the time periods. During the day, the dominant sources are traffic on nearby roads and the noise produced by the local residents. During the night, the noise is dominated by the noise from wildlife. This change in character can be seen in the values of the L_{A90} levels, which are 41 dB during the day and 47 dB during the night. The reduced difference between the L_{Aeq} and the L_{A90} during the night suggests that noise levels are relatively constant during the night time period.

3.2 POTENTIAL IMPACTS

Methodology

The power station is planned to have thirteen gas turbine generators that will all be operational for 24 hours a day. The noise level from these turbines has been mapped by Wartsila to show the noise levels affecting the environment. This is reproduced, as Figure 3.1. The noise model includes a bund to the south west of the proposed plant. The three closest noise sensitive receptors, R1 to R3 are also shown on this figure.

Assessment

To assess the impact of the power station on the noise sensitive receptors, the criteria that will be applied are the World Health Organisation (WHO) criteria specified in "Guidelines for Community Noise" (World Health Organisation, 2000). This report recommends environmental noise levels of 55 dB(A) for the day and evening, *"to prevent the majority of people from being seriously annoyed"* and 45dB(A) *"outside bedroom windows"* to avoid sleep disturbance.

Noise levels at the three receptor locations are given in Table 1.

Table 1: Predicted Noise Levels at the Nearest Noise Sensitive Locations

Noise Sensitive Receptor	Predicted Noise Level (L_{Aeq} dB)
R1	45
R2	48
R3	48

Noise levels from the proposed plant are less than the existing daytime noise levels of the area and are less than the WHO recommended limits. They will not therefore have any impact on the noise sensitive locations and can be therefore said to be insignificant during the daytime.

The predicted noise levels however are slightly above WHO recommended levels during the night time,.however noise levels are all below the existing ambient noise levels and as such are likely to have a negligible impact on the noise sensitive locations and can therefore be said to only have a minor significance.

3.3 MITIGATION MEASURES

No further mitigation beyond the inclusion of the bund is considered necessary.

3.4 CONCLUSIONS

Baseline noise levels of 50dB(A) daytime, and 51dB(A) night time have been measured in the area.

Noise levels from the proposed plant have been predicted from the noise map to be 45dB(A) at R1 and 48dB(A) at R2 and R3 (the nearest sensitive receptors). These noise levels are less than the existing noise levels for the area and less than the WHO guideline levels of 55dB(A) for day time levels. Night time noise levels slightly exceed the WHO guideline levels of 45dB(A), however baseline noise levels are higher than those predicted and therefore the impact is considered to be insignificant.

4. REFERENCES

Scott Wilson (2006), *Environmental and Social Impact Assessment Report – Kribi Power Project, Cameroon*. AES SONEL.

Scott Wilson (2007), *Resettlement Action Plan – Kribi Power Project, Cameroon*. AES SONEL.

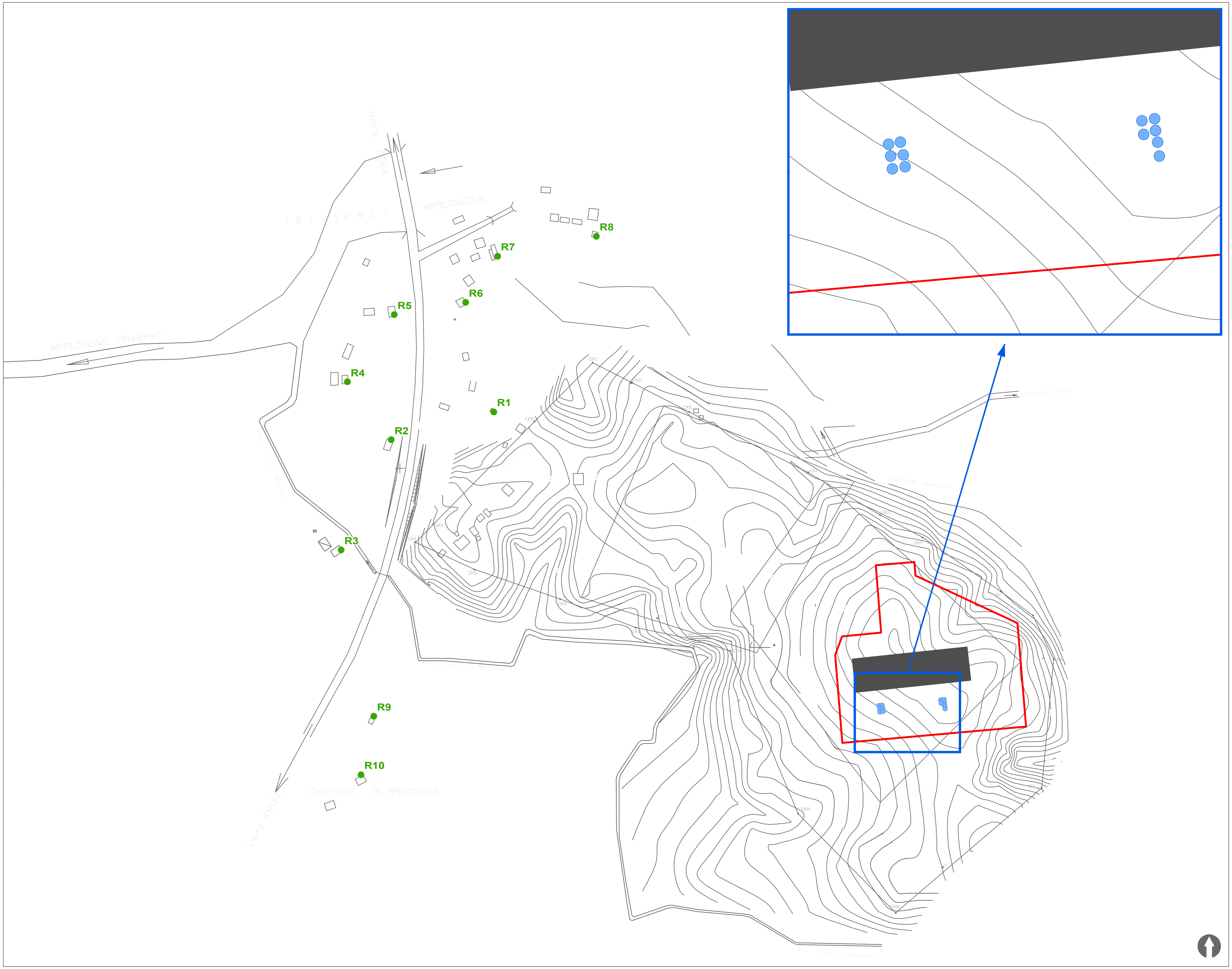
United States Environmental Protection Agency (USEPA) (2003), AERMOD*: Latest Features and Evaluation Results. Accessed [online] at: http://www.epa.gov/scram001/dispersion_prefrec.htm*, accessed on 05/05/06.

World Bank (1998), *Pollution Prevention and Abatement Handbook 1998 – Toward Cleaner Production. Accessed [online] at:* http://www.go.worlbamk.org/E6G093QFZ1

World Health Organisation (WHO) (2000) *Guidelines for Community Noise*

World Health Organisation (WHO) (2005), *Air Quality Guidelines – Global Update 2005. Accessed [online] at: http://www.euro.who.int*, accessed on 10/11/08.

FIGURES



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED

KEY:

- Receptor
- Point Source
- Plant Boundary
- Building

Revision Details	By / Check	Date	Suffix

DRAWING STATUS

Code	Description	Current Status	Appd	Date
P	Preliminary			
A	Submitted for Review	X	DD	20/11/08
C	For Construction			
I	For Information			
E	Cost Estimate			
AB	As Built			

Job Title

AES SONEL
KRIBI
POWER PROJECT ESIA

Drawing Title

FIGURE 2.1

PLANT SITE LAYOUT AT MPOLONGWE

Scale @ A3	
NTS	
Drawn: JV	Approved: GG

Stage 1 check	Stage 2 check	Originated	Date
DD		CH_ENV	20/11/08

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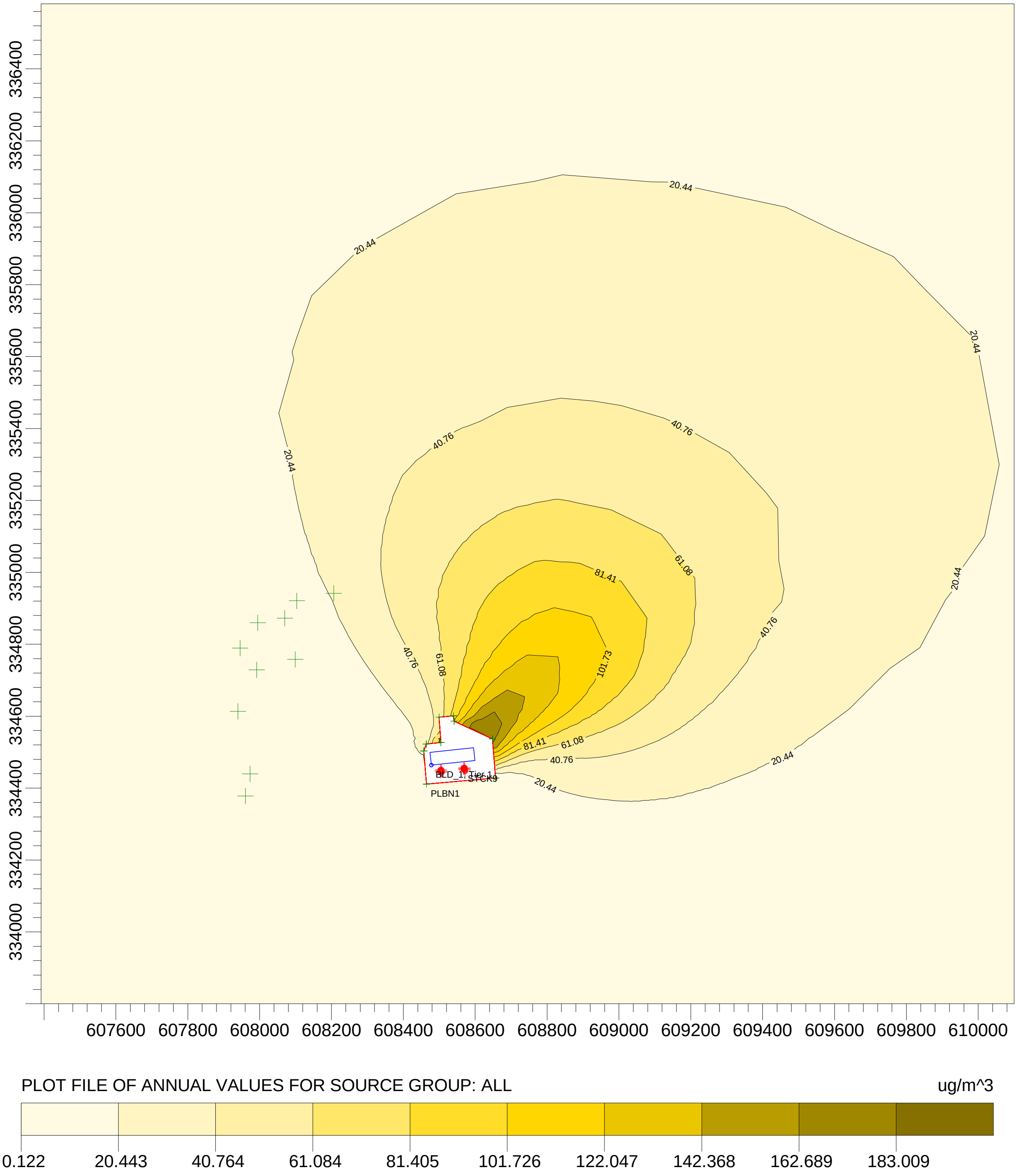
Drawing Number	Revision
D122445/ESIA/2.1	

PROJECT TITLE:

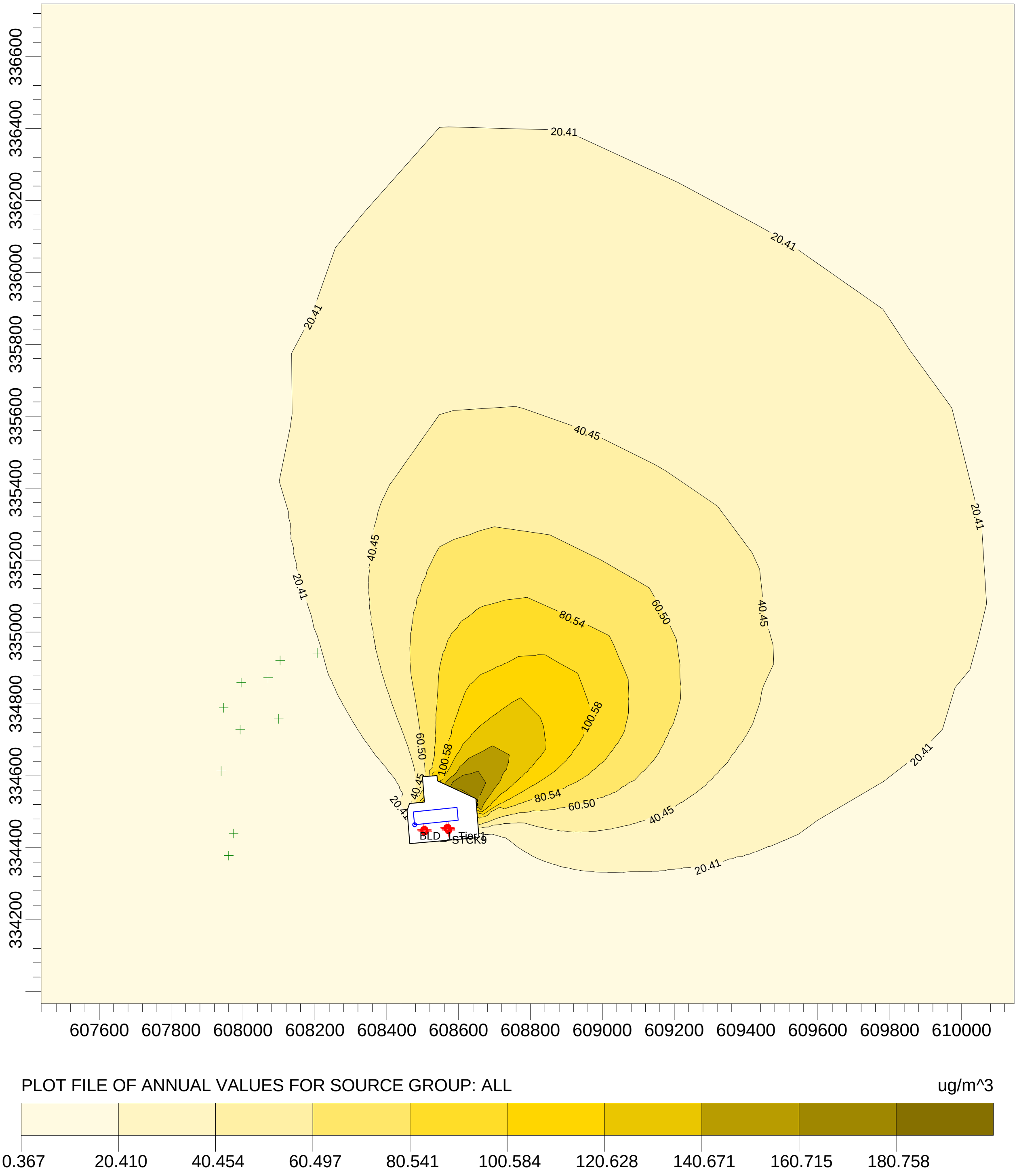
Kribi Power Plant Addendum, November 2008
Figure 2.2a: Predicted Impact on Annual Mean Nitrogen Dioxide Concentrations, 2003 meteorological data



COMMENTS: Drawn: GH Checked: DD Approved: GG	SOURCES: **13**		
	RECEPTORS: **55**	MODELER: **GH**	Scott Wilson
	OUTPUT TYPE: **Concentration**	SCALE: 1:17,000 0 — 0.5 km	
	MAX: **183.00935 ug/m^3**	DATE: **19/11/2008**	PROJECT NO.: **Kribi Power Plant**

PROJECT TITLE:

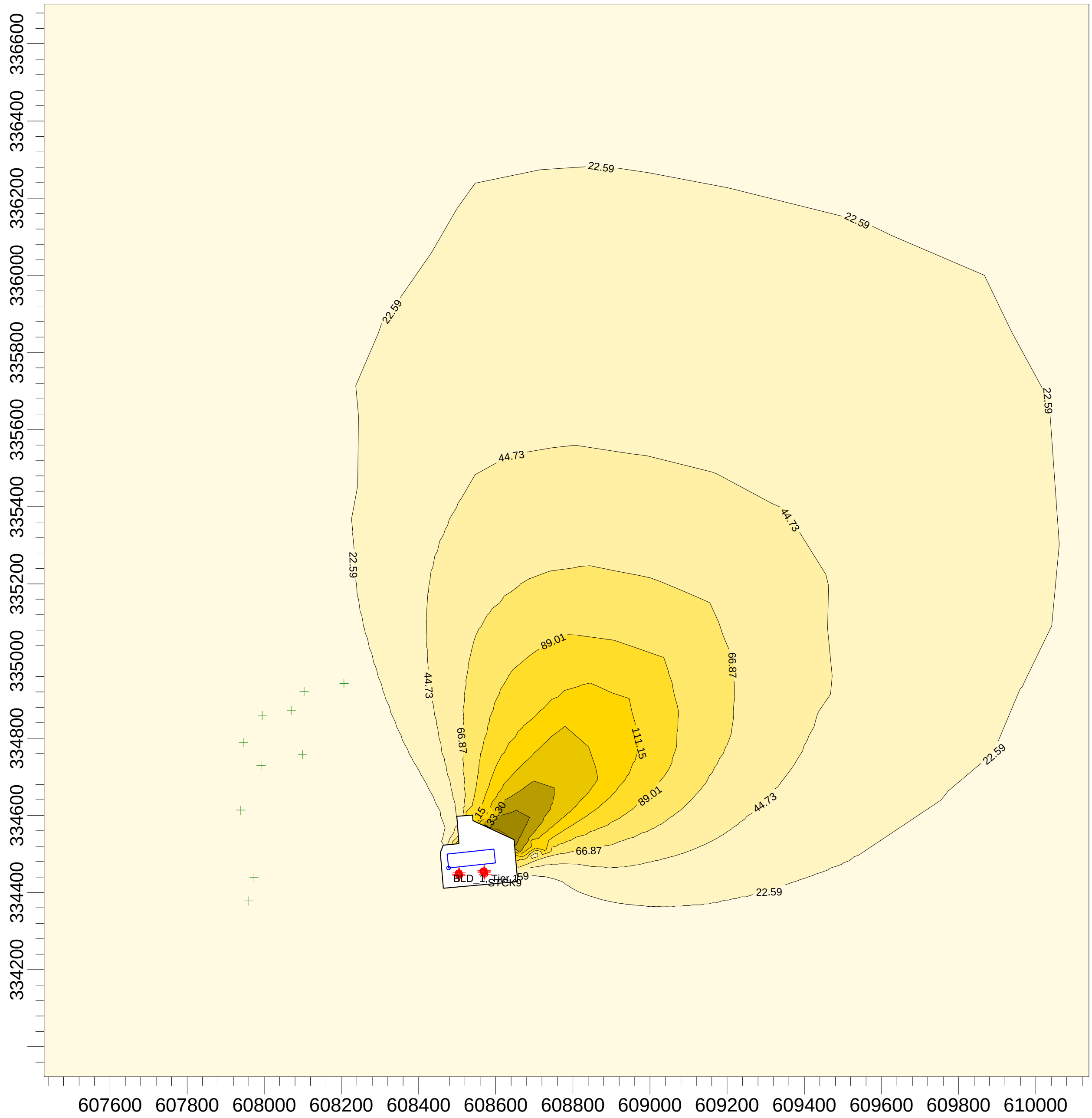
Kribi Power Plant Addendum, November 2008
Figure 2.2b: Predicted Impact on Annual Mean Nitrogen Dioxide Concentrations, 2004 meteorological data



COMMENTS: Drawn: GH Checked: DD Approved: GG	SOURCES: **13**		
	RECEPTORS: **2687**	MODELER: **GH**	Scott Wilson
	OUTPUT TYPE: **Concentration**	SCALE: 1:17,000 0 — 0.5 km	
	MAX: **180.7583 ug/m^3**	DATE: **19/11/2008**	PROJECT NO.: **Kribi Power Plant**

PROJECT TITLE:

Kribi Power Plant Addendum, November 2008
Figure 2.2c: Predicted Impact on Annual Mean Nitrogen Dioxide Concentrations, 2005 meteorological data



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL

ug/m^3

0.444 | 22.586 | 44.728 | 66.870 | 89.012 | 111.154 | 133.296 | 155.438 | 177.580 | 199.722

COMMENTS:

Drawn: GH
Checked: DD
Approved: GG

SOURCES:

13

RECEPTORS:

2687

MODELER:

GH

OUTPUT TYPE:

Concentration

SCALE: 1:17,000

0 0.5 km

MAX:

199.72159 ug/m^3

DATE:

19/11/2008

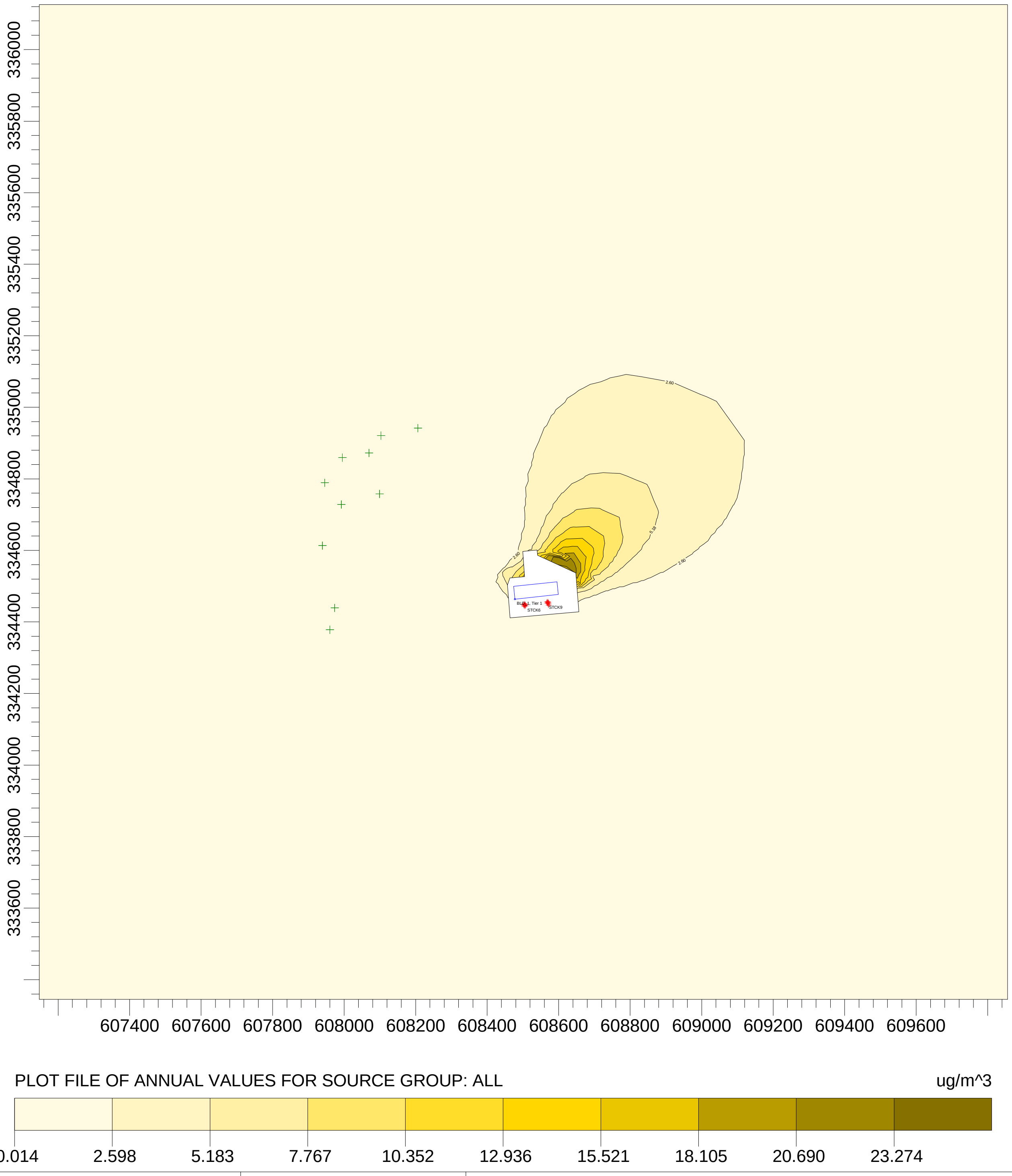
PROJECT NO.:

Kribi Power Plant

PROJECT TITLE:

Kribi Power Plant Addendum, November 2008

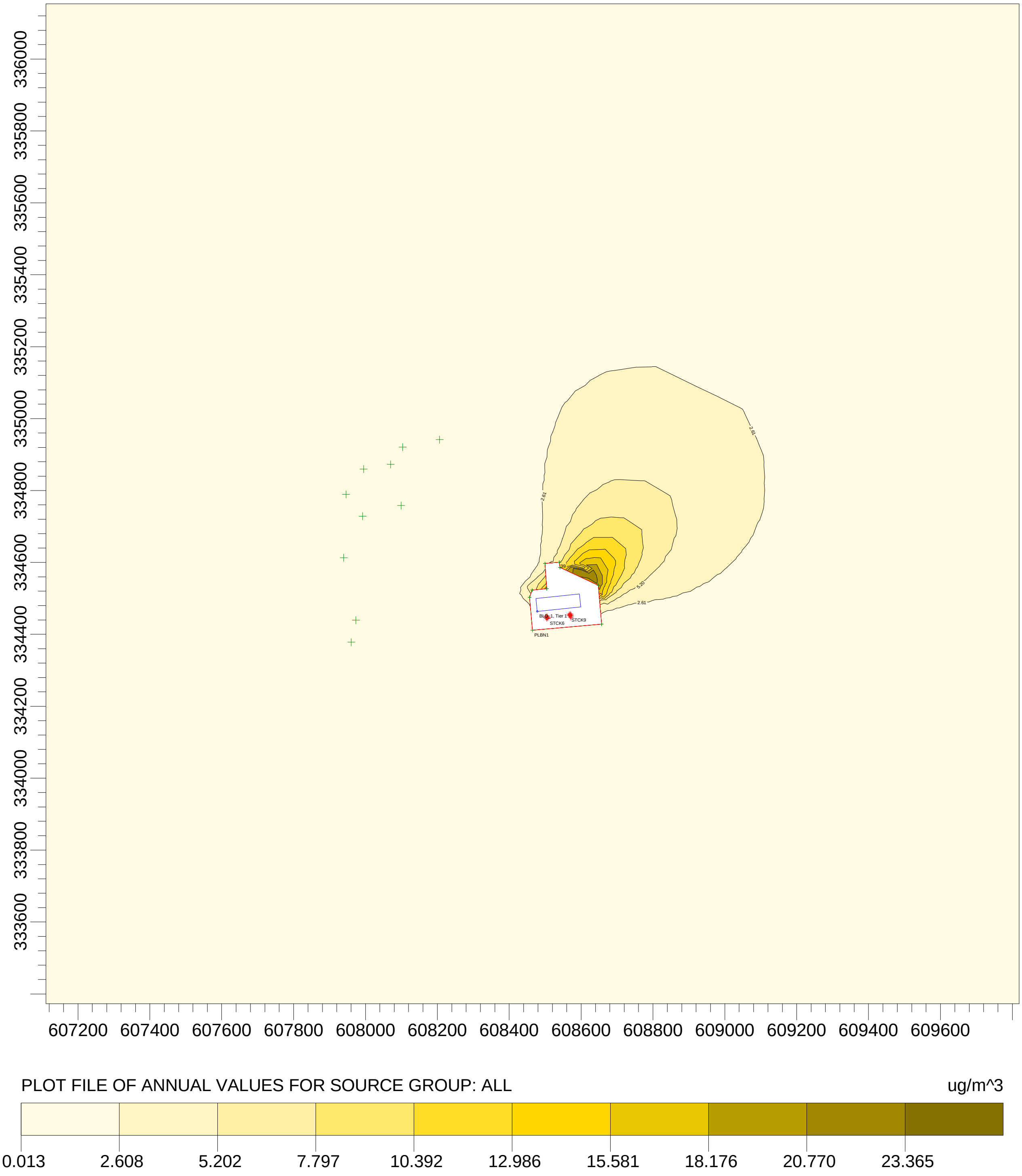
Figure 2.3a: Predicted Impact on Annual Mean Sulphur Dioxide Concentrations, 2003 meteorological data



COMMENTS: Drawn: GH Checked: DD Approved: GG	SOURCES: **13**		
	RECEPTORS: **29**	MODELER: **GH**	Scott Wilson
	OUTPUT TYPE: **Concentration**	SCALE: 1:17,000 0 ___ 0.5 km	
	MAX: **23.27407 ug/m^3**	DATE: **19/11/2008**	PROJECT NO.: **Kribi Power Plant**

PROJECT TITLE:

Kribi Power Plant Addendum, November 2008
Figure 2.3b: Predicted Impact on Annual Mean Sulphur Dioxide Concentrations, 2004 meteorological data



COMMENTS: Drawn: GH Checked: DD Approved: GG	SOURCES: **13**	
	RECEPTORS: **2692**	MODELER: **GH**
	OUTPUT TYPE: **Concentration**	SCALE: 1:17,000 0 — 0.5 km
	MAX: **23.36483 ug/m^3**	DATE: **19/11/2008**

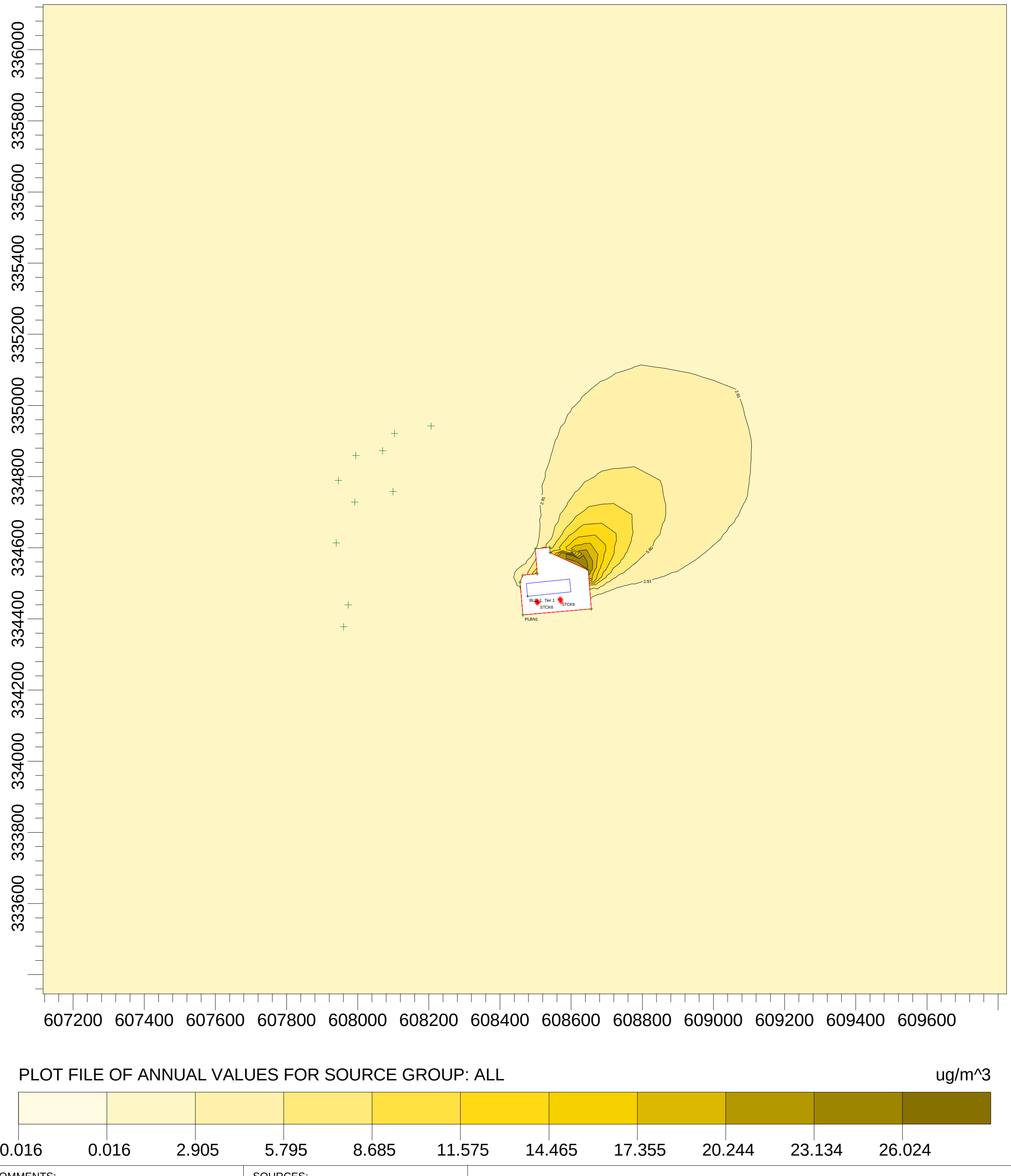
PROJECT NO.:

Kribi Power Plant

PROJECT TITLE:

Kribi Power Plant Addendum, November 2008

Figure 2.3c: Predicted Impact on Annual Mean Sulphur Dioxide Concentrations, 2005 meteorological data



COMMENTS: Drawn: GH Checked: DD Approved: GG	SOURCES: **13**		
	RECEPTORS: **2692**	MODELER: **GH**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:17,000 0 — 0.5 km	
	MAX: **26.02418 ug/m^3**	DATE: **19/11/2008**	PROJECT NO.: **Kribi Power Plant**

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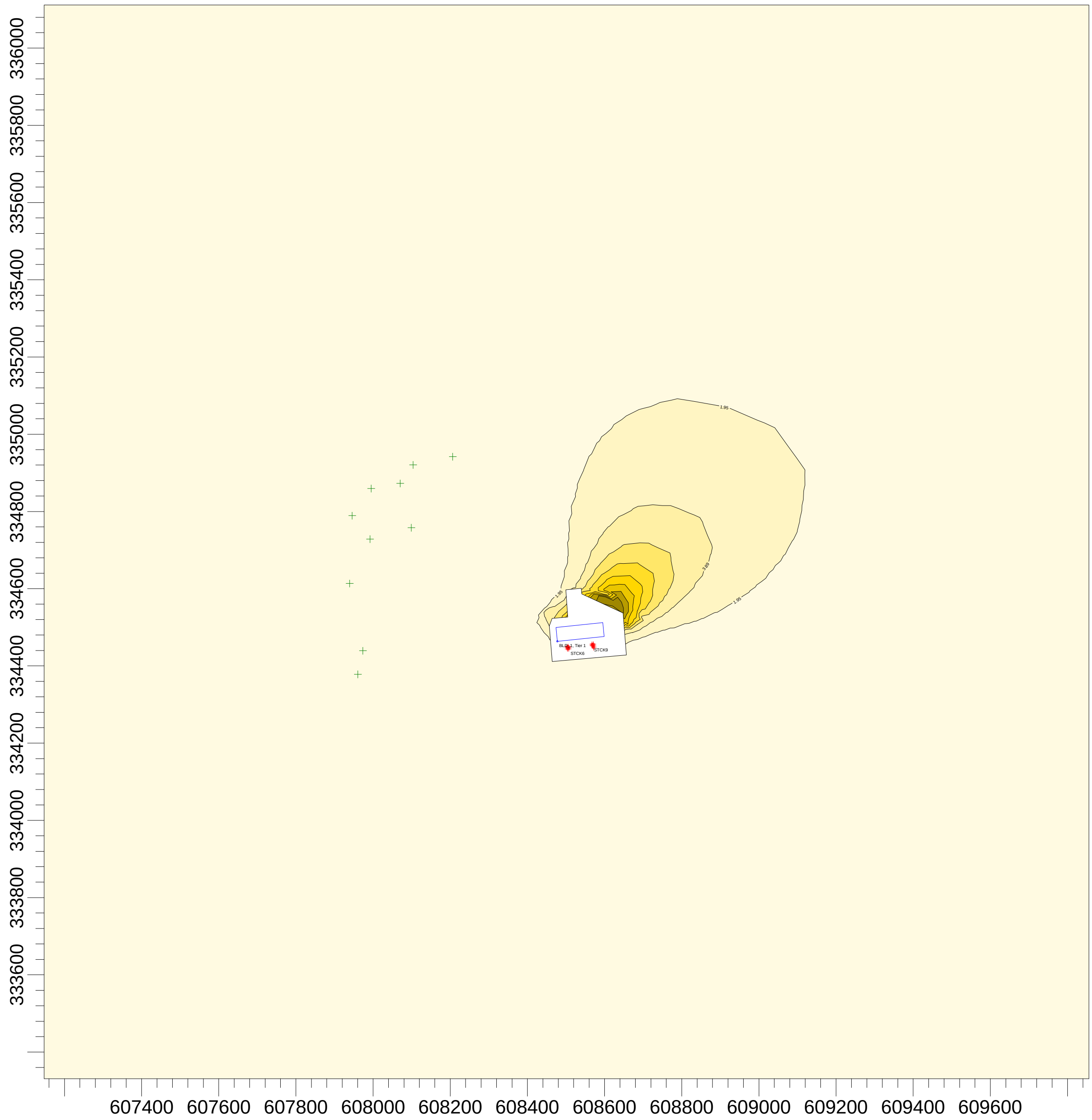
Kribi Power Plant Addendum, November 2008
Figure 2.4a: Predicted Impact on Annual Mean PM10 Concentrations, 2003 meteorological data



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL — ug/m^3

0.010 | 1.949 | 3.887 | 5.825 | 7.764 | 9.702 | 11.641 | 13.579 | 15.517 | 17.456

COMMENTS: Drawn: GH Checked: DD Approved: GG	SOURCES: **13**	
	RECEPTORS: **2692**	MODELER: **GH**
	OUTPUT TYPE: **Concentration**	SCALE: 1:17,000 0 — 0.5 km
	MAX: **17.4556 ug/m^3**	DATE: **19/11/2008**

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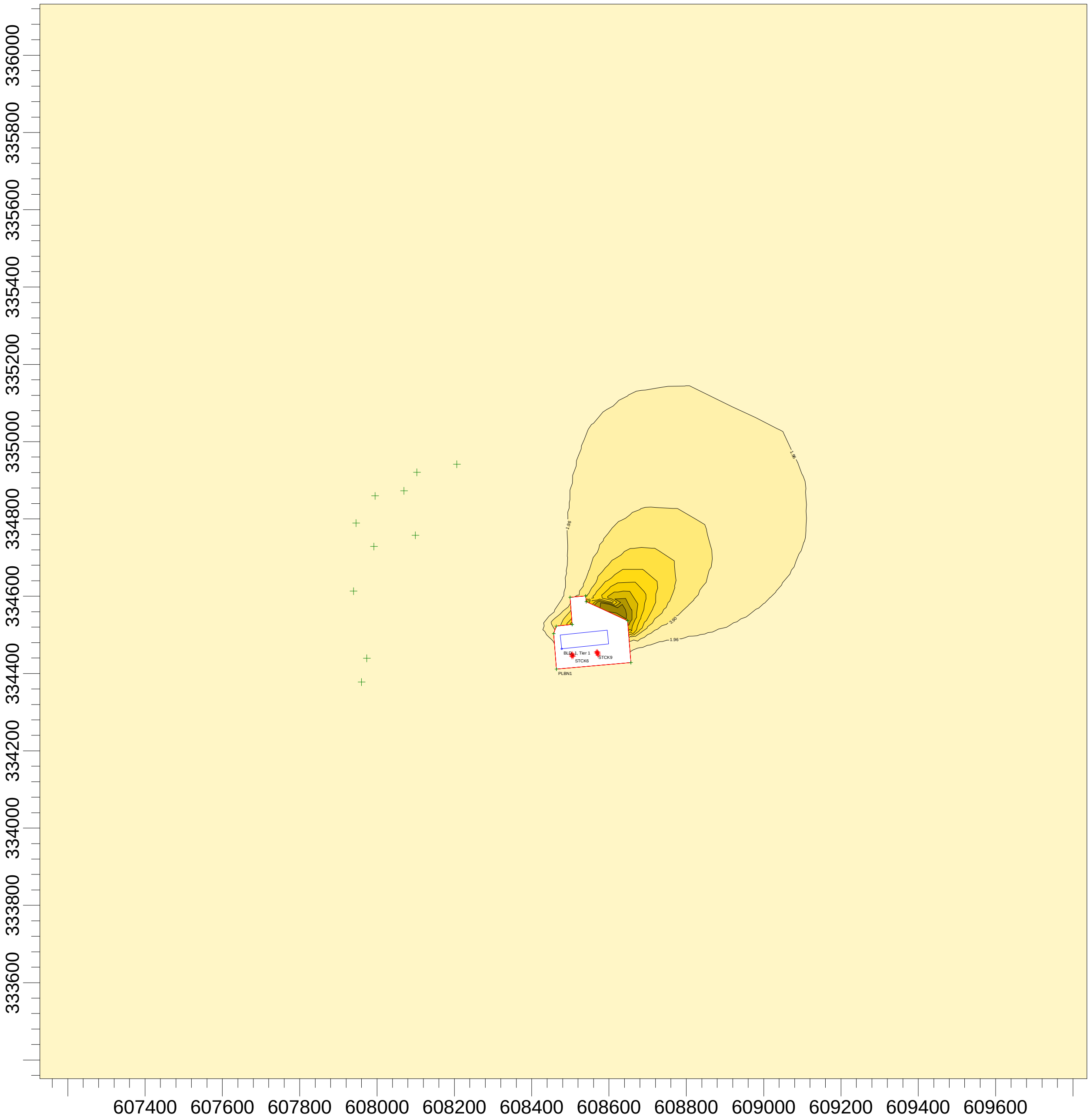
Figure 2.4b: Predicted Impact on Annual Mean PM10 Concentrations, 2004 meteorological data



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL — ug/m^3

0.010 | 0.010 | 1.956 | 3.902 | 5.848 | 7.794 | 9.740 | 11.686 | 13.632 | 15.578 | 17.524

COMMENTS: Drawn: GG Checked: DD Approved: GG	SOURCES: **13**	
	RECEPTORS: **2692**	MODELER: **GH**
	OUTPUT TYPE: **Concentration**	SCALE: 1:17,000 0 — 0.5 km
	MAX: **17.5235 ug/m^3**	DATE: **19/11/2008**

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Kribi Power Plant

PROJECT TITLE:

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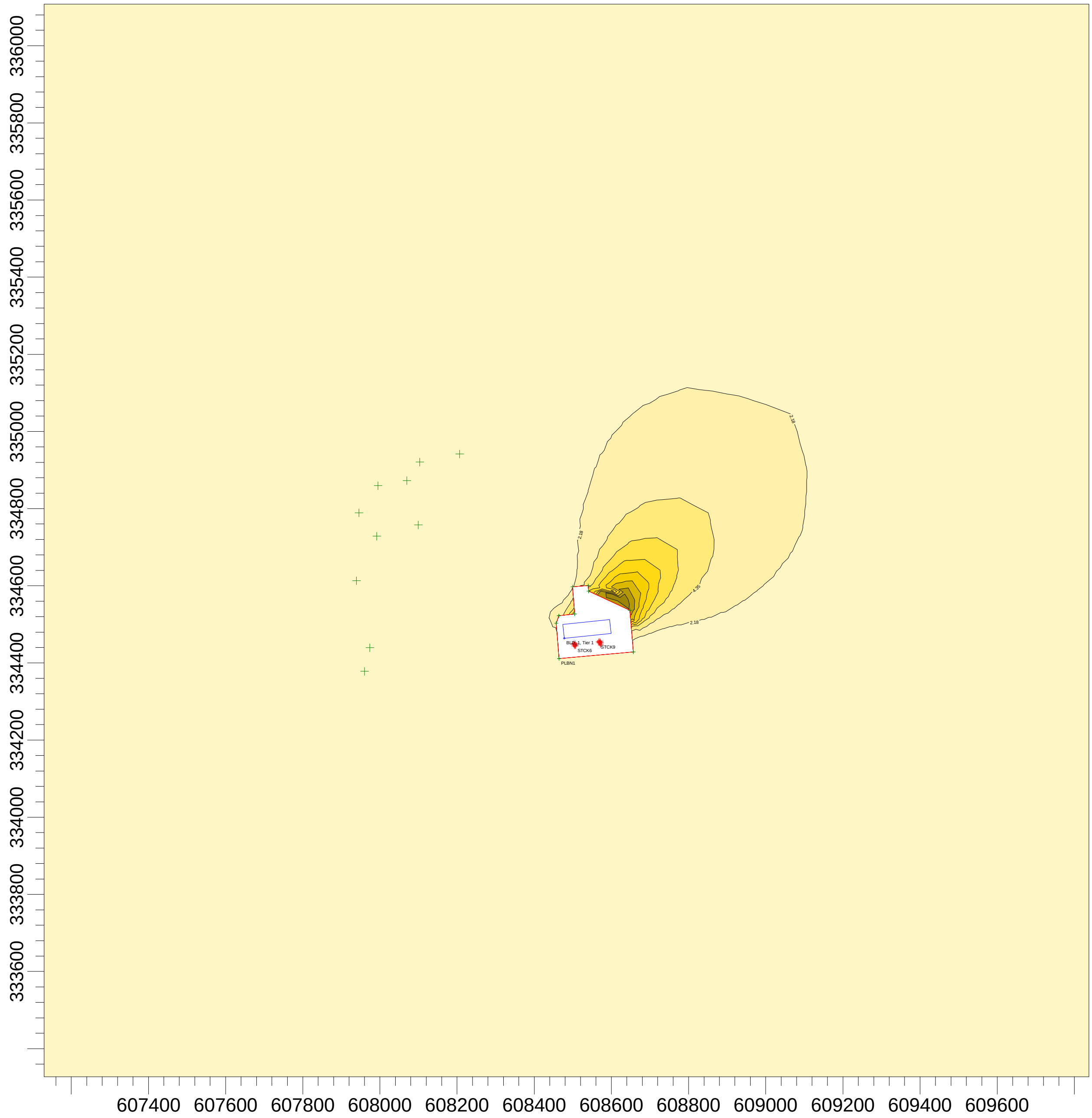
Figure 2.4c: Predicted Impact on Annual Mean PM10 Concentrations, 2005 meteorological data

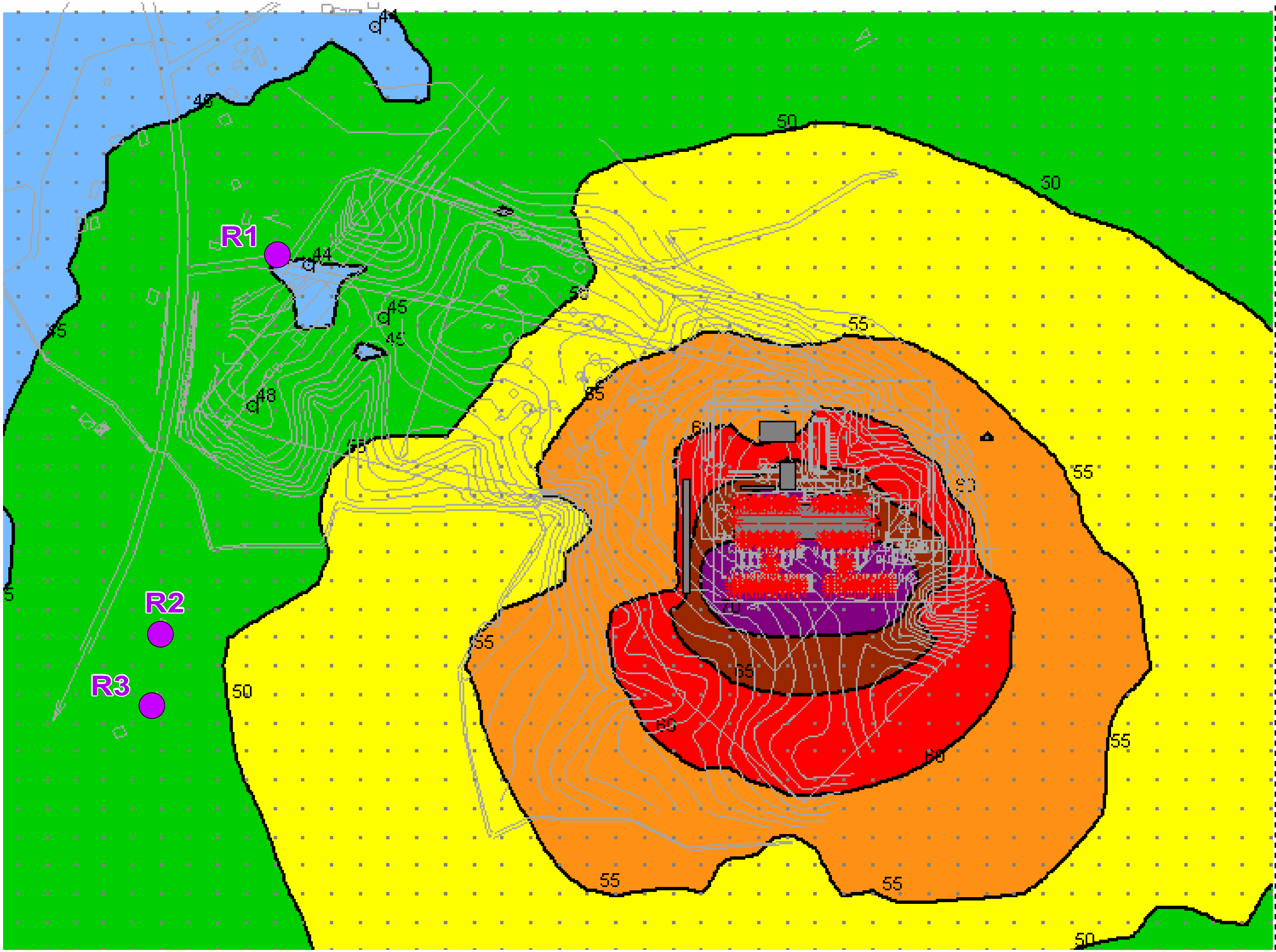


PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL ug/m^3

0.012 0.012 2.179 4.346 6.514 8.681 10.849 13.016 15.183 17.351 19.518

COMMENTS: Drawn: GH Checked: DD Approved: GG	SOURCES: **13**	
	RECEPTORS: **2692**	MODELER: **GH**
	OUTPUT TYPE: **Concentration**	SCALE: 1:17,000 0 0.5 km
	MAX: **19.51806 ug/m^3**	DATE: **19/11/2008**

PROJECT NO.:
Kribi Power Plant



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED

KEY:

R2 Noise Receptor

Revision Details	By / Check	Date	Suffix

DRAWING STATUS

Code	Description	Current Status	Appd	Date
P	Preliminary			
A	Submitted for Review	x	PS	21/11/08
C	For Construction			
I	For Information			
E	Cost Estimate			
AB	As Built			

Job Title

AES SONEL
KRIBI
POWER PROJECT ESIA

Drawing Title

FIGURE 3.1

NOISE LEVELS PRODUCED FROM THE THIRTEEN 18V50DF ENGINES IN OPERATION

Scale @ A3: NTS

Drawn		Approved	
JV		PS	
Stage 1 check	Stage 2 check	Originated	Date
PS		CH_ENV	21/11/08

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Drawing Number: D122445/ESIA/3.1

Revision