Takoradi Thermal Power Plant Expansion Project (T3)

Environmental Impact Assessment (EIA)

Revision 5
June 2009

Prepared By:

H-PI, llc

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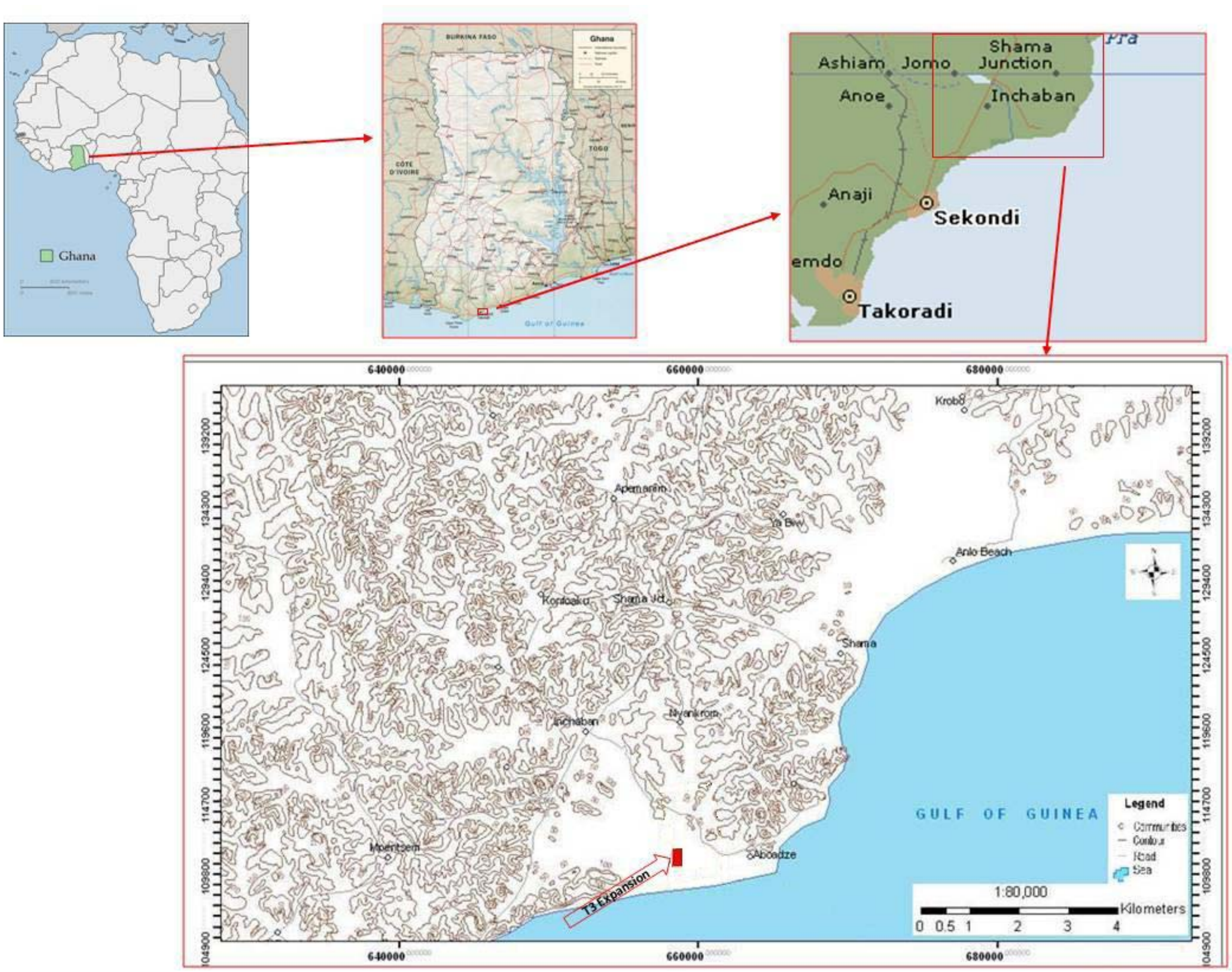
EXECUTIVE SUMMARY

1 Introduction

The Volta River Authority is currently undertaking a project (referred to as T3) to expand the existing Takoradi Thermal Power Plant (TTPP). See Figure 1.1, T3 Site Location for the location of the proposed T3 Thermal Plant.

Figure 1.1 T3 Site Location



The existing T1 plant is consists of a 330 MW light crude oil (LCO) fired combined cycle thermal generating plant. An EIA Report was prepared in 1995 in support of an application for funding from a number of agencies, including the World Bank, through the International Development Association. T1 began generating power in December 1997.

The design of T1 was structured as such to provide for the T2 expansion to accommodate future electrical energy demand growth and to effectively double the plant's output from 330 MW to 660 MW. A Supplementary Environmental Impact Assessment was undertaken of the proposed T2 expansion in 1999 to commence construction of the expansion project. This report supplemented the 1993 EIA Report and addressed specific environmental topics determined in consultation with the EPA.

The Supplementary Environmental Impact Statement (referred to hereafter as the '1999 SEIS') was submitted to the EPA in March 1999 and the EPA provided notice of Environmental Approval in April 1999. The 'Notice to Proceed' with the construction phase of T2 was issued to the contractor in February 1999 and construction has been completed for the first two phases of the project.

An Addendum Environmental Report was prepared in 2001 (referred to hereafter as the ' 2001 SEIS ') in support of the 1999 Supplementary Environmental Impact Statment to address certain specific environmental and social issues related to the third phase of the T2 project. The addendum was a financial requirement to ensure compliance of certain topics supported by the International Finance Corporation (IFC) and the Overseas Private Investment Corporation (OPIC), which provided the funding for the combined cycle phase of T2.

The Republic of Ghana has entered into a credit agreement with Society Generale Canada to finance the T3 expansion of the Takoradi Thermal Power Plant. These organizations require that an Environmental Impact Assessment Report be developed to address any predicted environmental and social issue associated with the construction and operation of T3. It is also necessary to demonstrate compliance with current environmental, health and safety criteria. This report therefore utilizes the three previous reports prepared for the study area as reference (1994 EIA Report, 1999 SEIS, 2001 SEIS).

This Executive Summary provides a standalone description of the environmental implications (benefits and adverse effects) of the T3 project. It has been prepared in accordance with current environmental, health and safety criteria.

2 Policy, Legal and Administrative Framework

2.1 Requirements of Co-Financers

To construct the T3 Thermal Power Plant the Government of the Republic of Ghana has entered into a credit agreement with Society Generale Canada. The Canadian entity Export Development Canada (EDC) will provide credit insurance for the construction of the 132 MW combined cycle Thermal Power Plant.

Environmental considerations are an integral part of loan agreements and bidding documents, as a result an extensive examination must be carried out on all projects to determine whether an environmental impact study or mitigation measures are required. As such, all local and other applicable environmental legislation shall be followed and complied with during all phases of the project, unless otherwise approved by the applicable regulatory authority. Project phases include, but shall not be limited to the environmental impact assessment process, project design and construction, and delivery of a facility that meets current and applicable environmental requirement.

The Export Development Act (Section 10.1) requires that Export Development Canada (EDC) before entering into a transaction that is related to a project, make the determination whether the project is likely to have adverse environmental effects despite the implementation of mitigation measures. This categorization will determine the nature and extent of environmental information that will be required by EDC in conducting its environmental review of the project.

Following careful and intensive review of the EDC Environmental Review Directive by the applicable parties it has been concluded that the T3 Thermal Power Plant will be classified as a “Category B” project.

2.2 Regulatory Conditions

Pursuant to EDC’s strict environmental policies and regulatory requirements, compliance with IFC General EHS Guidelines, more specifically local Ghana EPA and World Bank Guidelines, shall be observed and taken into consideration during the development of this Environmental Impact Assessment and all parties involved shall evaluate and implement processes that will ensure compliance.

2.3 Comparison of Predicted versus Regulatory Conditions

Predicted ground level concentrations resultants from T3 operation are presented in Appendix C and compared with Ghana EPA and World Bank Guidelines. Further discussion and evaluation of the potential effects of these emissions, mitigative measures and monitoring plans to address this effect are presented on sections 6, 7 and 8, respectively.

3 Description of Proposed Project

3.1 Introduction

This section describes the existing TTPP, provides a brief outline of the site characteristics, the history, need and objectives for T3. A discussion of alternative sites and designs considered (including a situation if T3 were not constructed), and a description of the key features for the site preparation, construction and operational stages of T3 are also provided.

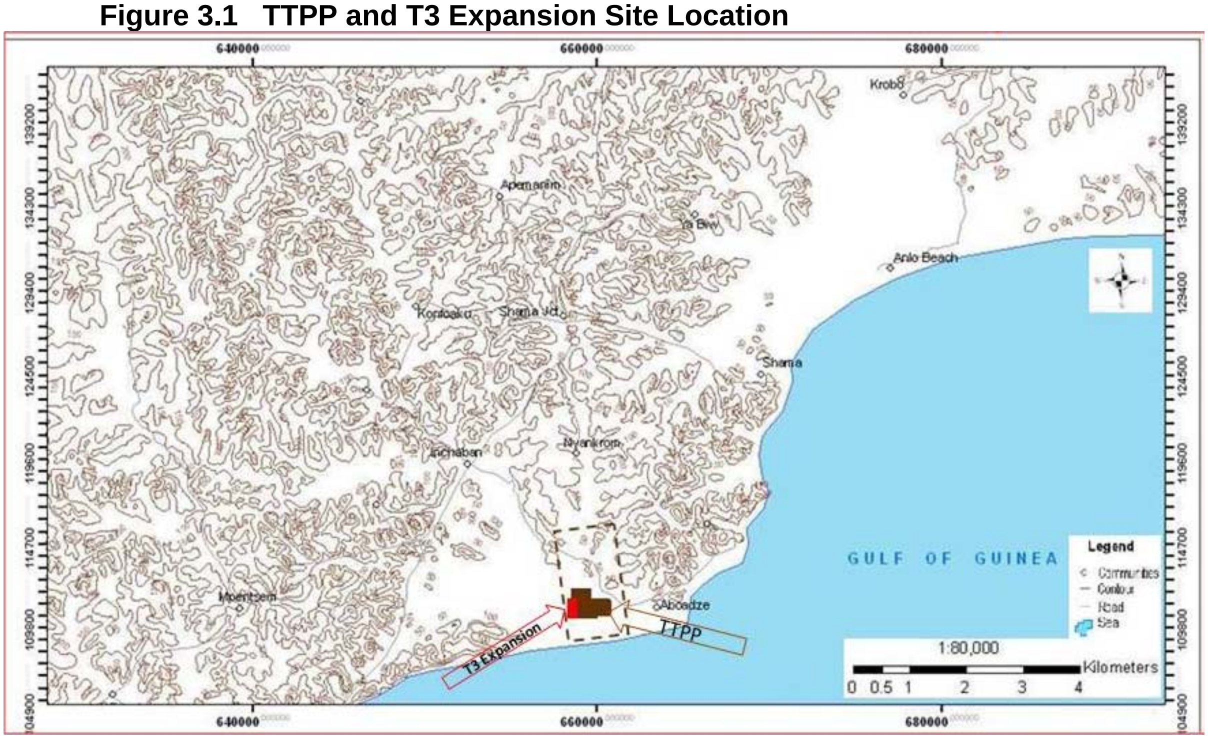
Information for this section was obtained from the following sources:

- 2001 SEIS Report
- 1999 SEIS Report
- 1995 EIA Report

As this report forms an addendum to the 2001 SEIS, which in turn supplemented the 1999 SEIS, which in turn supplemented the 1995 EIA Report, duplication of details contained within these reports has been limited to a minimum; where appropriate, reference to the relevant section in the 2001 SEIS, 1999 SEIS and 1995 EIA Report has been made.

In the context of this SEIS, 'the site' refers to the area on which T3 is to be constructed. The entire T3 site lies within the land acquired for TTPP (Figure 3.1).

Figure 3.1 TTPP and T3 Expansion Site Location



3.2 Existing Situation and Development of T3

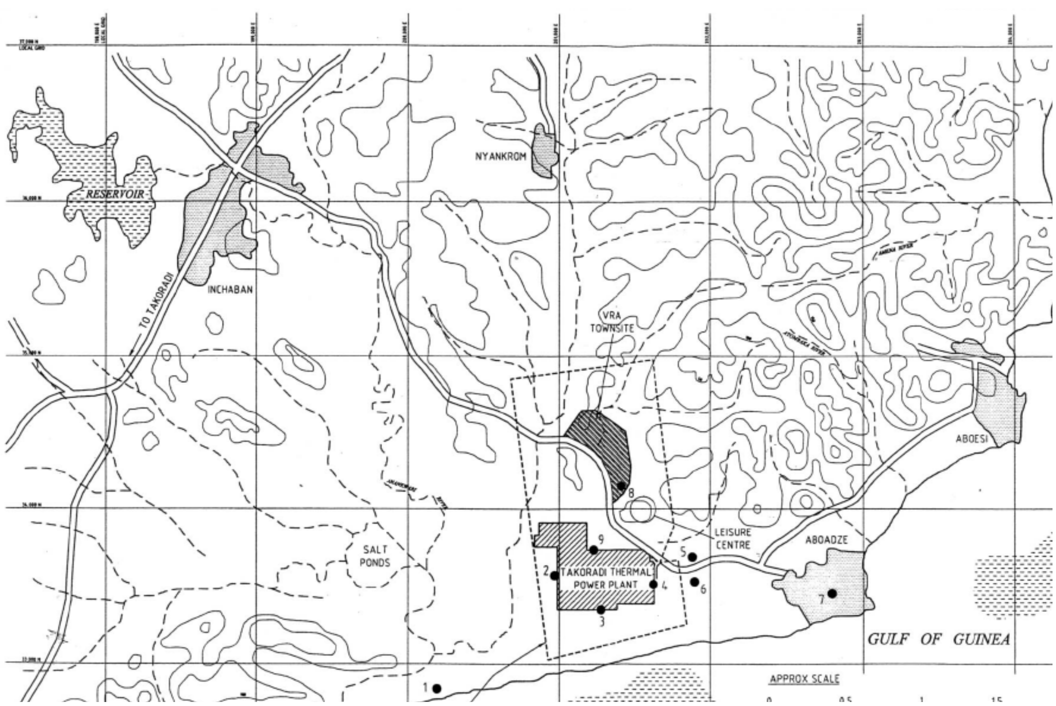
3.2.1 Existing Situation

Geographical Location, Site Characteristics and Land Use

The geographical location, site characteristics and former land use of the T3 site are described in section 2.2.1 of 1999 SEIS; a more detailed description of the site is provided in section 4.1 of the 1995 EIS.
Figure 3.1 shows the geographical location of TTPP on the southern coast of Ghana.

The TTPP is located on the south-west coast of Ghana approximately 15 km north west of the towns of Sekondi and Takoradi. It is situated roughly between five settlements of varying sizes, of which the nearest settlement (approximately 1 – 2 km to the east) is Aboadze. The VRA township for the plant is sited approximately 800m north west of the site boundary (see Figure 3.2). The surrounding area is relatively low lying, particularly the area immediately to the west and north of the site. The Anankwari and Atombaka Rivers and associated valleys flow to the west and east of TTPP respectively.

Figure 3.2 VRA Township Location



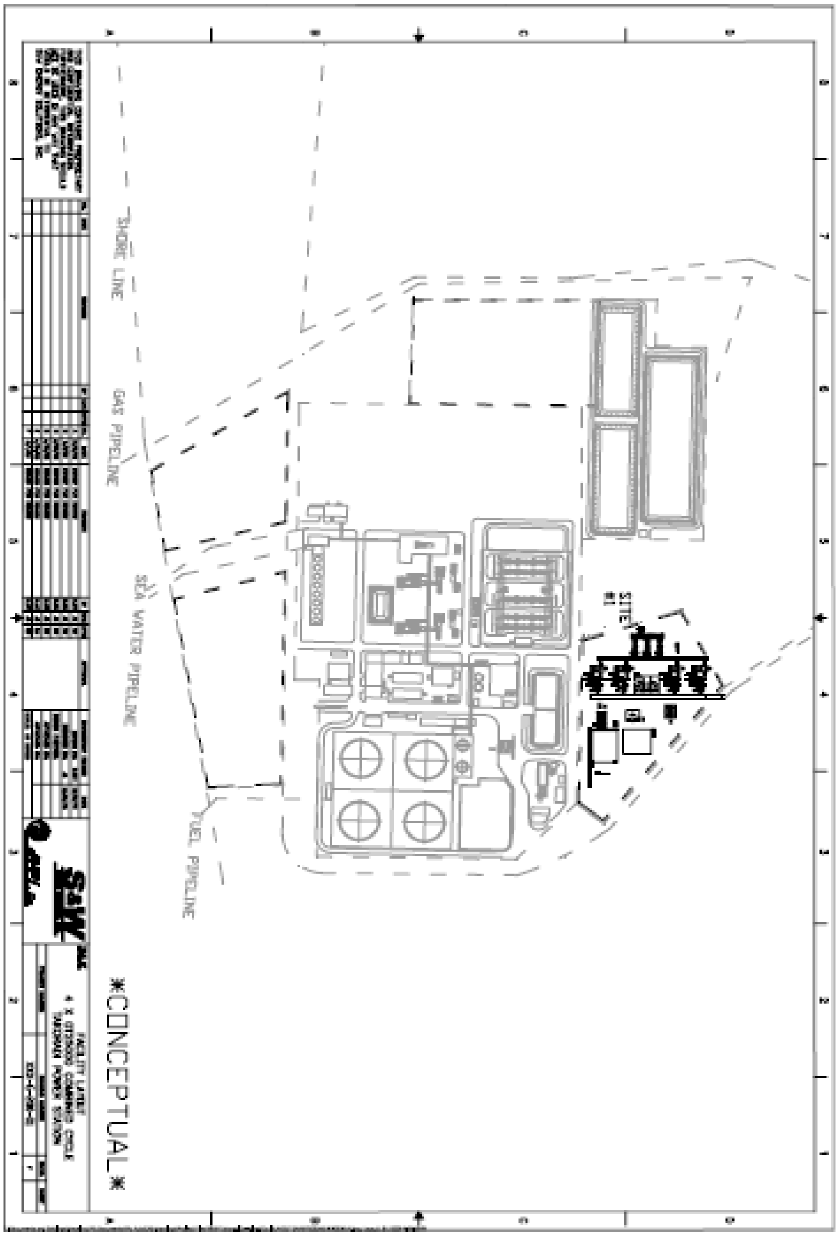
The land acquired by VRA for the construction of TTPP and its associated facilities and structures is approximately 168 ha in area (see Figure 3.2 VRA Township Location). The TTPP site is generally flat in profile, although some land raising was undertaken during the construction of T1, in order to raise the site 3.0 m above the height of the surrounding wetland. Further details relating to the regional context of TTPP and the physical characteristics are provided in Section 1 of 1995 EIA Report.

The area of the site allocated for T3, which lies within the existing TTPP site, is approximately 3.6 ha (see Figure 3.3). The total TTPP area is approximately 168 ha, which comprises T1 and facilities (26.5 ha), township (72 ha, including recreational facilities), T2 (7.5 ha), T3 (3.64 ha) with the remaining 58.4 ha consisting of construction laydown area and wetland. The TTPP site is located on the southwest coast of Ghana approximately 15 km north east of Takoradi town and between 1 to 2 km from the nearest settlement, Aboadze.

<u>Existing T3 Land Use</u>

The site for T3 has been partially cleared of vegetation during the construction of T1 and T2. It is bounded by drainage channels and Inchaban road to the east and north, and to the south by the existing T1/T2 generating plants. The location and site layout from TTPP, incorporating T3 is shown on Figure 3.3.

Figure 3.3 T3 Location With Respect to TTPP



Construction, commissioning and operation of T1 are complete. T2 simple cycle is complete, providing an additional 220 MW, with combined cycle to be completed in the near future adding another 110 MW to the project. When completed, T1 and T2 will provide a 660 MW light crude oil (LCO) fired thermal generating plant, which in turn will consist of:

- Four combustion turbine generators (CTGs);
- Four heat recovery steam generators (HRSGs);
- Two steam turbine generators (STG);

Additional facilities and support buildings include cooling tower systems, fuel supply and storage provisions, water supply pipeline, and drainage facilities. The VRA designated the fuel supplied as LCO; however, further analysis of its properties by the turbine manufacturer indicated that many of its properties closely resembles those of blended residual or Heavy Fuel Oil (HFO) and thus it will be treated as such for emissions compliance and performance purposes. At this time LCO is the principal fuel source of fuel. The design of the CTGs allows for conversion to natural gas, once it becomes available. Diesel is used as a start-up fuel.

Broadly defined, the layout of T1 and T2 is such that the power generating plant and transmission facilities are located in the western part of the site and the fuel storage and other facilities are located in the eastern part of the site. Sewage lagoons are positioned immediately north-west of the power generating plant. T3 will be positioned northeast of these structures.

T1 began generating power in December 1997 and began operating in simple cycle mode, generating up to 220 MW. The combined cycle mode was completed in 1999, bringing T1 to its design generating capacity of 330 MW.

T2 began generating power in 2000 in simple cycle mode bring the total generating capacity of Takoradi Thermal Plant to 550MW. The combined cycle conversion of T2 is still under development and once completed will increase the capacity by another 110MW.

3.2.2 Development of T3

The Need for T3

The ever-increasing demand for electricity in Ghana is placing a heavy burden on the available resources of TTPP and will soon outgrow its capability. The VRA has studied this ever growing demand and has projected the need for this plant to be placed on stream at this time. The T3 expansion of TTPP has been proposed in response to the recent energy crisis and will increase the total output of TTPP by 132 gross MW at ISO conditions to give the facility a total output capacity of approximately 792MW, when T2 expansion and T3 are completed.

In addition, power produced by T3 will reduce the need to import electricity from neighboring countries, and may provide the potential for exporting electricity to neighboring countries such as Burkina Faso, Benin, Cote d'Ivoire and Togo. This potential for exporting power may relieve Ghana's dependency on other nations for electrical energy, as well as providing a valuable source of revenue.

Evolution of T3

In summary, these alternatives included the following:

- The 'do nothing' option (i.e. a hypothetical situation where T3 is not constructed);
- Alternative site locations (Figure 5.2);
- Alternative technologies, including cooling water systems, and open and closed-circuit systems;
- Using alternative fuels, including LCO and residual fuel oil;
- Using alternative methods of fuel oil transportation; and
- Broad potential environmental impacts associated with the various
- Alternatives, such as:
    - o Air quality – fuel types, stack heights and control technologies
    - o Marine environment – cooling systems and single point mooring locations.

These alternatives were subsequently accepted or rejected primarily on the basis of practical, economical and environmental contexts relative to best meeting the specific objectives for relieving the national energy crisis.

As potential for further expansion has already been designed into T1, and because T3 will be constructed within the TTPP site, using similar technology, and sharing T1/T2 components, infra-structure and support services, it is considered that the alternative proposals prepared for T1 are essentially the same for T3. Therefore, the detailed assessment of the alternatives presented in the 1995 EIA Report is sufficient to cover similar considerations of T3 and therefore is not repeated in this section.

Within the boundaries of TTPP, the location chosen for T3 was determined after consideration of three possible locations. The following factors were taken into consideration; available space, equipment locations to accommodate space, accessibility, site preparation, least impact to existing environment and TTPP current operations.

The proposed expansion carried forward from the selection process as T3 was selected on the basis that it represented the most economically viable option for achieving the key objective of providing a rapid response to the energy crisis as well as involving minimal environmental disturbance.

For a 'Do-Nothing' scenario where T3 is not constructed, it is probable that:

- Ghana will continue to have a power supply deficit with the consequential socio-economic effects that this could generate;
- Consistency and availability of power supply will continue to fluctuate relative to the available water supply for the hydroelectric power plants;
- Ghana will continue to be partially dependent on imported power; and
- There would be new and potentially greater environmental implications involved if a new power station were built at an alternative site.

Objectives of T3

Taking into account the above, the primary objectives of T3 are to:

- Increase electricity output of TTPP by 132 gross MW;
- Provide a least cost fuelled plant;
- Supplement the hydroelectric power supplies;
- Assist with developing a more reliable electricity supply;
- Reduce Ghana's dependency on other countries for electricity;
- Utilize existing fuel supply;
- Provide surplus energy for export;
- Inject private foreign capital to the power sector; and
- Minimize environmental impact.

3.3 T3 Proposal

The proposed T3 expansion of the Takoradi Thermal Plant consists of a 132 gross MW oil-fired combined cycle thermal generating plant at ISO conditions. The purpose of the proposed T3 Thermal Power Plant is to furnish peaking power to the national grid and to provide base load capacity in times of low water levels when hydroelectric generation is affected.

Overall, T3 will involve the construction and operation of the following items:

- Four 25 MW Combustion Turbine Generators CTGs (open cycle);
- Four Steam Generators (OTSG);
- Two 16 MW Steam Generators;
- Four 88 ft. (27 m) stacks for each of the four STGs;
- Raw water storage;
- Cooling water system;
- Raw diesel fuel storage;
- Treated diesel fuel storage;
- Raw LCO fuel storage;
- Treated LCO fuel storage;
- Four continuous emissions monitoring systems, one per stack;

Figure 3.3 provides a general schematic of the T3 combined cycle plant, as envisaged at the Takoradi site and Figure 3.4 shows the main plant components and detailed equipment list.

Figure 3.4 T3 Plot Plan (Reference Appendix E Drawings)

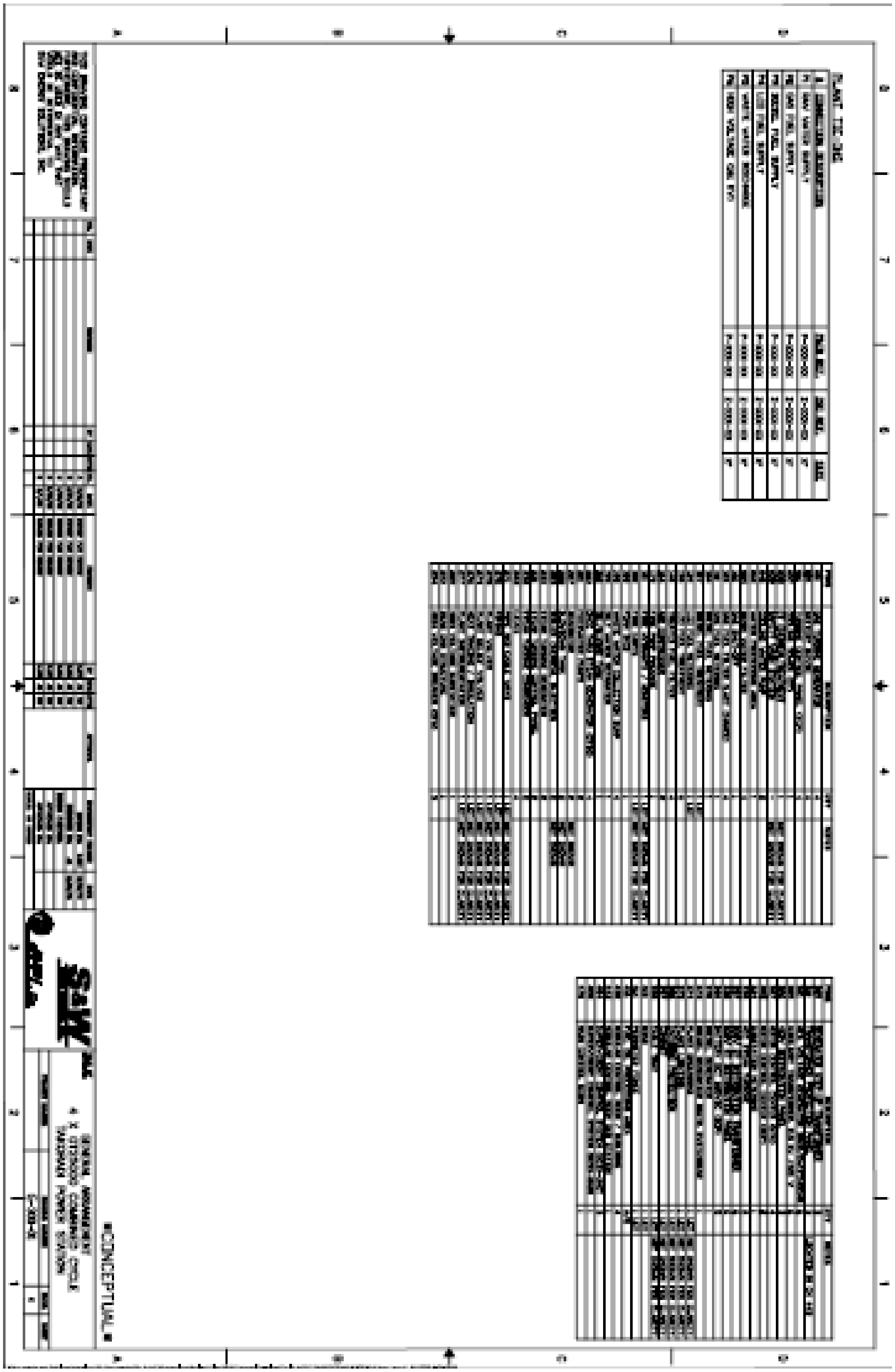


Figure 3.4 Plot Plan (Reference Appendix E Drawings) – cont.

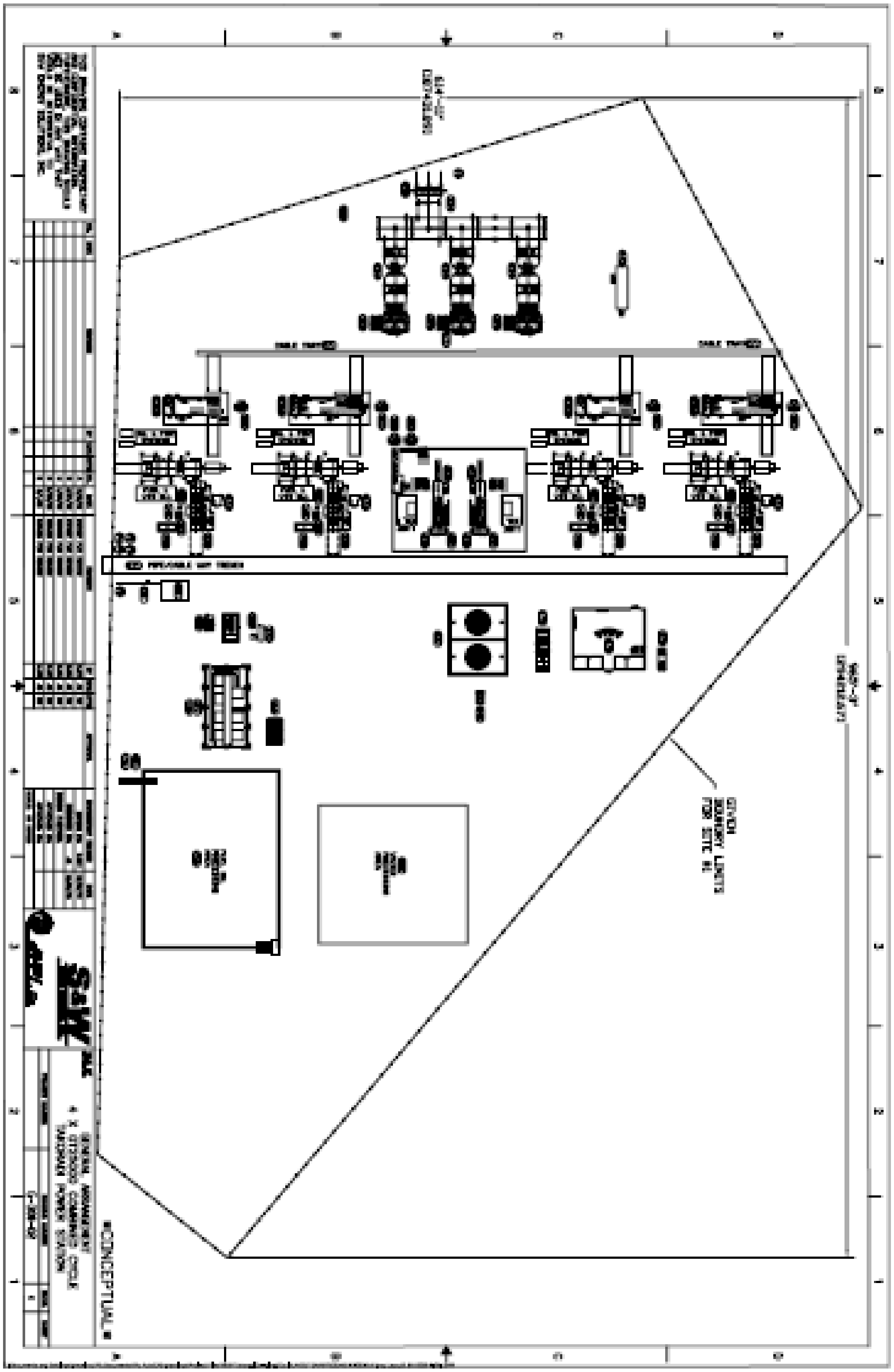


Figure 3.4 Plot Plan (Reference Appendix E Drawings) – cont.

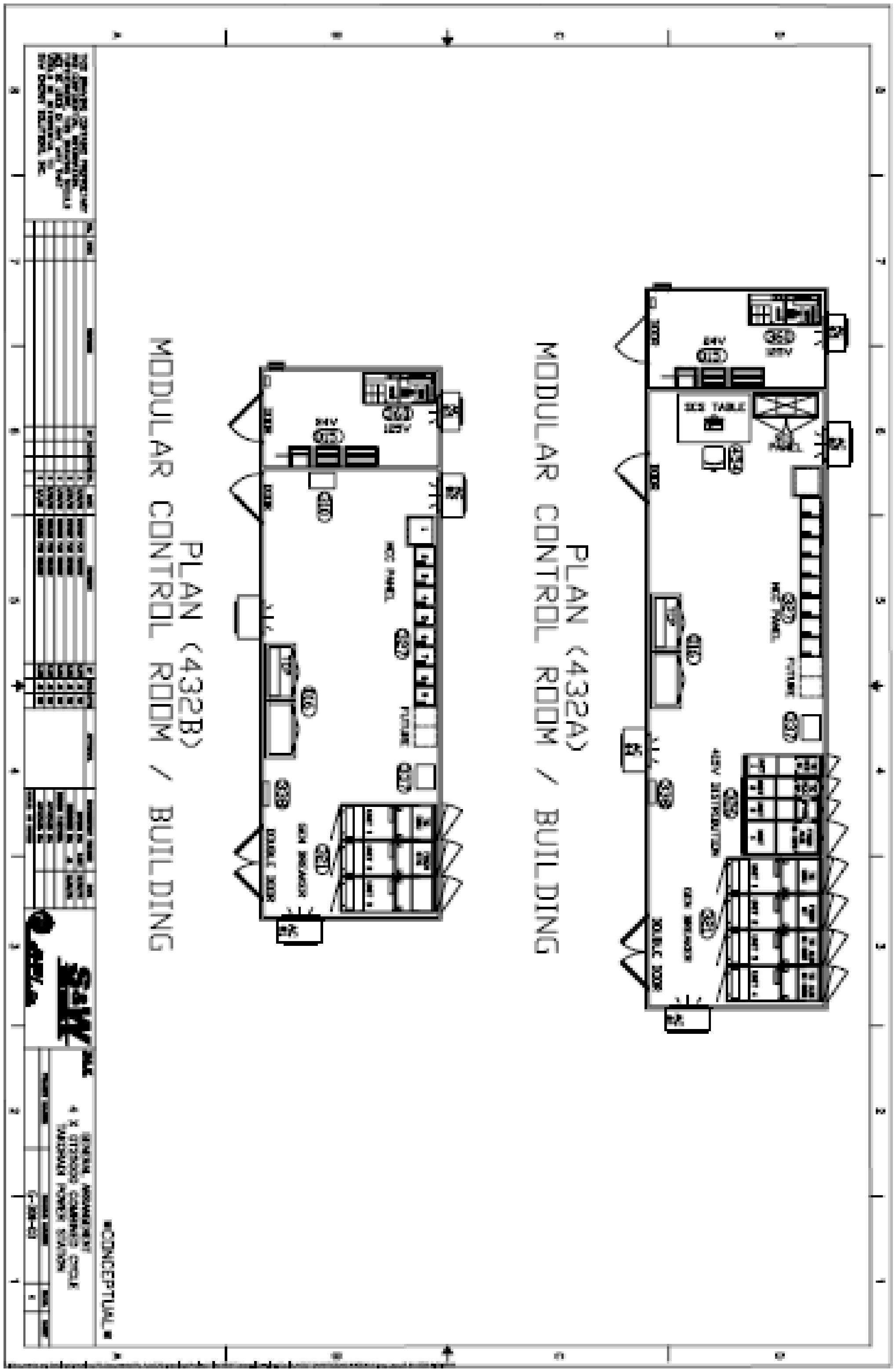


Figure 3.4 Plot Plan (Reference Appendix E Drawings) – cont.

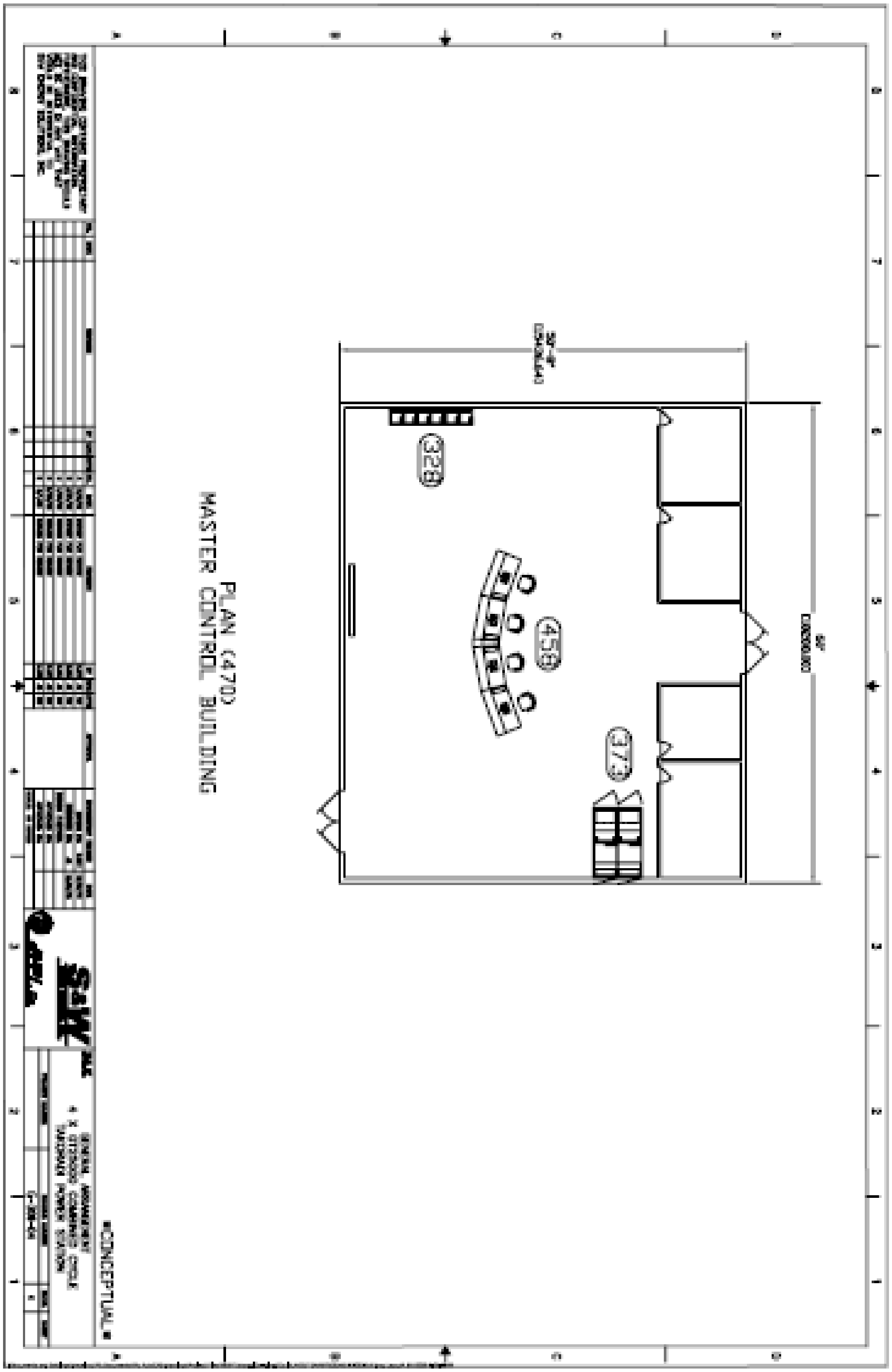
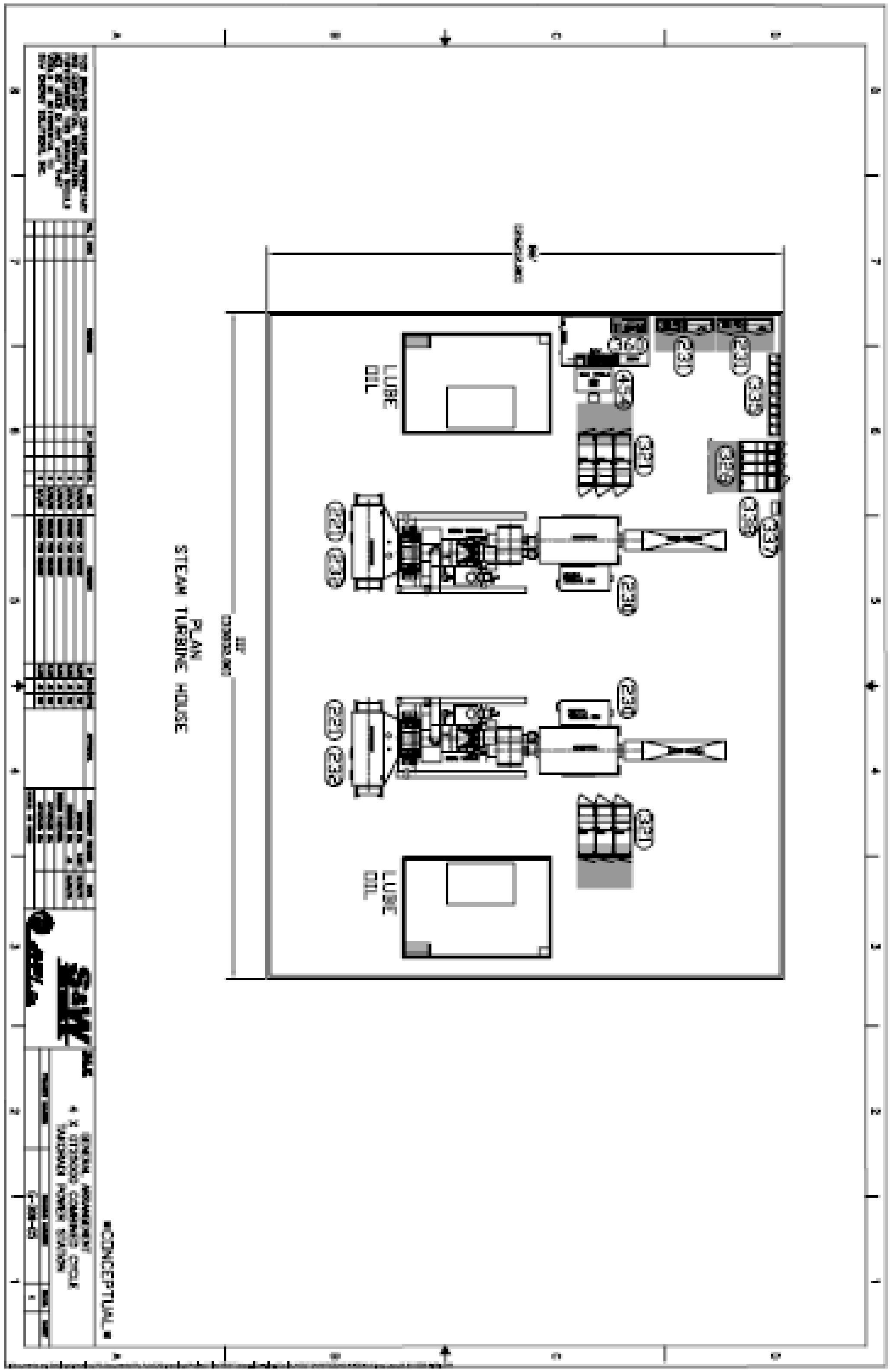


Figure 3.4 T3 Plot Plan (Reference Appendix E Drawings) – cont.



A brief description of the proposed plant, process and operation follows.

The proposed arrangement, defined as a combined cycle system, will consist of four (4) high efficiency 25 MW Combustion Gas Turbine (CGT) generators, burning liquid fuel, each with heat recovery boilers, which in turn produce steam to supply two (2) 16 MW steam turbine generators(STGs). In this arrangement, high temperature exhaust gases from the CTGs are utilized to produce steam in the steam generators for powering the STGs. The combustion turbines currently available are well suited to combined cycle operation, because of the high energy content of their exhaust gases. The temperature of exhaust gases discharged to the environment varies from approximately 193 °C during combined cycle operation to 499 °C during bypass (combustion turbine only) operation. The heat recovery system does not, in other respects, alter the components of the gaseous emissions. The plant will be equipped with four stacks (approximately 27 meters in height each); one at the outlet of each heat recovery boiler. Should the boilers not be operable, they are designed to be run dry. In simple cycle mode the T3 max capacity is 100 gross MW at ISO conditions, while in combined cycle mode T3 max capacity is 132 gross MW at ISO conditions.

Key Features:

- Use of light crude oil as the principal fuel supply for power generation with the option of converting to natural gas. Operation would also be possible on distillate oil.
- Fuel oil to be provided from TTPP storage tanks
- Closed loop cooling water system is provided with make up water being supplied from the existing Takoradi Thermal Plant. Cooling tower blowdown discharges into the Final Discharge Sump of the existing T1/T2 cooling tower blowdown facility. VRA has confirmed their blowdown system has the capacity to handle these volumes.
- Approximately 300 local workers will be required during the construction of the facility with 20 foreign supervisors and foremen. Most construction activity would be related to site preparation and assembly/interconnection of various pre-engineered components and buildings, and installation of utilities and services.
- A permanent work force of approximately 30 workers will be required for its permanent operation.
- Fresh and demineralized water requirement for the plant and emission control (NOx) requirement of approximately 473 gpm and 80 gpm, respectively, made available to T3 by the existing plant via the existing 6” water supply line and Demin Water Facilities.
- Construction and operational monitoring employed to refine final design and verify predictions of station impact.
- Community Impact Agreement with the village of Aboadze to mitigate and compensate for predicted negative impacts of the plant was put in place during

the construction of T1 and is recommended to be revised and updated if necessary.

- Improvements and support to the local community to include scholarship for students, construction of a playground for the Aboadze complex of schools.
- The project to be contracted on a turnkey basis, and will consist of six major sub-contracts, relating to CTGs, STGs, HRSGs, electrical distribution, civil works and eletro/mechanical works.

3.3.1 Site Preparation and Construction Details

As mentioned in section 3.2.1 above, T3 will be located adjacent to T1/T2; i.e. adjacent northeast of the existing power generating plant. This will provide for easy integration of T3 into T1/T2 and the setting up of shared facilities.

The site preparation and construction design requirements, activities, resources required and program associated with each of these phases are described below.

In addition, the appointed Engineering, Procurement and Construction (EPC) contractor will be contractually required to follow best environmental practices and exercise due care in order to limit adverse impacts on the surrounding human and natural environment. These practices and associated mitigation measures are discussed in details in Section 6. Furthermore, Volta River will undertake environmental monitoring programs during the site preparation and construction stages to assess the effectiveness of the mitigation measures. Further details are contained in Sections 7 and 8.

<u>Site Preparation Details</u>

The main site preparation activities for T3 largely comprise undertaking additional ground works on the allocated site, namely land raising/grading and excavations for the CTG foundations.

Certain areas within the site for T3 may require being raised using material sourced from local borrow areas. These areas were also used in association with the ground works for T1/T2 and no further borrow areas are required.

The major excavations for T3 are those required for the CTG foundations. At this stage blasting is not currently proposed, however, it may be required later where geological conditions dictate. Excess material generated during excavations will be either re-used or placed with other spoil material, from the construction of T1/T2, in the allocated area directly west of the plant. This area may subsequently used as a construction laydown area.

The main resources, namely materials, waste material areas, labor, access and services, and facilities and structures, required during site preparation are outlined below:

Materials	Land rising for Phase I may require material which will be obtained from T1/T2 sources.
Waste Material Areas	Spoil material from ground excavations will be reused where possible or deposited with T1/T2 spoil in a designated area directly west of the plant.
Labor	Approximately 120 workers will be required for the earthworks.
Access & Services	Access to the site will be via existing routes (sea and road) used for T1/T2.
Facilities and Structures	Temporary workshops and site offices will be required. These will largely be set up in designated areas within the TTPP site area.

Site preparation activities are scheduled to commence within six months of project initiation and will continue for four months.

Construction Details

Components associated with construction are detailed below.

The geographical layout of these facilities and structures is shown on Figure 3.4.

- Combustion Turbines
- Steam Generators
- Cooling Tower
- Generator Step-Up Transformer (GSU)
- Auxiliary Transformers
- High Voltage Breakers
- Air Compressors
- Gas Fuel Metering Station
- LCO Storage
- Diesel Storage
- Deaerator
- Blowdown Tanks
- Boiler/FW
- Chemical Injection Skid

- Water Processing Area
- Waste Water Collection Sumps
- Modular Control Room Buildings
- Admin/Maintenance building
- Modular Control Room Substation
- Main Control Room

The main resources, namely materials, waste materials areas, labor, access and services, and facilities and structures, required during the construction of T3 are outlined below:

Materials	Construction materials such as pipes, structural steel, wire, cable tray and conduit will be imported by sea via Takoradi port from USA and Europe and then transported by road to TTPP. Locally available materials will be used where possible, e.g. aggregate from local quarries and Portland cement.
Waste Material Areas	Spoil material will be deposited in the designated spoil area directly west of the plant, other construction wastes, such as packaging materials, plastics and wood, may be made available to employees for re-use in the local community. All unuseable materials will be disposed of at a local appropriate landfill site.
Labor	300 construction workers. Unskilled construction workers will be sourced from local villages, skilled labor will be obtained nationally and highly skilled workers and supervisors will be sourced from overseas, as necessary.
Access and Services	Access to the site will be via existing routes (sea and road) used for TTPP. Estimated average construction vehicle movements are 20 trucks and 10 cars per day. Electrical power will be supplied as per the current provisions for T1/T2, comprising a transformer located to the north of the site. The T1/T2 drainage, sanitary and sewerage systems will, with minor adjustments, be suitable to accommodate T3 requirements.

Facilities and Structures In addition to the facilities and structures detailed, some temporary structures will be required, including site offices, temporary workshops and construction laydown/storage areas. The capacity of some T1/T2 structures may need to be increased (e.g. fuel storage and processing) to accommodate T3 requirements.

Construction Schedule

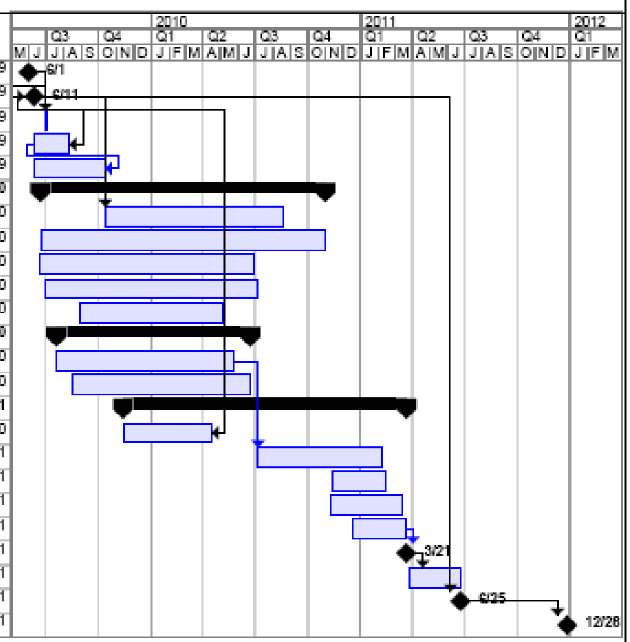
The construction of T3 will start once the Notice to Proceed for the project is granted by The Government of the Republic of Ghana. Construction is scheduled to take up to approximately two years to complete.

Preliminary project schedule for the construction, commissioning and startup of T3 is provided on Figure 3.5 below.

Figure 3.5 Construction, Commissioning and Startup Schedule

The Government of the Republic of Ghana
Contract No. 61738

ID	Task Name	Duration	Start	Finish
1	Effective Date	0 days	Mon 6/1/09	Mon 6/1/09
2	Commencement Date	0 days	Thu 6/11/09	Thu 6/11/09
3	Appoint Employer's Rep.	1 day?	Wed 7/1/09	Thu 7/2/09
4	Preliminary Engineering	2 mons	Thu 6/11/09	Wed 8/12/09
5	Detailed Engineering	4 mons	Thu 6/11/09	Tue 10/13/09
6	**Major Equipment Procurement**	**497 days**	**Mon 6/22/09**	**Mon 11/1/10**
7	GTG	10 mons	Tue 10/13/09	Thu 8/19/10
8	STG (2)	16 mons	Tue 6/23/09	Mon 11/1/10
9	HRSG (4)	12 mons	Mon 6/22/09	Tue 6/29/10
10	Condenser	12 mons	Mon 6/29/09	Tue 7/6/10
11	GSU	8 mons	Mon 8/31/09	Thu 5/6/10
12	**Balance of Plant Equipment**	**338 days**	**Mon 7/20/09**	**Wed 6/23/10**
13	Mechanical	10 mons	Mon 7/20/09	Wed 5/26/10
14	Electrical	10 mons	Mon 8/17/09	Wed 6/23/10
15	**Construction**	**493.38 days**	**Fri 11/13/09**	**Mon 3/21/11**
16	Civil Works	5 mons	Fri 11/13/09	Sat 4/17/10
17	Equipment Erection	7 mons	Wed 7/7/10	Wed 2/9/11
18	Piping	3 mons	Sat 11/13/10	Mon 2/14/11
19	Electrical	4 mons	Wed 11/10/10	Mon 3/14/11
20	I&C	3 mons	Sat 12/18/10	Mon 3/21/11
21	Mechanical Completion	0 days	Mon 3/21/11	Mon 3/21/11
22	Start-Up & Commissioning	90 days	Sat 3/26/11	Fri 6/24/11
23	Commercial Operation	0 days	Sat 6/25/11	Sat 6/25/11
24	Final Completion	0 days	Wed 12/28/11	Wed 12/28/11



Project: Schedule - Rev 01
Date: Fri 5/1/09

Task | Milestone | External Tasks
Split | Summary | External Milestone
Progress | Project Summary | Deadline

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3.3.2 Operation Details

T3 has been designed and engineered for safe, reliable and efficient operation and maintenance. Numerous features and procedures have been incorporated to facilitate operation and maintenance. These include, for example:

- Operating and maintenance training;
- Equipment and performance inspections and testing (prior to and after commissioning);
- Plant layout is such that it will minimize worker exposure to personal accident risk and contact with hazardous materials. The layout promotes cleanliness to avoid the unnecessary spread of dust, fumes, heat and noise from the plant, and provides easy access to equipment for regular maintenance;
- The provision of safety equipment; and
- The plant will be operated and controlled such that safeguard systems or system shutdowns will be automatically initiated upon failure of primary systems.

Environmental monitoring programs have been initiated to review the operational impacts of T1/T2 in order to assist in limiting or avoiding any adverse environmental impacts occurring. These programs, including additional requirements for T3, are summarized in Section 7.

The operational features and required resources are summarized below.

Operational Features

T3 comprises four (4) combustion gas turbines, four (4) OSTGs and two (2) steam turbines. T3 can be operated in either simple cycle mode or combined cycle mode configurations. Total gross MW capacity for T3 is 100 MW in simple cycle mode and 132 MW in combined cycle mode at ISO conditions.

Required Resources

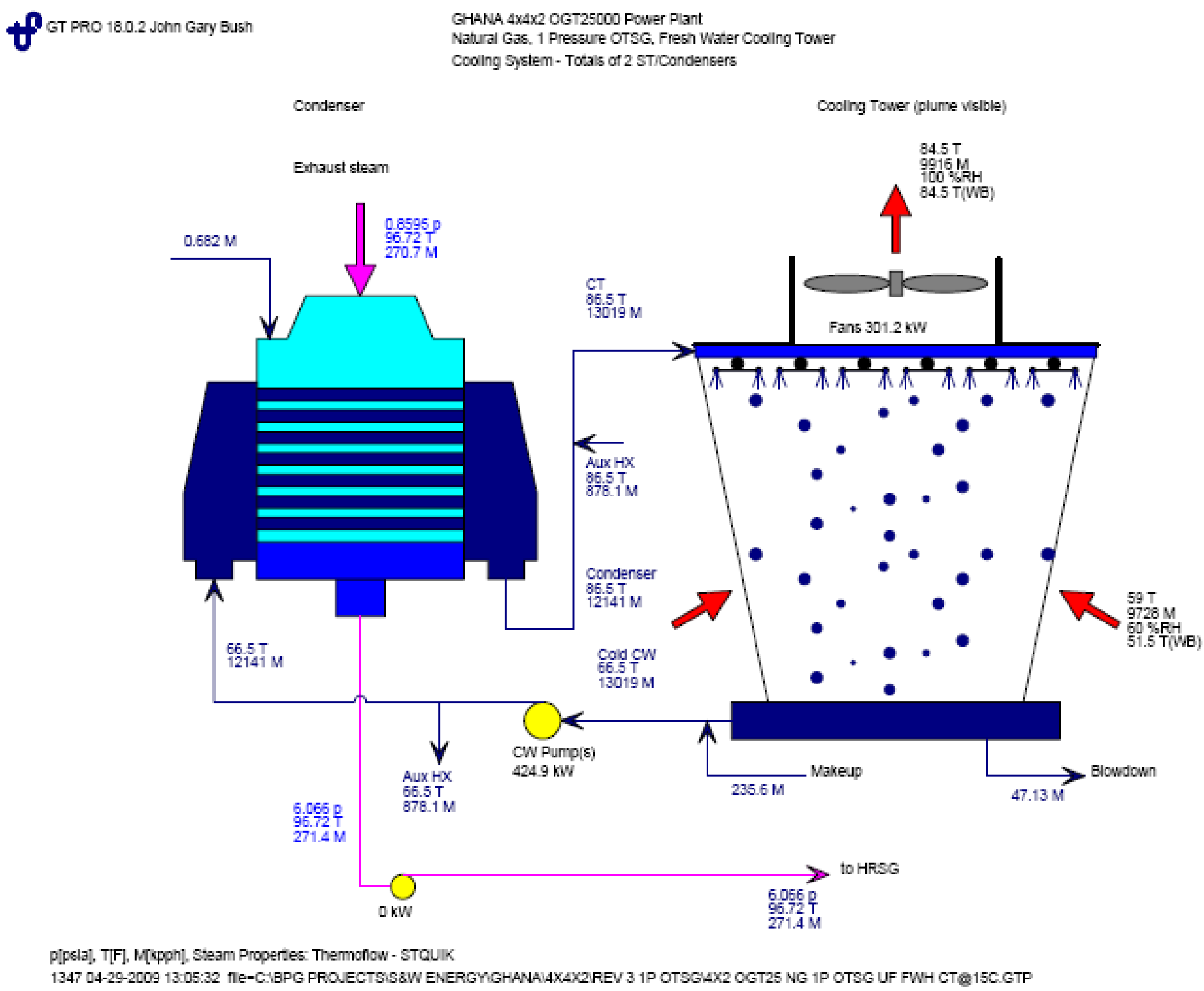
Resources required for T3 include materials, waste material areas, labor, fuel, access and services and facilities and structures, and are outlined below:

Materials (Other than fuel)	The primary operational materials required include water, chemicals and spare parts. The existing plant will accommodate T3 raw water requirements; demineralized water will be supplied from T1/T2 demin system; water is required for T3 potable, process, service and fire systems. An overview of processes water balance is shown on Figure 3.6 and detailed water requirements and discharges are

	outlined in Table 3.1.A suite of chemicals is also required for the water treatment processes. The chemicals used and volumes required are listed in Table 3.2. Spare parts requirements for the process equipment (such as for the CTGs) will be imported when required.
Waste Material Areas	Existing TTPP liquid waste storage/disposal areas will accommodate additional liquid waste associated with T3. The Shama Ahanta East Metropolitan Authority will be contracted to remove solid waste from site.
Labor	An additional 30 workers will be required for T3 operations. The existing worker facilities and social infrastructure may need to be expanded to support the extra personnel.
Fuel	As described in section 3.2.1 the primary fuel for T3 will be LCO and natural gas when available. Details relating to estimated fuel consumption (LCO and natural gas) for T3 are mainly described in Table 3.3. Tables 3.4 and 3.5 show OGT emission rates and applicable IFC guidelines, respectively. As previously mentioned in section 3.2.1, based on fuel specifications provided by the VRA the turbine manufacturer classified the fuel available as Heavy Fuel Oil (HFO) due to its metal concentration and contaminants, and as such the applicable guideline of 146ppm (NOx) for *Aeroderivatives & HFO* applies to the OGT25000 turbines (see table 3.5 highlited section). The LCO will be supplied from mainly West African sources. Natural Gas, when available, will be supplied from West African Sources.
Access and Services	Overall the existing site access, services and many ancillary facilities will be sufficient to accommodate T3. Minor upgrades of T1/T2 services will be required, see section 3.3.1, 'Site preparation and Construction Details;

Facilities and Structures	Shared components between T1/T2 and T3 have been listed in section 3.3.1. Some additional electrical power will be required to operate T3; this will be supplied by T1/T2.

Figure 3.6 T3 Cooling Water System Balance



**Note: An additional 80 gpm will be utilized for emission control of NOx.*

Source: Bush Power Group LLC

Table 3.1a T3 Cooling Water System Requirements and Discharges

Plant Water Accounting	Current flow	% included		
Total Water Consumption	473 gpm		236.3	kpph
Evaporative cooler	0	100	0	kpph
Fogger	0	100	0	kpph
External water to GT injection	0	100	0	kpph
Steam cycle makeup	0.682	100	0.682	kpph
Cooling tower makeup	235.6	100	235.6	kpph
Wet air-cooled condenser makeup	0	100	0	kpph
Total HRSG water addition	0	0	0	kpph
Condensate addition	0	0	0	kpph
Addition before LTE (FW Tank)	0	0	0	kpph
Addition at deaerator	0	0	0	kpph
Auxiliary cooling tower makeup	0	100	0	kpph
Total Water Discharge	94 gpm		47.13	kpph
HRSG blowdown	0	100	0	kpph
Cooling tower blowdown	47.13	100	47.13	kpph
Wet air-cooled condenser blowdown	0	100	0	kpph
Total HRSG water bleed	0	100	0	kpph
Deaerator bleed	0	100	0	kpph
IPE bleed	0	100	0	kpph
HPE bleed	0	100	0	kpph
Condensate bleed	0	100	0	kpph
Bleed before LTE (FW Tank)	0	100	0	kpph
Water condensed from GT inlet chilling	0	100	0	kpph
Auxiliary cooling tower blowdown	0	100	0	kpph

Table 3.1b Turbine Water Injection Requirements for Emission Control (NOx)

NOx Water Supply Equivelent to: 80 gpm	Current Flow	% included		
Water Injection (20 gpm/turbine)	40.11	100	40.11	kpph

Table 3.2 Chemicals and Volumes Required for T3

Area of Use	Chemical	Approximate Volume Required (Design Capacities)
Cooling Water Treatment	Sodium Hypochlorite	100 Gallons/Year
	Sodium Hypobromide	100 Gallons/Year
	H2SO4	100 Gallons/Year
	Corrosion Inhibitor	100 Gallons/Year
	Sodium Monosulfate	100 Gallons/Year
Demineralization System Treatment	Hydrochloric Acid	100 Gallons/Year
	Sodium Hydroxide	100 Gallons/Year
Closed Steam System	Phosphates	200 Gallons/Year
	Amines	200 Gallons/Year
	O2 Scavenger	300 Gallons/Year
Gas Turbine Chemicals	GT Compressor Cleaning Agent	300 Gallons/Year

Table 3.3 Estimated Fuel Consumption for T3

Fuel Type Alternatives	Fuel Heating Value (MJ/KG)	Heat Rate (KJ/KWHR)[LHV]	Output (KW)	Fuel Burn Rate (kg/hr)
LCO	43	10,876	23,500	5,944
Diesel	-	-	-	-
Natural Gas	50	10,714	24,700	5,293

Note: These are estimations based on the operation of a single CTG at 100% capacity on cold day (ambient temperature 20°C; 95% relative humidity). This is also a conservatively high fuel burn rate as a cold day output is much higher than the design day output; heat consumption will also be higher.

Table 3.4 OGT25000 Emission Rates

OGT Emission Rates	
Fuel	HFO/LCO
Ambient Temperature, °C	32
NOx ppmvd Ref 15% O2	146
NOx as NO2, lb/hr	124
CO ppmvd Ref 15% O2	80
CO, lb/hr	41
CO2, lb/hr	35060
HC ppmvd Ref 15% O2	84
HC, lb/hr	25
SOX as SO2, lb/hr	45

Table 3.5 IFC Emissions Guidelines for Combustion Turbines

Table 6 (B) - Emissions Guidelines (in mg/Nm³ or as indicated) for Combustion Turbine

Note:

- Guidelines are applicable for new facilities.
- EA may justify more stringent or less stringent limits due to ambient environment, technical and economic considerations provided there is compliance with applicable ambient air quality standards and incremental impacts are minimized.
- For projects to rehabilitate existing facilities, case-by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.
- EA should demonstrate that emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards, and more stringent limits may be required.

Combustion Technology / Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO_2)		Nitrogen Oxides (NOx)	Dry Gas, Excess O_2 Content (%)
Combustion Turbine			NDA/DA		NDA/DA	
Natural Gas (all turbine types of Unit > 50MWth)	N/A	N/A	N/A	N/A	51 (25 ppm)	15%
Fuels other than Natural Gas (Unit > > 50MWth)	50	30	Use of 1% or less S fuel	Use of 0.5% or less S fuel	152 (74 ppm)[a]	15%

General notes:

- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; S = sulfur content (expressed as a percent by mass); Nm³ is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to single units; Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- If supplemental firing is used in a combined cycle gas turbine mode, the relevant guideline limits for combustion turbines should be achieved including emissions from those supplemental firing units (e.g., duct burners).
- (a) Technological differences (for example the use of Aeroderivatives) may require different emissions values which should be evaluated on a cases-by-case basis through the EA process but which should not exceed 200 mg/Nm3.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2006):

- Natural Gas-fired Combustion Turbine – NOx
  - Guideline limits: 51 (25 ppm)
  - EU: 50 (24 ppm), 75 (37 ppm) (if combined cycle efficiency > 55%), 50*η / 35 (where η = simple cycle efficiency)
  - US: 25 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 15 ppm (> 850 MMBtu/h (≈ 249 MWth))
  - (Note: further reduced NOx ppm in the range of 2 to 9 ppm is typically required through air permit)
- Liquid Fuel-fired Combustion Turbine – NOx
  - Guideline limits: 152 (74 ppm) – Heavy Duty Frame Turbines & LFO/HFO, 300 (146 ppm) – Aeroderivatives & HFO, 200 (97 ppm) – Aeroderivatives & LFO
  - EU: 120 (58 ppm), US: 74 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 42 ppm (> 850 MMBtu/h (≈ 249 MWth))
- Liquid Fuel-fired Combustion Turbine – SOx
  - Guideline limits: Use of 1% or less S fuel
  - EU: S content of light fuel oil used in gas turbines below 0.1% / US: S content of about 0.05% (continental area) and 0.4% (non-continental area)

Source: EU (LCP Directive 2001/80/EC October 23 2001), EU (Liquid Fuel Quality Directive 1999/32/EC, 2005/33/EC), US (NSPS for Stationary Combustion Turbines, Final Rule – July 6, 2006)

Following commissioning of T3, it is envisaged that its engineering design lifespan will be 25 – 30 years.

4 Description of Existing Environment

This section consists of a description of the current baseline environmental characteristics for the proposed T3 Thermal Power Plant expansion project. The proposed site will cover approximately 9.0 acres (3.6 ha) of land immediately adjacent to the existing T1/T2 plant (see Figure 3.3), and for purposes of this study it is considered to be an expansion to the existing plant, given the close proximity to the existing plant and the minimal civil work required to commence construction of T3. Therefore, this report will take into account the presence of T1 and T2 and the mitigation measures put in place during their construction and throughout their operational phase.

The description of the main characteristics for each of the environmental topics covered on this section serve not only as a baseline to the anticipated effects of T3, described in section 6, but also as a comparison between the environmental characteristics studied on the previous EIA and SEIS reports for the area and the current conditions.

The proposed T3 Thermal Plant will be located adjacent to the existing Takoradi Thermal Plant (referred to as T1 and T2) , located on the southeast coast of Ghana in the Western Region in the District of Shama Ahanta East, immediately west of the village of Aboadze. The expansion T3 Thermal Plant will be positioned northeast of the existing TTPP. The approximate area encompassed by this environmental study is shown on Figure 4.1.

Figure 4.1 Approximate Area Encompassed by the Study

Access to the T3 will be through the existing site access to TTPP, which can be accessed by two main routes:

- 4km sealed/asphalted road off Accra-Takoradi highway at Inchaban. This road lies to the north of the plant and;
- 9.6km road off Accra-Takoradi highway at Shama Junction. This road passes through Shama, Abuesi and Aboadze and to the plant. The road is made up of a sealed portion of 3km from Shama Junction to Shama, 2.8km dirt/unsealed road from Shama to Abuesi and 3.6km from Abuesi to Aboadze and the plant. The Shama-Aboadze road lies to the east of the plant.

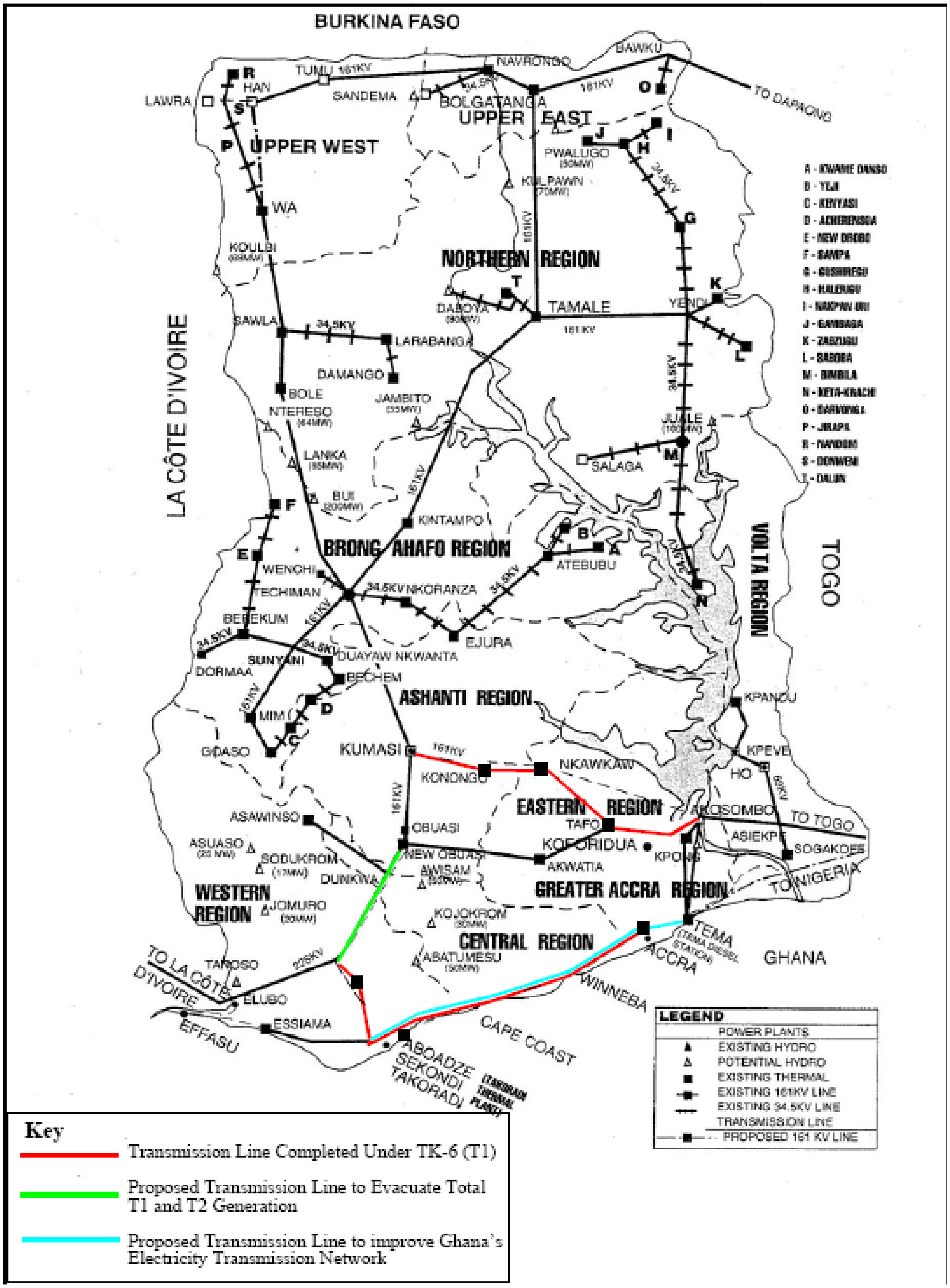
The Inchaban-Aboadze road that provides access to TTPP has been resurfaced to accommodate the increased traffic flows and it passes through a number of villages.

The transmission line from the existing Takoradi Thermal Plant (T1 & T2) runs parallel to, and north of the main Takoradi-Cape Coast Highway at Inchaban this road. The T3 Thermal Plant will evacuate its power output through the existing 161kV transmission line immediately west of the proposed site.

An overview of the topography of transmission lines in the area are shown on Figure 4.2.

The environmental impact resulting from the installation of this transmission line was thoroughly studied on the previous EIA and SEIS. There will be no major structure added to or around the existing transmission lines to accommodate the proposed T3 Thermal Power Plant and therefore no impact on the any environmental aspects is expected.

Figure 4.2 Transmission Line Topography



Sources of information used in the preparation of this section include:

- The 1995 EIA Report;
- The 1999 EIA Addendum (T2 expansion);
- The 2001 EIA Supplemental Addendum (Combined Cycle addition);
- African Environmental Research Consulting Company Ghana Limited (AERC);
- Bush Power Group LLC;
- S&W Energy Solutions;
- SGT Environment Services;
- Site visits by local Ghanaian company and owner's representative;
- Sound Environmental Solutions Inc.
- Hoover & Keith Inc, Acoustics and Noise Control Engineering

4.1 Physical Environment

The approximate area encompassed by the environmental study is shown in Figure 4.1. Certain topics described on this report expand to larger area than others due to the level of environmental concern related to the topic or data availability, however specific maps showing the approximate area of study for each subject will be provided throughout this report.

The proposed T3 Takoradi Thermal Plant will be located on the southwest coast of Ghana in the Western Region in the District of Shama Ahanta East. The proposed site for the plant is approximately 15 km northeast of the city of Sekondi-Takoradi, immediately to the west of the village of Aboadze. The site will cover an area of approximately 9.0 acres (3.6 ha).

The natural features surrounding the plant are diverse. South of the proposed site lies an up-land/higher ground stretching about 100m to the sea and dotted by shrubs and coconut trees. There is also a footpath used, by community members of Abuesi and Aboadze, to access the Anakwari lagoon located to the west of the plant. There is a combination of marshland and relatively higher rounds. The marshland forms part of the catchment Anakwari lagoon. The vegetation types include mangrove (see Figure 4.3) and other shrubs as well as coconut trees.

Figure 4.3 Portion of Anakwari Lagoon with Mangrove Vegetation (West of the Plant)

Other visible feature to the west of the plant is a newly constructed Esipon Stadium located about 4km from the plant. North of the proposed site some of the plant is also characterized by marshland and some higher ground which rises gently towards the VRA township located about 750m from the plant. Other major features include the old project office, the oxidation pond, the Regulatory and Metering (RM) Station for the gas from the West Africa Gas Pipeline and an unsealed road linking the RM station to the main road from Inchaban to the plant. East of the proposed plant lies the sealed/asphalted road which leads to the plant. Just after the road there is a u-shaped storm drain, a contractor's yard which houses scraps from the plant, proposed VRA scrap yard and the beginning of the Aboadze township (See Figure 4.4).

Figure 4.4 VRA's Scrap Yard & Storm Drain

The Western Region, where the T3 site will be located, comprises 17 Assemblies: 1 Metropolitan Assembly, 2 Municipal Assemblies, and 14 District Assemblies. The Shama District Assembly (SDA), which was inaugurated on the 29th February 2008 as one of the three newly created districts in the Western region, was originally part of the former Shama Ahanta East Metropolitan Assembly (SAEMA). The Shama District Assembly (SDA) is bordered to the west by the Sekondi-Takoradi Metropolitan Assembly (STMA), to the east by Komenda-Edina-Equafo-Abirem (KEEA) Municipal Assembly, to the north by Mpohor Wassa East Distric Assembly and to the south by the Gulf of Guinea. Shama, which is the district capital of SDA, is located 15km from Sekondi the regional capital and 280km west of Accra, the national capital. Major towns found in SDA include Shama, Aboadze, Aboesi, Inchaban, and Supomu Dunkwa.

Presently, the site is connected by a 4km asphalted road (north of the plant) off Accra-Takoradi highway at Inchaban or by a 9.6km road off Accra-Takoradi highway at Shama Junction (east of the plant). The transmission line from the existing Takoradi Thermal Plant (T1 & T2) runs parallel to, and north of, the Shama Junction access road. The T3 Thermal Plant will evacuate its power output through the existing transmission line, therefore there will be no expected environmental impact associated with the tie-in to the existing line.

The main landscape and visual effects are associated with the introduction of new man-made features into an otherwise natural attractive coastal environment. However, the adverse effects will largely be cumulative given the presence of T1and T2 and therefore generally slight in significance. Since the installation and expansion of T1 and T2 there have been a number of changes to the baseline landscape and visual character and quality of the area. The following were observed:

- Replacement planting of palm trees along the beach section previously cleared during the construction of the LCO supply pipeline and the seawater intake/discharge pipelines. The palms were generally approximately one foot high and had been planted approximately ten rows deep. Natural regrowth of ground vegetation was also underway and some grass seeding has been undertaken within the vicinity of the plant boundary, on the beach side in particular.
- Some further grass seeding and planting of areas has been undertaken within the vicinity of T1 and T2. Although it was stated in the 1999 SEIS that the majority of the aesthetic planting within the TTPP site (incorporating T3) would not be undertaken until all the construction activities (T1 + T2) have been completed, this has since been brought forward partially to reduce the risk of soil erosion and to achieve a more rapid integration of the plant in to the surrounding area.

In terms of changes to the visual aspects described in 1999 SEIS, the above are reflected accordingly, such that there is a general slight improvement in the baseline conditions, again, associated with the regeneration of vegetation on those areas formerly left exposed by T1 and T2 construction activities.

Changes to the landscape and visual character and quality of the area strictly associated with the ongoing construction of T3 are discussed in Section 6.3.8.

4.1.1 Topography, Geology and Soils

<u>TOPOGRAPHY</u>

Generally, the area has an irregular, hilly surface, rising in elevation from sea level to 50 m inland (Figure 4.5).

Figure 4.5 Area Surrounding T3 Site


The shoreline shows evidence of both deposit and erosion features. Cliffs, rising 5 to 10 m in elevation, are located 2.5 km east of Sekondi, which then recede along the shoreline in an eastwardly direction. A wave cut platform, backed by a sandy beach/ridge, is more typical of the area. There are rocky headlands at Aboadze and Aboesi with sandy bays between. The Pra River is the main watercourse in the area and discharges into the sea through a coastal lagoon just east of Shama. Immediately to the west of the proposed plant site is the Anankwari River and its tributaries which flow through a very low-lying, wet floodplain. Generally this river is isolated from the ocean by a sand bar that builds up across its mouth during the dry season. This river is controlled by a dam at Inchaban. Water is spilled from the reservoir depending upon rainfall amount, but otherwise the flow in the lower reaches results from a few small tributaries downstream of the dam.

At the proposed power plant site, land elevation ranges between 1 and 8-10 m with the higher ground forming a discontinuous ridge on the north side of the site. The freshwater swamp at west of the Aboadze thermal plant occupies a depression between the strand vegetation and the scrub or thicket vegetation. Almost the entire coastline is covered with coconut trees with doted thorny scrubs towards the west. The coastline is experiencing erosion and this has created a sand cliff along the coconut plantation occasionally uprooting the coconut trees (Figure 4.6).

Topographic maps of Ghana and Aboadze in addition to satellite imagery of Aboadze area are given on Figure 4.7, Figure 4.8, and Figure 4.9 respectively.

Figure 4.6 Coastline Erosion at Aboadze

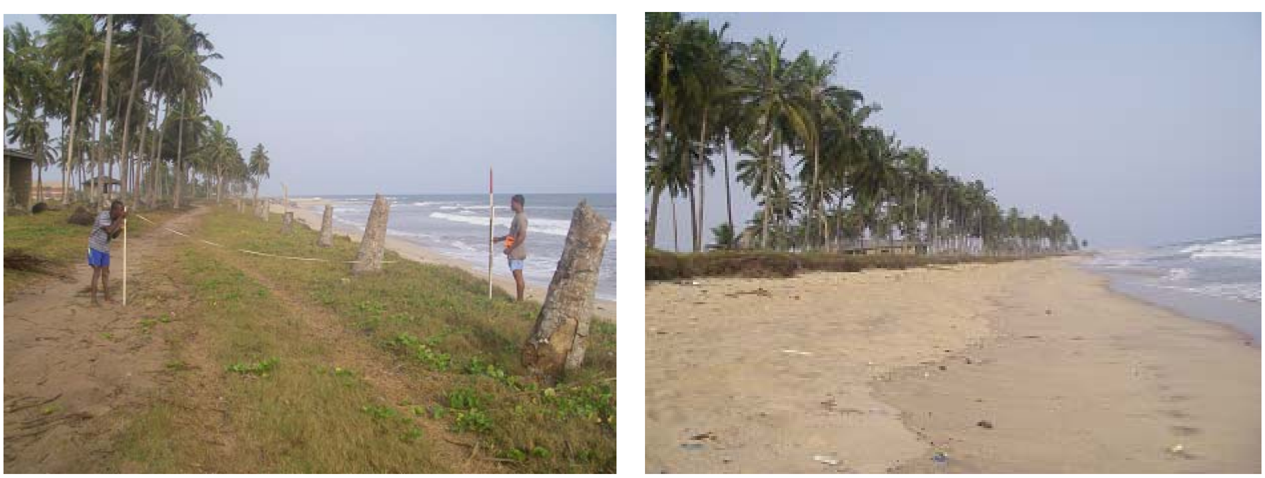
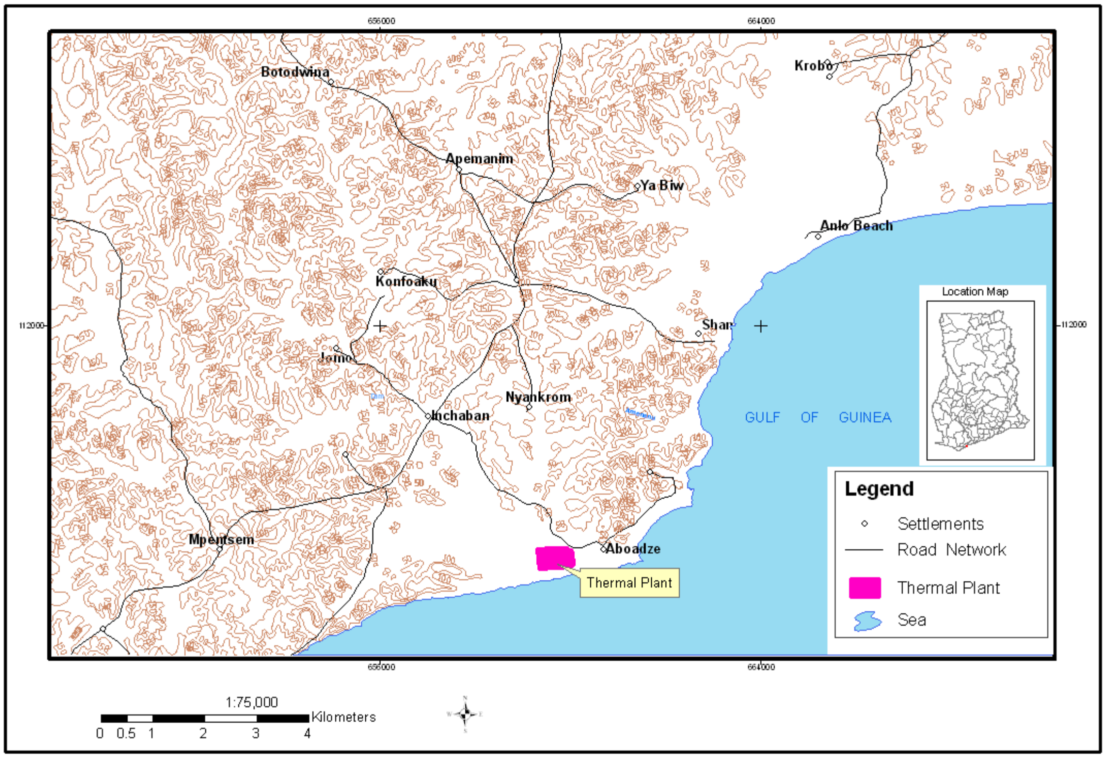


Figure 4.7 Topographic Map of Ghana

Figure 4.8 Topographic Map of Aboadze Area

TOPOGRAPHIC MAP OF ABOADZE THERMAL PLANT AREA



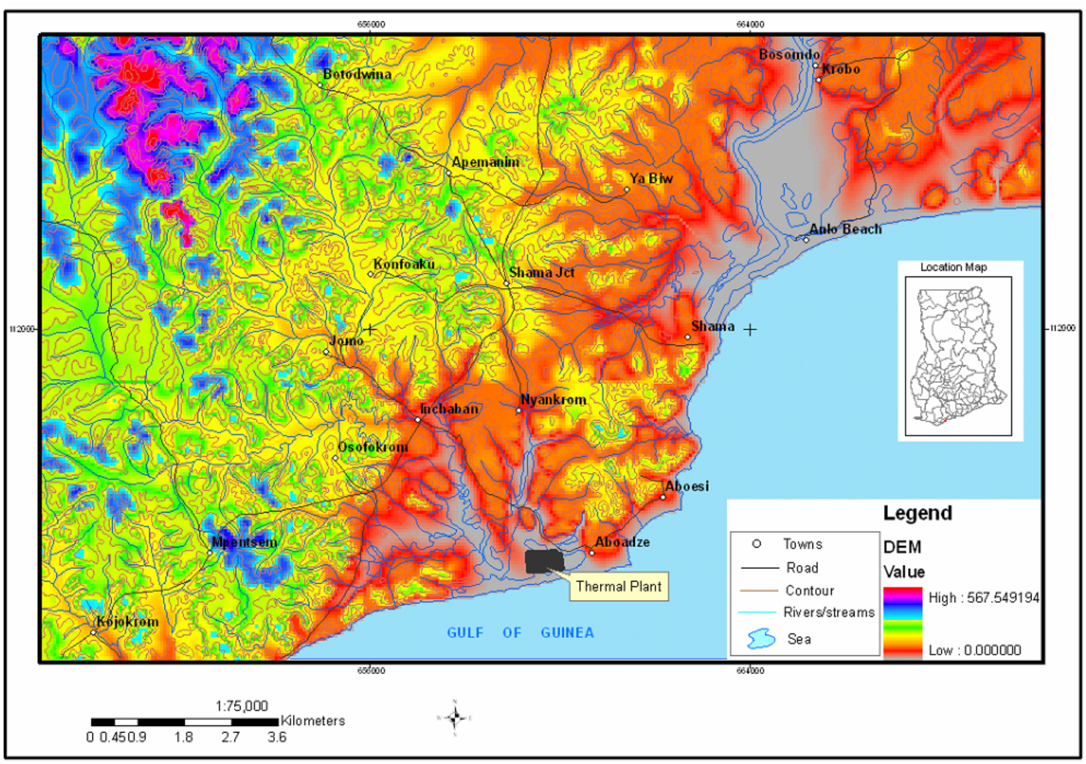
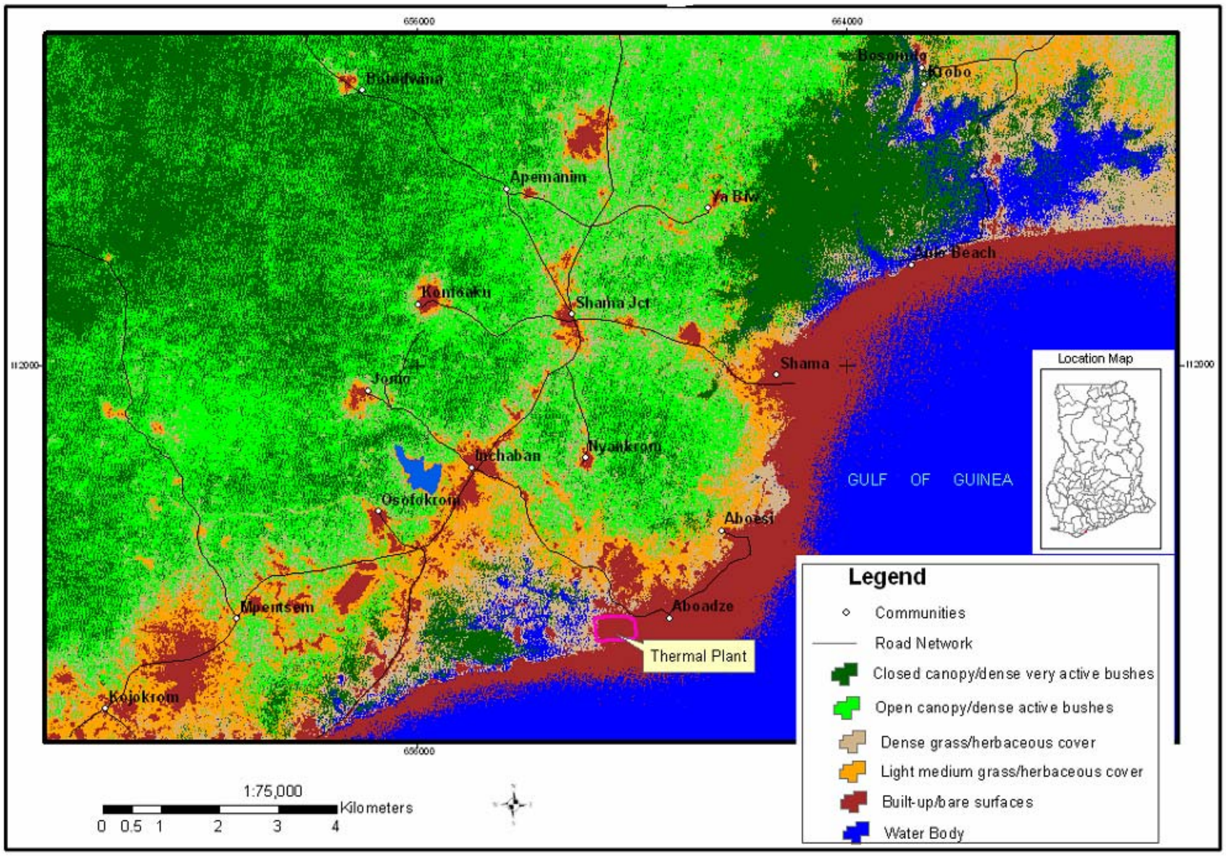


Figure 4.9 Satellite Imagery of Aboadze Area



In the southwest quadrant of the site, the beach ridge links with a northward extending knoll also at 5 to 6 m elevation which divides the central depression from the low-lying areas to the west. Two areas on the western boundary of the site, at 1 m elevation, have free-standing water, during the dry season, the extent of which is greater during the wet season. Seasonal flooding also extends into the lower ground in the north-central section of the site adjacent to the road.

Given the largely flat topography of the general surrounding area, its overall aesthetic quality and that T1 and T2 currently comprises numerous large scale buildings and high features compared to the smaller scale T3 Thermal Plant the existing visual impact of T3 can be described as adverse.

Therefore, the addition of a smaller scale plant on such close proximity to the existing plant is expected to pose minimal disturbance to the existing visual quality of the area, which is considered to be poor according to the previous studies for the area and recent visits to the proposed site.

However this study will evaluate any possible impact that may result during the construction phase of the project and consequently any mitigation measures to minimize them.

GEOLOGY AND SOILS

The coastal geological formations of Ghana were likely determined by continental drift during the Cretaceous period (about 135 million years ago), when Africa broke away from South America. The geological composition consists of hard granites, granodiorites, metamorphosed lava, and pyroclastic rock. Some coastal areas are covered by Ordovician, Silurian, and Devonian sandstone and shale.

Seismic studies have indicated that Ghana's seismicity is associated with active faulting, particularly near the intersection of the east-west trending Coastal Boundary Fault and the northeast to southeast Akwapim Fault Zone. It has been reported that the first major seismic activity in Ghana occurred in Elmina (Central Region) in 1615. Thereafter, subsequent events took place in 1636, 1862, 1906, 1939, and 1997. In 1997 alone, three events were recorded in January, February, and March with magnitudes of 3.8, 4.1, and 4.8, on the Richter scale respectively.

The underlying bedrock in the study area is of Precambrian to Carboniferous age, the basement rocks consist primarily of gneiss, granites and schist. Throughout most of the region, these rock types are overlain by sediments of the Sekondi Series which are believed to be of Devonian or Carboniferous age. They consist mainly of sandstones and shale; with occasional conglomerate strata. Overburden in the region consists of weathered bedrock that can reach thicknesses of 20 m. Southern Ghana is not a highly active seismic area; however, it is a region capable of producing significant earthquakes. The area 100 - 200 km east and southeast of the site is periodically seismically active. A series of fault lines have been mapped through the general region according to the 1995 EIA Report.

Sedimentary rock of the Ajua Shale and Elmina Sandstone units of the Sekondi Series underlie the project site. The Ajua Shale’s are present in an east-west depression across the north end or the site, but there are no surface outcrops. Outcrops of Elmina sandstone occur east of the site in Aboadze along the shoreline on the outer edge of the site, and along the basal ridge near the northern contact with the Ajua Shale. Surface outcrops along the tidal zone of the shoreline consist of fresh to slightly weathered sound rock; whereas, outcrops exposed further inland usually have a completely weathered mantle of 0.5 to 1 m overlying sound bedrock. The rock weathers to a brown, hard sand, and clay to clayey, sand.

The major soils of the area are forest and coastal savanna ochrosols. Forest ochrosols are developed in forest and savanna environment under rainfall between 900 mm and 1650 mm. The organic matter content of such soils is low, with pH generally less than 5.5. Coastal savanna ochrosols are mainly red and brown, moderately well drained medium to light-texture soils developed over Voltaian sandstone, granite, phyllites and schists. They are also generally low in organic matter due to insufficient accumulation of biomass (less than 2% in the topsoil).

Soil reaction ranges from near neutral, pH 6.0 - 7.0 near the surface, becoming slightly basic to moderately acid with depth. The soils within the wetland indicated total organic carbon (TOC) levels range of 0.3-1.1 and 0.059-0.769 % for the dry and wet periods respectively. Total organic matter (TOM) levels ranged from 1.0 to 1.8 %. The wetland areas recorded total hydrocarbon (THC) values ranging from 0.6µg/g to 1.1µg/g.

Iron in the soil ranged from 1299 µg/g to 2081µg/g. Other metal such as mercury ranged from 1.04µg/g to 1.55µg/g, while cadmium and lead concentration ranged from 0.4µg/g to 3.04µg/g. The concentrations of the remaining elements (e.g., zinc, copper, etc) were within the range of about 2µg/g to 20µg/g.

Tests for PAHs in the soil showed that phenanthrene levels ranged from 0.045µg/g to 0.262µg/g. There were differences in PAH content of topsoil layers compared to deeper soils (lower at deeper soils).

Microbes isolated and identified in the soil samples included levels of total coliform bacteria, thermotolerant coliform bacteria, *Pseudomonas* spp., *Clostridium* spp., Sulphate-reducing *Desulphovibrio* spp., hydrocarbon oxidizing bacteria, hydrocarbon degrading bacteria, and total heterotrophic bacteria, as well as the fungi moulds and yeasts. The levels of microbes isolated in the soil samples are presented in Table 4.1. The results showed high counts of total coliform bacteria in the different samples. High levels of coliform bacteria were recorded raging from 14 x 10^3 to 15 x 10^5 cfu/100g. Total coliform bacteria are normal flora of soil and their presence may not necessary indicate contamination. Faecal coliform bacteria count which is an indication of possible contamination of the soil with faecal matter ranged from < 1 to 110 cfu/100g, with the composite sample (15-50 cm) recording the highest count.

The total heterotrophic bacteria count was high in the samples, which ranged from 560 to 800 cfu/100g. These included the various coliform bacteria, the *Clostridia*, the *Pseudomonas*, and the hydrocarbon bacteria. The levels of sulphate-reducing bacteria in the different soil samples from the sampling areas were very low. This is because the activity of sulphate-reducing bacteria is particularly apparent in mud at bottom of ponds and streams and along seashores.

Hydrocarbon oxidizing bacteria and hydrocarbon degrading bacteria together with the total coliform bacteria formed the largest group of bacteria present. Values for hydrocarbon oxidizers in the various samples ranged from 18 to126 cfu/g. The hydrocarbon decomposers isolated ranged from 44 to110 cfu/g. The presence of hydrocarbon decomposing bacteria in a sample is an indication of presence of high oil content possibly from the thermal plant. The levels of hydrocarbon oxidizing bacteria ranged from 18 to126 cfu/g. Concentrations of *Clostridium* spp. recorded were very high for all the soil samples, reported values ranging from 400 to 960 cfu/g. Naturally soil samples harbor higher levels of clostridia.

There were high levels of mould but very low levels of yeasts in the soil samples. Values of mould ranged from 70 to 640 cfu/g. Moulds in soil assist with decomposition of organic compounds with some acting as pathogens.

Table 4.1 Soil Sample Analysis

Microbial parameter	A-Composite (0-15 cm)	A-Composite (15-50 cm)	B-Composite (0-15 cm)	B-Composite (15-50 cm)
Total coliform (g^{-2})	14620	154000	154000	150000
Fecal coliform (g^{-2})	< 1	110	< 1	< 1
Total heterotrophic	680	560	720	800
Bacteria (g^{-1})				
Pseudomonas spp. (g^{-1})	9	24	18	154
Clostridium spp. (g^{-1})	960	520	800	400
Desulphovibrio spp. (g^{-1})	< 1	< 1	< 1	< 1
Hydrocarbon oxidizers (g^{-1})	126	27	18	115
Hydrocarbon degraders (g^{-1})	80	44	90	110
Moulds (g^{-1})	640	440	480	70
Yeasts (g^{-1})	50	14	8	4

The soil assessment was based on a 60 m transects of which three sampling points were located at 10 m intervals. Within each habitat type, soil samples were taken from the depth of 0-15 cm and 15-50 cm at each of the sampling points. These were pulled together as composite samples.

A general geology and soil map for Ghana are shown on Figure 4.10 and Figure 4.11, respectively.

Figure 4.10 Ghana Geology Map

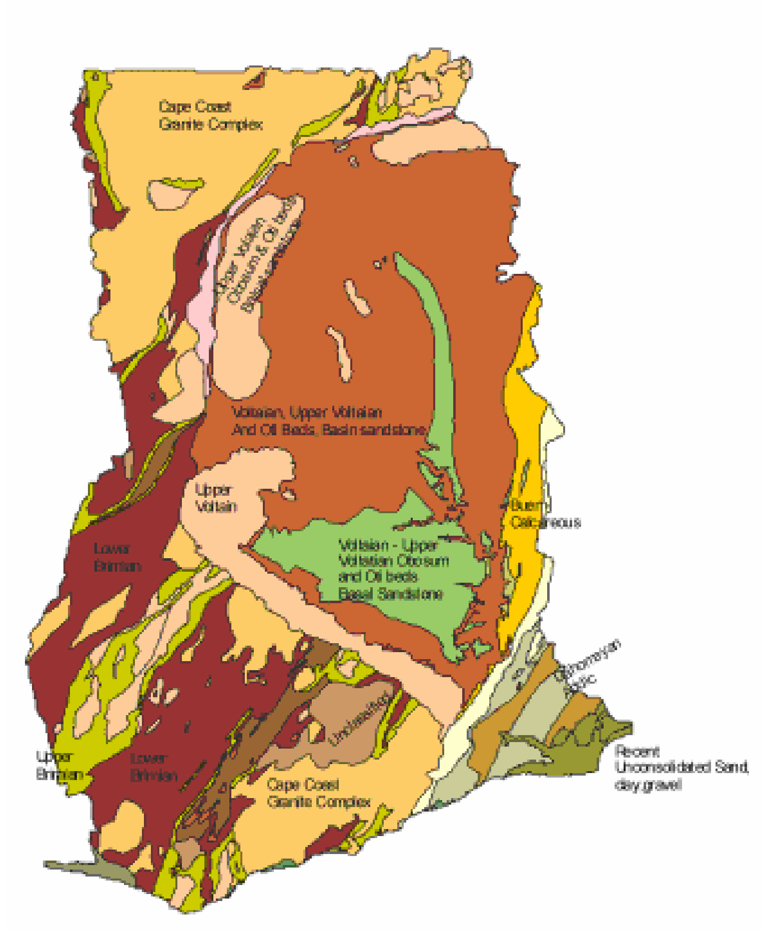
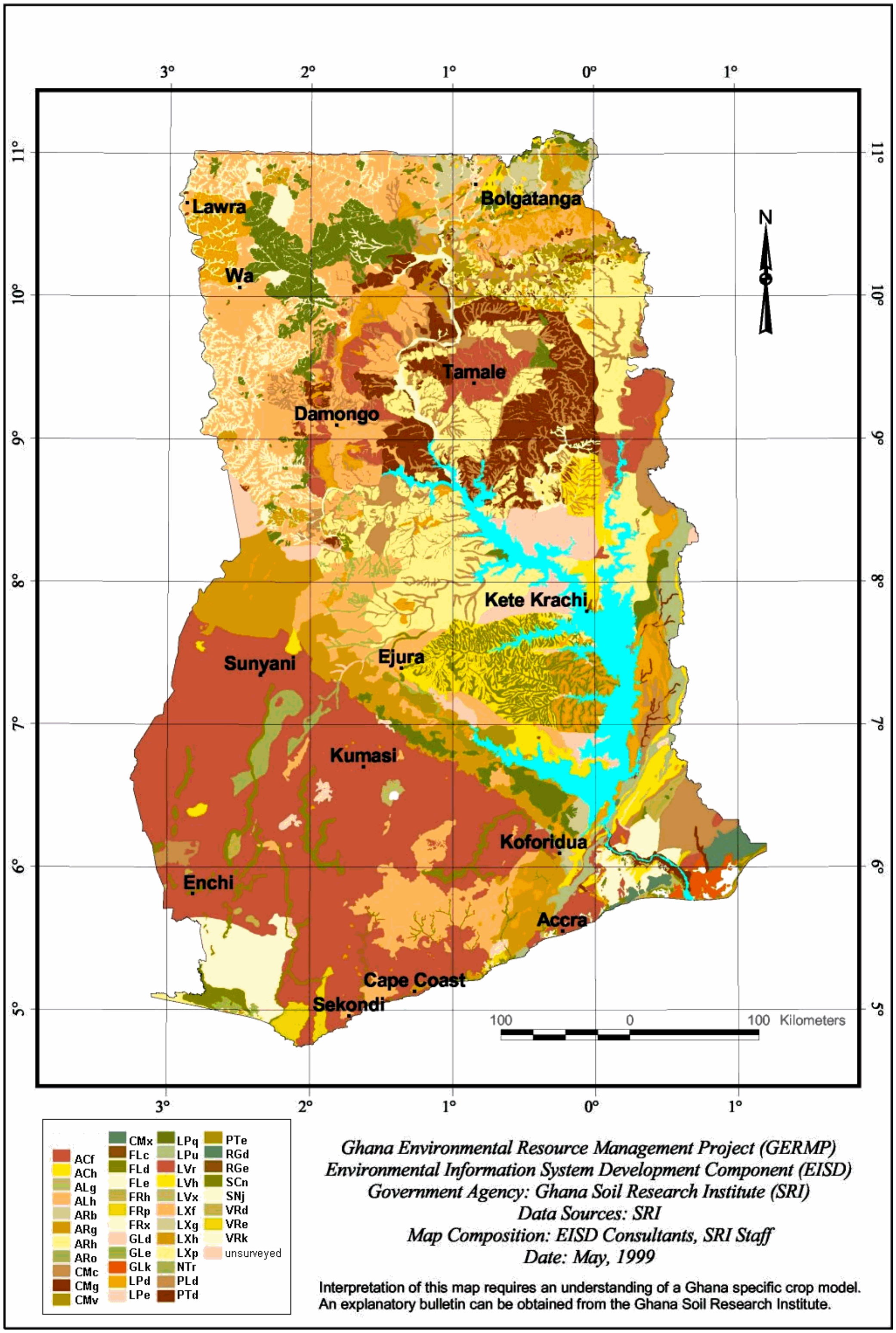


Figure 4.11 Ghana Soil Map



4.1.2 Climate and Air Quality

CLIMATE

This section describes both historical and current climatic data for an area of approximately 10km surrounding the T3 Thermal Plant, shown on Figure 4.1.

A summary of the climatic data for Takoradi, the nearest climate station, for the years 2000 to 2008 are provided on Table 4.2 below, and hourly data from the Takoradi Weather Station is given on Table 4.3.

Table 4.2 Climatic Data (2000-2008)

Takoradi Monthly Rainfall Total (mm)												
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	27.2	0.0	68.0	145.1	195.1	296.3	24.7	34.1	33.3	42.1	30.2	152.2
2001	tr	40.0	21.6	174.9	271.9	206.4	190.0	19.9	11.9	106.5	50.4	3.0
2002	13.7	35.8	17.3	181.9	181.5	307.6	247.6	67.4	5.2	88.8	67.2	6.8
2003	37.3	40.0	76.1	192.2	182.2	79.2	6.5	18.6	11.3	234.8	30.1	9.6
2004	59.3	77.2	96.2	14.0	189.4	132.3	98.9	15.2	135.8	251.2	24.5	13.2
2005	2.3	55.4	136.7	50.4	269.7	103.0	3.3	4.8	37.0	190.9	41.3	26.2
2006	4.3	6.8	11.2	22.6	360.4	228.4	132.2	30.9	23.9	85.4	22.8	4.6
2007	0.2	7.9	83.2	102.9	125.0	197.2	255.0	60.7	161.9	210.6	33.1	11.9
2008	28.7	1.6	41.9	104.0	220.1	352.0	107.7	103.8	54.8	58.6	102.9	52.3
Mean Daily Maximum Temperature (°C)												
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	30.5	31.7	31.7	31.1	31.1	29.0	27.9	27.3	27.9	29.7	31.2	30.7
2001	30.5	31.7	31.7	31.5	30.8	29.2	27.8	27.0	27.6	29.9	31.0	31.2
2002	31.4	32.1	31.7	31.6	31.5	29.2	27.6	27.4	28.2	29.7	31.1	31.7
2003	31.2	31.9	32.4	31.5	31.1	29.4	29.0	27.9	28.7	30.0	31.5	31.7
2004	31.2	31.8	32.3	31.4	30.6	28.5	27.7	27.2	28.5	29.8	31.0	31.2
2005	31.4	31.8	31.9	32.1	30.5	28.8	27.8	27.3	28.6	30.1	31.3	31.7
2006	31.2	31.9	32.0	32.7	30.7	29.9	28.5	27.8	28.6	29.8	31.1	31.6
2007	31.6	31.8	31.8	31.7	31.3	29.3	28.5	28.2	28.3	29.7	30.9	31.5
2008	31.3	32.1	32.1	31.8	31.4	30.1	29.3	28.6	29.0	30.5	31.2	31.8
Mean Daily Minimum Temperature (°C)												
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	23.4	23.3	24.8	24.0	23.7	23.4	21.9	21.9	22.4	22.9	23.6	23.5
2001	23.2	23.9	24.0	23.9	24.3	23.4	22.9	22.1	22.4	23.5	23.9	24.1
2002	23.5	24.4	24.8	24.6	24.6	23.5	23.2	22.1	22.6	23.5	23.5	22.7
2003	23.7	24.5	24.7	24.3	24.4	23.5	22.5	22.3	23.5	24.0	23.9	23.8
2004	24.0	24.5	24.8	25.0	24.3	23.4	22.6	22.5	23.4	23.7	24.1	24.3
2005	22.3	25.1	24.9	25.5	24.4	24.3	22.7	22.0	23.4	23.7	24.2	23.9
2006	24.2	24.7	24.3	25.3	24.1	23.5	23.4	22.9	23.2	22.6	23.9	23.8
2007	22.4	24.7	24.9	24.7	24.6	23.9	23.1	22.6	23.0	22.9	23.4	23.7
2008	21.1	24.3	24.3	24.5	24.1	23.8	23.3	22.6	23.1	23.8	24.0	24.0

Table 4.2 Climatic Data (2000-2008) – cont.

Mean Daily Relative Humidity (%) at 0600 hours

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	96	94	93	95	95	96	96	96	96	96	95	95
2001	97	94	94	94	95	96	95	96	96	95	94	96
2002	95	94	95	94	95	95	97	97	96	96	96	96
2003	96	97	95	96	96	96	96	97	95	96	95	95
2004	96	94	90	95	95	96	97	96	97	96	96	96
2005	94	95	94	95	96	94	96	96	96	96	95	96
2006	97	97	95	93	95	99	96	96	97	96	96	96
2007	92	95	94	95	95	96	95	97	99	96	96	96
2008	93	94	95	95	95	95	94	97	97	96	96	96

Mean Daily Relative Humidity (%) at 1500 hours

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	75	66	72	76	77	82	81	83	82	79	73	74
2001	76	71	74	74	77	81	83	84	82	75	75	76
2002	69	72	74	75	75	80	87	83	81	78	74	71
2003	74	75	75	76	76	81	76	80	81	78	73	72
2004	75	71	70	77	76	83	83	84	83	79	76	75
2005	66	76	75	76	80	82	82	81	81	76	74	74
2006	78	74	72	70	78	80	82	82	83	82	75	76
2007	60	75	75	77	76	82	82	82	85	80	76	73
2008	69	74	73	75	77	78	79	81	82	77	76	75

Mean Daily Wind Direction

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	SW	SW	SW	SW	S	SW	SW	SW	SW	SW	SW	SW
2001	SW	SW	SW	SW	S	SW	SW	SW	SW	SW	SW	SW
2002	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2003	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2004	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2005	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2006	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2007	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2008	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW

Table 4.2 Climatic Data (2000-2008) – cont.

Mean Daily Wind Speed (knots)												
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	2.5	3.2	3.5	3.2	3.1	2.9	3.1	3.7	4.5	2.9	4.3	2.3
2001	2.5	3.2	4.3	3.7	3.0	3.3	2.5	4.5	5.3	5.1	3.3	2.8
2002	2.3	4.7	4.6	4.0	3.9	3.7	3.4	4.5	5.3	5.1	3.3	2.8
2003	3.3	4.4	3.7	4.9	3.8	3.1	4.8	5.1	5.9	3.8	3.5	2.9
2004	2.3	3.6	4.0	3.7	4.3	3.9	3.3	4.7	5.1	4.8	3.5	3.8
2005	3.9	4.3	4.4	4.6	3.1	4.8	4.2	4.6	4.1	4.4	2.8	2.5
2006	3.2	4.7	4.4	4.6	3.3	3.5	3.9	4.5	4.4	4.0	2.5	2.5
2007	2.0	4.2	4.2	4.1	3.1	2.5	4.0	4.0	3.8	4.1	2.3	2.1
2008	1.8	3.3	3.7	3.4	3.0	3.3	3.6	4.1	3.8	4.1	2.9	2.8

Mean Daily Duration of Bright Sunshine (hours)												
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	6.3	7.3	6.1	7.4	6.7	4.9	6.6	4.4	4.8	7.4	8.9	6.5
2001	6.6	6.7	6.8	6.9	5.8	4.8	4.8	2.8	5.1	7.7	7.9	8.1
2002	4.5	6.6	6.8	6.8	7.4	3.5	3.1	4.1	5.3	7.1	8.2	7.4
2003	6.1	7.6	6.8	6.9	7.2	4.9	6.7	4.6	5.1	7.3	7.8	6.8
2004	6.0	6.1	6.6	6.4	7.0	3.6	5.4	3.7	5.3	6.4	8.7	7.7
2005	4.9	6.8	6.7	7.3	6.4	4.6	4.6	4.5	4.9	7.2	7.6	7.7
2006	6.8	7.2	6.9	6.6	5.5	5.5	4.9	5.1	4.0	6.3	7.3	7.3
2007	4.0	7.0	6.4	7.8	6.5	3.7	5.8	5.2	4.3	5.9	7.9	7.3
2008	6.7	6.0	7.0	6.3	5.9	5.3	5.5	6.2	5.0	7.9	7.1	7.6

Source: AERC Limited

Table 4.3 Takoradi Hourly Weather Summary (1973-1994)

```
------------------INTERNATIONAL STATION METEOROLOGICAL CLIMATE SUMMARY-------------------

 :STA 654670 | DGTK | TAKORADI AFB , ,GH-Telecom Summary
:LAT 04 53N :LONG 001 46W :ELEV 30(ft) 9(m) :TYPE NAVY SMOS V3 28051996
42 - Foreign STATION CLIMATIC SUMMARY (Derived from Hourly Data)

POR: (HOURLY): 1973-1994

     TEMPERATURE  (DEG F)|REL HUM|VAP|DEW| PR |WIND  (KTS)  |TOT|      MEAN NO. OF DAYS WITH (&)
        MEANS    |EXTREME|PERCENT|PR |PT.| ALT|             |SKY|  TEMP (DEG F) |        PRECIPITATION            |      OBSTR TO VISION  |
       |   |   |   |   | (LST) |IN.|(F)| FT.|PREVAIL|MAX|CVR|MAX|MAX|MIN|MIN|    |FRZ |    |HAIL|    |TH |FOG|SMOK|BLOW|DUST| OBS|
     MAX|MIN|AVG|MAX|MIN|   |   |HG.|   |  $ |DIR|SPD|SPD| + | >=| >=| <=| <=|R/DZ|R/DZ|SNOW|/SLT|PRCP|STM| * |HAZE|SNOW|SAND| VIS|
                        | 06| 15|                           | 95| 85| 75| 65|

 JAN  83  77  80  99  62  95  73 .85  74   30   S   5  21 SCT   #  16  15   1    1    0    0    0    1   3  17    9    0    #   22
 FEB  84  79  82 102  70  96  74 .92  77   25  SW   7  46 BRK   #  16   8   0    1    0    0    0    1   4  10    3    0    0   12
 MAR  85  79  83 102  64  96  72 .92  77   25  SW   8  64 BRK   #  20   9   #    2    0    0    0    2   7   7    2    0    1    9
 APR  85  79  82 102  71  95  76 .92  77   25  SW   7  40 BRK   #  18   9   0    3    0    0    0    3  11   4    #    0    #    4
 MAY  84  78  81 100  68  95  79 .91  76   25   S   5  32 BRK   #  15  11   0    6    0    0    #    6  11   1    #    0    #    2
 JUN  81  77  79 102  68  95  83 .88  75   15   S   5  66 BRK   #   5  12   0   10    0    0    0   10   8   2    0    0    1    3
 JUL  79  75  77 100  64  96  83 .83  73   15  SW   6  45 BRK   #   1  20   #    7    0    0    #    7   1   7    #    0    #    7
 AUG  78  74  77  92  66  96  84 .81  73   15  SW   6  65 BRK   0   #  23   0    8    0    0    #    8   #   7    #    0    #    7
 SEP  79  75  77  98  69  96  84 .84  74   15  SW   7  33 BRK   #   1  20   0    9    0    0    0    9   2   4    #    0    #    5
 OCT  81  77  79 100  68  96  80 .86  74   20  SW   8  60 BRK   #   6  17   0    7    0    0    0    7   7   3    0    0    #    3
 NOV  84  78  81 103  70  96  75 .89  76   25   S   6  60 BRK   #  16  16   0    2    0    0    0    2   7   8    1    0    #    9
 DEC  83  77  80 100  59  96  74 .88  75   25   S   5  16 BRK   #  15  14   #    1    0    0    0    1   4  16    6    0    #   18
 ANN  82  77  80 103  59  96  79 .87  75   25  SW   6  66 BRK   3 128 174   1   57    0    0    #   57  65  86   21    0    2  101
 POR  14  14  14  14  14   7   4   4   4    4   4   4  22   1  14  14  14  14   11   11   11   11   11  11  11   11   11   11   11

T = TRACE AMOUNTS ( < .05  < .5 INCHES
# = MEAN NO. DAYS < .5 DAYS
$ = PRESSURE ALTITUDE IN TENS OF FEET (I.E.  50 = 500 FEET)
@ = NAVY STATIONS REPORT HAIL AS SNOWFALL; ALSO NWS FROM JULY,1948-DEC.,1955
+ = THE PREDOMINANT SKY CONDITION
* = VISIBILITY IS NOT CONSIDERED
& = ANN TOTALS MAY NOT EQUAL SUM OF MONTHLY VALUES DUE TO ROUNDING
^ = 24 HR MAX PRECIP AND SNOWFALL ARE DAILY TOTALS (MID-NIGHT TO MID-NIGHT)
I = EXCESSIVE MISSING DATA - VALUE NOT COMPUTED
" = INCHES

---------------------------FEDERAL CLIMATE COMPLEX ASHEVILLE---------------------------
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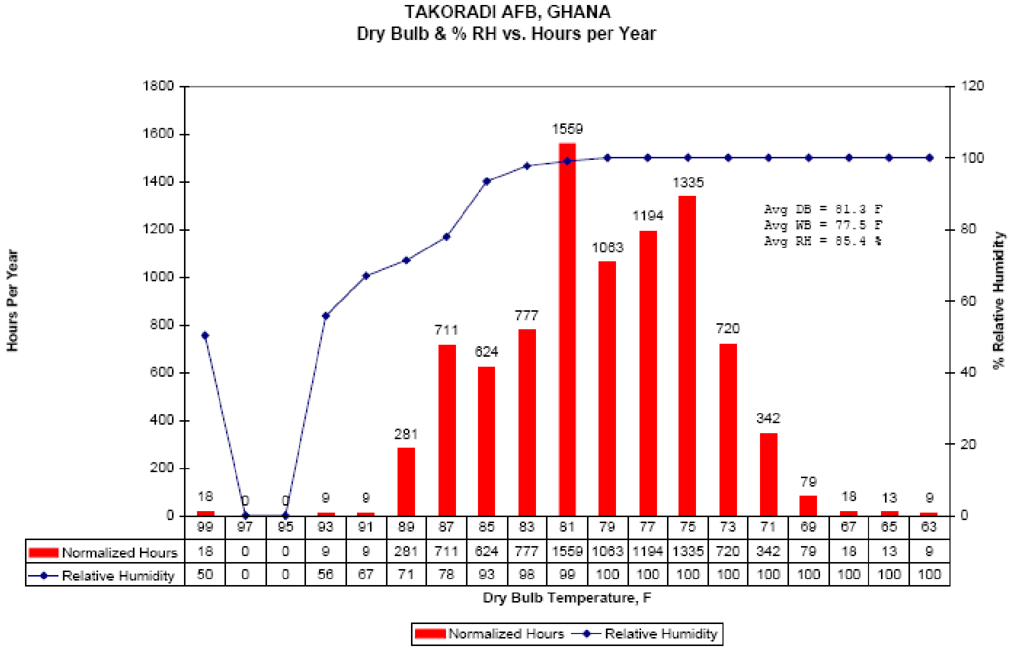
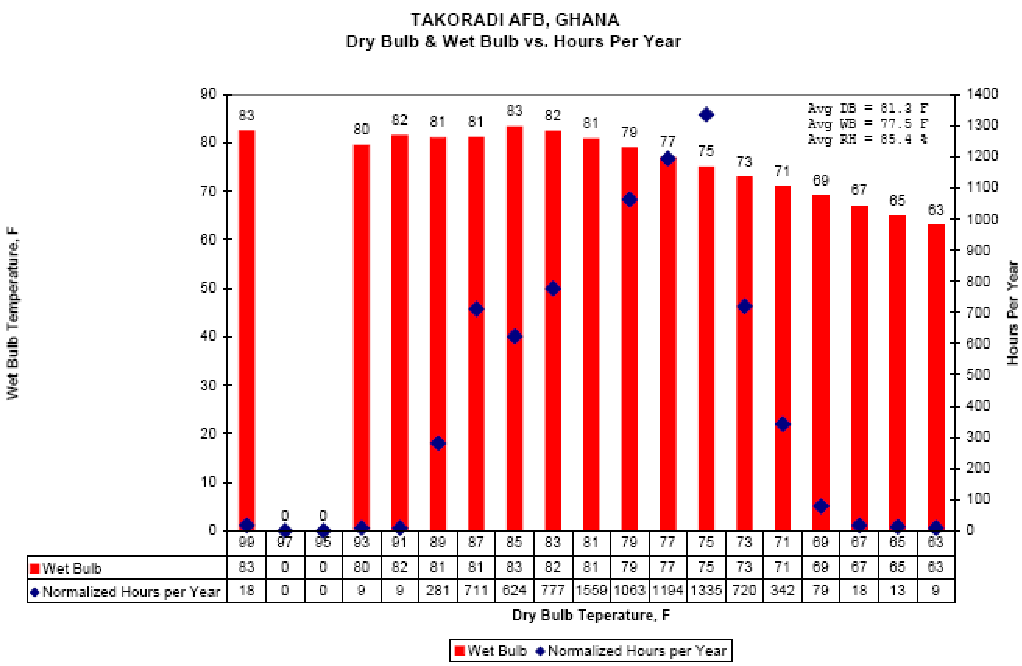
Source: Bush Power Group LLC

Meteorological conditions at Takoradi are characterized by stable temperatures. Overall, there is very little temperature variation throughout the year, with mean daily maxima averaging 27°C from July through September and reaching 30°C to 31°C, between November and April. Mean daily minimum temperatures vary only between 21°C to 23°C. Average relative humidity shows a consistent daily variation, reaching 95% overnight and decreasing to 70% to 80% during the day.

Figure 4.12 below shows Takoradi weather profile for the years of 1973-1994.

Figure 4.12 Takoradi Weather Profile (1973-1994)





Source: Bush Power Group LLC

Average annual precipitation at Takoradi is approximately 1200 mm, with May and June being the wettest months, when over 250 mm of rain falls each month. Rainfall statistics for the years 1950-1991 are shown below on Table 4.4 and a map showing mean annual rainfall for the country is given on Figure 4.14.

Table 4.4 Annual Rainfall (1950-1991)

ANNUAL RAINFALL		
	1st Period (1950-1970)	2nd Period (1971-1991)
Mean (mm)	1394.0	1106.9
Max (mm)	2033.5	1656.2
Min (mm)	815.1	470.8
Climatic Variability (CV)	20%	30%

Winds are relatively light but steady throughout the year, and show a diurnal variation related to the land/sea breeze effect, superimposed on the prevailing southwest monsoon. Average monthly wind speeds rarely exceed 4.5 knots (2.3 m/s), resulting in a very stable air regime. Research and current available data indicate that there is no recorded occurrence of cyclones.The maximum instantaneous wind speed recorded between 1961 and 1993 is 49 knots (25.2 m/s). Figure 4.13 below provides wind rose and speed data for Takoradi for the years of 1973-1994.

Figure 4.13 Takoradi Wind Rose and Speed (1973-1994)

Direction	Mean Speed Knots	Per Cent
N	3.1	1.3
NNE	12.9	0.4
NE	4.2	0.3
ENE	4.9	0.1
E	4.7	1
ESE	6	0.5
SE	4.3	1.2
SSE	4.8	2.5
S	5.6	14
SSW	6.5	12.7
SW	6.6	17.7
WSW	6	5.3
W	4.1	3.9
WNW	4.1	1.3
NW	3.1	1.7
NNW	3.1	0.9

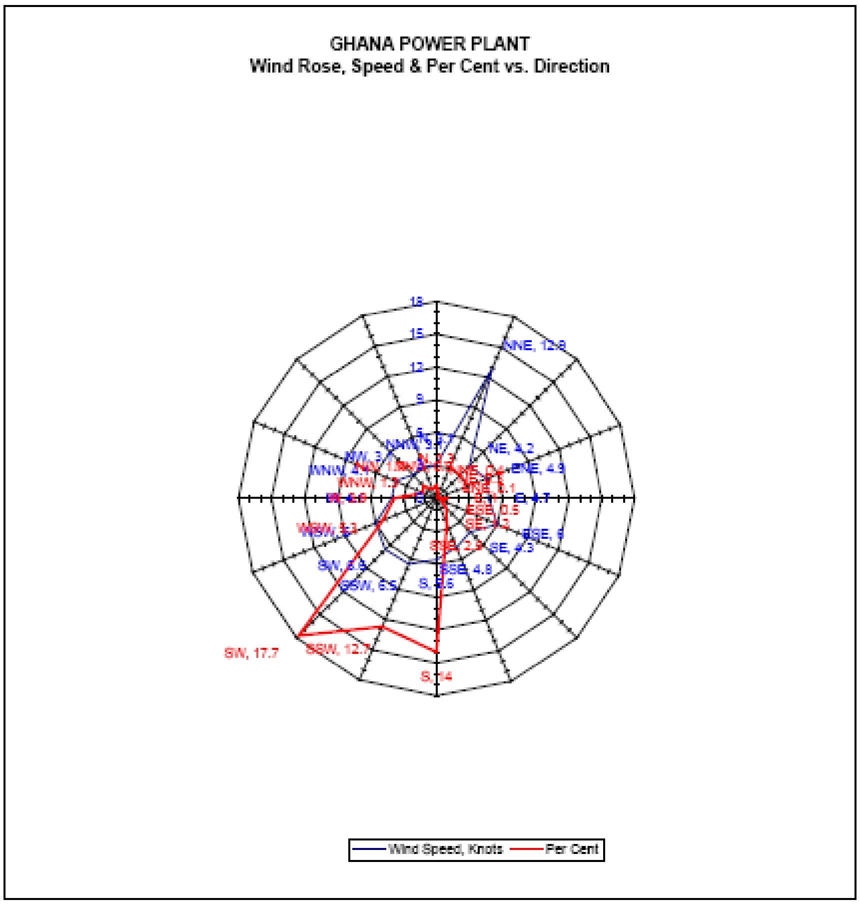
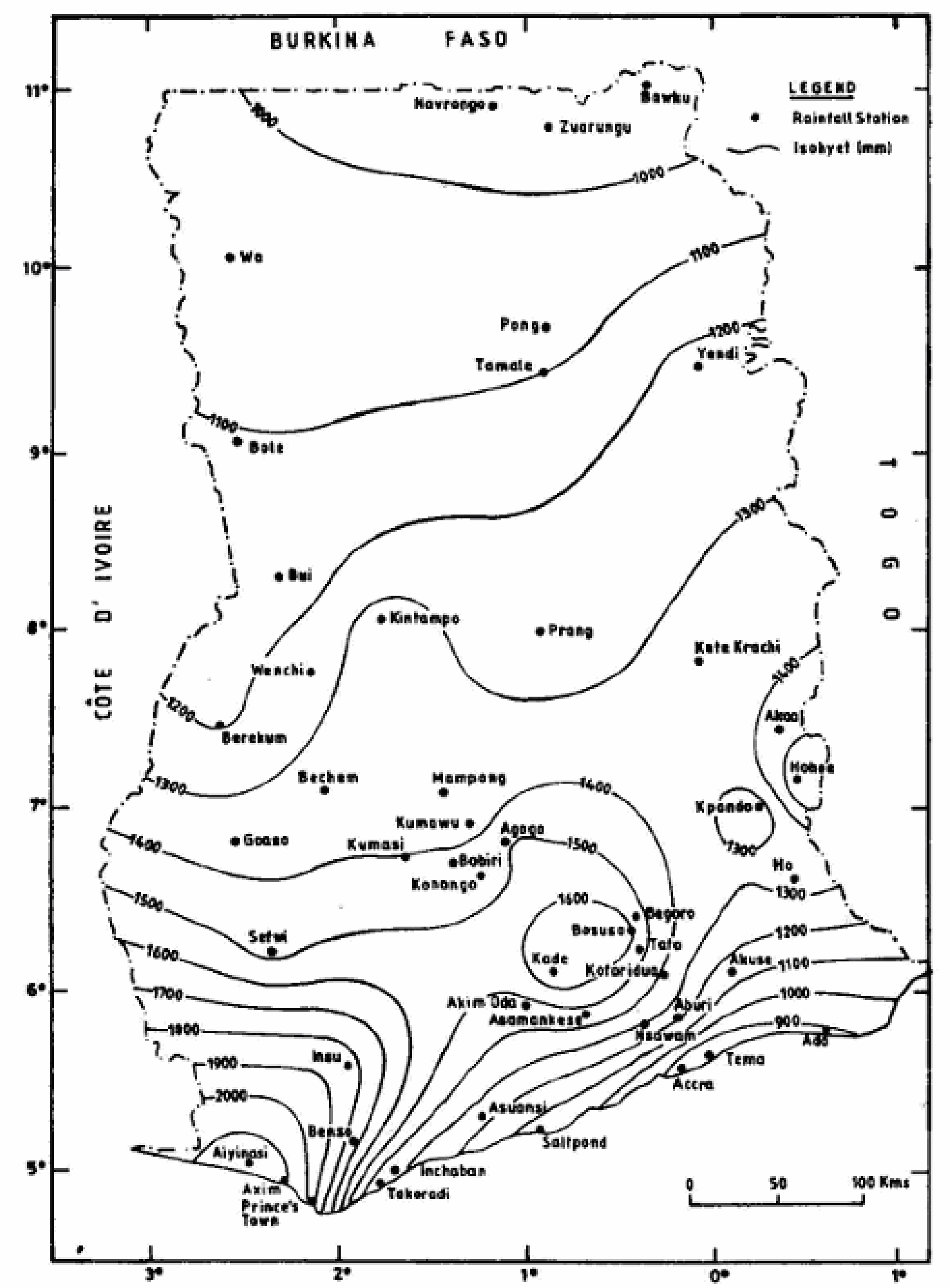


Figure 4.14 Mean Annual Rainfall



The 1995 EIA study also determined that 89% of the particulate matter was respirable. Their survey indicated that the major contributors to particulate matter in the Aboadze area were wood smoke from fish smoking operations, and salt spray from the surf zone.

The air quality near the proposed site is considered to be much lower than other parts of the country, considering the area for the proposed site is not highly industrialized.

Based on the recommendations of the 1995 EIA Report, three air quality monitoring stations were established to monitor air quality (SO_2 and NOx) and to assess compliance with air quality criteria. These monitoring stations are on the western boundary of the power plant site (regarded as a background site), at Aboadze village and in Beposo village, where the highest predicted pollutant concentrations occurred.

Available data from the 1998 AER indicates that all 24 hour average concentrations for SO2 and NOx fall within the maximum allowable limits.

Current Ghana EPA and World Bank standards and guidelines for air quality are given on Table 4.5 below. These parameters are used throughout the report, particularly on “Appendix C: Emissions and Air Dispersion Modeling”, as the basis for defining the significance of the measured and predicted air quality associated with T3.

Table 4.5 Air Quality Standards and Guidelines

	Ghana EPA		World Bank	
Pollutant	**Averaging Time**	**Time Weighted Average**	**Averaging Time**	**Time Weighted Average**
Sulphur Dioxide (SO_2)	24hrs	150 µg/m³	24hrs	150 µg/m³
	1yr	80 µg/m³	1yr	80 µg/m³
Oxides of Nitrogen (NO_x)	24hrs	150 µg/m³	24hrs	150 µg/m³
	1yr	-	1yr	100 µg/m³
Particulate Matter (PM_{10})	24hrs	70 µg/m³	24hrs	150 µg/m³
	1yr	-	1yr	50 µg/m³

Routine stack emissions and ground level air quality monitoring for T1 for the years 2001 to 2003 (Table 4.6) indicates the following:

- NO_x stack emissions have largely remained within acceptable criteria, with the exception of conditions where the NO_x control systems were temporarily offline;
- SO_2 stack emissions were within the relevant acceptable criteria;
- Where available, ground level PM_{10} and SO_2 concentrations monitoring data indicated that concentrations were well within the relevant acceptable criteria.

Table 4.6 Takoradi Thermal Power Plant (T1) Emissions Compliance Data

NO_x Emissions Compliance data

2001	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of NO_x data	223	525	444	533	604	352	307	42	22	180	223	264	3719
Hours of MAL compliance	208	516	437	532	602	350	307	42	18	179	223	264	3678
% Compliance	**93**	**98**	**98**	**100**	**100**	**99**	**100**	**100**	**82**	**99**	**100**	**100**	**98.9**

2002	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of NO_x data	630		458	601	670	663	89				553	600	4632
Hours of MAL compliance	609	350	434	589	613	640	79				553	600	4467
% Compliance	**97**	**95**	**95**	**98**	**91**	**97**	**89**				**100**	**100**	**96.4**

2003	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of NO_x data	837	328	190	89	189	295	291	303		30			2552
Hours of MAL compliance	823	328	190	89	189	267	238	303		30			2457
% Compliance	**98**	**100**	**100**	**100**	**100**	**91**	**82**	**100**		**100**			**96.3**

SO_2 Emissions Compliance Data

2001	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of SO_2 data	223	525	444	533	604	352	307	42	22	180	223	264	3719
Hours of MAL compliance	223	525	444	533	604	352	307	42	22	180	223	264	3719
% Compliance	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

2002	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of SO_2 data	630	368	458	601	670	663	89				553	600	4632
Hours of MAL compliance	630	368	458	601	670	663	89				553	600	4632
% Compliance	**100**	**100**	**100**	**100**	**100**	**100**	**100**				**100**	**100**	**100**

2003	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of SO_2 data	837	328	190	89	189	295	291	303		30			2552
Hours of MAL compliance	837	328	190	89	189	295	291	303		30			2552
% Compliance	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**		**100**			**100**

PM_{10} monitoring data (μg/m^3)

	VRA TOWNSHIP					ABOADZE			
	1999	**2000***	**2001***	**2002**	**2003**	**1999**	**2001***	**2002**	**2003**
Jan	40.9	30.5		355.5	132.6	57.1		432.6	147.1
Feb	54.9	60.8		51.2	18.8	81.4		84.1	55.8
Mar	41.2			45.9	34.1	70.1		77.3	69.4
Apr	32.1			48.2	20.4	32.1		65.8	58.6
May	23.4			39.5	12.3	41.8		58.7	16.0
Jun	18.4			36.8	30.4	33.8		45.6	
Jul	26.1			28.1	30.6			70.7	60.8
Aug	41.0			37.5	48.8			168.7	66.4
Sep				11.4	13.7			323.0	18.8
Oct	73.8		27.5	14.0	21.4		29.0	43.4	35.5
Nov	70.7		32.5	29.6	40.5		29.5	40.5	67.0
Dec			35.0	60.8	32.2		50.0	67.1	44.9
% Compliance	**90**	**100**	**100**	**92**	**92**	**83**	**100**	**58**	**91**
MAL (μg/m^3)	**70**								

Notes
* Data gaps are due to periods of equipment breakdown
Non compliance in August and September 2002 at Aboadze was due to daytime activities of school children on football field adjacent to monitoring site.
Non compliance in January attributable to the effect of the dust laden harmattan wind
MAL = Maximum allowable limit (70 μg/m^3 for 24hr readings, and 50-100μg/m^3 for annual average)

Ambient GLC for SO_2 measured at Beposo and Aboadze

BEPOSO (SO_2)	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Annual average GLC (ppm)		0.0010	0.0005	0.0013	0.0002	0.0001
Max allowable limit (ppm)*		0.028	0.028	0.028	0.028	0.028
Compliance, %		100	100	100	100	100

ABOADZE (SO_2)	**1997****	**1998**	**1999****	**2000****	**2001**	**2002**
Annual average GLC/ppm		0.001			0.0005	0.0002
Max allowable limit/ppm*		0.028			0.028	0.028
Compliance, %		100			100	100

** The World Bank Group Pollution and Abatement Handbook 1998 pg 424*
*** No sampling due to equipment breakdown*
Annual max allowable limit = 80 μg/m^3 (0.028 ppm), based on 1 ppm SO_2 = 2.86 mg/m^3

Ambient GLC for NO_x measured at Beposo and Aboadze

BEPOSO (NO_x)	1997	1998	1999	200	2001	2002
Annual average GLC/ppm	0.009	0.003	0.011	0.011	0.021	0.002
Max allowable limit/ppm*	0.048	0.048	0.048	0.048	0.048	0.048
Compliance, %	100	100	100	100	100	100

ABOADZE (NO_x)	1997 **	1998	1999 **	2000	2001	2002
Annual average GLC (ppm)		0.016		0.007	0.012	0.005
Max allowable limit/ppm*		0.048		0.048	0.048	0.048
Compliance, %		100		100	100	100

** The World Bank Group Pollution and Abatement Handbook 1998 pg 424*
*** No sampling due to equipment breakdown*
Annual max allowable limit = 100 $\mu g/m^3$ (0.048 ppm), based on 1 ppm NO_x = 2.05 mg/m^3

Note: Beposo is the point of maximum plant outfall predicted by the air dispersion modeling carried out as a part of the EIA, while Aboadze corresponds to the nearest community to the power plant

It should be noted that these results include contributions from sources other than the existing Takoradi Thermal Power Plant. The cumulative impact resultant from the addition of T3 will be minimal and will still maintain acceptable limits of emissions according to current environmental health and safety criteria. The air dispersion modeling (Appendix C) provides detailed data on T3 contribution to emissions.

Recorded 24 hour average PM_{10} concentrations ranged from 17 to 124 $\mu g/m^3$; compared to the limit value given in the 1995 EIA Report of 260 $\mu g/m^3$ for total suspended particulates.

Estimated ambient background concentrations in Takoradi provided in the 1995 EIA are reproduced below on Table 4.7 below for reference.

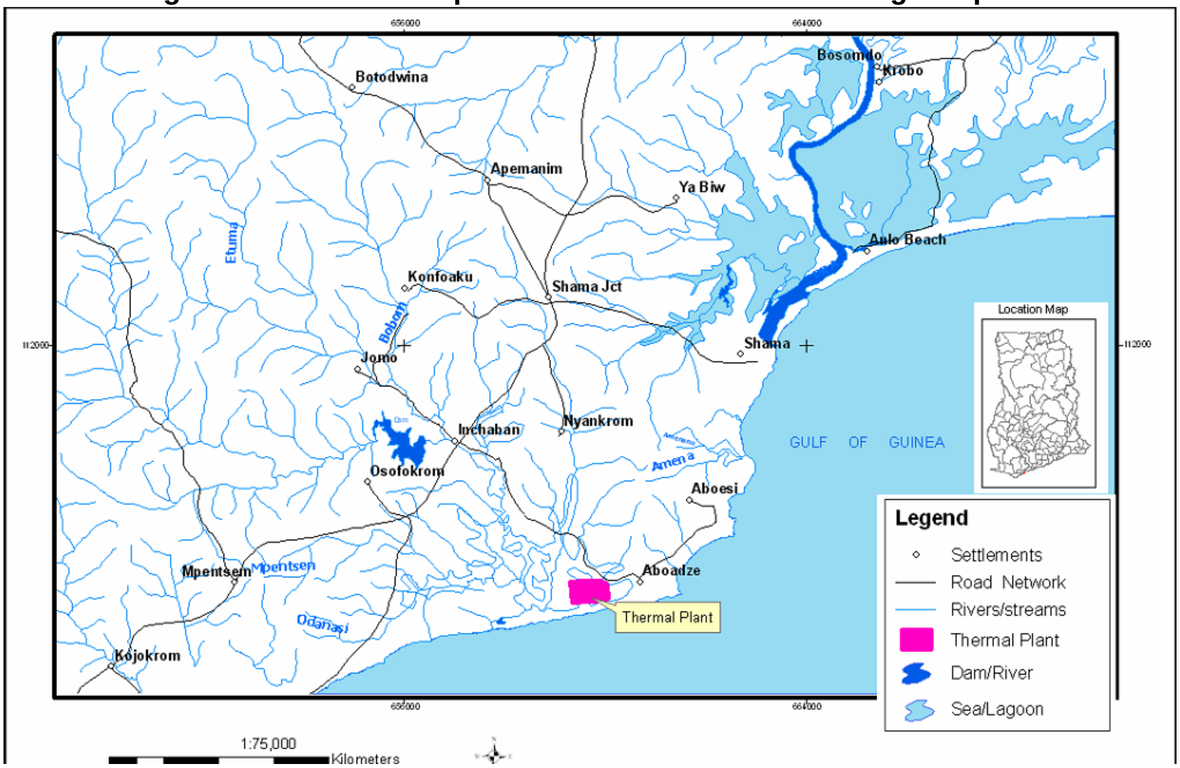
Table 4.7 Estimated Ambient Background Concentrations in Takoradi

Pollutant	Assumed Background Ambient Concentration ($\mu g/m^3$)
NO_2	7
SO_2	35
PM_{10}	84

4.1.3 Ground and Surface Water

Ghana is fairly well endowed with water resources, but there is a high variability in the amount of available water within the year and over several years. About 70 percent of the total land area of Ghana is drained by the Volta river system, which flows directly into the sea. The Volta Lake covers approximately 8,482 square kilometers while other areas, seasonally flooded, total 1,684 kilometers. Figure 4.15 provides an overview of basins and drainage patterns for Ghana.

Figure 4.15 Ghana Representative Basins and Drainage Map



Groundwater is found at the surface in the low lying areas and between 0 and 2m elevation elsewhere. The groundwater beneath the site is saline and unsuitable for drinking purposes.

The largest river in the area is the Pra which empties into Shama Bay just east of the project site. The Pra estuary is located 6 km from the site's eastern boundary and is considered to be an important fishery resource.

Monthly average flows over the 34-yr period of record range from a low of 42 m^3/s in February, to the maximum of more than 370 m^3/s in June, July and October. Minimum monthly flow during the 34-yr period of record was 4.96 m^3/s (February 1978), while maximum monthly flow was 1200 m^3/s (September 1968).

The Anankwari River and its tributaries drain the existing site and transmission line route. The Anankwari is dammed at Inchaban to provide the water supply for Sekondi, Aboadze and Aboesi. During the rainy season, water is spilled it the maximum operating levels of the reservoir is achieved; otherwise, there is no flow downstream of the dam. The water in the Anankwari River was deemed to be of generally good quality in the 1995 EIA Report.

Samples from selected water bodies west of the proposed site were taken on May of 2009 and analyzed by AERC for metal concentration, amount of solids present, and salinity and the results are given below.

Table 4.8 Surface Water Quality Near TTPP (May 2009)

Parameter	Estuary of Anakwari Lagoon	Middle of Anakwari Lagoon	Wetland 1	Wetland 2	Intertidal Zone 1	Intertidal Zone 2
pH	7.18	7.12	6.07	6.23	8.03	7.86
Cond.(uS/cm)	6360	3690	1792	1699	61780	58398
TDS (mg/L)	3220	1836	901	889	30900	29773
Sal (ppt)	4	3	1	1	34	34.5
Turb. (NTU	200	180	33	41	27	26
TSS (mg/L)	215	184	35	46	34	34
Nitrate (mg/L)	0.4	0.6	0.9	0.76	0.6	0.1
Phosphate (mg/L)	0.37	0.24	0.15	0.19	0.08	0.07
Sulfate (mg/L)	575	625	185	184	3450	3500
Iron (ppm)	1.718	1.982	2.609	1.974	0.224	0.231
Copper (ppm)	0.004	0.007	0.015	0.011	0.052	0.034
Lead (ppm)	0	0	0	0	0.141	0.366
Zinc (ppm)	0	0	0	0	0	0
Sample Locations						
Latitude	N 04 57 58 . 8	N 04 58 02. 9	N 04 58 07.4	N 04 58 07.9	N 04 58 04.9	N 04 58 04.9
Longitude	W 001 40 20.9	W 001 40 20.9	W 001 39 43. 6	W 001 39 45.	W 001 39 42 .5	W 001 39 42 .5

The proposed site will not have any immediate impact on the natural bodies of water since the plant requirements are confined to a closed loop water circuit for the steam system and water injection needed for emission control of NOx. Water for the closed loop circuit is provided by the existing T1/T2 plant and blowdown will be discharged into the Final Discharge Sump of the existing T1/T2 blowdown system. Water used for water for emission control will be supplied by the existing T1/T2 Demin Water System and vaporized during the combustion process in the turbines. There will be no liquid water discharge from this stream.

4.1.4 Coastal Environment

4.1.4.1 Lagoons and Estuaries

Over 90 coastal lagoons fringed by intertidal mud or sand flats and in some places by mangrove swamps occur along the coastline of Ghana. The lagoons form important vulnerable ecosystems, housing a wide variety of fish, shrimps, crabs, mollusks and polychaete species. Some of the lagoons have been recognized both nationally and internationally as migratory water bird habitats while some may serve as nursery areas for juveniles of marine fish and shrimp.

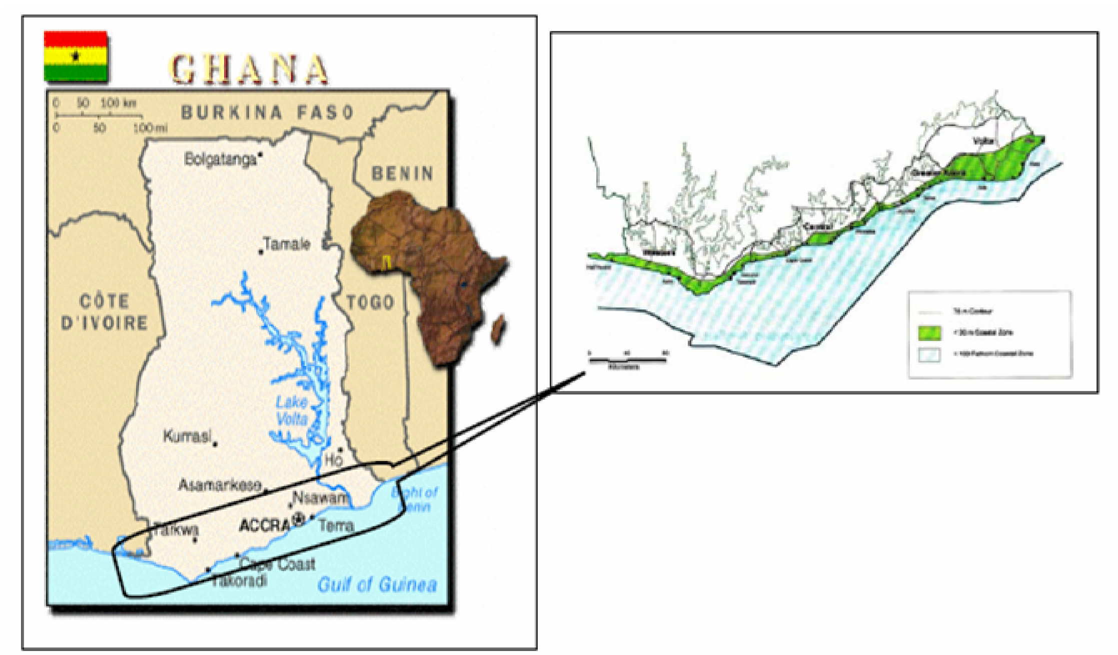
Two main types of coastal lagoons are encountered in Ghana. These are 'open' and 'closed' lagoons. The open lagoons have a permanent opening to the sea and are normally fed by rivers that flow all year round. They occur mostly on the central and western parts of the coastline where higher rainfall results in a more continuous flow of the rivers and streams. The closed lagoons are separated from the sea by a sand barrier. They are more common on the eastern segments of the coastline where rainfall is low and highly seasonal. Some closed lagoons open to the sea in the rainy season when floodwaters break the sand barrier. Storm surges may also erode sandbars and open up closed lagoons to the sea. Under other circumstances the sandbar may be manually breached during the rainy season to reduce the risk of flooding adjacent settlement where this is considered a threat.

The constant wave action of the sea works to build and maintain the coastal barrier that separates these lagoons from the sea. When river flow increases, the overflow cuts outlets through the coastal barrier allowing the freshwater of the river and salty sea water to mix. Lagoons tend to retain sediments transported by the rivers, and infilling leads to the formation of marshes and swamps. Estuaries are present at the mouths of those rivers that have sufficient flow to maintain an opening to the sea during all parts of the year. They are often very productive environments.

In the vicinity of the proposed project, the Pra River estuary is located 6 km east of Aboadze and the eastern margin of the site, while the Anankwari lagoon is located approximately 1 km beyond the western perimeter of the site. The Pra estuary and Shama Bay are considered to be one of the most important areas of the Ghanaian coastline in terms of fishery resources according to the 1995 EIA Report. Both rivers are associated with wetland complexes in their lower reaches, which vary considerably in extent, depending upon the season and amount of rainfall.

A map showing the coastal zone of Ghana is provided on Figure 4.16.

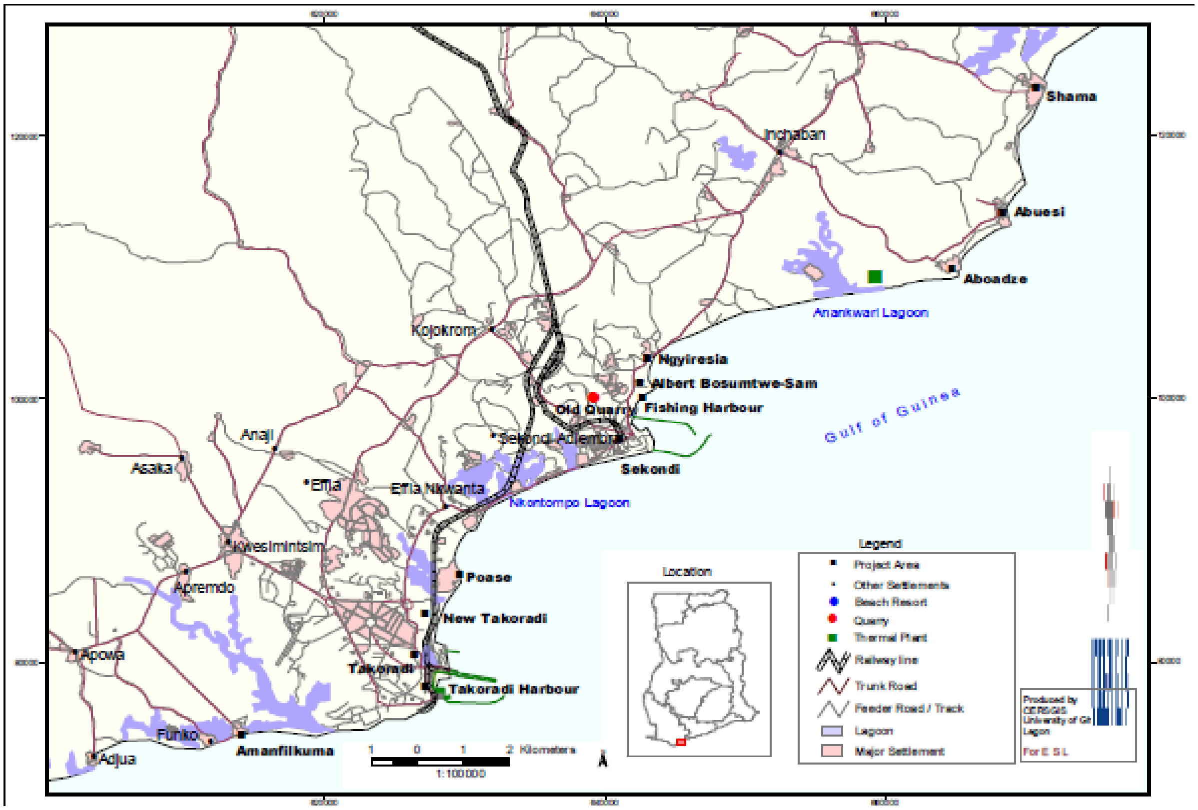
Figure 4.16 Ghana Coastal Zone



The Anakware lagoon (Figure 4.17) is a semi-closed shallow water body separated from the sea by a sand barrier, and connected at least intermittently to the sea by restricted inlets. It is usually oriented shore-parallel. Due to its interface location, between land and sea, and low depth, the lagoon is strongly submitted to natural constraints. Direct (wind) and indirect (rain through river flows) climatic and marine (tide) influences cause large differences and quick changes in the physical and chemical characteristics.

The high precipitation in the area often results in a more continuous flow of the watercourses and rivers that drain them into the lagoon.

Figure 4.17 Open Coastal Lagoons at the Western Region of Ghana



The Anakware lagoon also behaves as estuarine wetlands as it is linked to perennial streams and rivers as well as plains of estuaries that are seasonally inundated during the rainy seasons. The lagoon contains strands of mangroves typically *Avicennia* and *Rhizophora*.

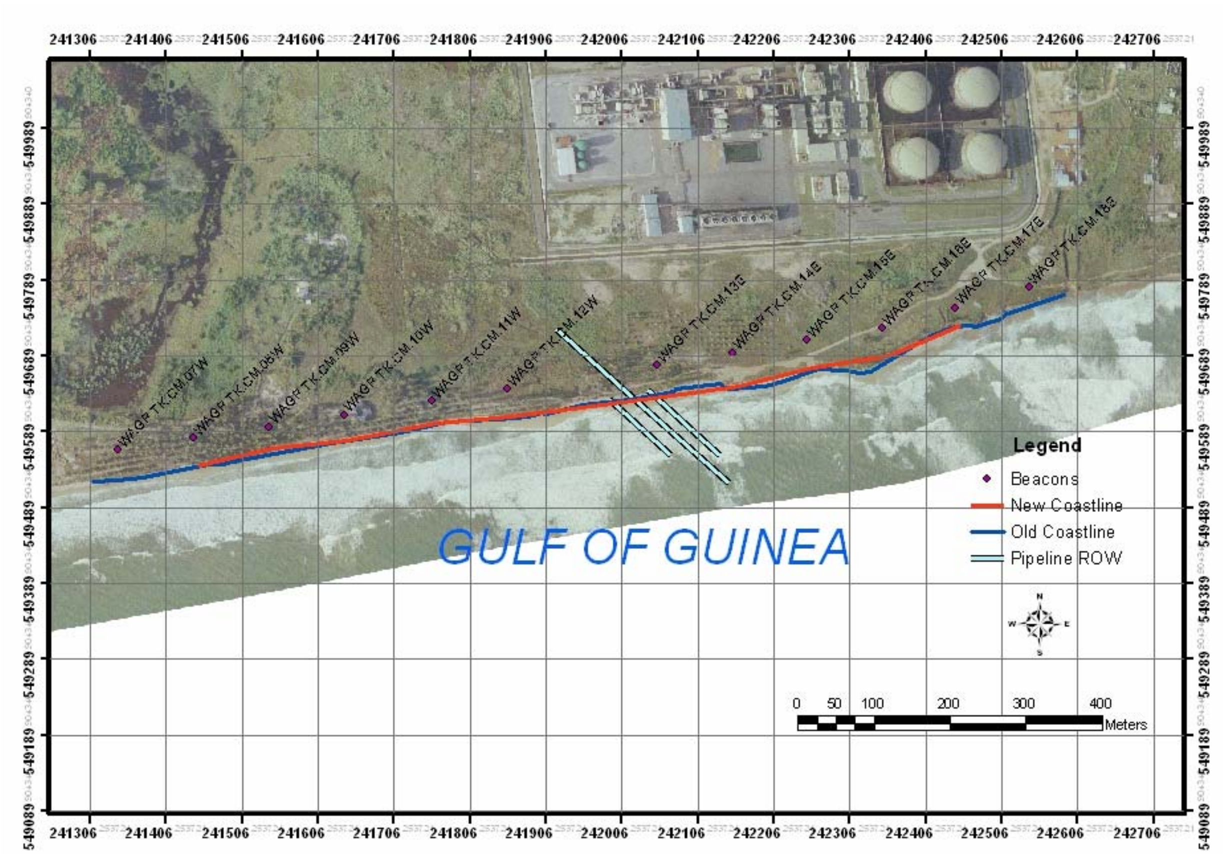
4.1.4.2 Physical Oceanography

The coast of the Gulf of Guinea shows slight concave curves between a series of capes (Palmas, Three Points, St. Paul and Formosa). The Volta and Niger rivers, both some distance to the east of the site, are the only large rivers discharging into the Gulf of Guinea and were historically the main sources of sediments for formation of the shores. The coastal orientation and the continuous action of the ocean swell from the southwest results in sediments being transported away from the capes and deposited on the shore between them. On a smaller scale, this pattern of deposition is repeated within the larger concave curves, making the coast a series of beaches intersected by rocky promontories and some cliffs. This pattern is apparent in the vicinity of Aboadze where the shore consists primarily of sandy beaches with rocky outcrops. The depth of the sand deposits is not likely large as evidenced by the occurrence of several exposed rocks in the near shore area. In shore of the 10 m contour, the bottom substrate consists of sand with rock outcrops changing to mud and sand in deeper waters.

Immediately in front of the Takoradi Thermal Power Plant, several rock outcrops are evident at low tide, but are filled between by sand deposits and overlain in their northern extremities, representing the upper portion of the beach zone. Low sand cliffs (1 to 1.5 m) are apparent at the shoreline interface, indicating the presence of a mildly erosive environment. Sand-winning activities, which are now outlawed, took place along the eastern margin of the site and may have impacted the local sediment transport regime. The discontinuation of future activities of this nature is expected to have a positive impact on the sediment budget of the shoreline. Beyond the beach/tide zone the bottom slope is more gentle, progressing seaward to the edge of the continental shelf, about 75 km from shore.

Figure 4.18 presents an aerial image of the Aboadze/Takoradi coastline.

Figure 4.18 Shoreline at Aboadze/Takoradi



Physical processes due to waves and currents do occur in the littoral zone leading to the movement of littoral drift. Littoral drift includes long shore drift and on-offshore drift, movements parallel and perpendicular to the shore respectively. The littoral zone extends seaward from the shoreline to just beyond the breaker zone.

Some predictions of in-shore water movements can be made based on the shape of the shoreline and the presence of a major river (Pra) discharging into the nearby bay (Shama Bay). This would indicate the likely presence of a counter clockwise gyre to the east of the site in Shama Bay.

The coastal surface currents are predominantly wind-driven and are confined to a layer of 10– 40m thickness. Littoral drift, which is the main driving forces in coastal circulation in this area, is generated by breaking waves. These littoral drifts, generally flowing in an eastward direction, flow at rates less than 1 m/s, but are responsible for transporting large volumes of littoral sediments. The direction of tidal current around the coast of Ghana is mostly North or North-East. The velocity of the tidal current is generally less than 0.1m/s. the maximum velocity of tidal current observed in a day of strong winds is about 0.5m/s. The wave induced long shore currents are generally in the west to east direction which is an indication of the direction the waves impinge the shoreline. The long shore currents may average about 1 m/s and vary between 0.5 and 1.5 m/s. The magnitude increases during rough sea conditions.

Waves reaching the shores of Ghana consist of swells originating from the oceanic area around the Antarctica Continent and seas generated by locally occurring winds. The significant height of the waves generally lies between 0.9 m and 1.4 m and rarely attains 2.5 m or more. The most common amplitude of waves in the region is 1.0 m but annual significant swells could reach 3.3 m in some instances. Swells attaining heights of 4.8-6 m, however, occur with a 10-20 year periodicity. The peak wave period for the swells generally falls in the range of 7 to 14 seconds. The swell wave direction is almost always south or south-west.

Other observations on the wave climate include a long swell of distant origin and with wavelengths varying between 160 and 220 m. This swell has a primary period of 12 seconds and a relatively regular averaged height between 1.0 and 2.0 m. The swells generally travel from southwest to northeast.

The tide on the coast of Ghana is regular and semi-diurnal. The average range varies along the coast as shown in Table 4.9 for the main cities. The tidal wave has virtually the same phase across the coast of the country. The average range of Neap and Spring tides increases from west to east. Tidal currents are low and have an insignificant influence on coastal processes except within tidal inlets.

Table 4.9 Tidal Range for Selected Area of the Coast of Ghana (in meters)

Location	Neap	Mean	Spring	Phase
Takoradi/Aboadze	0.58	0.90	1.22	107º
Accra	0.62	0.94	1.26	107º
Tema	0.64	0.96	1.28	107º
Aflao	0.68	1.00	1.32	108º

Other possible sources of intermittent increases of local water levels include line squalls and the transfer of energy from internal to surface tides. These processes could result in additional increases of about 0.30 m. The orientation of the swell reaching a coastline is partly responsible for the eroding of a natural headland whereas the angle and height of the waves reaching the coastline determines the magnitude of the erosion. At Takoradi, the installed port structures intercept sand, thus contributing to an ever increasing erosion problem to the east of the port.

Granulometric properties of the sediment were assessed from representative locations of the east and west of the thermal plant. The granulometric analysis revealed that sand with mean grain sizes ranging between 1φ and 2φ occur at the upper and middle parts of the beach face at all the station while a mean grain size of less than 1φ occurred at the lower parts (Table 4.10). The type of grain at the upper and middle intertidal is medium sand for all the stations except at the middle intertidal zone of the groyne area where coarse sand type occurs. Coarse sand also occurred at the lower parts of the other stations (Table 4.10). The sorting coefficient of the sediment was between 1φ and 2φ, indicative of generally poorly sorted sands for the entire intertidal zone (upper, middle and lower).

Table 4.10 Sediment Granulometric Analysis for Samples from Aboadze Beach

Station	Intertidal Zone	Mean Grain Size (φ)	Sorting Coefficient	Sand Type	Sorting Class
West of the Thermal Plant	Upper	1.60	1.20	Medium sand	Poorly Sorted
	Middle	1.28	1.31	Medium sand	Poorly Sorted
	Lower	0.89	1.08	Coarse sand	Poorly Sorted
Groyne Area	Upper	1.26	1.30	Medium sand	Poorly Sorted
	Middle	0.67	1.23	Coarse sand	Poorly Sorted
	Lower	0.71	1.31	Coarse sand	Poorly Sorted
East of the Thermal Plant	Upper	1.07	1.20	Medium sand	Poorly Sorted
	Middle	1.24	1.31	Medium sand	Poorly Sorted
	Lower	0.95	1.11	Coarse sand	Poorly Sorted

**Mean grain size is in phi (φ) units while interpretation is based on the Wentworth grain size classification scheme.*

Sea surface temperatures and salinities along the coast of Ghana can vary widely, with the oceanographic regime characterized by a seasonal major upwelling and a minor upwelling. Generally, the Tropical Surface Water (TSW) is characterized by warm, well-mixed water that extends from the surface to the depth of the thermocline (about 30m to 40m). The major upwelling occurs for approximately 3 months each year, beginning late June or early July and ending in late September or early October. This event is defined as that period when sea surface temperature falls below 25ºC. The upwelling is stronger and lasts longer along the western section of the coast. Surface temperatures can drop to as low as 17.5ºC during the upwelling, while salinity generally increases and dissolved oxygen declines. Sea temperatures tend to be lowest during this period as solar heating is limited by cloud cover and upwelling is frequent. The upwelling is known to have considerable influence on both the local fisheries and sub-region. The origin and mechanism of the upwelling is still not clear however. Several attempts have being made to explain the origin and mechanism of the coastal upwelling off Ghana but none is sufficiently conclusive to be accepted by most oceanographers. The position and dynamics of the upwelling are varied. The upwelling influences the migratory patterns of pelagic fishes and is linked with the marine fish catch in Ghana.

Salinity on average is highest in August and lowest in late October and November. Salinity is influenced by rains and high river discharges which dilute near-shore waters and upwelling that brings deeper, more saline waters to the surface.

In the off-shore region, the depth of the thermocline varies from 10 to 50 m on an annual basis, with the result that waters in shore of the 10-m contour, and often the 20- or 30-m contour, are isothermal; therefore, considered to be representative of the temperature of the water mass above the thermocline. The minor upwelling occurs for approximately 3 weeks; as early as December or as late as March, however usually in either January or February. The minor upwelling is defined as that period when surface temperatures fluctuate between 27.5 and 26.0ºC.

Average monthly sea temperatures recorded at Takoradi over a 4-year period (1968 to 1971) are presented in Table 4.11.

Table 4.11 Average Monthly Sea Surface Temperatures at Takoradi (1968-1971)

Month	Average Temperature
January	25.7
February	26.8
March	26.8
April	27.3
May	27.1
June	26.0
July	23.1
August	21.1
September	21.3
October	24.9
November	27.0
December	26.5
Annual Mean	**25.3**

Baseline seawater temperature monitoring began in October 1997 and daily readings are taken in order to be able to evaluate potential temperature rises attributable to the effluent discharge. The average monthly sea temperature in 1998 varied from 21.4°C in August to 29.2°C in November. The sea outfall will operate on a gravity basis where discharge will fluctuate with tidal movements.

Seawater temperatures at Takoradi for the period of May 1999 to April 2000 are given in Table 4.12 below.

Table 4.12 Monthly Sea Surface Temperatures at Takoradi (1999-2000)

Month	Temperature Range (ºC)	Average Temperature (ºC)
May 1999	27.5 – 29.0	28.4
June 1999	-	-
July 1999	22.0 – 25.5	23.3
August 1999	21.0 – 23.5	22.2
September 1999	21.5 – 24.0	22.3
October 1999	21.5 – 28.0	25.3
November 1999	27.5 – 29.0	28.5
December 1999	27.0 – 30.0	28.7
January 2000	24.0 – 28.0	26.0
February 2000	26.0 – 29.0	27.4
March 2000	28.0 – 30.5	29.5
April 2000	26.5 – 29.7	28.4

The information provided above are used for reference only considering the T3 Thermal Plant will have no impact on the seawater temperature.

4.2 Biological Environment

4.2.1 Terrestrial Vegetation

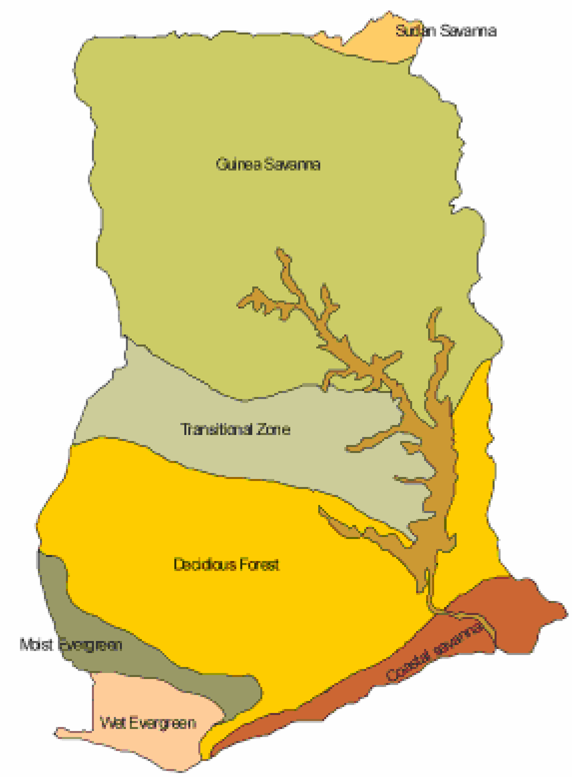
The 1995 EIA Report divided the terrestrial plant communities along the coastal zone into three major environments: intertidal zone, strand zone and evergreen shrub zone. Figure 4.19 gives a general overview of the vegetation and ecological zones throughout Ghana.

Growth is related to windiness, saline conditions, salt spray, and looseness of the soil.

The intertidal zone is the present beach zone and has little plant life except for well-attached marine algae and microscopic organisms. (This zone was included in the terrestrial vegetation zoning although it is also part of the marine environment).

The strand zone can be divided into the pioneer zone, where plant cover is low and growing conditions difficult, and the main strand zone where there are more stable communities. The pioneer zone is characterized by rhizomatous or stolonilerous species with their underground spreading root systems stabilizing the shifting substrate.

Figure 4.19 Ghana Ecological Zones



The main strand zone has a higher ground cover, better soil texture, and higher organic matter. There is a greater variety of plants and not all are adapted to saline conditions. Common grasses are Androdopon qavanus and Heterodopon contortus. This zone is often the site of copra (coconut palms) plantations. Landward, the strand zone gradually merges into the evergreen shrub zone. The shrubs may be dwarfed and shaped by the prevailing winds.

In Ghana, immediate coastal zone vegetation is broadly mapped as strand and mangrove. On a broad scale, the regional vegetation pattern of the area inland of Sekondi-Takoradi and extending east just beyond Shama Bay (encompassing the project area), is dry semi-deciduous. Mangrove communities may develop, especially within the coastal lagoons, and locally, these are mainly found to the west of Cape Three Points and east of Shama. Mangrove communities are, however, prevalent along the banks of the Pra River, extending upstream as far as the main highway bridge. No mangrove communities are present along the southern edge of the site.

The area surrounding the proposed T3 site is comprised of three main zones of flora/vegetation in the study area: coastal stand, seasonal swamp/wetland and grassland; and isolated clumps.

The vegetation composition at Aboadze was assessed by walking on demarcated transects and listing all the species encountered. Figure 4.20 illustrates typical vegetation types around TTPP.

The vegetation is characterized by flora of the *Cyperus-Ipomeoa* association dominated by *Cannavalia obtusifolia, Cocos nucifera, Cyperus articulatus, C. maritimus, Imperata cylindrical, Ipomoea pes-caprae, Opuntia vulgaris, Paspalum vaginatum, Phoenix reclinata, Sporobolus virginicus, Thespesia populnea,* and *Triumfetta rhomboidea*. The *Cyperus-Ipomoea* association is clearly evident in the area. Graminae and Papilionaceae are the dominant families, with herbs dominating the life form. Portions of the Aboadze have been converted into coconut (*Cocos nucifera*) plantations. The vegetation comprised of thickets, wetlands, and strand especially at the western section of the Thermal plant. The strand zone is stabilized by the cultivation of coconut palms, with the exception of a central area, which was subjected to previous sand extraction activities. Coconut palms, sisal, and *Sesuvium* sp. are the dominant plant species in the coastal belt. The coastal strand is characterized by flora of the *Cyperus-Ipomeoa* association. The freshwater swamp at Aboadze occupies a depression between the strand vegetation and the scrub or thicket vegetation. It is dominated by *Cyperus articulatus*. Further inland, the wet low-land area is dominated by grasses and sedges; while native shrubs are present in limited numbers on one of the higher knolls near the north boundary of the site. Wild oil palms are scattered throughout the site at elevations above 3 to 4 m. The majority of the land above 3 m. with the above noted exceptions is subject to shifting cultivation.

Figure 4.20 Typical Vegetation Around TTPP

During construction of T2 there was no significant change to the terrestrial vegetation described above. Very little vegetation was observed and where present it largely comprised grass of little ecological value. A number of buffer zones, planted with suitable vegetation mixes, have been established to minimize visual impacts on completion of construction of T2 and the same practices will be observed during the construction of T3.

4.2.2 Wildlife

The animals observed and recorded at Aboadze are presented in Table 4.13. The conservation status is also given. There were 15 species recorded (excluding interviews), comprising seven species each of herpetofauna and birds, and one species of mammal. Five of these species, which are all birds, are of conservation significance. Two species recorded (*Milvus migrans* and *Neophron monachus*) are of both international (CITES Appendix II) and national (National Schedule I) conservation concern, while three species (*Ploceus cucullatus, Lonchura cucullata, and Streptopelia semitorquata*) are of national conservation concern (National Schedule II) (Table 4.13).

Table 4.13 Composition and Conservation Significance of Wildlife at TTPP

Species	Common Name	Recorded Species	Conservation Significance	
		Aboadze	CITES	National
AMPHBIA				
Bufo regularis	Common Toad	X		
Hylarana galamensis	Common Frog	X		
REPTILIA				
Squamata: Lacertilia				
Agama agama	Rainbow Lizard	X		
Lygodactylus conraui	Gecko	X		
Mabuya affinis	Skink	X		
M. Perroteti	Orange-flanked skink	X		
Squamata: Serpentes				
Psammophis sibilans	Hissing Sand Snake			
AVES				
Accipitricidae				
Milvus migrans	Black Kite	X	II	I
Neophron monachus	Hooded vulture	X	II	I
Columbidae				
Streptopelia semitorquata	Red-eyed Dove			II
Alcedinidae				
Halcyon malimbicus	Blue-breasted Kingfisher	X		
Corvidae				
Corvus albus	Pied Crow	X		
Estrildidae				
Lonchura cucullata	Bronze Mannikin	X		II
Ploceidae				
Ploceus cucullatus	Village Weaver	X		II
MAMMALIA				
Rodentia				
Lemniscomys striatus	Spotted Zebra Mouse	X		

Note: CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna publishes a list of three Appendices (CITES Appendices, 1975) which limits global trade of certain categories of animal species.

- *Appendix I species are threatened species which cannot be traded in*
- *Appendix II species are species for which levels of trade are limited*
- *National Criteria (Ghana Wildlife Conservation Regulations)*

Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971, and Ghana Wildlife Conservation (Amendment) Regulations, 1988; 1995) also categorise animal species into two main Schedules based on the level of protection required for a particular species

- *Schedule I species are completely protected (i.e., their hunting, capture or destruction is prohibited at all times)*
- *Schedule II species are partially protected (i.e., their hunting capture or destruction is absolutely prohibited between 1st August and 1st December of any season, and the hunting, capture and destruction of any young animal, or adult accompanied by young, is absolutely prohibited at all times).*

Some small antelope (e.g., duikers) may be found along the transmission line. No snakes were seen, but it is suitable habitat for possibly pull adders, cobra, and green mambas.

The sewage lagoons in particular were observed to contain/support a variety of wildlife including frogs, fish, pied kingfishers, species of cormorant, geese and coots, as well as aquatic insects.

Each species has its own period of peak abundance that may vary somewhat from year to year. For most of the waders the period of maximum abundance occurs between August and March, with the months of November and December being the periods of highest abundance and diversity. The months of May, June and July have the lowest number.

During migration periods, birds are relatively abundant along most of the coast, utilizing the beaches, lagoons and estuaries as feeding areas and the coastal zone as a route between individual lagoons. It was noted that numerous species were present generally within the TTPP site, township and immediately surrounding area. These included pied crows, vultures, raptors (buzzards/hawks), weaver birds, various finches, egrets and wagtails, and at least another three unidentified bird species.

In the local area, the Hwin River estuary, located just west of Takoradi is a major stopover point that is utilized by migrating waterfowl. In the vicinity of the project area, shorebirds (mostly terns) utilize the Aboadze/Aboesi area extensively during migration.

The abundance and species composition of shorebirds at the intertidal area and the swampy wetland are presented in Table 4.14. A total of 31 individual shorebirds comprising two waders and five ‘others’ were recorded at the swampy wetland. There were six species of waders (total of 9) and two species of ‘others’ recorded in the intertidal area. The birds were seen either feeding and/or wintering in these ecological areas. The species richness and abundance in these areas were low possibly due to the scarcity of foraging items.

Table 4.14 Species Composition and Shorebirds at Aboadze

Common Name	Scientific Name	Location	
WADERS		**Swampy Area**	**Intertidal area**
Black-winged stilt	*Himantopus himantopus*	1	1
Whimbrel	*Numenius phaeopus*		1
Grey plover	*Pluvialis squatarola*		2
Common sandpiper	*Tringa hypoleucos*	9	2
Sanderling			1
Ringed plover	*Charadrius hiaticula*		2
Total Waders		10	9
OTHERS			
Grey heron	*Ardea cinera*	3	
Little egret	*Egretta garzetta*		4
Western reef heron	*Egretta gularis*		1
Purple heron	*Ardea pupurea*	2	
Great-white egret	*Egreta alba*	1	
Pied kingfisher	*Ceryle rudis*	1	
Black kite	*Milvus migrans*	4	
Total Others		11	5

The shorebirds data was obtained using opportunistic counts having spotted them with binoculars. Most of these shorebirds are indirectly influenced by the seasonal nature of the climatic conditions, which affect their habitats and availability of prey items.

No rare or endangered species of wildlife were found within approximately 500m of the site, apart from lizards which were observed in the site for T2 by GIBB staff during November 1998, January 1999 and February 1999.

The previous EIA reports and site visits also indicated that there are no designated sites of ecological or nature conservational value on or around the T3 Thermal Plant site and surrounding areas and the area is not considered to be of any ecological significance.

4.2.3 Marine Environment

Considerably extensive research by the previous EIA Reports for the Takoradi area has been done regarding the marine environment. The T3 Thermal Plant will not however have any impact whatsoever on this environmental topic. Nevertheless, additional research has been performed by a local Ghanaian company and provided in this section.

The upper part of the littoral zone, often referred to as the littoral fringe, is an area dominated by sea spray and wave splash and subject to wide variations in water level and wave direction.

The eulittoral zone, corresponding to the intertidal area of the shore, is generally divided into zones and populated by barnacles and small amounts of algae. Large mussels, limpets and carnivorous snails are among the population of these subzones, along with some species of crabs where wave action is considerable.

Aboadze is an area of exposed rocky shores subjected to persistent waves, which impose limits on organisms present. The distribution of coastal marine flora and fauna is dependent on tidal levels, coastal geomorphology and seasonal variations. The depth of breaking waves and sheltered condition created as a result of the groyne berm is expected to enhance stable conditions that may provide opportunities for successful colonization by marine flora and fauna.

Several species of rocky shore epibenthic fauna are present. These consist of gastropods, bivalves, crustaceans, echinoderm (echinoidea), and actinarians (Cnidarian).

A clear distinct band of macro algae is easily visible from the upper intertidal to the lower intertidal during the low tide period. Macro algal and epibenthic faunal species that were identified and quantified in the field are presented in Table 4.15. Only species that recorded frequency of occurrence (F) greater than 20% are presented with their corresponding densities. There were a total of 15 rocky shore species found on groyne berm. This comprised 4 species (20.7%) of macroalgae and 11 species (73.3%) of epibenthic fauna. The most occurred species on the groyne berm transect were *Cheatomorpha linum* (100%), *Thais heamastoma* (80%) and *Patella siafiana* (60%).

A total of 34 species comprising 24 species (70.59%) of macroalgae and 10 species (29.41%) of epifauna were encountered in the rocky area west of the groyne berm. Most species found to occurred appreciably was *Ulva fasciata* (F=62%). However, the highest densities were associated with *Ulva fasciata*, *Padina durvillaei*, *Sargassum vulgare*.

The data was obtained through a belt transect located from the low tide mark to the upper shore (Figure 4.21). A quadrant frame of $1m^2$ was placed continuously on each transect from the low tidal mark to the high-tidal zone of the rock stretch. The percentage cover of macro algae and number of individuals of solitary animals (including mobile animals under rocks) were quantified in each quadrant after identification using taxonomic guides and manuals (e.g., Edmunds 1978 and

Lawson 1956). Approximately 32 quadrants were covered. Figure 4.22 shows quadrant analysis of rocky shore biota.

The above description applies generally to beaches and littoral zones having hard substrates. In areas with stable sand substrates polychaetes and crabs are the main inhabitants. Rocky, off-shore reels and shoals are often well colonized by various red, blue-green and solitary algae species, providing habitat and feeding grounds for various invertebrate and fish species. Off-shore reefs and cobble banks, especially those near Tema, are quite unstable being subject to surface movement and cobble tumbling due to tide and wave-induced surge action, which is especially prevalent during the rainy season (May/June). This results in the removal of much of the algal growth, and a corresponding reduction in benthic populations.

Table 4.15 Rocky Shore Species at Aboadze

Species	Aboadze Groyne Transect			Aboadze Transect (west of groyne)		
	Total	Density	F (%)	Total	Density	F (%)
MACROALGAE						
Lithothamnia						
Ralfsia expansa						
Hydropuntia dentate						
Hypnea musciformis						
Ulva fasciata	56	2.8	40	274	10.54	62
Caulerpa taxifolia						
Centrocera clavulatum				68	2.62	31
Chaetomorpha antennina						
Gelidiopsis variabilis						
Padina durvillaei				240	9.23	35
Chaetomorpha linum	916	45.8	100	16	0.62	23
Sargassum vulgare				253	9.73	27
Enteromorpha flexuosa	24	1.2	30	76	2.92	31
Dictyota ciliolate				24	0.92	23
EPIFAUNA						
Anthopleura spp.				21	0.81	27
Patella safiana	664	33.2	60			
Cthamalus dentate	2.5	0.125	25			
Nerita atrata	9	0.45	25			
Planaxis lineatus	4	0.2	20			
Fissurella nubecula						
Thais heamastoma	85	4.25	80			
Llittorina cingulifera						
Pagrus sp.						
Siphonaria pectinata	8	0.4	30	73	2.81	23
Cerithium atratum						

Note: Density and frequency of occurrence (F) of rocky shore species from transects at Tema and Aboadze. Density of macro algae are given as percent cover per meter square, and epibenthic fauna as individuals per meter square except for Cthamalus dentate. Only species with > 20% Frequency of Occurrence (F) are presented.

Figure 4.21 20 Meter Belt Transect at Aboadze

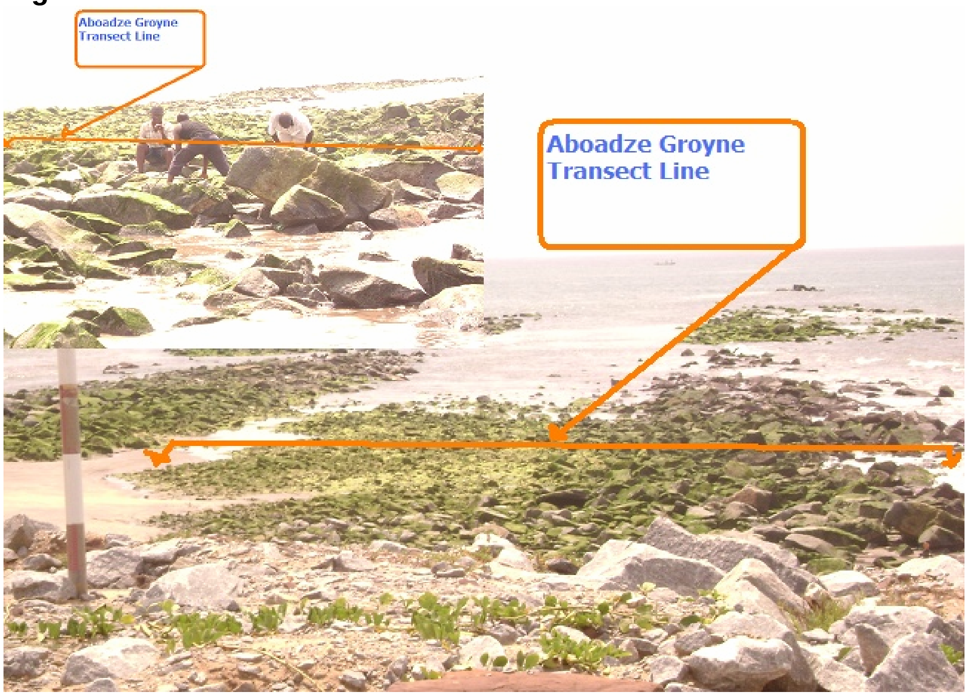
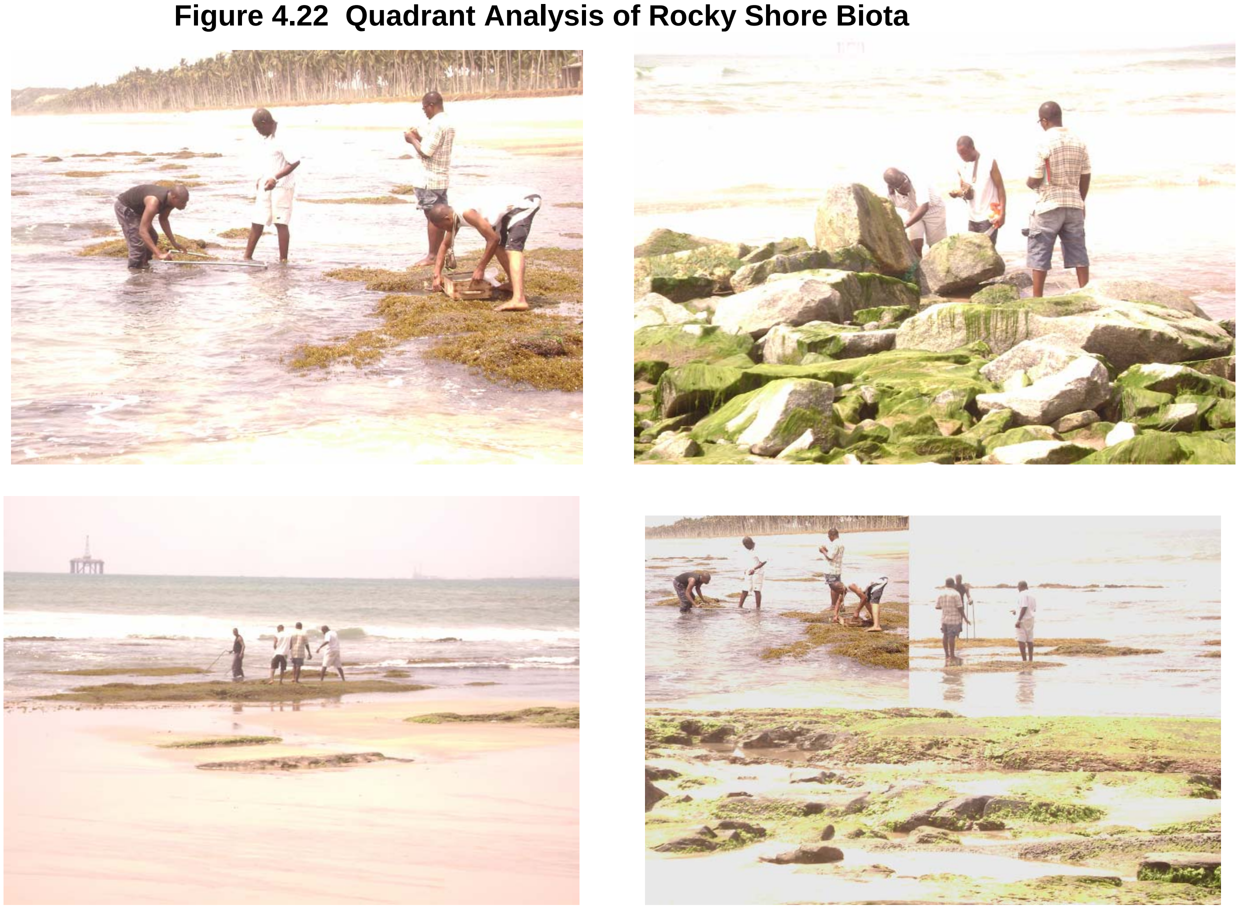


Figure 4.22 Quadrant Analysis of Rocky Shore Biota



Sandy beaches or shores often occur along coastal areas where waves or current actions deposits and reworks sediments. Typically, sandy shores consist of minute grains of sand or crushed shells and rock.

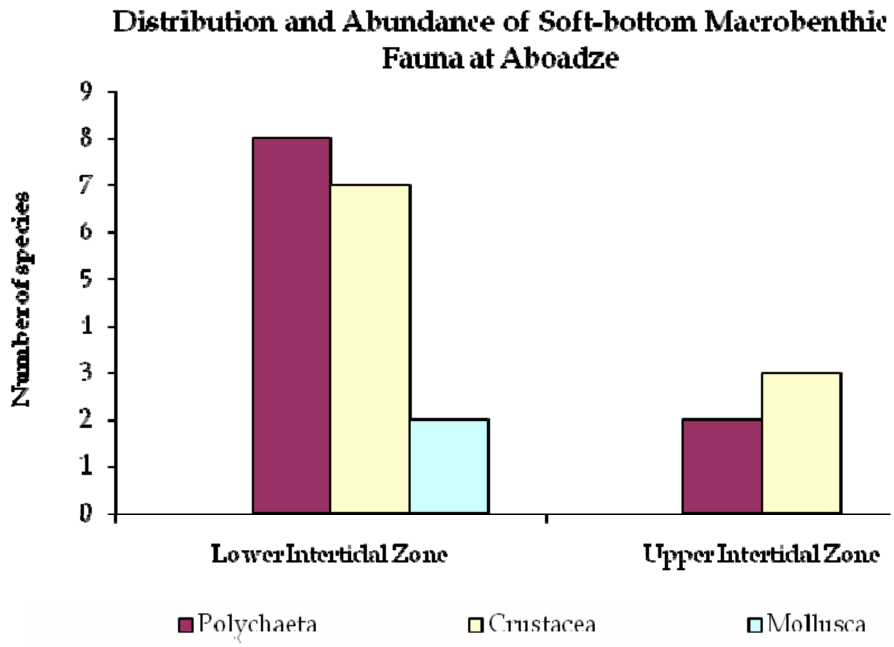
Benthic communities form an important part of the marine ecosystem, providing a food source for other invertebrates, fish, birds and mammals as well as cycling nutrients and materials between the underlying sediments and overlying water column. The benthos comprises diverse species which are relatively long-lived and sedentary, and which exhibit different tolerances to stress, making them useful indicators to assess environmental conditions.

A total of 17 species comprising 8 polychaete species, 7 crustacean species, and 2 molluscan species were identified in the Aboadze sandy beach (Table 4.16). Figure 4.23 shows the distribution and abundance of major fauna groups. The dominant species encountered were the polychaetes and crustacean in the lower intertidal zone. Polychaetes ranked very low in the upper intertidal zone than crustacean. The lowest rank group in the lower intertidal was the mollusc which were virtually absent in the upper intertidal zone. Most of these species have been recorded in other sandy beaches in the coast of Ghana and as such are not unique to Aboadze beach.

Table 4.16 Intertidal Macrobenthic Fauna

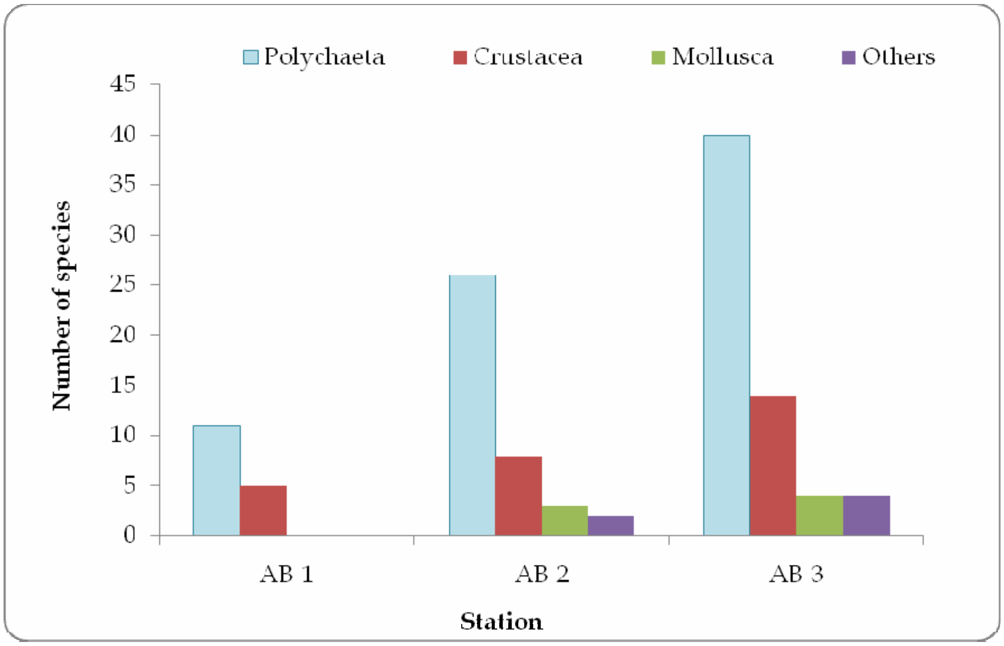
SPECIES	ABOADZE	
	Lower Intertidal Zone	Upper Intertidal Zone
Polychaeta		
Cirriformia afer	+	-
Diopatra monroi	++	-
Eunice vitata	+	-
Eurythoe sp	++	+
Marphysa sanguinea	+	-
Nereis sp.	+++	-
Polydora antennata	+	-
Syllis gracilis	++	+
Crustacea		
Aorid sp.	++	+
Talitrus sp.	-	-
Cirolana spp	+	-
Exocirolana sp.	-	++
Mysid sp.	++	-
Phoxocephalid sp.	+	-
Ocypoda cursor	-	+
Mollusc		
Terebra sp.	+	
Oliva sp.	+	
Abundance range: - = 0, + = 1 – 5, ++ = 6 – 10, +++ = 11 – 15, ++++ = 16 – 20, +++++ = 21+		

Figure 4.23 Distribution and Abundance of Soft-Bottom Macrobenthic Fauna at Aboadze



Most marine ecological studies have indicated that the offshore subtidal macrobenthic fauna are dominated by polychaetes, crustaceans, molluscs, and echinoderms. As expected, polychaetes were the dominant taxa followed by the crustaceans and mollusks in that order (Figure 4.24). The results also indicated that species richness (number of species) of these major taxonomic groups increased with increasing depth water depth. Water depth influences the distribution of other environmental variables that could affect species diversity in general.

Figure 4.24 Distribution of Major Macrobenthic Species off Aboadze Subtidal Environment



The number of species showed strong positive correlations ($p<0.05$) with percent silt, total organic carbon and water depth (Table 4.17), indicating that species richness is influenced by suite of environmental variables.

The common macrobenthic faunal species encountered in the analysis were the polychaete worms, *Glycera unicornis*, *Diopatra neapolitana* and *Prionospio cirrifera*; as well as the crustaceans, *Ischyroceros* sp., *Synchelidium* sp., *Harpinia* sp. and *Tanaids* sp. These species occurred in at least more than one sampling locations.

Table 4.17 Correlation Between Macrobenthic Community and Environmental Variables

Variable	Abundance	No. Species	%Clay	%Silt	%Sand	TOC	Depth
Abundance	1.00						
No.Species	0.55	1.00					
%Clay	0.57	-.038	1.00				
%Silt	0.33	0.97	-.059	1.00			
%Sand	-0.99	-0.40	-0.70	-0.17	1.00		
TOC	0.64	0.99	-0.27	0.94	-0.5	1.00	
Depth	0.58	0.99	-0.34	0.96	-0.44	0.99	1.00

Species abundance showed strong significant correlation with total organic carbon, water depth and clay fraction. Therefore the macrobenthic faunal abundance in the area may a function of sediment grain size (relatively high clay content and moderate sand fractions), as well as water depth and percent organic matter content in the sediment. Clayed sediments usurp the potential to adsorbed organic carbon onto their surfaces.

The majority of the information relating to the fish community in the near-shore and offshore area has been obtained from catch records of the artisanal and commercial fisheries and from Interviews with local fishery officers and recorders.

Generally, major pelagic stocks off shore of the project area include Sardinella species (flat and round sardines) , anchovy, and tuna species, while demersal species include members of the sparidae family (sea breams, pandoras and dentexs) with red pandora (Paqellus bellottic) being the most abundant. Shellfish are primarily present in lagoons, estuaries and the near-shore zone. A breeding/nursery area for shrimp has been identified directly off shore and extending to the west of the proposed project site. In the near-shore zone in front of the proposed project site, no significant fishery resources apparently exist. Fisheries officers indicate that sting ray are the only species caught immediately offshore, while juvenile grey mullet were being fished by one person in the surf zone during a site visit in late June 1993. Sardinella larvae and juveniles are known to come in shore to feed near estuaries and beach zones. The extent of usage of the near-shore zone near the project area by these species is presently unknown.

The Anakware lagoon/estuary and other inland water bodies constitute important sources of fish and shellfish. Although, the fish landings from these water bodies may be comparatively small, they nevertheless provide substantial quantities of fish for subsistence purposes.

The fisheries in the freshwater marshy wetland located west of the thermal plant are not active but the occasional fishing activities are restricted to method of basket fishing. During the rainy periods, the wetland overflows and then establishes connection with the Anakware lagoon/estuary. During this period, the sizeable people engaged in fishing utilizing primarily basket trap and hook and line fishing methods using dugout canoes. The composition of fish species often caught include *Clarias* spp., *Heterobranchus sp.*, *Polypterus* spp. The cichlids include *Tilapia* spp., *Hemichromis* spp., and Tilapia zilli. *Macrobrachium* spp. are also caught. These fish species occur in moderate quantities. However, the dominant species is the black chin tilapia *Sarotherodon melanotheron.*
Due to its openness to the sea, the Anakware lagoon/estuary is used by most marine species as spawning and foraging grounds (owing to high primary

production providing rich food source). The estuarine vegetation also provides refugia for these marine fish species. The dominant fish species are the *Mugil cephalus,* but other species of moderate occurrence comprised of several typical marine fishes.

4.3 Sociocultural Environment

4.3.1 Population and Demographics

The proposed T3 Thermal Power Plant is located on the newly created Shama District, which covers a land area of about 215km^2 and comprises 48 settlements. The population of the district, according to the 2000 Population and Housing Census was 68,642 with 33,683 males and 34,959 females. The estimated population growth rate of the district stands at 3.5% (GSS, 2000), higher than the regional and national growth rates of 3.2% and 2.7% respectively.
Figure 4.25 shows a population density overview of Ghana and Figure 4.26 shows an overview of the population density for the past six years.

Figure 4.25 Ghana Population Density

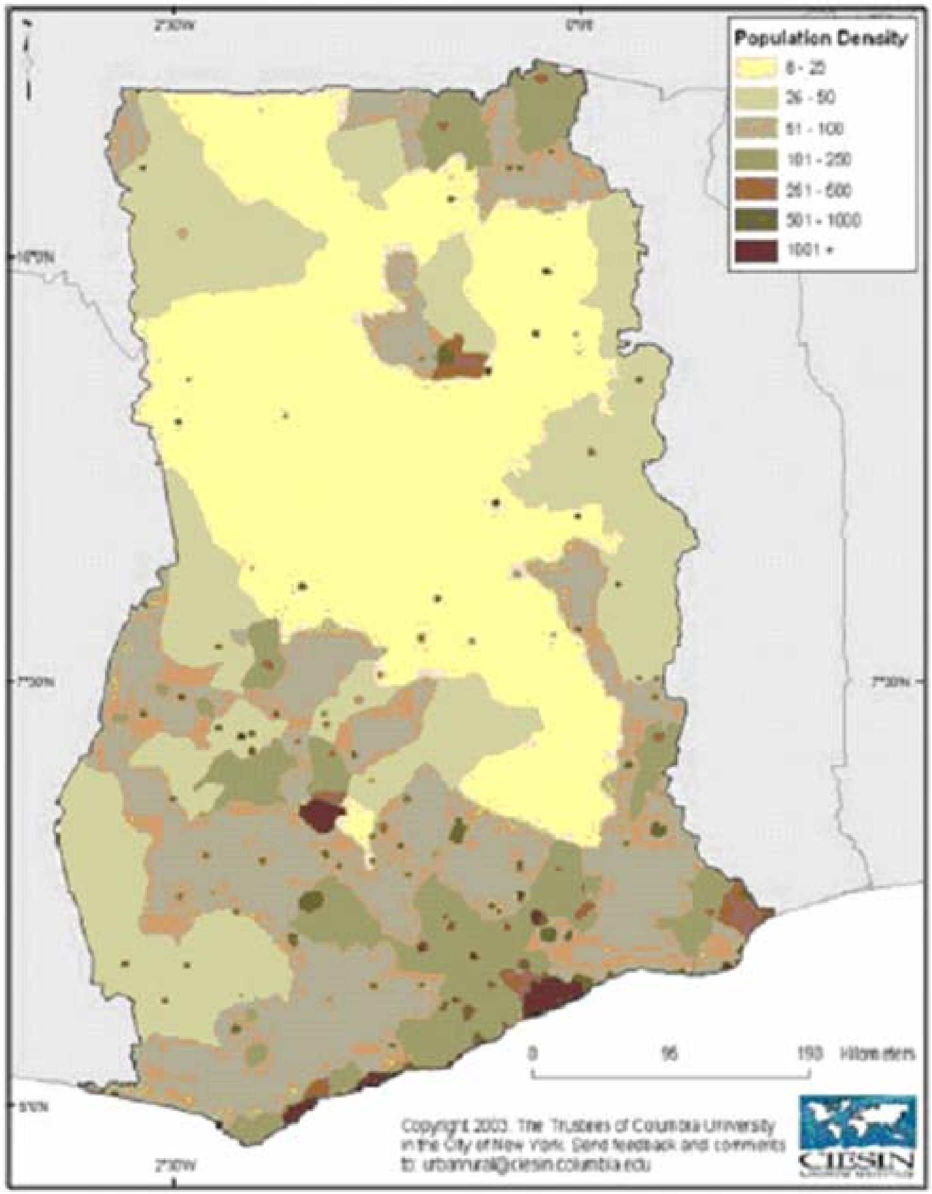
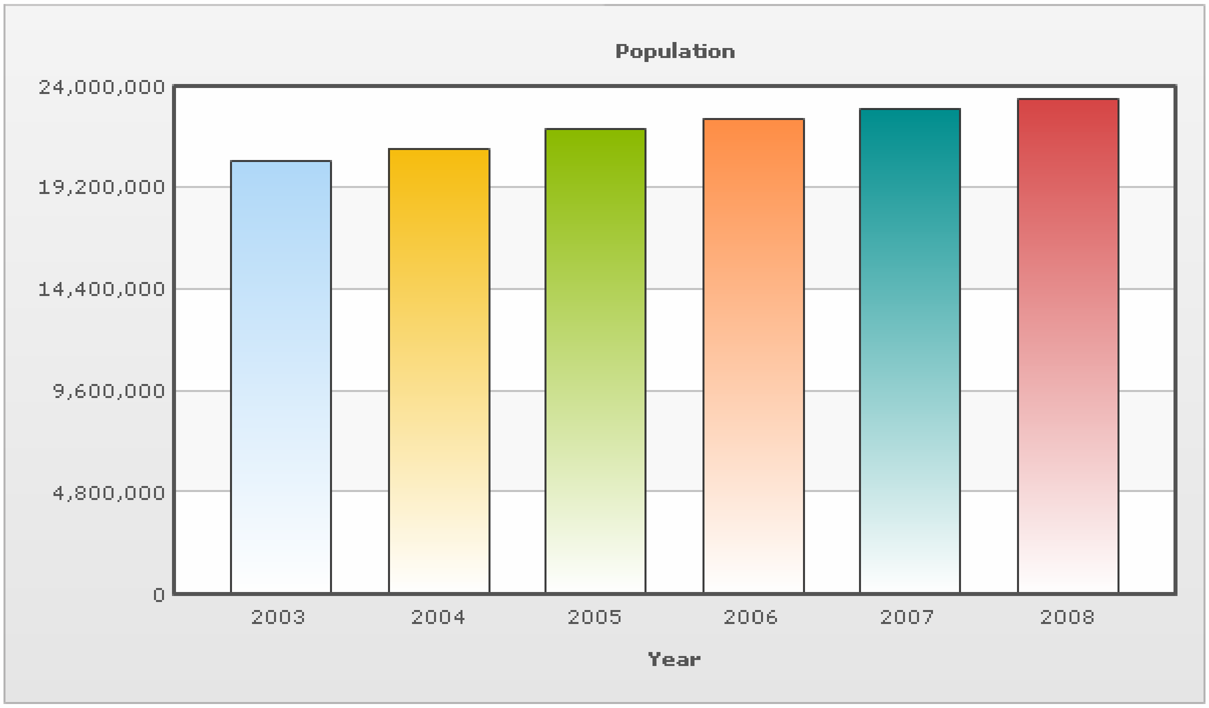


Figure 4.26 Population Density (2003-2008)



**Population density of 101 persons per sq km. (July 2008 est.)*

According to the 2000 population and housing census, the population growth rate of 3.5% and 3.2% for SDA and SAEMA respectively gives a projected population of 419,577 for the year 2004 for the three sub-metros. The high population in Takoradi sub-metro and Sekondi sub-metro is a result of the numerous infrastructures and high economic influence in the twin city and their ability to attract migrants and retain residents.

With a total land area of 215 kilometer square the district is plagued with an increasing trend in population density due to an increasing number of its inhabitants. The population density (i.e., the number of persons per square kilometre) has therefore moved from 319 persons in 2000 to 410 persons in 2008. This makes the district one of the densely populated districts in the region showing an increasing pressure on the land, other available resources and the district economy in general. The urban population covers 32% of the total land area while the rural composition is 68%.

The city of Sekondi-Takoradi, located approximately 25km southwest of the proposed site, is the third largest urban centre in the country having a population of 93,000 in 1984. The previous EIA Reports predicted a small economic growth for the Sekondi-Takoradi area due to its physical constraint and declining economic opportunities. The Statistical Services of Ghana estimated in 1984 that the population growth for that region would be around 3%.

According to the 2000 Census the second largest settlement in the immediate vicinity is Shama, located at the mouth of the Pra River, with a population of approximately 9,855. Immediately to the east of the proposed project location is the village of Aboadze with a population of 9,399 and then 1.5 km east, again, is Aboesi with a population of 9,873. The settlement of Inchaban has a population of 5,486 people. Throughout the area, there are a number of smaller villages with a population of less than 3,000.

Most of the local population lives in village communities although there are smaller, scattered single family units throughout the area.

Table 4.18 Population Size of Selected Towns

Towns	Population	Locality
Shama	9,855	Urban
Abuesi	9,873	Urban
Aboadze	9,399	Urban
Inchaban	5,486	Urban
Supomu Dunkwa	3,540	Urban
Beposo	1,661	Semi Urban

Source: Medium Term Development Plan (SAEMA)

Table 4.19 Population Statistics

Region	Area (Sq Km)	Population	Density	Growth Rate (%)
Western	23,921	1,924,577	80.5	3.2
Central	9,826	1,593,823	162.2	2.1
Greater Accra	3,245	2,905,726	895.5	4.4
Volta	20,570	1,635,421	109	1.4
Eastern	19,323	2,106,696	79.5	1.9
Ashanti	24,389	3,612,950	148.1	3.4
Brong Ahafo	39,557	1,815,408	45.9	2.5
Northern	70,384	1,820,806	25.9	2.8
Upper East	8,842	920,089	104.1	1.1
Upper West	18,476	576,583	31.2	1.7
Total Country	**238,533**	**18,912,079**	**79.3**	**2.7**

Source: 2000 Population and Housing Census, GSS

Currently, the estimated population of the Shama District is 88,314, comprising 43,436 males (49.1%) and 44,978 females (51.9%). The high proportion of females is evident from intense involvement of women in trading in the district. Inadequate family planning services in the district is a major contributor to the high growth rate and population of the district (see Table 4.20) to address this issue, the new assembly in collaboration with the District Directorate of Ghana Health Service is in the process of developing measures to control the population growth and to avoid enormous strain on the district economy.

Table 4.20 2000 Census Summary

Area	Male	Female	Total
Takoradi Sub – Metro	86,794	88,642	175,436
Sekondi Sub – Metro	56,697	57,460	114,157
Shama Sub – Metro	39,278	40,295	79,573
Total	**182,769**	**186,397**	**369,166**

Source: Ghana Statistical Service, 2000

In the entire Western Region there was a slightly higher male population to female (50.6% compared to 49.4%) in 1984. For the study area, however, it was only in Takoradi that males outnumbered females. Also, 45% of the total Western Region population was under the age of 15 in 1984 and less than 10% were in the 'over 50' age category. In the Shama Local Authority approximately 40% of the households consisted of more than 4 people with 27% having 6 or more members.

The population structure of the district shows a broad base pyramid that tapers to the top indicating a concentration of growth at the base, as presented in Table 4.21 below.

Table 4.21 Population Structure

Age Group	Percent
0-14	44.8
15-64	51.9
≥ 65	3.3

Source: Ghana Statistical Service, 2000

The table shows a high concentration of the population within the economically inactive group (48.1%). This is typical of age structure in the developing economies where there is often too much demand on the National and Local structure to provide services consumed by children and the aged. As a result the district has a high dependency ratio i.e., the ratio of the non productive or economically inactive persons (persons between 0 – 14 and above 65 years) to the productive or economically active persons (persons of age 15 to 64). The dependency ratio of the district is 115.8 dependants to 100 economically active persons. This is higher than the regional dependency ratio of 88.3%. The actual burden on the economically active in the districts that are predominantly unskilled is extremely serious and this has led to the low standard of living of the people in the district.

Generally, as age increases the population for both sexes decreases. However, the slightly high economic active population constitutes a potential source of labor and employment for the emerging industries such as Quarries and Oil. The urban population constitutes about 55.6%t of the total population of the district. Urban centers include densely populated areas such as Shama, Abuesi, Aboadze, Inchaban and Supomu Dunkwa. Communities such as Beposo, Komfoeku, and Shama junction with populations below 2,000 each constitute the semi-urban communities of the district. The district has only 48 settlements which are mostly concentrated in the urban parts of the district and the numerous rural centers. Fertility rate in the district is 3.1 percent, which is lower than that of the national rate of 4.0. Thus on the average there are 3 children per woman in the district. About a third of the population lives in houses owned privately by other individuals (renting) while another third live in their own houses. The number of households per house is 2.4 and this is greater than the regional value of 1.6.

Migratory pattern in the district has basically been internal. This pattern has greatly been influenced by the predominance of agriculture, the extended family system and lack of education in the district, among others. Majority of the population are indigenes or non migrants. Majority of the migrants in the region either moved from other regions (28.3%) or were born in another locality (10.0%) in the region. The in-migrants to the region are mostly from the Central (7.2%) and Ashanti (5.1%) regions.

4.3.2 Ethnic, Religious and Cultural Background

4.3.2.1 Ethnic Groups

The ethnic groups represented include Fantes, Elmina, Ekumfi, Komenda and Sekondi. The population of Aboadze is predominantly Fantes who have migrated from the surrounding areas. They account for 86.49% of the population whiles settlers' accounts for about 13.51% of the population. The official language of the people of this district is English: but the common local dialects are Ahanta and Fante.

Historic data indicates that the village used to be ruled by a council of seven elders from different groups. This system was replaced by the Apofohene (chief fisherman), given the importance and recognition given to their primary economic source, fishery.

4.3.2.2 Religious and Cultural Groups

In terms of religion, the district harbors different shades of groups (with Christianity accounting for 78.6%) but there is religious tolerance and peaceful co-existence among the various groups in the district. It is believed that the first Methodist Church in the village was established by Albert Nkrumah, a Fante from Ekumfi, who settled at Aboadze in the 18th Century (as a fisherman).

The churches include among others Presbyterian, Baptist, Holy Fire Chapel,The Truth Tabernacle, Catholic, Jehovah Witness Kingdom hall. There are also two mosques. The closest churches to TTPP are the Truth Tabernacle Church and the Wall of Fire Church located about 500m east of the proposed site.

Fetishes were the only known forms of worship before the establishment of the first churches. Currently, the elders of the village recognize two main fetish shrines in the community - Burburase Shrine, Kwekudonsuro Shrine - and libations are poured at these spots in August during the annual Apaatwa festival of the people of Dwomo. An old catholic cemetery, which is no longer in use, can also be located in Aboadze whilst other cemeteries by the Methodist Church etc, have been relocated about 3 km away from town.

The Shama Traditional Council, which comprises three divisions, coordinates all activities of the traditional authorities in the district. The Council meets regularly to discuss issues affecting the development of the various communities. Council meetings are also used to settle chieftaincy disputes among the various families. The traditional councils thus serve as alternative source of settling disputes and a focal point for initiation and implementation of development projects. The paramount Chief of Shama traditional area is Nana Kweku Binah II.

The colourful Nye-yi Pra festival is one festival which many people will love to witness in the district. It is celebrated from September to November annually. The festival is a major source of tourist attraction and can serve as a major source of revenue generation for the district if properly looked at.

4.3.3 Historical Resources

The area of the proposed development was initially settled by the Akan speaking people with the study area falling under the jurisdiction of the Ahanta tribe. Sekondi-Takoradi, also know as Shama Ahanta East Metropolitan Assembly (SAEMA), like most coastal towns of Ghana, has had a long association with the

Europeans. From the 15th century onwards, the Ahanta area, which covers the metropolis and the entire southeastern part of the Western region, was a scene of intense trade with Europeans. The main trade commodity was gold. At the beginning of the 20th century, a wharf was built at Sekondi to mark a significant industrial and commercial leap in the area. The area became known as European Town. A new and modern harbor was built at Takoradi in 1928 and it became the most important port in the country until the development of Tema.

To protect their interests, the Europeans constructed 76 forts along the Ghana coast under the ownership of the British, Dutch, Danes and Portuguese. The nearest fort to the proposed site (Fort San Sebastian) is at Shama on the Pra estuary. The landowners of Aboadze are said to have migrated southward on hunting expeditions and settled at the village of Dwomo, 2.5 km off the main Accra-Takoradi road in Inchaban. Aboadze started as a hamlet with the name Akuraban (meaning hamlet) and was predominantly settled by migrant fishermen.

It is noted in section 3.3.2 of the 1999 SEIS that, based on available information, there were no sites of archaeological/historical significance in the TTPP site and surrounding area. It is also understood that no material of archaeological or historical interest was encountered during the construction of T1 and T2 (including in the borrow areas).

4.3.4 Aesthetics and Tourism

The coastal area of Ghana offers varied opportunities for tourism and holds significant potentials. The major assets are the broad beaches and cliffs, the coastal lagoons and estuaries having a rich birdlife, historical monuments (forts, castles, lighthouses, etc.) and cultural activities. Table 4.22 below provides data on the revenue brought into Ghana by international tourism.

Aboadze is a relatively undeveloped, rural fishing community, with a sizeable number of children. The shoreline in the village and the near-shore area is almost completely taken up by canoes. It would appear to be a very lively, close-knit community.

Table 4.22 Ghana International Tourist Arrivals and Receipts

Year	Arrivals	Receipts (US$ M)
1995	286,000	233.2
1996	304,860	248.8
1997	325,435	265.59
1998	347,925	283.96
1999	372,653	304.12
2000	399,000	386
2001	439,833	447.83
2002	482,643	519.57
2003	530,827	602.8

Source: Ghana Tourist Board

The coconut palm plantings along the beach ridge combined with the shore line provide for a very pleasant atmosphere around the site area.

A significant feature of the Ghanaian coast is the presence of historical monuments with three of them, at Cape Coast and Elmina, designated as World Heritage sites by UNESCO. These sites are significant for tourism because of their rich and diverse history. Overall, there are about 40 forts and castles dotted along the entire coast, with 24 of them designated as structures of historical importance. These forts and castles contribute financially both to national and local economies because of the attraction it presents to both local and foreign tourists. The castle at Shama is considered to be a very important tourist point, while the fishing villages themselves may draw a limited number of tourists.

Fort Orange (Sekondi)

Shama Fort

There is a growing number and patronage of beach resorts in Ghana both on public holidays, special occasions and weekends. There were 18 beach resorts in the country in 1996 with majority in the Greater Accra, Central and Western

Regions. The high patronage of beaches has its attendant littering and pollution of beaches and nearshore waters (Nunoo & Quayson, 2003; Anon. 2004).

Tourism for the country is the fourth largest source of foreign exchange earnings and it contributes to approximately 5% of the country's GDP (GTB, 2006).

The Shama Ahanta District can boast of some unique tourist features which require further development. This includes Fort Sebastian with the tomb of the ancient first black philosopher Amo, the estuary of River Pra at Shama and the colorful Nye-yi Pra festival which is celebrated in November annually.

4.3.5 Infrastructure

The district is endowed with various infrastructures (social, physical and others) including clinics, schools (nursery, primary, JHS and SHS), health center, pharmacy, chemical shops, boreholes, KVIP, electricity, telephone, rural bank, police station, market and small industries.

The Aboadze township located east of the plant has a number of schools, churches and other amenities.

There are both private and government schools at the primary and Junior High level. These include Roman Catholic Primary and Junior High School, Islamic Primary and Junior High Schools, Abuesi/Aboadze Junior High School, God's Grace Elite School, which has a daycare, kindergarten and primary divisions and VRA International School.The closest school is the God's Grace Elite School also located to the east and at about 500m.

The VRA Township is located at about 860m north of the plant. The township houses the senior staff members of the company. The township also has a club house and football field. The VRA International School is also within the confines of the township. The township is well structured with sealed road networks and beautiful lawns.

There is also a Community library, a newly built market, a community cold storage facility built by VRA and a Rural Bank. A VRA clinic serves the needs of the company workers as well as that of the community. The VRA also has an air quality monitoring facility within the Aboadze township which is located at about 750m from plant.There is also a telephone mast located to the north east on the highest point with an area of about 32m above sea level.

A 150-mm waterline from the Ghanaian Water and Sewage Corporation water treatment plant at Inchaban provides potable water to 65% of the Aboadze and Aboesi. The TTPP water supply is provided by a dedicated 6" raw water line from the Municipal Water District. The Anankwari River at Inchaban is the major source of supply of piped water in the district. The waterline is located beside the Aboadze-inchaban road. The water supply has been described as erratic at times according to the Volta River Authority.

Cellular phone network service covers the entire district. Their services are provided by four cellular network firms currently operating in the district. The major networks with coverage in the district include Kasapa, Vodafone (formerly Onetouch), Tigo and MTN (formerly Areeba). Certain urban communities also enjoy fixed line services from mainly Ghana Telecom (now Vodafone). The communities include Shama, Aboadze, Inchaban, and Abuaesi.

Postal services are also available at Shama and Inchaban. The ratio of telephones per population is lower than the regional average of 1:148. Teledensity in the region is 0.3 telephones per 100 persons, which is below the national average of 0.7. This is however the third highest in the country, an indication of the extremely low teledensity in the country as a whole. Greater Accra has the highest teledensity of 3.2 telephones per 100 persons. The district has three rural banks in Shama, Beposo and Aboadze.

The Takoradi Accra highway, the main highway leading from the ports, passes through Inchaban 5 km northwest of the proposed site. Roads in the district have seen little upliftment in the last decade. An area such as Awuna Beach has been linked to the main Cape coast road. The asphalted road stretching from Sekondi to Cape coast passes through the district. Komefoeku and Assakae roads have been developed. Majority of the roads in the district are in fair condition and others in poor condition. Feeder roads in the food production centers are badly serviced and this affects the marketing of farm produce leading to high post harvest losses. The country's main 161-kV transmission line is also in the same vicinity.

The Aboadze Thermal Plant can be accessed by two main routes, which, include;

- 4km sealed/asphalted road off Accra-Takoradi highway at Inchaban. This road lies to the north of the plant and;
- 9.6km road off Accra-Takoradi highway at Shama Junction. The said road passes through Shama, Abuesi and Aboadze and to the plant. The road is made up of a sealed portion of 3km from Shama Junction to Shama, 2.8km dirt/unsealed road from Shama to Abuesi and 3.6km from Abuesi to Aboadze and the plant. The Shama-Aboadze road lies to the east of the plant.

The hospitality industry in the district is up and running. Most of the facilities in the industry are located in the urban centers of the district. Hospitality facilities at Shama include: D&A Guest House, Aboesi Beach Resort, Hotel Applause, and Joggin Hotel.

Two of the country's major ports are located at Takoradi and Sekondi, southwest of TTPP. Both harbors are protected by breakwaters. Takoradi can accommodate ocean going vessels with drafts up to 10 - 11 m. While Sekondi's Harbour has only a 5- 1o 6-m draft, Sekondi is used exclusively by the navy, whereas, Takoradi is used for commercial vessels. However, the area immediately offshore from the TTPP is not used as a shipping route or anchorage for the ports.

The Sekondi-Takoradi metropolitan area has an airport.

Aboadze is supplied with electricity. Aboadze has a police station, headed by an Inspector of Police and the crime rate is low.

There are no waste disposal sites near the proposed site and both domestic refuse and human excreta are discharged directly into the sea.

Under the T1 Community Impact Agreement, infrastructure improvements have been carried out to, for example, limit dust generation by construction vehicles on the local road network. Additionally, reconstruction of the local road network, a cold storage facility, a planning layout for Aboadze and Aboesi, the reconstruction of five school blocks, the construction of public places of convenience and a clinic were being provided under this agreement.

On the basis of informal discussions undertaken for this Addendum with site personnel and members of Aboadze community and Shama Ahanta District Assembly, it is understood that there has been a general growth in the size of the immediate communities since the development of T1. This has largely been in response to the presence of direct employment at T1 (during its construction and operation) and in association with opportunities to generate an income providing support and services to the T1 (and now T2) workforce. Most notably a small food market of approximately 25 people working at 20 stalls was established adjacent to the T2 construction laydown area, providing food and drink to the local workers.

Other projects were proposed and developed during the construction of T1 and T2 and an updated status for those projects will be provided on the final EIA report. Among these community improvements provided by T1/T2 are:

- Construction of four schools in Aboadze and one school in Abuesi;

- Road improvements between Inchaban – Dwomo and Inchaban – Aboadze – Abuesi (a total of approximately 5 km) are complete Construction of the four schools in Aboadze and one school in Abuesi.
- The completion of an 80-ton capacity cold storage facility at Aboadze was completed and commissioned in November 2000.
- A health clinic have been constructed – the clinic now serves both the Aboadze community and the TTPP township.

In an effort to maintain the VRA's continuing effort to the local community and improvements to Aboadze infrastructure, T3 construction budget contains a provision that will allow for the construction of a playground for the Abodze complex of schools and may be increased to possibly provide for new facilities for Aboadze.

Figure 4.27 gives an overview of the main infrastructures around the Takoradi Thermal Plant.

Figure 4.27 Aerial Map of TTPP

4.3.6 Education

The District has three educational circuits managing 54 pre-schools, 57 primary schools, 39 junior high schools and 2 senior high schools. Class enrolment ranges from 46 to 50. For higher education, facilities are located In Sekondi-Takoradi. The closest university is located at Cape Coast. One primary school is located approximately 350 m to the east of the proposed plant perimeter, while the other two schools are approximately 500 m to the north-east (Figure 4.28).

Figure 4.28 Aboadze Primary School

The educational sector is plagued with very low educational standard. The poor standard stemmed from variety of factors. These include inadequate classroom blocks, furniture and other learning materials. Inadequate trained teachers have also been identified as one of the numerous factors. In view of that, the district has been experiencing poor academic performance at the BECE examination over the years.

Access to education at the various levels is very low compared with the regional and national figures. These are however projections from SAEMA which are been used for SDA. Accessibility to primary schools in both the rural and urban localities of the district is fairly good. 20 per cent of the localities have primary schools within less than a kilometer. The average pupil to teacher ratio for the primary school in the region is about 1:33, the same as the national average. The situation is not different from that of the district. The region also records a net primary school enrolment rate of 74.9 per cent, which is higher than the national rate (69.9 per cent). The district has a higher female net primary school enrolment rates than their male counterparts. Most primary school children in the region (85.3 per cent) take less than 30 minutes to reach the nearest school, about the same proportion as the national average (85.4 per cent).

The number of primary schools in the district far outnumbers the junior high schools. This is an indication of high drop out of school after primary school. 40 per cent of communities have JHS within them; and an additional 40 per cent of localities have JHS within 1-5 kilometers. Enrolment in junior high schools in the district is generally low compared to primary resulting to a low pupil to teacher ratio.

With only 2 senior high schools, access to senior high school in the district is very poor compared to the primary and JHS. Many children, particularly those from the rural areas, are therefore unable to have access to senior high education in the district because of both distance and affordability. There is a further drop out of school after JHS due limited number of schools available.

The Assembly has therefore decided to improve the situation by allocating substantial amount in its annual budget to address the situation.
Recent statistic data shows that 62% of the total population had attended or were presently attending school, consisting of 73% males and 51% females. Almost 70% of those that attended completed middle school. The adult literacy rate for Western Region is 56.5 per cent, which is higher than the national average (53.4 per cent). The rate ranges from 42.1 per cent in Juabeso/Bia to 72.7 per cent in Shama/Ahanta East Metropolitan Area. Only two districts (Shama/Ahanta East Metropolitan Area and Wassa West (62.2 per cent)) have adult literacy rates above the regional average. There are marked differences between males and females, with males being more literate and Jomoro District recording the widest gap of about 37.6 per cent. Table 4.23 below shows recent school enrollment data for Ghana.

Table 4.23 School Enrollment

Level/Type	1999/2000		2000/2001		2001/2002		2002/2003		2002/2003		2002/2003	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Pre-School	63,740	62,086	65,134	62,449	355,385	346,919	389,299	379,519	413,034	404,643	480,216	468,434
Public	23,714	23,469	26,368	25,828	230,778	226,819	260,706	256,028	262,019	257,938	276,214	271,736
Private	40,026	38,617	38,766	36,621	124,607	120,100	128,593	123,491	151,015	146,705	204,002	196,698
Kindergarten	276,411	270,605	263,398	258,686					320,939	316,176	369,019	362,312
Public	204,565	201,933	192,789	190,638					227,953	225,608	242,592	239,659
Private	71,846	68,672	70,609	68,048					92,986	90,568	126,427	122,653
Primary	1,352,992	1,207,888	1,302,405	1,175,252	1,359,150	1,227,284	1,323,320	1,200,917	1,403,913	1,282,220	1,525,548	1,403,988
Public	1,123,394	991,587	1,081,569	966,327	1,116,801	996,948	1,116,691	1,004,748	1,153,228	1,043,546	1,217,099	1,111,225
Private	229,598	216,301	220,836	208,925	242,349	230,336	206,629	196,169	250,685	238,674	308,449	292,763
Junior Secondary	455,154	377,865	437,006	367,239	468,514	397,122	468,923	396,285	498,686	420,548	548,156	462,090
Public	405,486	330,765	382,918	316,649	404,860	337,035	404,906	335,847	423,943	350,039	450,597	371,608
Private	49,668	47,100	54,088	50,590	63,654	60,087	64,017	60,438	74,743	70,509	97,559	90,482

The Youth literacy rates in all the districts in the region are higher than the adult literacy rates. The rate for the region is 72.6 per cent, which is higher than the national average (68.7 per cent). Four out of the eleven districts (Jomoro, Shama/Ahanta East, Wassa West and Wassa Amenfi) have higher youth literacy rates than the regional average. Shama/Ahanta East records the highest literacy rate (84.3 per cent) and Juabeso/Bia the lowest (56.4 per cent). Also, among the youth, at the regional and district levels, males are more literate than females with lower sex differentials than among the adults.

As part of the Volta River continuing effort to support the local community, part of T3 budget will provide scholarship for local students.

4.3.7 Land Tenure and Land Ownership

Land tenure in Ghana is widely communal in nature, and this dictates the pattern of land administration. The 1992 constitution recognizes land ownership under three groups--public land, private lands and stool lands of which the latter also includes family lands.

In the Aboadze area the land is termed “Stool Lands” and comes under the control of the Paramount Chief but the right of use lies with the families who are direct beneficiaries of any returns from the land. The Dwomo Stool (the Stool with custody of land in the vicinity of Aboadze) resides in Dwomo, 3 km from the Takoradi-Accra highway to the north of Inchaban.

The inhabitants of Aboadze are migrant fishermen who have no legal ownership rights to the land. The Stool is the custodian of the land and as such can release land for projects of community or national interest such as this project. They can also reassign land for example making land available to compensate displaced farmers.

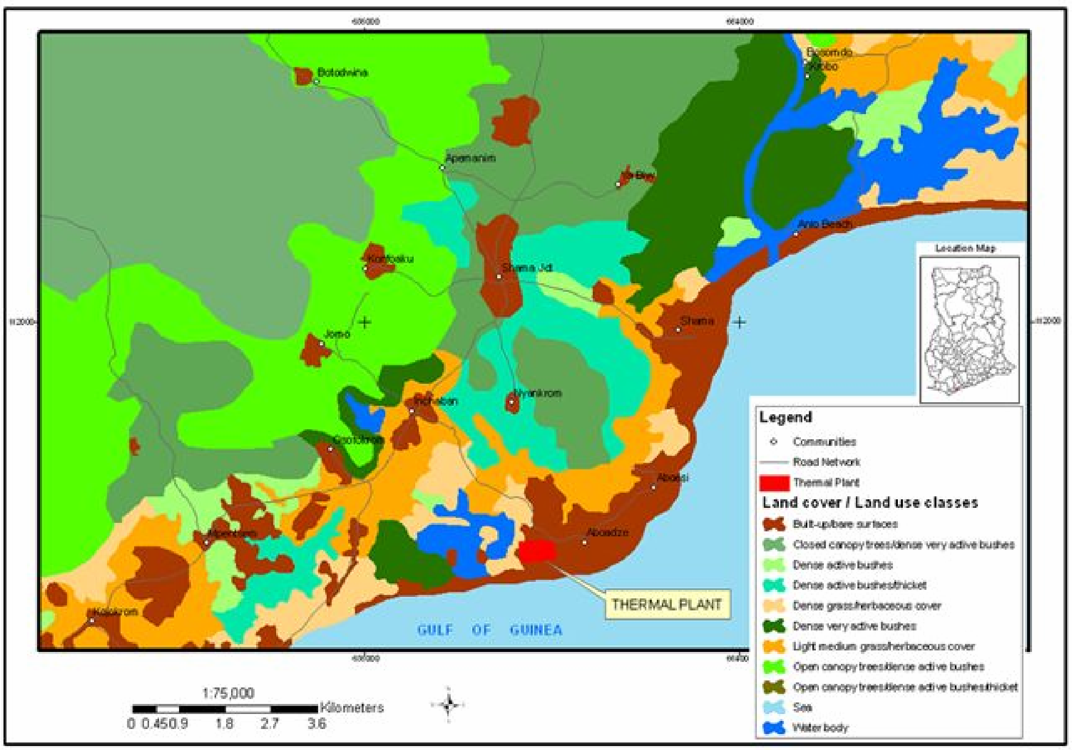
By the State Lands Act, Act 125, 1962, the central government or delegated authorities, wield sweeping powers with regard to compulsory acquisition (expropriation) and compensation of land holdings for purposes in the interest of the general public. Payment of prompt and lair compensation for those affected by such acquisitions is guaranteed by the constitution. Under the Volta River Development Act (amended), the Authority is empowered to acquire land compulsorily for their operations, using the State Lands Act.

Such method was used to obtain the land for T1 and T2, and in turn T3 which is accommodated within the land already acquired and occupied by TTPP. Consequently there will be no land acquisition of reassignment needed for the development of T3. TTPP lies south of the land owned by VRA and T3 in turn lies northeast of T1 and T2 (Figure 3.3).

4.3.8 Land Use

The regional area exhibits a range of land uses from intense urbanization in the Sekondi-Takoradi area to well established plantations of coconut and oil palm, to areas of native forests and savannas further to the north.
Figure 4.29 shows a general overview of the land use in Ghana.

Figure 4.29 Land Use Map of Ghana



Within the Shama Ahanta East District, about 45% of the land area is suitable for agricultural production (17 700 ha), with approximately 30% of that area (=6000 ha) currently under cultivation. The remainder is native forest, swamp/wetland and areas of urban development.

Small farm plots and plantations of certain types of fruits and vegetables are found throughout the vicinities of T3.

Coconut palms have been planted along the beach ridge and on the high knolls on either side of the Aboadze-Inchaban road, and farm plots are also found among heavily wooded area around the town site.

A few dwellings, with garden plots, are located 200 to 300 m east of the proposed plant boundary and a cemetery is found on a knoll north of the road. Adjacent to the cemetery is an area where sand has been extracted. The Aboadze town site is located 500 m from the eastern boundary of the proposed plant site. The town is typified by closely spaced houses that extend down to the shoreline.

A small settlement is present on the beach ridge approximately 500 m beyond the western site boundary.

4.3.9 Fisheries

The Fisheries sector is estimated to contribute about 3% of the nation's gross domestic product (GDP) and 5% of the Agriculture GDP. These figures, however, are an underestimation. Fish is the preferred and cheapest source of animal protein and about 75% of total annual production of fish is consumed locally. The per capita consumption of fish was estimated at about 27 kg per annum; representing 60% of animal protein intake by the Ghanaian populace.

As an economic policy, the Government of Ghana allows exportation of fish. Since the launching of the Ghana Economic Recovery Program in 1984, fish is now the country's most important non-traditional export. In 2004, about 50,000 MT of fish and fishery products were exported, earning about US$123 million (Ghana Export Promotion Council, 2005). This amount represents about 3.5% of the country's total export earnings. It has been estimated that the fisheries resources in Ghanaian water bodies supports the livelihoods of a total of 500,000 fishers, fish processors (including fish canneries and cold stores), traders and boat builders, who together support twice as many dependants.

Local fish production has never been enough to meet local demand. Importation of fish is, therefore, allowed to supplement local production. However, as a policy, fish imports are allowed only during the lean fishing season. The policy aims at ensuring a stable and good price of locally produced fish during the major and minor fishing seasons. The fisheries sector supports other industries of the economy. About 40,000 MT of fish waste is used in the manufacture of poultry and livestock products annually.

As expected, subsistence and commercial fishing is a significant activity along the coast of the Shama Ahanta East Metropolitan Assembly (SAEMA). The coastal fishery is exploited by four fleets: the artisanal or canoe fleet, the semi- industrial fleet, and the industrial fleet, and the tuna fleet. Most of the commercial marine fishing of these fleets takes place within the Ghanaian 200 miles Exclusive Economic Zones (EEZ).

Around 70% of total marine production for Ghana is from traditional artisanal inshore fishery. Data gathered by SAEMA indicates that fish production within their district is 16,692 tonnes per year which accounts for around 36% of the Western Region's fish production. The SAEMA District has about 1,086 active fishing canoes with about 73.2% of them being motorized.

Shama has about 46.4% of the total canoes and 36.1% of the total fishermen; Abuasi has 14.3% canoes and 27.0% fishermen; Aboadze has 14.3% canoes and 20.1% fishermen. The types of fishing practiced in the District consist of purse seine and beach seine. The gears employed are the Nifa ‐ nifa, seine net, lobster net, set net, Ali net and the drift net. The dominant gears in the area are the seine nets, the set nets, Nifa ‐ nifa and the Ali net.

The semi-industrial (in shore) fleet consists of locally built trawlers and purse seiners of varying lengths. These boats also generally operate in the coastal zone as well.

The industrial fleet (distant water vessels) consists of trawlers generally >35 m in length. In 1986, there were 24 vessels in the industrial fleet. With implementation of the 200 nautical mile economic exclusion zone, most of these vessels only operate in Ghanaian waters.

Nationally, the semi-industrial fleet landed from 15 000 to 22 000 tons of fish per year between 1981 and 1986. The principal species included in the catch were considerably similar to those of the artisanal fleet. The most productive fishing occurs during the major upwelling in July to September and to a lesser extent during the minor upwelling in January and February.

Aboadze, Shama and Aboesi are all very active fishing villages. Agyepong et al, (1990) estimated that the village of Aboesi, 1.5 km to the east of Aboadze contained 825 fishermen.

Fisheries Department officials estimated that there are approximately 1000 fishermen in Shama. There are no direct estimates available for number of fishermen in Aboesi, however, it was estimated that there are approximately one-third as many boats as in Aboadze, this would then suggest 250 - 350 fishermen. Within the project area, records of landings (by species) are available for the Shama Ahanta East District, as well as for the three fishing villages (Shama, Aboesi and Aboadze) closest to the proposed site. This information is summarized in Table 4.24. The artisanal fisheries In Shama, Aboadze and Aboesi contribute between 25 and 50% of the District's landings.

Table 4.24 Fish Landings in Shama, Aboesi and Aboadze Area (in metric tons)

Year	Shama	Abuesi	Aboadze	Total
1989	1690	1290	965	4205
1990	2895	1960	1770	6625
1991	2003	1945	1490	5438
1992	2500	2156	1893	6649

Updated data for monthly fish landings of the industrial fishing fleets of the SAEMA fishing industry from 2006-2008 are presented in Figure 4.30. The highest peak of catch was reported in June 2008 (i.e., 8972.20 metric tonnes), and also between August to October coinciding with the upwelling periods in the country. Two upwelling seasons (major and minor) occur annually in Ghanaian coastal waters. The major upwelling is said to have started when sea surface temperatures (SST) fall below 25°C and usually occurs between late June or early July and late September or early October. The minor upwelling occurs either in December, January or February and rarely lasts for more than three weeks. During the upwelling periods, biological activity is increased due to greater concentrations of nutrients in the water column that have been drawn up from deeper waters.

The annual total fish landings ranked highest for the year 2007 (Figure 4.31) with both 2006 and 2008 depicting relatively similar numbers.

Figure 4.30 Monthly Catches of Fish Landings (2006-2008)

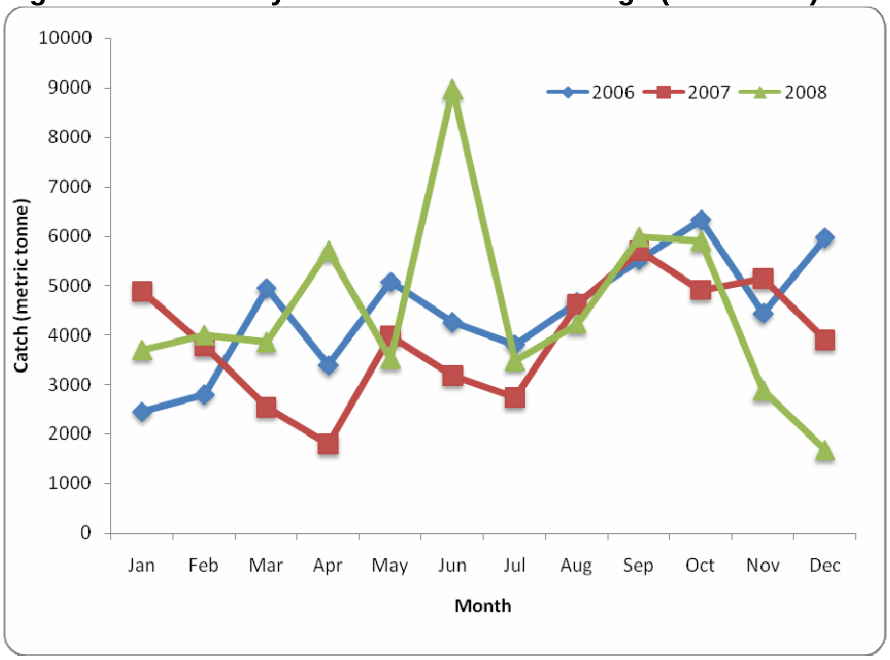
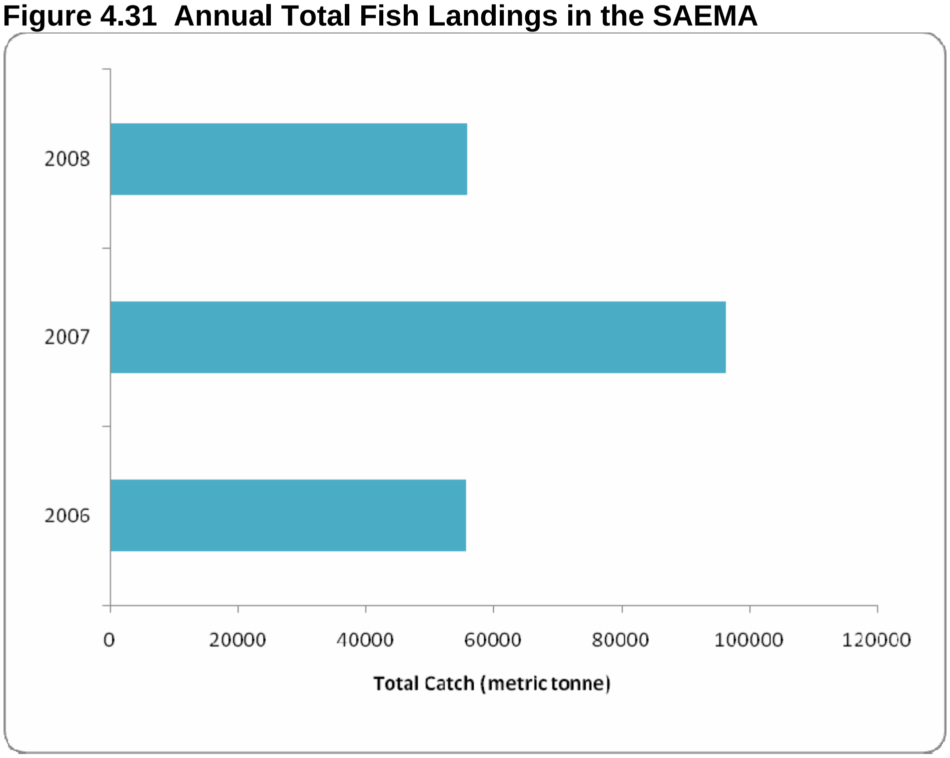
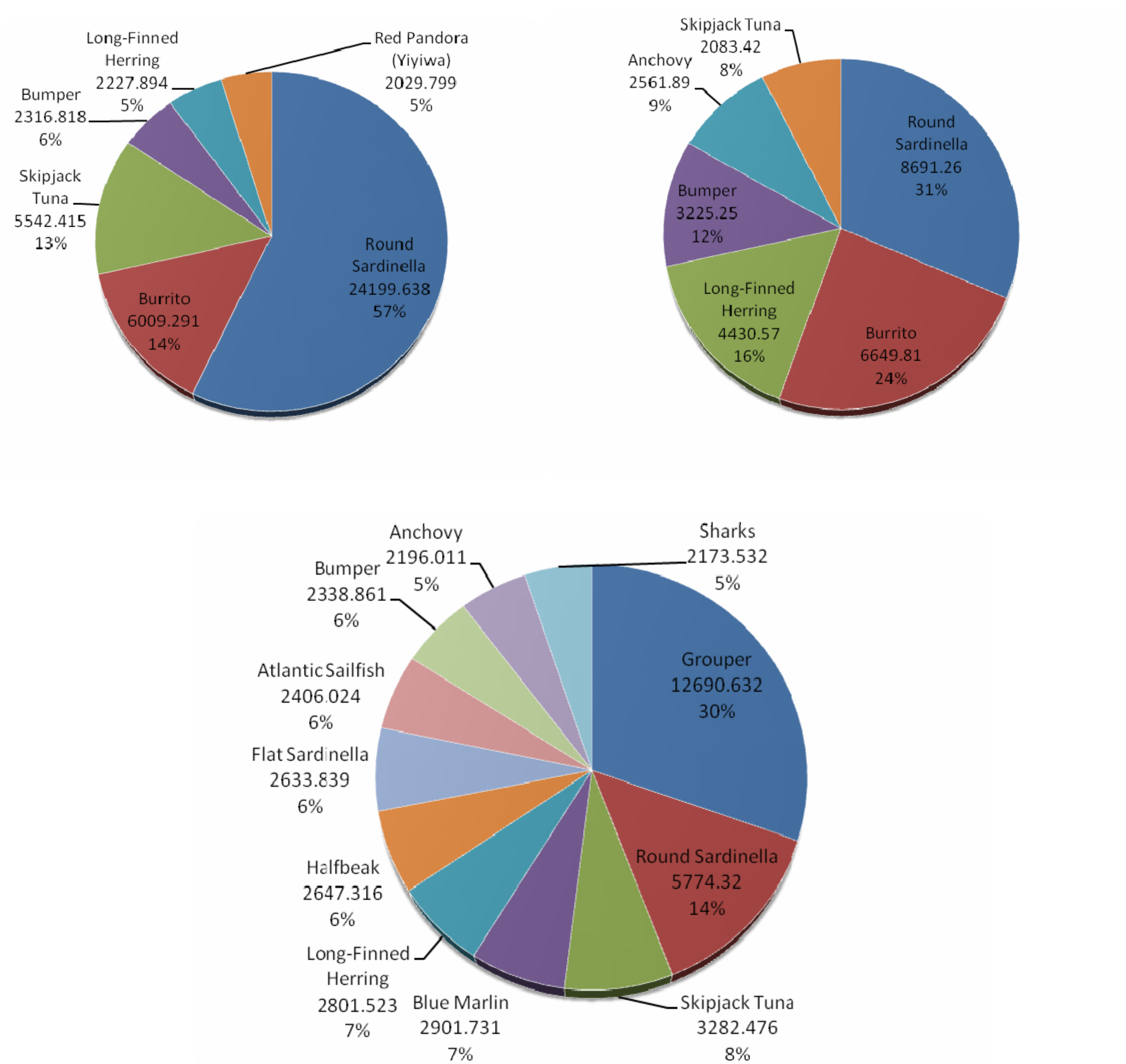


Figure 4.31 Annual Total Fish Landings in the SAEMA



The common most dominant species between the years (2006-2008) were the round sardinella (*Sardinella aurita*) with a range of 14-57%, Long-fin herrings (*Illisha Africana*) ranging from 6-13%, Bumper (*Chloroscombus chrysurus*) range of 6-12% and the Skipjack tuna (*Katsuwonus pelamis*). The tuna species was the only dominant offshore species.

Figure 4.32 Dominant Fish Species in SAEMA (2006-2008)



Cassava fish, long-finned herring, ribbonfish, shrimp, tuna, lobster and cuttlefish are the species that are generally taken in shore of the 10-m contour, and are the species of importance in Shama Bay and in the vicinity of the Pra River estuary.

Crab and shrimp are also caught in the coastal lagoons and river mouths, and shrimp are exploited off shore. Shrimp is also a major resource in the area and are an important component of the beach scene fishery in Shama Bay. Shrimp breeding grounds are said to occur along the Shama Bay shoreline and the estuary is utilized during early life stages. The tuna fishery is operated by both artisanal and tuna fleets, utilizing their own unique techniques. The canoe fishery is limited to the in- shore coastal zone while the tuna fleet operates from the coast to the equator.

Lobsters are present along all of this shoreline, among the rock, and are said to be locally most abundant between Shama and Aboesi. No lobsters are reported to be taken across the front of the proposed site or near the Anankwari estuary. Lobsters are marketed in Sekondi-Takoradi and are also purchased locally (Shama) for export. Cassava fish are locally the most important species in Shama Bay, being present in abundance in the Pra River mouth, and to a lesser extent farther west along the shoreline to Aboadze Point. Catches are smoked and sold in the villages, as well as being shipped into Sekondi-Takoradi, although primarily still utilized for local consumption. Anchovy are also taken locally in Shama Bay, directly off the Pra River mouth during the upwelling.

Species evenness and Shannon-wiener diversity indices were higher in 2008 than in 2006 and 2007 (Table 4.25). However, the highest species richness occurred in the year 2007 with 2008 recording the lowest species richness. These are useful quantitative tools for determining changes in fish community structure spatio-temporally.

Table 4.25 Diversity Indices for Fish Species from 2006-2008 in the SAEMA

Year	Number of Species	Margale'f Species Richness	Pielou's Evenness	Shannon-Wierner Diversity
2006	38	3.189	0.4765	1.733
2007	42	3.372	0.4678	1.748
2008	33	2.757	0.5929	2.073

4.3.10 Employment/Manufacturing

4.3.10.1 Employment

Approximately half a million people were employed in the Westem Region when the population census was undertaken in 1984, and 65% of these were in the agriculture, hunting, forestry and fishing sector. The major breakdown by occupation for the Western Region, Sekondi-Takoradi and Shama Local Authorities in 1984 is provided in Table 4.26.

Table 4.26 Breakdown by Occupation for the Western Region, Sekondi-Takoradi and Shama Local Authorities

Occupation	Western Region	Sekondi-Takoradi	Percentage	Shama	Percentage
All occupations (Over 15 years) -Total -Male -Female	530,228 285,884 264,384	71,219 36,305 34,914	13 14 13	23,321 10,769 12,552	4 4 5
Professional, technical and related workers -Total -Male -Female	20,294 13,248 7,046	5,759 3,483 2,276	28 26 32	609 407 202	3 3 3
Clerical and Related Workers -Total -Male -Female	12,417 9,481 2,936	6,359 4,437 1,922	51 47 65	223 177 46	2 2 2
Wholesale and retail trade -Total -Male -Female	58,199 3,860 54,339	19,852 1,440 18,412	34 37 34	5,831 130 5,681	10 3 10
Agriculture, animal husbandry, forestry workers and hunters -Total -Male -Female	354,742 173,726 172,016	8,735 4,968 3,757	3 3 2	12,882 7,832 5,050	4 5 3
Agriculture, animal husbandry -Total -Male -Female	223,506 77,456 146,050	6,093 2,473 3,620	3 3 2	7,322 2,796 4,526	3 4 3
Fisherman, hunters and related workers -Total -Male -Female	12,759 12,642 117	1,976 1,951 25	15 15 2	3,522 3,491 31	28 28 26
Production, transport, equipment operators, labourers and related workers -Total -Male -Female	79,156 54,518 24,608	23,820 16,927 6,899	30 31 28	3,546 2,032 1,514	5 4 6

Agriculture (including fishing, animal husbandry and hunting), production and transport works, sales work and professional and technical works are the four broad category of employment avenues or occupation in the district. About 58% are into agriculture, 14.5% of the population are in the production and transport work sector, whiles 10.2% are found in the sales work sector. The remaining 5.4% are professional or technical workers.

Also industrial activities in the district could be categorized into agriculture (excluding fishing but including forestry and hunting) (58.1%), mining and quarrying (2.4%), manufacturing (10.2%) and wholesale and retail trade (10.3%).

About 52% of the total population constitutes the economically active group in the district. About 17% of the economically active population is mainly employees of private and public sector. Within this legally permissible working age group (15 years and older), self-employed persons (72.9%) make up the majority of the economically active; 68.3% have no employees working for them while 4.6% have employees.

The employment at these local communities is summarized in Table 4.27. Although employment for agriculture, hunting, fishing, and forestry are all put into one category, for the seaside communities of Shama, Aboadze and Aboesi, this can be equated with fishing activities.

Table 4.27 Employment for Select Communities

Number in Employment							
Locality	**Sex**	**Total Aged 15 and Over**	**Total**	**Agriculture Hunting Fishing Forestry**	**Unemployed**	**Homemaker**	**Other**
Shama	M F	1927 2269	1641 1735	1199 72	135 69	16 245	235 219
Aboadzi	M F	715 903	567 759	455 14	41 18	9 44	98 82
Aboasi	M F	621 648	526 564	450 15	12 14	3 48	80 22
Sekondi	M F	9433 8932	6363 5135	285 95	842 646	84 2122	1942 1029
Inchaban	M F	738 764	579 615	134 232	70 21	 61	89 63

The economy of the coastal dwellers is tied to the extractive sector of fishing, salt production and subsistence farming. Subsistence exploitation for fishing, using traditional methods, occurs in coastal lagoons as well as the marine environment.

Within the Sekondi-Takoradi area significant numbers of people are employed in industry. Employment is found in sawmills, plywood factories, paper mills, an aluminum products factory, tobacco plant and cocoa processing. In addition, there is an active harbor exporting cocoa, timber, fish, minerals and importing oil. 58% of the population in the Shama Ahanta East District are engaged in agriculture, crops include peppers, cassava, maize, plantain and a wide variety of tree crops such as coconut, oil palm and citrus. The district is especially suited to coconut production which has a high income potential. Livestock production such as sheep, goats, pigs, rabbits and fowl is also undertaken.

Worker rights legislation within Ghana includes the prohibition of forced or compulsory labor, setting a minimum age for employment at 15, and restricting certain types of hazardous labor for workers under 18. While it is reported that forced labor is not practiced in Ghana, it has also been reported that the violation of child labor laws is common particularly in the agricultural sector and both enforcement and prosecution for violations are erratic.

4.3.10.2 Fisheries

Commercial fishing is locally important, as noted in Section 4.2.3 supplying domestic, national and international markets. The major fishing communities in the district are Abuesi, Shama and Aboadze. Theses occupy about 7km out of the 10km strip of the coast of the district. The three fishing communities have about 1,500 registered seas worthy canoes. Outside the upwelling periods, fishing is reduced to subsistence levels, with fewer trips undertaken. Most (estimated at 80%) of the women are also involved in either fish smoking or fish mongering (trading) operations.

Aboadze, Aboese and Shama are known nationally as important fishing areas, and as such attract fishermen from other places. A fish recording station is currently operated by the Fisheries Department at Shama, and a similar station operated at Aboadze until the mid-1980s. Artisanal (canoe) fishing operations employ 20 to 25 persons per canoe, and the daily incomes of the vessel are divided on a 50/50 basis between the crew and the owners.

The majority of the annual income is achieved during the 2- to 3-month upwelling period, with operations reduced to subsistence levels outside the upwelling periods. Income from the fishing operation depends on the quantity of fish caught, and the price at landing. Yearly incomes per vessel for average to good years are estimated to range from 7 to 20 million Cedis (US $11,000 to US $31,000), with those actively involved In the Sardinella fishery often achieving the upper figure. Income potential for canoe owners is then up to 10 million Cedis (a US $15,000) from which the vessel and equipment loans are repaid, while crew incomes average 400,000 to 500,000 Cedis (US $620 to US $770) per member, depending on number of crew members. Daily incomes are reported to be as high at 25,000 to 30,000 Cedis (US $40 to US $50) during peak portions of the season.

Fish production over the last decade has been fluctuating annually with a mean value of about 400,000 MT as shown in Table 4.28.

Table 4.28 Fish Production in Ghana (1993-2004)

Year	Marine Fisheries Landings (MT)	Inland Fisheries Landing (MT)	Total Fish Landing (MT)
1993	316,680.3	40,000	356,680.3
1994	276,165.50	42,000	318,165.5
1995	273,672.40	52,400	326,072.4
1996	301,907.2	60,500	362,407.2
1997	295,223.8	62,700	357,923..8
1998	278,663.7	63,800	342,463.7
1999	268,885.1	81,900	350,785.1
2000	354,566.6	82,500	437,066.6
2001	370,952.9	81,000	451,952.9
2002	290,008.1	81,000	371,008.1
2003	331,412.0	82,000	413,412.0
2004	352,405.1	81,500	533,905.1

4.3.10.3 Industry

More than 60% of the manufacturing industries in Ghana are situated in the larger towns along the coast. Most industries are encountered in the Accra-Tema area, followed by Takoradi and Cape Coast. The industries include a wide variety of food-processing-, metal production-, textile-chemical-, and cement factories as well as oil refineries. A free port has recently been established at Tema and it is expected to further enhance the industrial development. TTPP is considered to be a large industrial establishment in the coastal zone.

The main industrial employment in the area is centered in Sekondi-Takoradi. Historically, Sekondi was the sole commercial port in the country exporting gold and then cocoa. It slowly slipped from commercial prominence after 1920 when Takoradi was chosen as the site for a new harbor.

Sekondi is now the administrative centre for the Western Region and has the head offices for the Ghanaian Railroad. Takoradi is the manufacturing centre with saw mills, plywood factories, paper mills, an aluminum products factory, tobacco plant, and cocoa processing. It has a very active harbor exporting cocoa, timber, fish, minerals and importing oil. Over 25% of all manufacturing in the Western Region is carried out in the Sekondi-Takoradi area. Also almost half the public administration and defense employees of the region are in this area as well as those industries related to transportation requirements.

4.3.10.4 Agriculture

Though fishing and its allied businesses are the major occupations of the rural coastal inhabitants, farming also plays an important role in their economic activities. Farming along the coast is done on subsistence level and it is usually by the use of simple implements like cutlass and hoes, characterized by slash and burning of the farms before planting.
Table 4.29 and Table 4.30 below provide recent data on land used for agriculture in Ghana and Livestock population, respectively.

Table 4.29 Agricultural Land (In Hectares)

Total Land Area	23,853,900
Agricultural Land Area	13,628,179
Area under cultivation	4,320,000
Area under irrigation	7,500
Area under inland waters	1,100,000
Total Land Area	23,853,900

Source: Ministry of Food and Agriculture

Table 4.30 Livestock Population

Type of Livestock	2000	2001	2002	2003
Poultry	1,940	2,080	2,270	2,500
Sheep	1,270	1,280	1,350	1,400
Goats	1,400	1,460	1,470	1,620
Cattle	1,090	1,090	1,110	1,130
Pigs	710	690	680	670
Poultry	1,940	2,080	2,270	2,500

Source: Ministry of Food and Agriculture

Within the Shama Ahanta District, 45% of the total land area (17,700 ha) is considered to be suitable for agricultural crop production. Thirty-seven percent of the population (89 000 persons) is engaged in farming on a land area of approximately 6000 ha, which represents a farming intensity of slightly over 30%. In terms of agricultural production, the District ranks ninth of the eleven districts in the Region.

Most of the farms are less than a hectare and they solely depend on the rains. There are a few irrigated farms along the coast. Farming activities are mainly centered on food crops and vegetables, while livestock and cash crops are on the periphery. The major crops grown are cassava, plantain, cocoyam, maize, rice, oil palm and vegetables. The availability of land, favorable climatic conditions, high soil fertility and flexible land tenure system places the district at an investment destination. Quite recently the assembly facilitated the negotiation and release of large track of land to the free zone board to indicate its readiness to prospective investors for the allocation of land for industrial purposes. Table 4.31 provides further details regarding the crop production for the years of 2001 to 2005.

Table 4.31 Crop Production (Metric Tonnes)

Crop	2001	2002	2003	2004	2005
Maize	738	845	880	1,616	1,790
Rice	107	162	160	215	224
Cassava	16,999	19,265	19,270	19,492	22,298
Yam	112	143	140	165	125
Cocoyam	483	495	500	569	432
Plantain	1,083	1,170	1,190	2,804	3,051

Source: Metro Agric Directorate, SAEMA

With reference to the crop production trend in the SAEMA, total yield per acre has been comparatively low and varied. The average farm size is also around 5 acres of land. The total cultivable land is estimated to be 50.8% of the total land area. From Table 4.32, cassava seems to be the major crop grown. Large volumes of cassava produced in the metropolis are from SDA. The presence of a cassava processor at Awuna Beach therefore helps reduce post harvest losses by processing them into gari. There is therefore a thriving investment opportunity in cassava processing which need to be fully exploited.

Table 4.32 Yield per Hectare (Metric Tonnes)

Crop	2001	2002	2003	2004	2005
Maize	1.26	1.39	1.42	1.40	1.41
Rice	1.11	1.15	1.14	1.17	1.16
Cassava	8.13	8.78	8.80	8.82	8.81
Yam	4.00	3.97	3.50	4.02	3.80
Cocoyam	4.09	3.69	3.57	4.12	3.93
Plantain	4.77	3.45	2.70	8.20	8.50

Source: Metro Agric Directorate, SAEMA

Yield of rice per hectare seems to be the least among the selected crops as shown in Table 4.33. The vegetation of the district is however favorable for large scale production. The district vegetation is mainly thin shrub to dense and this is suitable for rice production. The main cause of the low yield is the low rainfall volumes experienced in the district. The mean annual rainfall is about 138cm and the lowest being 100cm whiles the highest is 170cm. That notwithstanding large scale farming, using irrigational methods is a major area also of high investment potentials.

Yield per hectare for the various crops have risen steadily owning to the increase in the area of land been cultivated. According to Table 4.33 the total land area for maize more than doubled in 2005 and there was a corresponding increase in the quantity of maize harvested. This is an indication that if the total cultivable land is fully exploited, the volumes of production would increase.

Table 4.33 Area for Crop Production (Hectares)

Crop	2001	2002	2003	2004	2005
Maize	586	608	620	1,154	1,270
Rice	96	141	140	184	193
Cassava	2,091	2,194	2,190	2,210	2,531
Yam	28	36	40	41	33
Cocoyam	118	134	140	138	110
Plantain	227	339	440	342	359

Source: Metro Agric Directorate, SAEMA

Weather conditions and soil type in the District can support a wide variety of tree and food crops (coconut, oil palm, citrus, cassava, maize, rice, cocoyam, pepper, tomato, eggplant).

Land area devoted to peppers, tomato and eggplant in the District is estimated at 100, 115 and 100 ha, respectively. Yields of cassava, maize, plantain and coco yams are low to below average in comparison to other districts in the Region.

Soil pH ranges from near 6 in the east to 5 in the west. Farmers follow a shifting cultivation pattern, allowing land to lie fallow for 3 or more years between successive crops. Land preparation is by hand, and mixed cropping is the general rule. Women are extensively involved in production, processing and marketing generally outnumbering their male counterparts.

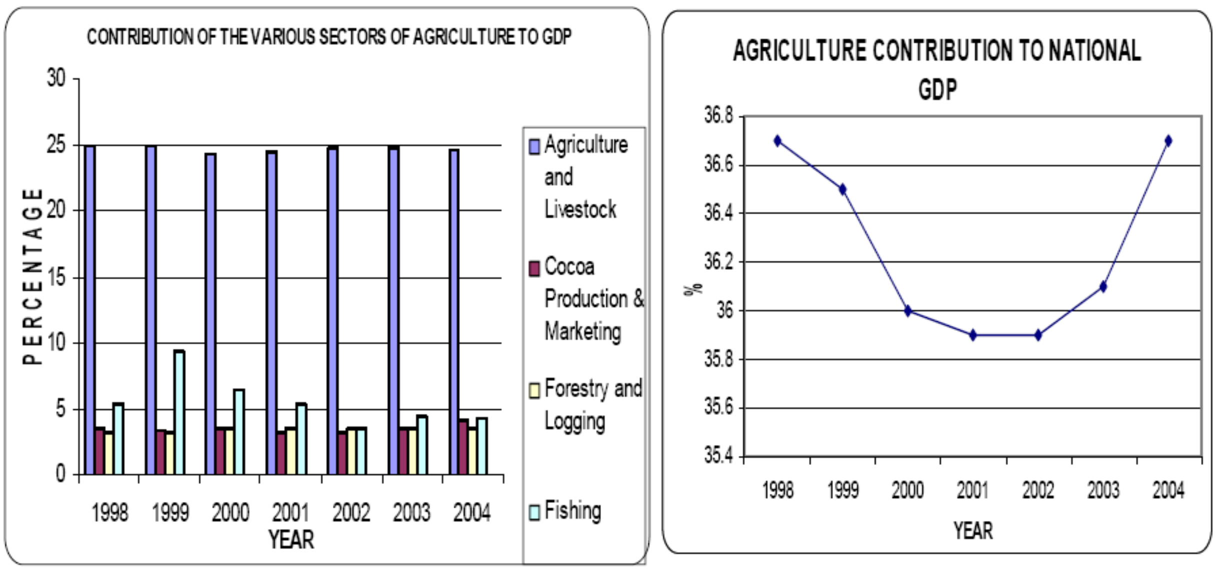
Tree crops are an important component of agricultural production in the area, with 250 ha of coconut, 300 ha of oil palm, and 40 ha of citrus under cultivation in the District. Coconut is an important cash crop which is a major source of income for the population in the coastal areas of the Central and Western regions. The Shama Ahanta District is especially suitable for coconut production, providing stable temperature conditions and a constant water supply in the coastal zone. Coconut production also has high income potential, yielding net incomes of up to 177,000 Cedis (US $270) per hectare versus potential net incomes of 40,000 Cedis (US $60) and 4,000 Cedis (US $6) per hectare for cassava and maize, respectively.

Shallots farming also constitute a major source of income for many household in the coastal strip between the sea and the Keta lagoon in the Volta Region. Recently pineapples are being cultivated on commercial basis along the main road from Kasoa (Accra) to Cape Coast, while oil palm and cashew cultivation is also gaining some grounds in the Central and Western regions. In addition, agro forestry is being encouraged to produce fuel wood for the fish smoking industry.

Livestock production in the District ranks fourth of the eleven districts in the Region, but the District has the second highest cattle production (660) in the Region. Small ruminants are kept by many rural and urban families. The abundant rainfall ensures a continual supply of vegetation for livestock grazing. Coconut and oil palm plantations have considerable amounts of undergrowth, which can be efficiently utilized by livestock. Sheep, goats, pigs, rabbit and fowl are also raised.

From 1998-2004 the agricultural sector contributed an average of 26.26% annually to the National GDP (details on coastal areas are not available). Most of the agricultural subsectors also saw higher growth in 2004. In addition, agriculture contributed significantly to foreign exchange earnings and tax revenue.

Figure 4.33 Agriculture Contribution to Ghana's National GDP (State of Ghanaian Economy)



4.3.11 Public Health

Public health in Ghana is strongly correlated with standard of living, with poor, rural areas having low levels of public health. In these areas, water-borne and water- related diseases such as guinea worm, cholera, typhoid, hepatitis, dysentery, malaria, yaws, schistosomiasis, and onchocerciasis are common. The lack of suitable and efficient means of human waste disposal results in a continued cycling of disease pathogens and bacterium back to the people through numerous media including food, water supplies, and by direct exposure.

In urban areas, approximately 95% of residents have access or are supplied with safe drinking water. In rural areas, this proportion decreases to less than 40%, while in small settlements of less than 500 people; the percentage can be as low as 15%.

The diseases of particular social and economic concern in the Shama Ahanta East area have been identified as upper respiratory infection and acute poliomyelitis, measles, tuberculosis, tetanus, especially neonatal tetanus, AIDS and leprosy (Shama Ahanta East Annual Report, 1992). The top 10 diseases reported by the health services are given in Table 4.34 below. Malaria tops the list with 10% of the population having the disease. Also, it can be assumed that these figures do not include a large segment of the population.

Table 4.34 Top 10 Diseases in Shama Ahanta Metropolitan District (1991)

Disease	Cases	% of Population
Malaria	35,616	10.0
Upper Respiratory Infection	7,652	2.3
Acute Eye Infection	6,750	2.0
Accidents and Fractures	4,730	1.4
Diseases of the skin	4,031	1.2
Diseases of the oral cavity	3,262	1.0
Diarrhoeal disease	3,207	0.9
Ear Infection	2,986	0.9
Hypertension heart disease	2,048	0.6
Intestinal worms	1,298	0.4
Total	**71,580**	**21**

There are two hospitals, two health centers and one clinic in the district. Apparently the Shama Health Center is being upgraded into district hospital to serve as a referral point for all satellites health facilities. It must be emphasized that many remote areas have no access to health facilities. Health facilities are located in the urban centers of the district (Shama, Aboadze and Supomu Dunkwa). In this regard, the new Assembly in conjunction with the District Health Directorate is making frantic effort to establish Community Health Planning Services (CHP Compound) in ten communities by 2010 to improve geographic access to health services delivery.

In addition to government institutions, there are five defense forces health institutions (mainly at Sekondi), about five private midwife clinics, 15 company clinics and one PPAG center in Takoradi. Beyond the actual clinics and health posts, there are outreach clinics, and house-to-house immunization is carried out. The district has 41 vaccination points; however, general vaccination coverage is low. Other primary health care activities include training and supervision of traditional birth attendants (TBA). A total of 186 TBAs had been trained by 1992 and they are visited in their local villages monthly by a trained midwife.

In terms of personnel's, the Health Directorate has a District Director and other requisite auxiliary health professionals in all the facilities. These professionals are determined to improve health delivery in the district. All the two hospitals have qualified medical doctors.

Generally it is considered that health coverage in the District is poor (Shama Ahanta East District Annual Report, 1992). This is related to a number of issues from a lack of community interest and understanding in health services, competition between villages for services rather than cooperation, and lack of health funds to be able to service the more remote areas.

With orthodox medical facilities largely inaccessible to the rural communities, herbal or traditional healers are the main providers of health care.

Data on SAEMA (Table 4.35) shows high incidence of malaria in the district. The number of reported cases rises every year. High incidence among children below 5 years has also been recorded. As noted earlier, the number of hospitals, clinics and health centers in the district is small to support the population demand and a great majority is under staffed. Most of these health providers are located in the urban centers. Nearly half of the persons in households have a health facility less than 30 minutes away from their residence - it is 46.9 per cent, for the region, and almost 11 percentage points lower than the national average of 57.6 per cent. About nine out of every ten women in the region (95.5 per cent) aged 12-49 years, who had a live birth 12 months prior to the survey received prenatal care. Prenatal care is slightly higher for the region than for the country as a whole (93.4 per cent). Less than half (46.9 per cent) of the, children under five, in the region were delivered with the assistance of a trained health professional (doctor, nurse and midwife).

Table 4.35 Three Year Trend of Selected Diseases of Public Health Importance

Incidence/ Cases By Year	2004		2005		Mid 2006	
	Cases	Incidence	Cases	Incidence	Cases	Incidence
Guinea Worm	0	0	0	0	0	0
Malaria	34,399	81.9	54,516	126.1	34,308	77.1
< 5 yr Malaria	18,619	257.9	19,452	261.7	4,175	54.4
Malaria in Preg.	N/A	0	804	46.5	286	16.0
TB	N/A	N/A	103	0.20	80	0.17
CSM	0	0	1	0.2	0	0
Cholera	0	0	0	0	229	51.3
Y/F	0	0	4	0.9	3	0.6
AFP	3	0.7	2	0.4	5	1.12
Measles	93	22.1	44	10.1	15	33

Source: Metro Health Directorate, SAEMA

Majority of the population in the district have therefore resulted to traditional healing, which is the most readily available health care services to the population in the district since there are healers in almost every community in the district. Over 90 per cent of the population can reach them within a radius of 5 kilometers. 92 per cent of the localities have traditional healers, the highest in the region. Without these healers, primary health care in the district would be an unmitigated disaster. A very small portion of the population in any given district travels more than 10 kilometers to reach a traditional healer. The regional traditional healer to patient ratio is estimated at about 1 to 370, which is almost the same to the national average of about 1 to 400. Less than 36 per cent of the localities enjoy hospital facilities within their locality, and less than 9.7 per cent within 5 kilometers.

The ratio of registered traditional medical practitioners to the population for the region is 1 to 1,127.The region has a population of 10,140, as of 2001, per publicly owned health facility, which is slightly below the national average of 11,289.

The various indicators of child’s nutritional status in the district are not different from that of the region. The proportion of children in the region who are stunted (short for their age) is 38.5 per cent and higher than the national average (32.4per cent). Also, wasting (children underweight for their height) is 7.4 per cent for the region which is almost half the national average (15.5 per cent). The region records 22.4 per cent of children underweight, which is lower than the national average (25.8 per cent).

The immediate health goals in the District are to provide 80 to 90% coverage on pregnancy and deliveries. Presently, although over 80% of the women registered their pregnancies, only 36% had supervised deliveries. The Child Health Service is to target at least 80% of the under 1-yr old children to provide immunization, growth monitoring and nutritional needs. Generally, the larger communities are relatively well serviced, but there is a need to reach out to the smaller communities.

In the area of the proposed project health services are poor. There was only one health post at Shama which services Shama, Aboadze, Aboesi, Inchaban and the surrounding villages before the construction of T1. As part of the T1 Community Impact Agreement a public health facility is to be set up at Aboadze.

There are plans to upgrade this health post to a polyclinic with a resident doctor. However, there is presently no adequate doctor's residence available with potable water and electrical power supply. In these circumstances, it is difficult to attract medical staff. Also, it is physically difficult to operate health outreach services in these villages. The staff frequently cannot locate their destination through the general maze of the village layout. Also, the fishing communities have an overall general lack of interest in public health and have poor sanitation.

4.3.12 Coastal Pollution

Coastal pollution attributed to wastes originating from the two main sources: direct human origin and industrial origin are examined below and their predicted impacts on the coastal zone and marine environment are presented on section 6.2.6.
The construction of T3 however, will not pose any impact on the coastal pollution since the waste associated with the construction of T3 will be disposed in the designated areas, addressed in the previous EIA and SEIS Reports, within the TTPP compound. Waste disposal areas and processes utilized during the construction of T3 are addressed in detail on Section 6.3.6.

4.3.12.1 Waste of Human Origin

Poor domestic sanitation and improper disposal of municipal solid and liquid wastes are the most widespread problems affecting the coastal areas of the Western, Central, Greater Accra and Volta Regions of Ghana.

An assessment of domestic pollution along the coast in 1994 indicated that 6 districts experienced ‘extreme’ and ‘high’ domestic pollution while 9 other districts had ‘moderate’ pollution. Forecast of domestic pollution loads by coastal districts show an alarming trend to year 2020. Under projected economic growth of 8.03% per annum up to year 2020, 16 out of the 21 coastal districts of Ghana will have ‘high’ and ‘extreme’ levels of domestic pollution. By 2020, 13 of the districts will have domestic pollution levels that Accra is facing today.

The principal causes of the poor domestic sanitation include high population densities in coastal towns; lack and inadequate toilets in households and other basic sanitary infrastructure, malfunctioning sewage treatment facilities, high rate of population growth along the coasts, poverty, littering, illiteracy and inadequate institutional capacity for monitoring and enforcement of legislation and bye-laws. Pictures shown below illustrate some of the many effects of improper disposal of solid waste from human origin.

Sewage line blocked by wastes of human origin in Accra

Chemu Lagoon

Poor domestic sanitation has contributed to pollution of coastal ecosystems and unsightly conditions that hinder economic development opportunities or make them very expensive. Proper facilities for sewage treatment do not exist in most communities along the Ghanaian coast or, for that matter, in neighboring countries, so it is common to find excrement on beaches and coastal fringes due to defecation in the open. Untreated or poorly treated sewage is also deposited in coastal lagoons and beaches.

The severity of impact of these discharges is determined, to a large extent, by the circulation characteristics of the receiving water body. In some areas, lagoons which have little or no exchange with the sea are the primary receiving body. This causes high levels of de-oxygenation to occur due to oxygen demand of the decomposing sewage with a resultant decrease in aquatic life. This impact is less severe in areas of higher water exchange, but ultimately depends on the ability of the receiving body to assimilate the quantity of wastes received. Two coastal lagoons, Korle and Chemu (near Accra), are already considered to be grossly polluted and the entire fisheries in these lagoons have been lost.

In addition to creating a direct health hazard from contact with fecal remains on beaches, high levels of coliforms and other pathogenic bacteria in coastal waters subjected to moderate to heavy sewage disposal cause contamination of local shellfish. Ingestion of these products can expose consumers to the risk of infection of typhoid, cholera, or hepatitis. Parasitic worms are also transferred in these media. Local water supplies are also degraded by inadequate sewage disposal techniques.

In the vicinity of the proposed thermal station, few data are available on pollutant loading by the human population. Local beaches are, however, used for the disposal of human waste and the cities of Sekondi and Takoradi are both upstream (in terms of the prevailing long-shore current) of the project area. Loading of BOD5 and suspended solids to the coastal zone from these two cities has been estimated at 4906 and 6976 tonnes/annum, respectively (UNEP, 1989), which is approximately 20% of the total loads estimated for the Ghanaian coast. The Pra estuary, immediately east of the project area, is heavily impacted by sewage pollution, as well as by the mining operations in its catchments zone. The resultant water quality is considered to be low overall (Biney, 1982). Compared to other coastal estuaries examined during the study, BOD5 (7.0 mg/L) was the highest, while dissolved oxygen (4.9 mg/L) was among the lowest of all estuaries. Low transparency (Secchi disc 11.25 cm) was attributed primarily to the mining operations upstream, while nutrient levels (orthophosphate - 0.07 mg/L, nitrate nitrogen - 6.7 mg/L, and ammonia nitrogen - n.4 mg/L) were high in comparison to the range exhibited by other Ghanaian estuaries.

No immediate information is available on microbial populations in the Pra estuary. Levels of fecal coliforms in certain reaches of the Volta estuary were found to be in excess of 1000/100 mL. Similar conditions may exist in the Praestuary. Solid wastes are positively correlated with human population density; with the areas most affected being those near coastal settlements. Accumulations of plastics of up to 200 g/m² have been observed in some of the most polluted areas.

4.3.12.2 Wastes of Industrial Origin

Industrial wastes encompass those released by industries and factories in the production of manufactured items, as well as the byproducts and/or discards of local cottage industries and agricultural activities (i.e., fishing). Most industrial effluents are discharged directly to the nearest watercourse. As most large industrial processes are located in populated areas, these areas are the greatest contributors of industrial loading to the coastal environment. Wastes from some industrial processes, (estimated at 1414 tons/year), such as breweries and edible oils industries, contribute to the BOD5 while other industries, such as mining, contribute to the load of suspended solids (estimated at 3669 t/yr).

Industrial water pollution is a ‘moderate’ to ‘high priority issue in 6 out of 21 coastal districts. This is partly because most industries do not comply with EPA maximum permissible environmental quality discharge limits. Again most industries are sited in the moderately developed coastal towns, in particular, Tema, Accra, Cape Coast and Sekondi-Takoradi. For instance, Greater Accra Region, which is less than 1% of the total land area of Ghana, is home to over 60% of Ghana’s industries.

An assessment of the extent of industrial pollution along the coasts of Ghana was based on information from District

Environmental Plans (DEPs) and Local Environmental Action Plans (LEAPs). According to the assessment, while only 3 districts, Accra, Tema and Sekondi-Takoradi fell within a 'high' or 'extreme' pollution category in 1994, at least 13 districts are expected to experience a 'high' or 'extreme' industrial pollution by 2020.

Available data shows serious pollution of surface waters in Accra and Tema from the discharge of untreated or poorly treated industrial wastewater. This has resulted in serious pollution and degradation of coastal surface water bodies that serve as sink to industrial wastewater discharges.

As previously noted, the Pra estuary is the recipient of high loads of suspended sediments, largely originating Iron and gold mining operations at Dunkwa and Obuasi, and diamond mining operations at Oda. Kade, and Akwatla.

Trace metals, such as mercury, lead, cadmium, zinc, and copper are wastes or byproducts of numerous Industrial processes, and are discharged directly into the water courses that flow into the coastal zone. Estuaries, lagoons, and near-shore waters are efficient in trapping dissolved and particulate metals, most of which are then available to bottom dwelling organisms. The concentrations of a number of these elements have been determined in sea water, sediments, algae, shrimp and fish along the Ghanaian coast, and are presented in Table 4.36 below.

Table 4.36 Trace Metal Concentrations in the Ghanaian Marine Environment

	Mercury	Lead	Cadmium	Zinc	Copper
Sea water (ng/L)	<20	-	-	-	-
Sediment (mg/kg)	0.002 – 0.04	6 – 35	-	1 – 80	2 – 20
Algae (mg/kg)	0.02 – 20	1 – 2	<0.1	2 – 5	1 – 2
Shrimp (mg/kg)	<0.02	0.9 – 2	<0.1	5.6 – 6.3	2 – 6
Fish (mg/kg)	<0.02 – 0.3	<0.2 – 0.65	<0.1 – 0.3	0.5 – 16	<0.2 – 5.6
WHO Concentration for fish flesh limit (mg/kg)	0.5	-	-	-	-

Mercury, potentially one of the more serious contaminants of fish and shellfish in terms of human health risks, is presently below the World Health Organization (WHO) recommended concentration limit of 0.5 mg/kg of fish flesh. In the vicinity of

Takoradi, the mean concentration of mercury in water samples was 22 ng/L while concentrations in flesh of ten commercial fish species averaged 0.22 ± 0.06 mg/kg. Concentrations of other metals are generally within acceptable limits. However, areas of specific concern (such as the Korle Lagoon) have been identified. Shrimp generally have higher levels of lead, copper, and zinc than fin fish, presumably due to their preferred habitat in estuaries and lagoon mouths. These areas are the main receptors and traps of land-based pollutants.

Pesticides are used in agricultural production and to control disease vector species (i.e., black flies and mosquitoes). Although about 60 compounds are officially recognized in Ghana (UNEP, 1989), no data are available on the distribution of these pollutants in the local marine environment.

The IFC policy on pest management (OP 4.09) focuses on large scale agricultural sector pest control projects involving the use, transportation, handling, application and disposal of pest controlling chemicals (for flora or fauna). The primary pest management activities currently undertaken at T1 are relatively small scale operations in comparison to the scope of the IFC policy. They include controlling the prevalence of mosquitoes and hence reducing the risk of malaria within the plant and at the VRA Township. A program for disinfestations and fumigation of the township and project site offices is undertaken on a quarterly basis. Employees and families are given prior notice of the next spraying which is undertaken over a period of 6 days, typically in the morning, and focuses on the drains, gutters, lawns, offices and immediately surrounding areas. This operation is undertaken under contract by an outside company.

It is also understood that the growth of vegetation within the fenced substation area for T1/T2 is managed using chemical herbicides and the same practices will be extended for T3. This currently comprises an area of approximately 135 m^2.

4.3.12.3 Oil

Oil contamination of beaches in the Gulf of Guinea is not an infrequent occurrence. Much of this contamination is thought to originate from passing ships (off shore) on the main Middle East to Europe oil route. However, local sources such as harbor facilities and operations, and refineries may also contribute. Contamination of beaches in Ghana is not considered to be a serious problem. Some areas (such as Takoradi) have higher incidences and levels of oil contamination than others due to the prevalence of oil handling activities. Locally, sources of crude and refined oil on beaches and in the water may include tanker accidents and tank washings; refinery discharge; municipal and industrial discharge; and losses from pipelines and off shore exploitation and production facilities. The disposal of used motor vehicle crank case oil into coastal streams is also seen as a significant contributor to local oil contamination problems.

Oil is transferred and spread along the coastal zone by the action of waves and long shore currents which in the project area, run from west to east. Oil, depending on its form, is deposited as either a liquid or as tar balls. Tar balls are especially prevalent in the vicinity of Takoradi (22 g/m^2) due to the ongoing oil handling activities. They are less prevalent at Sekondi (4 g/m2) and Elmina (7 g/m^2).

Concentrations are again high at Cape Coast (24 g/m^2), but then decrease farther eastward (Biney, 1982).

A report was prepared in March 2000 by VRA on the environmental management of waste oil sludge disposal options at TTPP where a number of waste disposal options were discussed and conclusions drawn on the most appropriate method to adopt. Options included construction of a temporary storage facility, controlled incineration (i.e. the original option), waste oil recycling (including using a chemical treatment process) and open-air incineration. It was concluded that the waste oil recycling option would be adopted as the primary method for waste oil/sludge disposal at TTPP, on the basis that the environmental implications that would otherwise be associated with incineration (controlled or open air) would be reduced. It is understood that the incinerator will only be used when the collection of the waste oil/sludge by others is interrupted and it becomes necessary to empty the collection tank.

The plant operators have implemented a monthly program, which will be extended to the operation of T3, of waste oil sludge analysis to identify the nature and concentrations of the heavy metals Vanadium, Lead and Nickel present in waste oil sludge. This will enable the Environmental Manager to identify possible metals concerns before oily wastes are removed off site via road tanker by waste oil reuse companies. The TTPP laboratory is used for this sludge analysis.

In terms of waste management, in addition to the information on wastes produced and methods of disposal provided in Table 3.7 of the 1999 SEIS for T1, there have been the following changes:

- The waste oil sludge is not all being burned on site as originally planned. At the time of the May 2000 visit T1 had disposed of waste oil as follows:
  Incinerated: 90 m^3
  Sold to third parties: 300 m^3
  Sent to TOR: 1500 m^3
  TOTAL: 1890 m^3

- This pattern has reportedly continued and is expected to do so. Due to the high cost of incineration and the commercial market for this product, it is expected that 5-10% of the waste generated will be incinerated; 15-25% would be sold to third parties with the balance going to the Tema Oil Refinery (TOR).

- Currently, waste oil is disposed of in accordance with the provisions of the Environmental Management Plan for the Disposal of Oily Wastes where wastes are removed off site via road tanker by waste oil reuse companies. T3 will follow the same provisions, since its waste oil will be disposed of in the T1/T2 disposal facilities.

- Discussions are also ongoing for the use of waste oil at a local steel manufacturing company and by another company for use as boiler fuel.

- As there is no burning of the waste oil/sludge on site, regular monitoring of the quality of waste oil/sludge commenced only in February 2001, in follow up to IFC and

OPIC suggestions. However, prior to setting up the arrangement with TOR, samples of the waste oil/sludge were analyzed in order to determine its suitability for TOR.

Some of the measures put in place during construction and operation of T1 and T2 will be utilized for T3. However, the environmental impact associated with oil spills and disposal are expected to be minimal as the most of the waste disposal will be routed throughout the existing TTPP where processes and environmental management plans are already in place and under monitoring.

5 Analysis of Alternatives

The African continent has not been spared by the electric utility industry reform sweeping across the globe. The electric utility industry in Ghana is prominently confronted by deficient capacity to accommodate the ever growing population and industrialization of the country.

The Ministry of Energy is seeking to improve the electric power capacity of Ghana in order to support the Government of Ghana's economic development goals. The hydro-based power generation system has been deemed insufficient and at times unreliable, due to weather conditions, to satisfy current and projected future needs for an increase in the country's energy capacity.

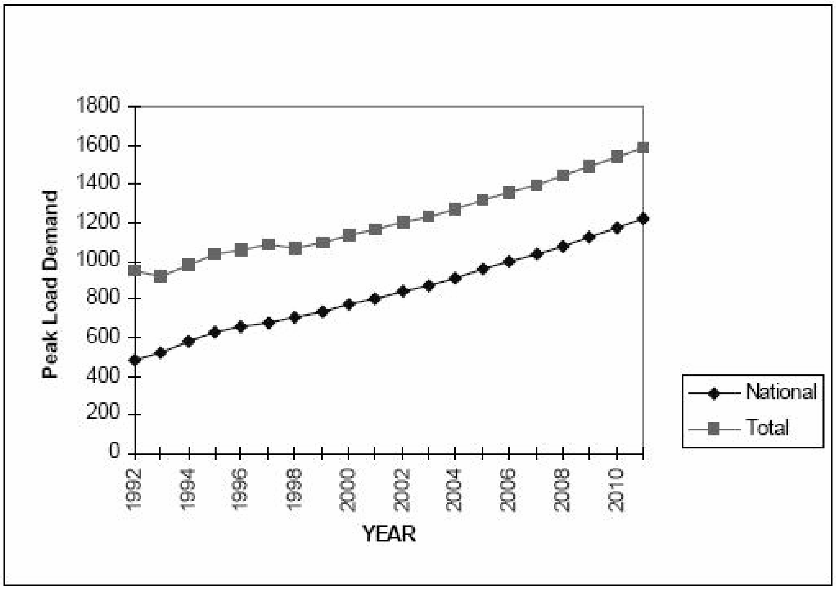
In order to meet the growing demand for electricity, the country has been progressively moving towards a mix of hydro and thermal based systems with the installation of different thermal plants throughout the country, such as:

- Takoradi Thermal Power Plant with a power generating capacity of 550MW (an additional 110MW will be possible once the steam turbine for T2 is commissioned);
- Tema 1 Power Plant with a power generating capacity of 126MW;
- Mines Reserve Plant with a power generating capacity of 80MW
- Tema 2 Power Plant is currently under construction and will provide an additional 50MW once completed;
- Kpone Thermal Power Project is currently under construction and will provide an additional 230MW once completed.

Domestic demand growth has been estimated at 10% between 1985 and 1993. Electric power supply and consumption as a proportion of total energy is therefore set to increase from the current level of 10%. Meeting energy requirements for economic development has its environmental consequences as expected. However, the benefit of the increased energy capacity for the country and its population largely exceed and justifies the minimal impact that T3 Thermal Power Plant may pose to the environment and society.

Figure 5.1 below shows the projected peak load demand according to the VRA.

Figure 5.1 Load Demand According to the VRA



Ghana's total installed public generating capacity is approximately 1,936 MW of which 1,180 MW (60.95%) is hydroelectric, based on two dams on the Volta River at Akosombo, 1,020 MW and Kpong, 160MW. Total diesel generating capacity is 30 MW. These are all operated by the VRA. The Takoradi Thermal Power Plant has added 550MW with a potential for another 110MW once the combined cycle phase of T2 is completed. The Tema 1 and Mines Reserve Power Plants have added another 206 MW and an additional 280MW will be available once the Tema 2 Plant and Kpone Thermal Project are completed.

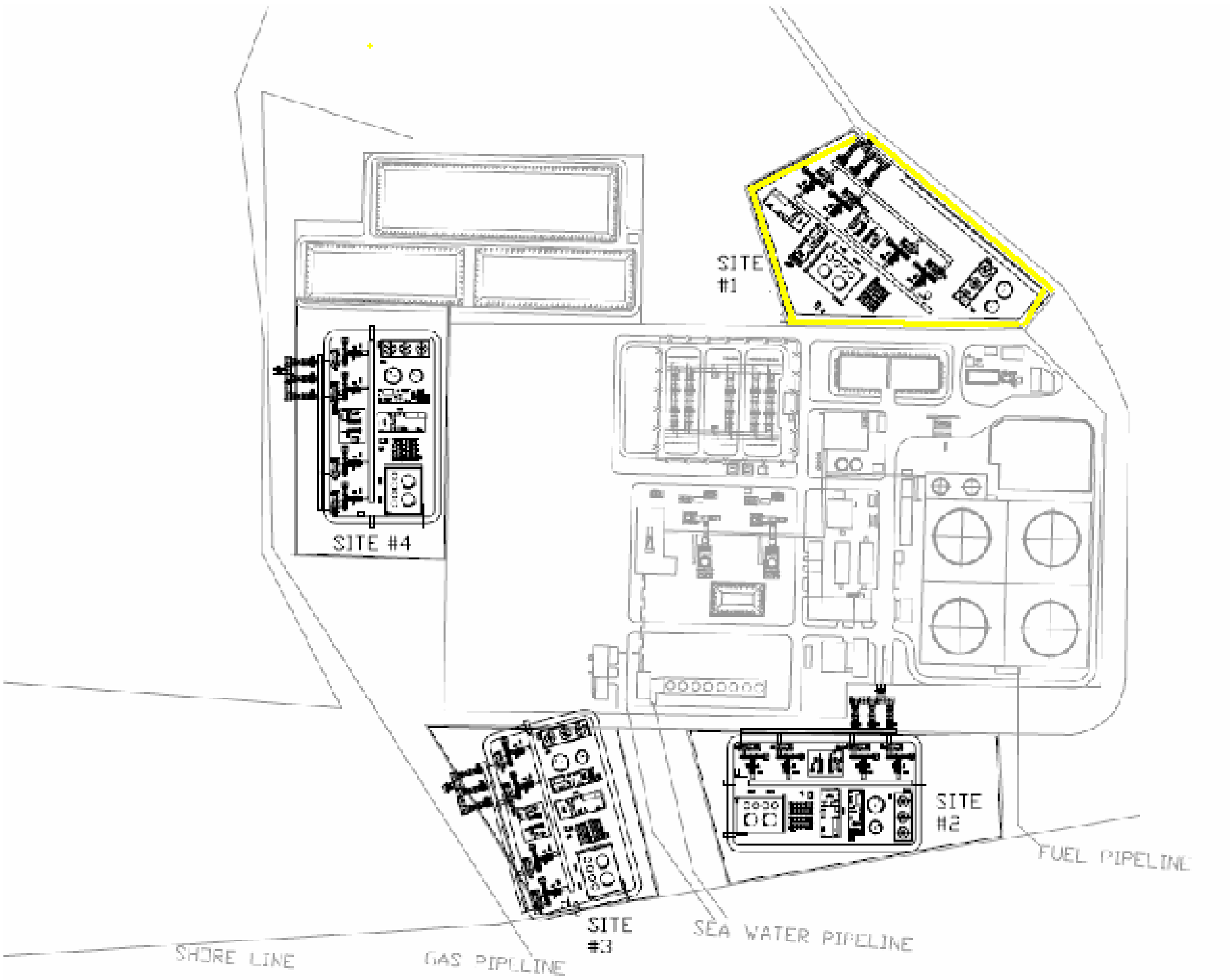
The ever-increasing demand for electricity in Ghana is placing a heavy burden on the available resources of TTPP and will soon outgrow its capability. This will create a shortfall in energy which must be addressed before it becomes critical. The T3 expansion of TTPP has been proposed in response to the recent energy crisis and will increase the total output of TTPP by 132 MW to give the facility a total output capacity of 682 MW, when completed.

In addition, power produced by T3 will reduce the need to import electricity from neighboring countries, and may provide the potential for exporting electricity to neighboring countries such as Burkina Faso, Benin, Cote d'Ivoire and Togo. This potential for exporting power may relieve Ghana's dependency on other nations for electrical energy, as well as providing a valuable source of revenue.

Alternatives for different technologies and fuels were evaluated and accepted or rejected on the basis of practical, economical and environmental contexts. Since T3 will be constructed within the TTPP site, using similar technology, and sharing TTPP components, infra-structure and support services, it is considered that the alternative proposals prepared for T1 are essentially the same for T3. Therefore, the detailed assessment of the alternatives presented in the 1995 EIA Report is sufficient to cover similar considerations of T3 and therefore is not repeated in this section.

Within the boundaries of TTPP, the location chosen for T3 (site 1) was determined after consideration of four possible locations (see Figure 5.2). The following factors were taken into consideration; available space (recent site survey indicated that site 4 location was allocated to T2's combined cycle expansion and would no longer be available), equipment locations to accommodate space (site 2 would possibly encroach in gas and water easements), accessibility, site preparation, least impact to existing environment (site 3 posed possible erosional impact to the coastal line and encroached in a gas easement) and TTPP current operations.

Figure 5.2 Alternative T3 Site Locations



The proposed expansion carried forward from the selection process as T3 was selected on the basis that it represented the most economically viable option for achieving the key objective of providing a rapid response to the energy crisis as well as involving minimal environmental disturbance.

The objectives of T3 in addition to augmenting the current supply and efficiently meeting the potential growth in electricity demand resulting from the improved economic performance of the country, also include diversifying Ghana's predominantly dependence on hydro-electric power.

6 Significant Environmental Effects and Mitigation Plan

6.1 Introduction

The potential environmental effects described for each environmental topic, are defined as those likely changes (beneficial or adverse) to the existing environmental conditions. They represent the likely gross effects, i.e. those effects resulting after the site preparation, construction and operation of T3. These mitigation measures are described in Sections 6.3 and 6.4.

The Mitigation Plan comprises descriptions of the following:

- Mitigation measures associated with T1/T2 that have been accounted for in the description of the gross environmental effects of T3 in Section 4;
- New mitigation measures required for T3 to help reduce the significant environmental effects identified in Section 4;
- A description of the nature and significance of any residual effects likely to remain after site preparation/construction and operation has commenced, despite the incorporation of the new mitigation measures with T3; and
- Any contingency plans for emergency scenarios that may be relevant for each environmental topic considered.
- Expectation as a result of T1 and T2 construction and operational support to the communities.

6.2 Significant Environmental Effects

6.2.1 Air Quality

Air quality effects can arise during both the site preparation/construction and operation of T3, whereby the following are the key issues:

- Dust generation during site preparation;
- Emission and dispersion of pollutants from TTPP stacks during operation; and
- Fogging and salt deposition from cooling towers during operation

As the potential site preparation/construction effects were assessed in detail in the 1995 EIA Report, this assessment has concentrated on addressing the scale and significance of air quality effects associated with the operation of T3.

A complete air dispersion model is presented on Appendix C and it clearly indicates that the the maximum concentrations of NO_x, CO, SO_2 and PM_{10} (PM_{10} predicted emissions indicate that the criteria for $PM_{2.5}$ would consequently meet applicable standards) from the operation of T3 will be negligible compared to the maximum allowable limits for air quality standards set by Ghana EPA and World Bank Standards. A summary of the results are presented on Table 6.1.

Table 6.1 Summary of Emissions and Air Dispersion Modeling

Compound Name	Compound Molecular Wt.	Background Conc. ug/m3	Modeling Conc. ug/m^3	Model+Background Conc. ug/m3	Modeling Conc. ppm	Modeling Conc. ppb	World Bank Standard ug/m3	NAAQS Standard ppb	NAAQS Standard ppm	NAAQS Averaging Period
NO_x	46.0000	0.0108	3.20	3.2058	0.0016	1.5611	100.00	54.00	0.0540	Annual
NO_x	46.0000	0.0108	12.04				150.00			24-hour
CO	28.0000	0.0000	51.10	51.0960	0.0409	40.8768	**	35,500.00	35.5000	1-hour
CO	28.0000	0.0000	10.93	10.9320	0.0087	8.7456	**	9,500.00	9.5000	8-hour
SO2	64.0000	0.0007	1.07	1.0657	0.0004	0.3730	80.00	35.00	0.0350	Annual
SO2	64.0000	0.0007	1.28	1.2763	0.0004	0.4467	150.00	145.00	0.1450	24-hour
PM_{10}***		30.2850	1.14	31.4213			50.00			Annual
PM_{10}							150.00			24-hour

* No background data available for CO.
** No World Bank Standards estblished for CO
*** The background levels for PM10 are skewed and are probably too high because the monitor is next to a dusty soccer field!

Based on this comparison, it can be concluded that there is little likelihood of the operation of the plant resulting in air quality limit values being exceeded under the assumed conditions, therefore no further investigation or additional mitigation measures will be required.

6.2.2 Social Issues

The potential social impacts likely associated with the site preparation/construction and operation of T3 includes the following:

- pressure on existing community infrastructure and increases in traffic and of road traffic accidents;
- employment opportunities and influx of migrant workers;
- competition for food supplies leading to an increase in prices;
- disruption of local communities with an increase in crime and anti-social behavior and increases in prostitution leading to higher risk of HIV/AIDS;
- increase in mosquito breeding areas from areas of standing water leading to an increase in malaria; and
- increase in traffic and road traffic accidents.

Methodology of Assessment

The assessment of potential social effects has been made on the basis of objective comparisons between known activities associated with T3 against the existing conditions observed. The significance of these effects has been assessed by taking into account the existing baseline condition, the expected change or demand, the expected geographical area affected and the timing of the impact.

Potential Significant Effects – Site Preparation and Construction

There are expected to be no significant adverse effects on the community infrastructure, i.e. site access, site services and construction worker social requirements, associated with T3. While site preparation activities will require approximately 50 workers, these are significantly lower numbers than associated with T1/T2 construction. Furthermore, during T1/T2, appropriate arrangements were made to accommodate worker requirements; these will be sufficient to accommodate T3 worker requirements.

T3 will have a slight to moderate beneficial impact with regard to employment opportunities due the worker requirements for the site preparation and constructions stages (approximately 50 for site preparations and a maximum of 300 for construction). This benefit will primarily last the duration of these stages (up to 2 years in total), although some further employment opportunities will be available during the operation of T3.

In terms of migrant influx, the influx of migrant job seekers did not lead to, for example, the establishment of squatter camps during the site preparation/construction of T1/T2, therefore there will be no such an occurrence during T3. Those workers who did enter the area found accommodation within the VRA township or in nearby towns, principally Aboadze. Given the smaller site preparation/construction workforce required and that it is anticipated that the existing T1/T2 accommodation arrangements will be sufficient for T3, no significant adverse impact is expected.

Food service outlets were provided in association with T1/T2 and significant increases in food prices were not observed as a result of T1/T2, as marketing is normally completed in Sekondi-Takoradi. Given the food outlets, absence of significant food price increases with T1 and that the site preparation/construction workforce requirements for T3 are lower than T1/T2, no significant adverse effect is expected with T3.

Previous expectations of disruption to surrounding communities and the introduction of anti-social behavior by immigrant workers associated with T1/T2 have proved to be unfounded. There have been no major disruptions to village life to date and there is no reason to expect this situation to change with the site preparation/construction of T3.

The single male nature of the majority of the site preparation/construction workforce for T1/T2 and potentially for T3 may lead to a potential increase in prostitution in the general area surrounding TTPP. This in turn may potentially lead to an increase in HIV/AIDS and other sexually transmitted diseases (STDs); the full significance of which is beyond the scope of this assessment. However, given that the workforce required for site preparation and construction stages will be smaller than that associated with T1/T2, the overall scale of change in risk is expected to be lower.

There are also public health concerns relating to the potential increase in mosquito breeding areas in bodies of still water, such as retention pond lagoons, sewage lagoons and the water reservoir, which in turn may have the potential to increase the incidence of malaria. However, as the site preparation/construction of T3 will not produce any additional areas of standing water, no significant change to risk of malaria breeding areas over and above that associated with T1/T2 will occur.

Potential Significant Effects – Operational

Of the potential social impacts listed above, the following may also result during the operation of T3, and may therefore become more permanent effects than those lasting the duration of the site preparation/construction period only:

- Employment opportunities;
- disruption of local communities with an increase in crime and anti-social behavior; and
- increase in prostitution leading to higher risk of HIV/AIDS and STDs.

A slight cumulative benefit will occur during the operation of T3 whereby between 25- 30 permanent job opportunities will be created.

There is expected to be no significant adverse impact resulting from community disruption, including conflict with the community's commercial activities, with the operation of T3. This is made on the assumption that no disruption/anti-social behavior has so far been recorded during the operation of T1/T2. In addition, and as a consequence of the permanent employment, T3 workers are more likely to bring their families thus introducing a more stable element into the local community, thereby further reducing the potential for disruption/anti-social behavior.

There are also currently very good relations between TTPP and the community and T3 will implement appropriate measures to address any community concern that may arise.

There is a potential cumulative adverse impact associated with an increase to risk of exposure to HIV/AIDS and other STDs for the T3 operational workforce. However, this impact is expected to be slight given that the T3 operational workforce will be small and more likely to comprise married individuals with their families at the VRA township.

6.2.3 Water and Wastewater

Methodology of Assessment

The assessment of the water and wastewater impacts from the construction of T3 was determined by site visits, previous studies undertaken and additional reports concerning the construction of T3.

Potential Significant Effects – Site Preparation and Construction

Most of the water and wastewater systems designed for T1/T2 will be used during the construction and operation of T3 and therefore the additional impacts of T3 should be minimal.

The water requirements for the construction phase of T3 will be minimal and will be met by the existing Takoradi Thermal Plant dedicated 6" line.

There are no seawater requirements for T3.

The VRA water facilities were confirmed to be sufficient to accommodate T3 water requirements. As the water supply facilities were fully evaluated in the 1995 EIA Report and impacts were defined as negligible, no further analyses of T3 impacts are required.

Wastewater generated during the construction and commissioning of T3 will be discharged via the effluent lagoons of T1/T2 after proper neutralization processes at the chemical cleaning lagoon. Storm water will be discharged to the existing site stormwater channel. Wastewater will mainly consist of surface water and water from equipment commissioning. Effluent lagoons have sufficient capacity to accommodate the discharges produced during construction. The wastewater discharges were fully evaluated in the 1995 environmental assessment and, as there are determined to be no additional significant impacts, no further analysis was undertaken.

During site preparation/construction activities there is a potential for both suspended solids, e.g. soil, and other contaminants (e.g. metals, oils, grease) to enter the storm water channels. There is also the risk of accidental spills of fuel that could cause contamination of watercourses.

Potential Significant Effects – Operational

Since the water usage in T3 is limited to a closed loop cooling water system and water injection for emission control of NOx, the water requirements for the operational phase of T3 are minimal. Approximately 473 gpm will be used as makeup for the cooling water system and 80 gpm for the water injection system. This requirement will be easily supplied by the existing Takoradi Thermal Plant dedicated 6" line and T1/T2 Demin Water facility.

All effluents produced during the operation of T3 will be discharged into the Final Discharge Sump of the existing T1/T2 blowdown system.

TTPP will provide treated LCO for T3 operation. T3 will use the existing plant's oily/water system facilities. The water/sediment sludge mix from operation will be discharged to the existing plant oil/water lagoon, where it is treated by gravity separation, allowing clean water to be discharged to the surface water channel and the oil to be held in a waste oil tank. Disposal of oily wastes will be removed off site via road tanker by waste oil reuse companies.

The expansion of the plant will result in a more frequent delivery of fuel. It is considered that the existing Oil Spill Contingency plan, together with regular training exercises and maintenance of the equipment will provide sufficient cover for the potential additional risk of spillage created by the development of T3.

6.2.4 Noise

Methodology of Assessment

In order to predict the likely consequences of T3 on the noise environment, it is necessary to consider the estimated noise levels associated with T1/T2; this provides the basis on which assumptions for the likely activities and therefore noise generation associated with T3 may be made.

Sound level data from typical site preparation and construction site activities have been used as the basis for site preparation and construction noise level predictions for T3. However, it should be noted that the site preparation and construction noise level predictions are only indicative, and based on an assumed plant; the type of plant actually used may differ slightly.

Current noise monitoring data provided by the VRA (Table 6.2) indicates that TTPP is in compliance with Ghana EPA limits, except at the western boundary of the plant where the slight exceedance is attribitued to TICO GT's, and necessary measures were taken to mitigate the slightly high noise levels. These results have been used to derive likely noise levels at locations in the vicinity of the TTPP site.

Table 6.2 Noise Monitoring Results at T1 Boundaries [dB(A)] – Jan-March 2009

Area	EPA Limit [dB(A)]	Noise Levels [dB(A)]			Remarks
		Jan 2009	Feb 2009	Mar 2009	
Eastern Fence	70	53.0-55.0	52.0-54.0	54-55	Compliant with allowable limit
Northern Fence	70	64.3-66.0	64-66	60-62	Compliant with allowable limit
Southern Fence	70	58.2-62.8	57.1-60.5	59-61	Compliant with allowable limit
Western Fence	70	69.0-70.0	69.5-73.3	68-72	2-3 dB(A) above compliance limit due to TICO GTs
Aboadze Village (day)	55	50-54	50-54	51-53	Compliant with allowable limit
VRA Township (day)	55	53-55	53-55	54-55	Compliant with allowable limit
Aboadze village (night)	48	43-47	43-47	44-47	Compliant with allowable limit
VRA Township (night)	48	46-48	46-48	45-47	Compliant with allowable limit

NOTES:

a) Eastern fence corresponds to the fence east of the crude oil storage tanks
b) Northern fence refers to the fence dividing T1 from T3 and land adjacent to the raw water tank
c) Southern fence is next to the T1 cooling tower
d) Western fence is west of the T2 gas turbines

Potential Significant Effects – Site Preparation and Construction

The site preparation stage, involving the preparation of the area for construction will require the use of plant and equipment which can have the potential to produce excessive noise levels.

Based on the assumed plant, the predicted noise levels attributed to site preparation and construction activities respectively are detailed below. These noise levels have been predicted without accounting for the screening effects of T1/T2, i.e. they represent a worse case situation.

Predicted Noise Levels – Site Preparation

Location	Predicted L_{Aeq} dB
• Beach at Amuzu	50
• Adjacent to Lorry Park, Aboadze	55
• Environmental Monitoring Station, Aboadze	51
• VRA township	52

Predicted Noise Levels – Construction

Location	Predicted L_{Aeq} dB
• Beach at Amuzu	52
• Adjacent to Lorry Park, Aboadze	58
• Environmental Monitoring Station, Aboadze	53
• VRA township	54

As would be expected, given the greater level of site activity during the construction stage, predicted noise levels tend to be, on average, 2 dB greater than those predicted for the site preparation stage. This noise level change is unlikely to represent a significant adverse impact.

Overall site preparation/construction noise levels (including the operational noise from T1/T2) should not exceed 55 dB(A) (Ghana EPA limit for residential area) outside plant boundaries at the specific noise sensitive receptors considered. Noise levels within the plant perimeter should not exceed 70 dB(A) (Ghana EPA limit for industrial area). In addition, these activities will be intermittent and in most cases limited to daylight hours over the project construction phase.

Noise levels associated with the site preparation and construction of T3 are considered likely to be less than those associated with the site preparation and construction of T1/T2 at the noise sensitive receptors due to the screening afforded by T1/T2 and the smaller scale of activities.

Prior to operation of T3, it may be necessary to undertake steam blows during the commissioning of the T3 plant. Steam blows undertaken during the commissioning of T1/T2 have resulted in noise complaints. The frequency and number of steam blows required during the commissioning of T3 will depend upon circumstances at the time and cannot be specifically quantified at this stage. The likely effect of steam blowing will be significantly adverse, but very short lived. However it is important to point out that this activity will not be a routine occurrence and will potentially occur during the commissioning period for T3 only.

Potential Significant Effects – Operational

A preliminary environmental sound level assessment was performed in June 2009 by Hoover & Keith Inc. Acoustics and Noise Control Engineering and indicates that the operation of T3 would increase the ambient sound levels at the nearest noise sensistive receptor by 6 to 11 db(A).

The original site selection of site 4 (southwest of the original plant) would position the primary sources of noise emissions equipment approximately 1500 meters to the nearest off-site noise sensitive area (NSA), the VRA clinic. The VRA later advised that recent site survey indicated that site 4 location was allocated to T2's combined cycle expansion and would no longer be available. The subsequent relocation of T3 to site alternative 1, which posed the least impact to the existing environment, substantially reduced the distance to approximately 250 meters from the major noise emission sources to the nearest off-site noise sensitive area. The relocation consequently decreased the dispersion area for the noise emissions which in turn resulted in Ghana EPA and World Bank standards non compliance levels (Table 6.4), an impact that it was previously not accounted for.

The complete preliminary environemtal sound level assessment is provided in Appendix D.

Table 6.3 below provides a summary of sound pressure levels at the nearest off-site noise sensitive area, the VRA clinic (part of the VRA complex), and indicates that up to 1000 meters distance from the principal souces of sound level the levels are above the required guideline of 55 db(A). It is worth noting that the nearest residential area to the proposed site is approximately 2000 meters, a distance in which the sound levels meet current guidelines. Nevertheless, a slight impact to the environment is noted and necessary mitigative measures will be carried out to fully comply with World Bank and Ghana EPA guidelines.

It can be observed from the community noise monitoring results (Table 6.2) and predicted sound levels from T3 (Table 6.3) that even though noise levels at the fenceline have increased, the Aboadze village has not been adversely impacted by noise from the operational activities of the station.

Based on this preliminary modeling, it appears that the only mitigation measures needed for this project are associated with meeting acceptable sound levels at the VRA clinic, the nearest noise sensitive area. Several options are being evaluated and will be implemented after discussions and an agreement has been reached with the VRA.

Further investigation and additional studies will be conducted in a timely manner to confirm the current predictions and any necessary mitigative measure will be implemented, as agreed upon with the VRA, to ensure compliance.

Table 6.3 Summary of Sound Pressure Levels at the NSA (VRA clinic - 250 m.)

Description	Octave Band Center Frequency - Hz									Awt
	31.5	63	125	250	500	1000	2000	4000	8000	
CT Enclosure	63	61	62	64	54	52	50	46	38	59
CT Intake	74	68	68	47	30	7	20	37	38	53
OTSG Exhaust Stack	71	66	65	63	58	50	38	24	13	59
OTSG Shell	84	74	74	68	59	47	44	39	23	63
Steam Turbine Generator (STG)	62	65	65	60	54	51	46	34	34	57
Total	**85**	**76**	**76**	**70**	**63**	**56**	**52**	**48**	**41**	**66**

Table 6.4 Ghana EPA and World Bank Noise Level Criteria

Zone	Description of Area of Noise Reception	Permissible Noise Level [dB(A)]	
		Day 06.00-22.00	Night 22.0-06.00
A	Residential areas with negligible or infrequent transportation.	55	45
B1	Educational (School), and health (Hospital, clinic) facilities.	55	50
B2	Areas with some commercial or light industry.	60	55
C1	Areas with some light industry, places of entertainment or public assembly, and places of worship such as churches and mosques.	65	60
C2	Predominantly commercial areas.	75	65
D	Light industrial areas.	70	60
E	Predominantly heavy industrial areas.	70	70

The Noise Monitoring Program will be extended to accommodate and monitor T3 operational phase, and in the event the noise levels are higher than predicted, necessary mitigative measures, such as installation of barriers and strict enforcement of personal protective equipment use, will be implemented.

6.2.5 Access and Traffic

Methodology of Assessment

The methodology for the assessment of potential access and traffic impacts associated with T3 comprised:

- site visits during May 2009;
- reviewing available documentation; and

- making qualitative assessment of potential effects on the basis of available information for T3 activities against the baseline conditions.

Potential Significant Effects – Site Preparation and Construction

The main T3 site preparation and construction activities that are relevant to access and traffic issues include the ground works and the delivery of construction materials which will involve increased traffic movements along all the primary access roads to TTPP.

It is important to note that T3 traffic volumes and movements will be less than those associated with T1/T2 given the smaller scale of T3.

The potential environmental effects during site preparation and construction are likely to be associated with:

- The requirement of new access roads;
- Disruption to local, non-TTPP traffic (due to congestion and/or the need for traffic management);
- Changes to roadside air quality and noise levels; and
- Driving Conditions and Risk of accidents.

The access roads to the site established during the construction of T1/T2 (predominantly the upgraded Inchaban to Aboadze road) are considered to be adequate for use by T3 construction traffic; however, new access roads may be required. Additionally, the primary access routes to and from site will be maintained throughout construction, i.e. no traffic diversion or road closure will be required. Consequently there will be no significant disruption to non-TTPP related traffic utilizing these routes.

During both Phase I and II, the transportation of construction equipment and site staff will occur and will in turn generate new traffic levels on local roads, in particular heavy construction vehicles. Estimated changes in traffic levels are an average of approximately 30 trucks and 40 cars per day. While it is predicted that the volume of T3 construction traffic could increase as the construction program progresses, the increase is not expected to exceed the peak traffic levels attained during T1/T2 construction. Therefore it is expected that there will be no significant cumulative increase in traffic flows and hence no associated change to the level of environmental impact over and above that for T1/T2.

Bus services will be provided for T3 workers. However, it is probable that the number of buses likely to be required will be less than those required for T1/T2, given the smaller T3 construction workforce.

There will be situations where unusual or wide loads will be transported to the site via road. This could result in obstruction to traffic flows, driver frustration and a possible increase in accident risk particularly within Takoradi and at key junctions. The frequency of such journeys is low and in any case, the duration of the impact will be limited to the length of the journey only.

As a consequence of the T3 construction traffic flows and or the incidence of traffic obstruction, there is the potential for a slight adverse impact on air quality and dust levels, and noise levels. Those most likely to be affected by these temporary changes to air quality and noise levels include people travelling on foot/bicycle along the road corridors and where homesteads/ settlements are located within 50 to 100 m of road. However, these effects should last the duration of the site preparation/construction period for Phase I and II only, and, in any case, are unlikely to reach levels associated with T1/T2 at its peak given the lower volume of T3 construction traffic.

It is also important to note that the proportion of site preparation/construction traffic relative to non-TTPP related traffic is expected to be low, and therefore the overall impact of TTPP generated traffic is also likely to be diluted.

The increased incidence of speeding and associated implications to road traffic accidents, along improved roads in Ghana is a national problem.

During the site preparation/construction of T3 there is a potential for T3 related traffic to disrupt traffic flows particularly where slow moving vehicles are involved. However, the volumes of T3 site preparation/construction traffic are significantly lower than those volumes associated with T1/T2 and therefore the relative impact, albeit temporary, is expected to be less adverse.

Potential Significant Effects – Operational

There will be no change to the 'designated' access routes to T3 for operational traffic.

During the operation of T3 it is likely that commuter traffic (either by private car or public bus services) for TTPP will be minor given that the VRA township will house the majority of the workforce. Therefore commuting will be over very short distances.

However, there is still likely to be a flow of equipment, resources and waste into/out of TTPP via road. This flow of traffic is not expected to represent a significant proportion of the total traffic flow present on the local road network, as well as being considerably smaller than vehicle flows associated with the T3 site preparation/construction stages.

The requirement for wide or unusual loads to be transported from Takoradi Port is likely to significantly decline once construction has been completed, although in the unlikely event of equipment failure of a T3 component it may be necessary to transport a replacement to T3. The associated impacts, although adverse, would likely be short lived lasting the duration of the journey only.

Given the likely lower volumes of T3 related traffic and a reduced likelihood of slow moving traffic (in the absence of heavy vehicles required during plant operation) there is expected to be a relative improvement in air quality and noise levels in areas adjacent to the relevant road network.

A slight improvement in driving conditions relative to site preparation/construction stage conditions may occur due to the benefits of the VRA township, lower TTPP related traffic volumes, and the fact that operational traffic is unlikely to contain heavy, slower moving vehicles, unlike during the construction stages.

6.2.6 Land Issues and Waste Management

Methodology of Assessment

The main methods used for the assessment of potential impacts relating to land issues and waste management are:

- Site visits by GIBB during November 1998, January 1999 and February 1999;
- Review of available documentation, specifically;
    - Takoradi Thermal Plant Environmental Assessment prepared for Volta River Authority. Acres International (1995);
    - Takoradi Thermal Power Plant Annual Environmental Report January-December 1998, VRA (1999);
    - Proposed Expansion to Takoradi Thermal Power Plant, Ghana.
    - Environmental Scoping Report. GIBB Environmental (1999);
    - Contract documents for construction of T1 and T2

AERC and HPI staff visited both the proposed development site and the areas occupied by the current construction, commissioning and operation of T1/T2. Additional information was obtained from interviews and consultations with site staff.

The wastes that arise from the construction and operation of T3 will be entirely similar in nature to those that are produced by the construction and operation of T1/T2. The construction and operation of T3 will proportionately increase the amount of wastes arising from the site as a whole.

Potential Significant Effects – Site Preparation and Construction

Additional land acquisition is not required for the construction of T3. Therefore there are no impacts relating to land acquisition.

There is a requirement for some earthworks, specifically land raising/grading and excavation for foundations, in preparation for the construction of T3.

- Potentially significant issues relating to the proposed earthworks include:
- Vegetation cover loss from the borrow areas and in the area of the earthworks;
- Erosion around the borrow areas; and
- Traffic movements between borrow areas and the earthworks location.

It is proposed to source the material required for T3 from the existing borrow areas created for T1/T2. Since these areas have already been cleared of vegetation further clearance will not be required.

There is a potential for soil erosion from poorly managed borrow areas, potentially creating problems with reinstatement and also leading to impacts on the local wetland ecosystems caused by sedimentation. Potentially significant erosion impacts can also occur if rehabilitation of the borrow areas is poor. This can lead to an unsightly visual impact.

The impact of earthmoving equipment transporting material between the borrow areas and the T3 site will be localized due to the close proximity of the borrow areas to the site.

Site preparation and construction wastes produced from T3 will be similar in nature to those currently produced at T1/T2. This will include:

- Spoil material from excavations and earthworks;
- Packaging materials of wood, cardboard and plastic;
- Empty chemical, oil and paint containers;
- Scrap metal from construction and packaging;
- Waste oil; and
- Domestic garbage.

The potentially significant impacts of the wastes generated include:

- Land contamination from paints, oil and chemicals;
- Improperly stored wastes can become unsightly areas, and general eye-sores;
- Health related issues from improper waste management, such as pests and disease can result where waste is stored too long or allowed to decompose in inappropriate areas.

Potential Significant Effects – Operational

The operation of T3 will produce additional wastes of a nature similar to the operational wastes generated by T1/T2.

These wastes will include:

- Packaging materials of cardboard and plastic;
- Office wastes;
- Clinical wastes from the infirmary;
- Empty chemical, oil and paint containers;
- Maintenance wastes including parts, lubricants, rags etc.;
- Food wastes form the canteen;
- General household wastes from the VRA township; and
- Sludge wastes produced infrequently from the sewage and chemical lagoons.

Hazardous and toxic wastes produced at the site include used or contaminated oils, used industrial solvents, industrial corrosives and acids used for cleaning, descaling and other related processes. These wastes are treated within the wastewater system on site; no hazardous solid wastes are produced during construction or operation.

The solid wastes produced by the construction and operation activities of T3 can be integrated into the provisions that have been introduced as part of T1/T2.

Unmanaged waste materials can lead to the contamination of land and water resources, health hazards and health and safety implications. The next section identifies specific mitigation measures to avoid these effects.

6.2.7 Ecology

Methodology of Assessment

This section describes the likely ecological consequences of T3 on the terrestrial environment. The methodology is based on an objective appraisal between the existing conditions (relative to available documentation and site observations) and the site preparation, construction and operation activities. Potential ecological effects resulting from T3 may include the following:

- Vegetation clearance and habitat loss;
- Disturbance of wildlife; and
- Habitat contamination.

These effects and their likely significance and duration are discussed below.

Potential Significant Effects – Site Preparation and Construction

A portion of relic wetland between the western site boundary and a parallel running track of spoil material generated during the T1/T2 construction stage, will be used as a lay down area for T3. While this represents a cumulative loss of habitat/vegetation, the area affected is small and has already been disturbed and isolated from the surrounding wetlands due to the spoil disposal from T1/T2. The overall impact is therefore considered to be of minor significance.

There is also the potential for ecological impacts to arise from the use of local borrow areas during raising of the T3 site during site preparation. However, the same borrow areas will be used for T3 as for T1/T2, and therefore, no additional ecological impacts through vegetation clearance/habitat loss are anticipated.

There is the possibility that surrounding wildlife may be disturbed by noise generated during the site preparation/construction stages. It is predicted that in terms of human perception, there will be a slight increase in noise impact during site preparation/construction. However it is considered unlikely that any significant effects to the wildlife will occur from T3 given that the noise environment has already been affected by T1/T2. For birds in particularly, it is probable that some degree of acclimatization has occurred such that noise levels are less likely to be more disturbing than when first encountered.

Other potential ecological impacts during site preparation/construction of T3 are related to the contamination of vegetation/habitats, caused by dust generated on access roads, accidental spillage of chemicals and the escape of waste materials.

Given that measures have already been set up in association with T1/T2 to limit such occurrences, it is expected that any cumulative impact caused by the site preparation/construction of T3 will be minor.

Potential Significant Effects – Operational

There will be no further habitat loss/vegetation clearance required during the operation of T3.

During the site preparation/construction stage of T3, it is likely that the disturbance of wildlife in the surrounding area will be less than during the site preparation/construction of T1/T2. This is due to the predicted operational noise levels (T1/T2 + T3 on combined cycle mode) being lower (between 7 to 11 dB) than the site preparation/construction stage levels. In addition, since the predicted increase in operational noise levels between T1/T2 and T1/T2+T3 is small (2-3 dB) it is concluded that any cumulative impact on wildlife due to noise disturbance will be minimal.

The main impact of T3 during operation is likely to be associated with vegetation/habitat contamination due to the settling of stack emissions (containing trace metals, particulates and carbon residues) downwind of TTPP. Given the prevailing wind direction, the area most likely to be affected will be north-northeast of the TTPP. This general area currently comprises subsistence farming and therefore any ecological impact will be limited. It is important to note that it is expected that deposition from the plant will only be a potential problem to vegetation when LCO is in use, as natural gas is less likely to produce particulate matter; a particularly damaging component to vegetation.

Dust generation from access routes or exposed borrow areas, spillages and effluent/wastewater releases may remain a potential source of pollution during the operation of T3, although it is expected that dust generation in particular will be reduced once construction has been completed.

6.2.8 Landscape and Visual Character

Methodology of Assessment

The assessment of impacts on the landscape and visual character by T3 was based on an objective appraisal of the proposed structures and features of T3 relative to the observed existing conditions, and in light of the T1/T2 landscape planting proposals and other agreed measures.

Potential Significant Effects – Site Preparation and Construction

The main potential site preparation and construction impacts associated with T3 on the landscape character and quality of the surrounding area could include the following:

- Loss of further vegetation and changes in land use
- Introduction of new structures and features

As described above, a small area of land adjacent to the western site boundary of the existing plant will possibly be used for lay down areas in T3. No significant adverse impact on the landscape character is expected to result given the area of land involved and its position between T1/T2 and the spoil area.

During the site preparation stage, further borrow material will be required. This will be sourced from existing borrow areas but represents a small proportion of T1/T2 borrow requirements. Consequently, the likely landscape impacts during the site preparation stage are expected to be minimal at most.

It is expected that with the construction of additional stacks for the power units, they will have a slight adverse impact on account of T3 reinforcing the intrusive, man-made feature of T1/T2. Despite the flat exposed landscape, which affords limited natural screening, this effect is deemed slight and incremental, as T3 is an expansion of an existing feature (T1/T2) that has already affected the landscape character and quality. Furthermore, T3 will occur within the TTPP site rather than as a separate, isolated structure and the construction activities will be relatively smaller scale and generally limited to the designated site (for example no further pipeline excavations will be required along the beach).

The primary potential visual effects of T3 would be similar to those discussed for the landscape effects above. While no further views of TTPP will be opened up, the new exhaust stacks for T3 will add further prominent structures into the skyline. However, this effect is also expected to be slight and incremental given the existence of T1/T2's exhaust stacks.

It is important to note that immediately after construction the adverse visual intrusion of T3 from overlooking areas is likely to be more significant than that expected in later years. This is due to the areas of exposed earth on former construction site access tracks, lay down areas within TTPP and borrow areas, other disturbed sites and/or the restored areas (such as the beach) which will form harsh, unnatural and noticeable features. While this effect is expected to be temporary, on account of the proposed T1/T2 landscape planting proposals, the planting at this stage will not yet have established therefore providing minimal visual relief.

Potential Significant Effects – Operational

There is expected to be no further adverse change to the landscape character and quality during the operation of T3, over and above that described in connection with the construction of T3.

Some slight localized improvements may occur with time as the T1/T2 landscape planting proposals mature, thereby helping to restore and/or integrate TTPP and other planted/restored areas, as far as possible, into the landscape.

Overall, there will be no further adverse change to the visual effects of T3 during its operation than associated with its construction, or in relation to its operation.

The exception, albeit infrequent and short-lived, will be during the release of visible plumes and or any fogging that may occur in the operation of the plant. However, this will be a combination of both T1/T2 and T3. This is unlikely to be a significant adverse effect.

Some improvements to the views of TTPP may result from the T1/T2 landscape planting proposals, particularly once the taller vegetation has matured and is therefore providing maximum screening, in addition to improving the aesthetic quality of the plant at ground level.

6.3 Existing and Proposed Mitigation – Site Preparation and Construction

6.3.1 Air Quality

While the potential site preparation/construction air quality effects of T1/T2 have not been duplicated in this report, having been covered in detail in 1995 EIA Report, the mitigation measures to be incorporated into T3 have been summarized below. These include:

- minimization of traffic speeds on site to reduce dust generation;
- trucks carrying fine materials will be sheeted;
- traffic will utilize hard surfaced roads wherever possible;
- topsoil stockpiled for any substantial period of time will be covered, seeded or surface bonded to minimize wind erosion;
- plant on site will be well maintained in order to minimize exhaust emissions; and
- batching processes will be subject to dust collection or water spray systems to minimize fugitive dust emissions.

6.3.2 Social Issues

The site preparation and construction stages of T1/T2 showed little negative impact on local communities, in particular Aboadze. Due to the small scale of T3, relative to T1/T2, it is unlikely that the site preparation and construction stages of T3 will result in any additional negative social impacts. The Community Impact Agreement and other mitigation measures put in place for T1/T2 are on-going and will also provide mitigation for the impacts of T3.

The increased risk of HIV/AIDS and STDs posed by the increase in the single male population of the area and the attendant increase in prostitution is difficult to mitigate. However, awareness training and education programs to inform workers of the risks and consequences of their actions will be provided by Volta River. The TPP Infirmary will provide information to the workforce and local community.

6.3.3 Water and Wastewater

During construction there is the possibility that accidental spills of fuel, etc. could cause considerable contamination of watercourses. Every precaution will be taken to prevent accidents, and oil and fuel areas will be bounded. All workers will be trained in the handling, storing, and disposal of hazardous materials. In the event of a spill, there will be an emergency response plan in place so that the spill can be contained immediately. Emergency spill containment material and cleanup equipment will be distributed and stored in appropriate places so that any spill can be cleared up as quickly as possible to minimize any adverse effects.

6.3.4 Noise

The T3 site preparation and construction activities will be well screened from Aboadze, due to presence of T1/T2 buildings and structures and with potential screening attenuations. There will also be some screening provided by T3 for the VRA township and Aboadze village.

The main site preparation and construction activities will largely take place during normal weekday day time periods.

In order to minimize noise emissions to noise sensitive receptors in the vicinity of T3 the following mitigation plan for the site preparation and construction will be undertaken:

- all vehicles, plant and machinery to be fitted with effective exhaust silencers;
- all vehicles, plant and machinery will be maintained in good repair and in accordance with the manufacturer's instructions;
- air compressors to be of the type which is sound reduced with properly lined and sealed acoustic covers, and to be operated with the covers closed;

- all pneumatically operated precision tools to be fitted with properly maintained mufflers or silencers of the type recommended by the manufacturers;
- any machinery which is intermittent in use, to be shut off in periods of non use or, where this is impracticable, to be throttled back to a minimum;
- dump trucks to be only left running when necessary and shut down when not in use;
- noise emissions during night time hours will be minimized;
- general screening and specific local screening when necessary;
- maintain good communication with the public/local communities;
- noise monitoring so that remedial actions can be quickly taken with appropriate training of staff to undertake measurements;
- training of workers to appreciate actions to minimize noise emissions; and

During the commissioning of T3, due care will be undertaken to reduce the potentially significant disturbance to local people produced during steam blows. This will include maintaining clean plant pipework such that the number and frequency of steam blow to clear debris can be reduced; and where required, scheduling steam blows to less noise sensitive times of the day/week. Advance warning of steam blows will also be provided to the local community to reduce the level of disturbance/alarm caused.

6.3.5 Access and Traffic

The main site preparation/construction mitigation measures that will be applied relate to limiting the potential risk of road traffic accidents. This will involve closely managing and controlling the movements of site vehicles and especially those carrying unusually large or heavy loads to reduce the risk of causing accidents or unnecessarily blocking the roads to other users. This will include liaising with local police and local government/authorities on appropriate traffic management measures to implement, particularly when moving loads between Takoradi Port and TTPP.

6.3.6 Land Issues and Waste Management

Land

Land loss for the T1/T2 development, covering the T1/T2 site and borrow areas, was mitigated by payments of cash compensation to the land users for the loss of crops based on values provided by the Land Valuation Board. In addition, a Community Impact Agreement was signed to provide facilities to the local communities. T3 will provide for a playground for the Aboadze complx of schools and possible new facilities for Aboadze. These mitigation measures were addressed in the EIA for T1 and will continue to be observed during all phases of T3.

Further mitigation in lieu of cash compensation for the land loss is not required as no further land acquisition is necessary.

Borrow Areas

Borrow areas will be graded and re-vegetated to prevent long-term erosion. Top soil will be spread out and seeded if required. Borrow areas used during T3 construction will be reinstated.

The reinstatement of borrow areas is a contractual requirement for the relevant contractors.

Solid Waste

Solid waste will be disposed off-site to reduce potential health and pollution concerns. All solid waste that is not reusable in the local community will be taken by Shama Ahanta East Metropolitan Authority or a local contractor to an off-site disposal facility operated by the authority.

Good housekeeping procedures will be maintained throughout. These measures include allocated waste collection areas, regular inspections and audit of disposal contractors.

6.3.7 Ecology

Mitigation measures that will be incorporated during the site preparation/construction stages, to minimize the occurrence and scale of ecological impact are as follows:

- Utilizing existing T1/T2 construction storage and laydown areas where possible to avoid, any additional/accidental encroachment into the surrounding area;
- Extending the landscape planting proposals to include planting of borrow areas and construction access tracks and lay down areas no longer required once construction is complete;
- Incorporating native species common to the area into the landscape planting proposals.

Mitigation measures to limit the potential air and water related impacts on the natural environment during site preparation/construction of T3 have been described in section 6.3.1 and 6.3.3 respectively.

6.3.8 Visual and Landscape Character

During the site preparation/construction stages the following mitigation measures will be applied to reduce the opening up of new views and/or subsequent degradation of the landscape character:

Ensuring no further accidental vegetation clearance or other disturbance/encroachment into areas not previously affected by T1/T2 occurs during the construction of T3.

Extend the landscape planting proposals and continue to plant as soon as practically possible elements of the landscape planting proposals around TTPP in general and T3 so that benefits of the planting can be achieved quickly.

The landscape planting proposals, which will help to integrate TTPP into the landscape and surrounding views, are more likely to be effective once T3 and TTPP as a whole is operational.

6.4 Existing and Proposed Mitigation – Operational

6.4.1 Air Quality

In common with the mitigation measures agreed for T1/T2, measures will be put in place to limit the emissions from the operation of the proposed new units.

The utilization of gas turbine technology in combined cycle mode will result in high generating efficiencies which in turn will minimize the emission of CO_2 and NO_x per unit of electricity produced.

The plant design will incorporate best available technology (BACT) options to minimize the impacts resulting from its operation.The impact of other pollutant gases will also be minimized by judicious choice of technology, fuel and stack design.

The air dispersion study, provided in Appendix C, predicts that the ground level concentrations resultants from T3 operation are negligible compared to the maximum allowable limits for air quality standards set by Ghana EPA and World Bank guidelines.

Emissions of SO_2 and PM_{10} will be minimized by the use of fuel of less than 0.2% S and various gas and water filtration processes. This, in conjunction with a stack height of approximately 27 m, is predicted to result in negligible ground level concentrations. In the event of gas firing, emissions of SO_2 will be reduced to trace levels.

For NOx, emissions will be minimized by the application of water injection technology. This will again result in negligible ambient air quality via atmospheric dispersion from the 27 m stack.

6.4.2 Social Issues

A Community Impact Agreement has been established to offset any adverse effects associated with T1/T2. These measures will continue during the operation of T3 and will evolve where necessary to accommodate any new issues that may develop. It is expected that the good relations with the local communities will continue.

The workforce and community educational and awareness training programs for risks associated with prostitution, undertaken during the site preparation/construction stages will be continued for an appropriate period during operation.

6.4.3 Water and Wastewater

All discharges from T3 will be collected in the extended plant aeration sewage lagoons after proper neutralization treatment in the chemical cleaning lagoons. Storm water will be released into the existing site stormwater channel. The Environmental Management Plan already in place will be extended to T3 to ensure discharges are in compliance with current environmental health and safety criteria guidelines.

The use of extended aeration sewage lagoons for the treatment of non-industrial waste from the TTPP and the VRA township are designed to meet GhanaEPA and World Bank environmental criteria guidelines and were confirmed that its capacity will accommodate T3's additional discharges. Monitoring of the water quality prior to discharge of the effluent from the TTPP lagoons to the common discharge sump should prevent pollution when the effluent is discharged to sea.

The collection of the majority of the wastewater produced from the site in the common discharge sump prior to discharge at sea enables the monitoring of the water quality. This ensures that water quality standards are met, prior to discharge.

To prevent the leakage of oil/fuel from tanks into the ground and ultimately into watercourses, all storage facilities, even temporary facilities, will be in a bermed area with an impermeable liner and of a capacity greater than that of the tank. The oily water treatment system allows rainwater to be removed from the bermed area and the oil removed before discharge.

6.4.4 Noise

It is recommended that TTPP fence line noise levels attributable to site operations do not exceed 55 dB in order to ensure acceptable noise levels at noise sensitive receptors in the vicinity of the plant. However, it is more sensible to establish monitoring stations at representative locations and base noise limits on the periods and guidelines detailed by Ghana EPA and World Bank. Therefore, 1 hour noise levels attributable to on site operations expresses as one hour L_{Aeq} should not exceed the Ghana EPA and World Bank limits (Table 6.4) at the nearest off-site noise receptor.

As discussed in section 6.2.4 a preliminary environmental sound level assessment was performed in June 2009 by Hoover & Keith Inc. Acoustics and Noise Control Engineering which indicated that the operation of T3 would increase the ambient sound levels at the nearest noise sensistive receptor by 6 to 11 db(A). Noise measurements will be undertaken when plant is commissioned to ensure that the actual noise levels are not excessive. Although monitoring will be discussed in section 8.4, it is noted that the results of noise surveys will be used to determine if further mitigation measures, in addition to possible mitigative measures that will be implemented upon further analysis of sound pressure level, as discussed in section 6.2.4., as necessary.

It can be observed from the community noise monitoring results (Table 6.2) and predicted sound levels from T3 (Table 6.3) that even though noise levels at the fenceline have increased, the Aboadze village has not been adversely impacted by noise from the operational activities of the station.

It can be observed from the community noise monitoring results (Table 6.2) that even though noise levels at the fenceline have increased, the Aboadze village has

Additional environmental noise assessment will be carried out and possible necessary mitigative measures will be defined, upon consultation with the VRA, and implemented to ensure compliance with Ghana EPA and World Bank Guidelines. An addendum to this report may be prepared to reflect specific measures that shall be taken to mitigate the excessive noise levels at the nearest off-site noise sensitive receptor (VRA clinic).

6.4.5 Access and Traffic

The risk of road traffic accidents has increased following the road surface improvements undertaken for T1/T2. The following mitigation measures will be introduced to help reduce the risk of vehicular/pedestrian accidents within the vicinity of TTPP:

- Awareness/educational programs on the hazards of speeding/drink-driving for workers in particular;
- Introduction of traffic management features, such as road markings; and
- Providing for regular maintenance of site vehicles, worker buses and other TTPP related vehicles.

In terms of operational traffic, although volumes will be lower than those associated with the site preparation/construction stage, careful management and control of vehicle movements into/out of TTPP will be maintained to keep TTPP traffic induced effects to a minimum.

6.4.6 Land Issues and Waste Management

Existing Waste Management Procedures

A number of procedures for the handling of wastes were identified in the EIA for T1. These will be incorporated into an Environmental Management System (EMS) for T3. Procedures in the T1 EMS include commitments to:

- reduce waste where practicable;
- recycle wastes where possible;
- use recycled materials where possible; and
- disposal of all residual wastes in a safe and responsible manner.

Mitigation measures employed for construction wastes will also be undertaken for operational wastes, such as disposing of solid waste off site, using the Municipal Authority or a local contractor to remove waste and maintaining good housekeeping practices.

Ecology

No further relevant mitigation measures for limiting any adverse ecological impacts are required during the operating of T3, other than those detailed for air quality, water and wastewater and landscape and visual issues (see sections 6.4.1, 6.4.3 and 6.4.7 respectively).

6.4.7 Landscape and Visual Character

The proposed T1/T2 landscape planting plan will be extended to accommodate T3. Broadly defined, the plan largely comprises two distinct planting regimes; the first consists of surrounding the plant and sewage lagoon areas with a mixture of natural grasses, small (5 m high) and medium (10 m high) height spreading shade trees, low level evergreen plants. The proposed bunds (1.0 m high, above site level) will partially surround TTPP and will also be planted; thus maximizing the potential screening capabilities of the planting proposals.

The second planting regime is within TTPP whereby in addition to the mixture of plants for the first planting regime, low level flowering plants and shrubs such as bougainvillea, will be planted on landscaped turf. These proposals will improve the quality of views of the TTPP as well as improve and restore elements of the landscape character and quality affected during the construction of T3 and by its continued presence thereafter.

Additional planting will also be undertaken to restore the borrow areas, where applicable, and due care will be given to supplementing the currently proposed species mixes with appropriate native species for ecological enhancement.

In addition, the stacks are to be painted to help diffuse their visibility in the skyline.

6.5 Residual Effects

6.5.1 Air Quality

Site Preparation/Construction

Any residual air quality effects associated with the site preparation/construction stage are likely to occur for the duration of this stage only.

Operational

While a localized residual effect will remain despite the emission control designing of TTPP (T3 included), this is expected to be of minor significance given that predicted pollutant concentrations (NO_2 and SO_2) would not exceed current environmental, health and safety criteria guidelines.

In terms of global CO_2 emissions, again there will be a slight residual effect; however, Ghana's CO_2 emissions will still remain a very small proportion of total CO_2 emissions (i.e. approximately 1/30 of 1%).

6.5.2 Social Issues

Provided the mitigation measures described in sections 6.3.2 and 6.4.2 are carried out, it is expected that there would generally be no significant residual effects on social issues, attributed to T3 during site preparation/construction or the operational stages.

In an effort to maintain the VRA's continuing effort to the local community and improvements to Aboadze infrastructure, T3 construction budget contains a provision that will allow for the construction of a playground for the Abodze complex of schools and may be increased to possibly provide for new facilities for Aboadze. Any additional mitigation identified during T3 operation will be addressed to ensure the good relations with the local community are maintained.

This excludes the issue of prostitution and risk to HIV/AIDS and other diseases which may still remain despite carefully organized educational programs through the TTPP Infirmary.

6.5.3 Water and Wastewater

Site Preparation/Construction

The wastewaters produced during construction of T3 will be treated and discharged to the environment via the existing T1/T2 wastewater facilities. There should be no residual impacts from construction activities.

Operation

During operation there will be treated wastewater discharges to the extended aeration sewage lagoons associated with T1/T2. All discharges from T3 will be collected in the extended aeration sewage lagoons after proper neutralization treatment in the chemical cleaning lagoons. Storm water will be drained to the existing site stormwater channel. The Environmental Management Plan already in place will be extended to T3 to ensure discharges are in compliance with current environmental health and safety criteria guidelines.

Monitoring of the water quality prior to discharge of the effluent from the TTPP lagoons to the common discharge sump should prevent pollution when the effluent is discharged to sea.

Monitoring of the discharges to ensure current environmental, health and safety criteria guidelines are met will prevent significant residual impacts.

6.5.4 Noise

Site Preparation/Construction

It will not be possible to completely remove noise generated during the site preparation/construction stages for T3, however, taking into account the screening effects of T1/T2, it is predicted that noise levels at the four specific noise sensitive receptors in particular, will remain within Ghana EPA and World Bank environmental, health and safety criteria guidelines.

In terms of steam blowing, the noise generated is unavoidable, however the duration of steam blowing events is short lived and attributed to commissioning of T3 only; it is therefore concluded there will be no long term residual effect.

Operation

Based on the preliminary environmental sound level assessment performed by Hoover & Keith Inc it is expected that the operational levels of T3 will exceed Ghana EPA and World Bank environmental, health and safety criteria guidelines at only the single receptor (VRA clinic) that is in close proximity to the proposed T3 site.

As discussed in the previous sections, further additional studies will be conducted to confirm the current predictions and any necessary mitigative measures will be discussed with the VRA and implemented to ensure compliance and that minimal residual effects are experienced.

6.5.5 Access and Traffic

Some slight residual impacts relating to risk of accidents from speeding/drink driving may remain, despite mitigation measures, on account of the improved road surfaces.

6.5.6 Land Issues and Waste Management

Site Preparation/Construction

The residual impacts of site preparation and construction stages will be temporary in nature.

Solid waste will be generated, even after measures have been taken to prevent and minimize waste arising, leaving a continued requirement for off-site disposal. This residual impact will be managed by implementing management procedures and by regular inspection and auditing as detailed in Section 8.

Operation

Solid waste will be generated, even after measures have been taken to prevent and minimize waste arising, leaving a continued requirement for off-site disposal. This residual impact will be managed by implementing management procedures and by regular inspection and auditing as detailed in Section 8.

6.5.7 Ecology

Site Preparation/Construction

It is expected that there will be no residual effects after completion of the site preparation and construction stages for T3 provided the mitigation measures are carried out accordingly.

Operation

Any residual effects, in ecological terms, are likely to be associated with air emissions, as it will not be possible to eliminate emissions from T3. However, with the conversion of TTPP to natural gas, this residual effect is expected to be reduced. The residual impact is not considered to be significant.

The possibility of pollution through accidental spillage (albeit rare) and effluent discharge remains. The emergency spillage contingency plans and water pollution control measures/procedures will help to minimize the occurrence of major ecological effects.

There is also likely to be a residual effect associated with wildlife disturbance during the operation of TTPP, however, it is also likely that local wildlife will continue to become acclimatized to the plant. Therefore the significance of this residual effect is expected to be negligible.

6.5.8 Visual and Landscape Character

Despite the T1/T2 landscape planting proposals and careful construction site management to limit any further accidental land/vegetation disturbance adjacent to T3/TTPP there will inevitably be a residual visual and landscape impact associated with TTPP as a whole. It is not strictly possible to isolate T3 as it is contained within the T1/T2 site. This residual effect is due to the large scale nature of TTPP, the visible stacks and on account of the flat exposed landscape it is situated in, for which it is not possible to screen/integrate without potentially drawing more attention to the plant. The significance of the residual effect is considered to be slight to moderately adverse. However, given time the significance of this residual effect will reduce due to the planting maturing and providing optimum screening and aesthetic benefits, as well as local people becoming accustomed to the presence of TTPP as a whole. TTPP will inevitably form a distinctive man-made landmark on the coast.

6.6 Proposed Contingency Plans – Site Preparation and Construction

6.6.1 Introduction

This section describes proposed contingency plans that can be adopted in the event of any emergencies (such as accidental oil spillage) or other scenarios that are not expected to occur under normal/planned circumstances during the per-construction/construction and operation of T3.

6.6.2 Air Quality

Contingency plans are not applicable for air quality issues.

6.6.3 Social Issues

Contingency plans relating to social issues during the site preparation/construction stages of T3 include the provision of procedures and guidance for the accidental release/spillage of hazardous substances on site or in transit and fires.

In order to prevent health problems from fire, spillage or other similar event the appointed contractor will produce a documented emergency response plan that details the necessary actions should such an event occur either on site or site vehicles when off site. This will be provided to all members of staff and prominently displayed around the facility. In addition, the necessary fire prevention, fire fighting and spill control equipment will be available and members of staff trained in and familiar with their use.

6.6.4 Water and Wastewater

The contingency plans implemented during the site preparation and construction of T1/T2 will be extended to the construction and operation undertaken for T3.

The TTPP Oil Spill Contingency Plan, where implemented effectively, will be extended to cover the T3 construction and operation stage. Training of relevant personnel in spill prevention, control and clean-up will be undertaken. Spill containment and clean-up materials will be available in the areas most at risk of oil spill.

All additional storage facilities, even temporary facilities, will be located in bermed areas with an impermeable liner capable of retaining 110% of the capacity of the largest storage tank in the berm.

6.6.5 Noise

As noise nuisance can become a particularly contentious issue for local communities, a system of meetings and reporting will be initiated to coordinate the control of noise emissions during the site preparation and construction stages of T3. This has been addressed in more detail in Section 8.4.

6.6.6 Access and Traffic

A set of procedures will be produced in connection with the transport of wide loads such that the appropriate authorities will be notified in advance of transport so appropriate traffic controls/management may be implemented to avoid congestion and or any increased risk of accidents.

6.6.7 Land Issues and Waste Management

Waste management procedures will be developed for the site and a waste management manual produced. This will include details of:

- segregation and storage of specific waste materials;
- handling procedures for wastes;
- inventory and on-site management of hazardous waste; and
- personal protective equipment requirements.

The waste management procedures will include initiatives for waste reduction, re-use and recycling and treatment of hazardous wastes. All site staff involved in solid waste management will be trained in the implementation of the waste management procedures. Staff will be provided with appropriate protective equipment and given guidance on environmental hazards associated with on-site wastes.

6.6.8 Ecology

During the site preparation/construction of T3 there is a risk of accidental spillage of hazardous materials. The procedures set up in connection with water and wastewater issues (see section 6.3.3) will help reduce and limit the occurrence and/or resulting ecological impact, should such an event occur.

6.6.9 Visual and Landscape Character

In the event of any accidental encroachment into or disturbance and loss of surrounding vegetation during the site preparation and construction of T3, replacement planting will be provided.

6.7 Proposed Contingency Plan – Operational

6.7.1 Air Quality

Contingency plans are not applicable for air quality issues.

6.7.2 Social Issues

The contingency plans described in section 6.6.3 will equally apply during T3 operation.

6.7.3 Water and Wastewater

The contingency plans implemented during the operational stage of T1/T2 will be extended to cover the additional operational processes implemented in T3.

6.7.4 Noise

Should further investigation regarding operational noise levels from T3 confirm the preliminary assessment results, necessary corrective measures will be discussed with the VRA and implemented prior to the operational phase of T3. Monitoring at the TTPP site fence line, Aboadze village and VRA township will continue, but for the purposes of noise control only. Noise limits for the operation of the site will be assessed at the existing noise sensitive receptors (see Section 6.3.4).

The system of meetings and reporting initiated during the site preparation and construction stages of T3 will continue during full operation to coordinate the control of noise emissions.

6.7.5 Access and Traffic

The contingency plans for the transportation of wide/unusual loads described in section 6.6.6 would equally apply in the operational stage, should the need arise.

6.7.6 Land Issues and Waste Management

Refer to the above section on site preparation and construction wastes.

The waste management procedures will be adapted to the operational stage of the project. The site EMS will incorporate procedures for reuse and recycling of wastes along with detailed training needs for site staff.

6.7.7 Ecology

The contingency plans described for the site preparation/construction stages of T3 (section 6.6.8) will be sufficient to cover any emergency situations during T3 operations.

An oil spill response plan produced for T1/T2 will be modified to accommodate T3. Additionally, training will be provided to ensure that the risk of spillage is reduced at the start, and that the implementation of the response plan will be effective and efficient. The procedures will be displayed around the work place to ensure all staff is familiar with the necessary actions required in the event of a spillage. The oil spill response plan also details the response to other disasters such as fire; this, too, will be updated to include the T3.

6.7.8 Visual and Landscape Character

There are unlikely to be any emergency conditions that would require a contingency plan for visual and landscape issues.

7 Environmental Management Plan

The provisional Environmental Management Plan (EMP) for T3 is presented in tabular form in this section.

The objective of the EMP is to:

- Detail work programs to prevent or reduce adverse environmental effects; and
- Confirm financial commitment to environmental management through budget estimates, schedules, staffing and training requirements and other necessary support services to implement the mitigation measures.

Below (Table 7.1) is a Summary of the Proposed EMP:

Table 7.1 Summary of Provisional Environmental Management Plan (EMP)

EMP ISSUE	DESCRIPTION OF ACTION
1. GENERIC RESPONSIBILITIES AND ROLES	**Mitigation Measures and Monitoring**
	1. Setting up the EMP. Define job descriptions for and appoint staff
	2. TIC Environmental Policy.
	3. Complete EMP.
	4. Annual Environmental Report (AER).
	5. Environmental technical training.
	6. Awareness training.
	7. Documentation
	8. Record site conditions prior to any construction work.
	9. Prepare site plans and restoration plans
	10. Public and Authority/Agency Liaison.
	11. Development of an Environmental Management System (EMS)
	12. Audit Review Program.
2. AIR QUALITY	**Mitigation Measures**
	1. Ensure measures taken to control dust emissions.
	2. Ensure measures taken to install and efficiently operate NOx control equipment.
	3. Ensure stack height is adequate for dispersion of turbine emissions.
	4. Ensure sufficient emission controls and adequate maintenance of plant vehicles
	Monitoring
	1. Design and set up monitoring program.
	2. Purchase and install air emissions monitoring equipment for T3.
	3. Develop air quality monitoring procedures to include appropriate calibration/maintenance.
	4. Undertake staff training.
	5. Undertake air quality monitoring.
	6. Tabulate data and interpret ready for inclusion in AER.
	7. Commitment to preventative maintenance of monitoring equipment (3 month intervals)

Table 7.1 Summary of Provisional Environmental Management Plan (EMP) (Continued)

EMP ISSUE	DESCRIPTION OF ACTION
3. SOCIO-ECONOMIC AND PUBLIC HEALTH ISSUES	**Mitigation Measures**
	1. Public Health. Ensure air quality mitigation measures are adequately controlled.
	Mitigation
	2. Socio-economics. a. Maintain the Community Impact Agreement set up under T1.
	b. Measures to reduce risks of accidents on improved roads, for example raising risk awareness.
	c. Raise the awareness of the risk posed by HIV /AIDS with respect to prostitution.
	Monitoring
	1. Public health. Air quality monitoring program.
	2. Socio-economics a. VRA to continue with current monitoring with additional monitoring to ensure the mitigation measures in place for T1 and T2 are sufficient to cope with the demands of T3.
	b. Monitor local traffic accidents, health statistics and success of awareness raising measures.
	c. Monitor the land-use in the area immediately surrounding the site.
4. WATER AND WASTEWATER ISSUES	**Mitigation Measures**
	1. Water supply. Potable water for Phase 1 of the plant.
	2. Wastewater treatment facilities include septic tanks and the sewage lagoons already installed for T1 and T2, which are suitable for combined operation of T1, T2 and T3. Effluents will be discharged to the existing T1/T2 collection points.
	3. Storm Water site drainage. Maintain boundary collection systems. Contain and treat spills.
	4. Collect and treat wastewater from the plant.
	Monitoring
	1. Continue to observe Effluent and Water Quality Monitoring Program.
	2. Continue to follow monitoring procedures already in place.
	3. Undertake staff training.
	4. Undertake water quality monitoring.
	5. Tabulate data and interpret.
	6. Provide commitment to maintenance.
5. NOISE	**Mitigation Measures**
	1. Ensure plant components are selected to minimize excessive noise levels.
	2. Ensure sufficient noise controls at source.
	3. Ensure noise bund is as required.
	4. Control construction work times.
	5. Necessary corrective measures to address excessive noise levels at the NSA will be coordinated with the VRA and implemented prior to T3 operation.
	Monitoring
	1. Design and set up monitoring program sites not permanent.
	2. Purchase further noise monitoring equipment (part of start up and testing effort) if required.
	3. Enhance noise monitoring procedures and actions in the event of non-compliance.
	4. Undertake/continue additional staff training.
	5. Undertake noise monitoring in accordance with methods and procedures.
	6. Tabulate data and interpret.
	7. Monitor site operations to identify where careless practices are contributing to noise emissions.

Table 7.1 Summary of Provisional Environmental Management Plan (EMP) (Continued)

EMP ISSUE	DESCRIPTION OF ACTION
6. ACCESS AND TRAFFIC	**Mitigation Measures**
	1. Existing access and haul routes will be used for transport of construction materials.
	2. Controlled loading of materials on and off vehicles.
	3. Appropriate Speed Limits will be set on all roads used by plant traffic.
	4. Proper maintenance of site vehicles.
	5. Provision of bus service to reduce road traffic.
	6. Vehicle speed control measures, education programs and hazards awareness guidance.
	Monitoring
	No monitoring proposed.
7. LAND ISSUES AND WASTE MANAGEMENT	**Mitigation Measures**
	1. Local borrow areas will be rehabilitated to former condition by contractor, audited by EM.
	2. Waste management procedures will be developed and a waste management manual produced.
	3. Providing training, safety equipment, and hazard guidance to waste management personnel.
	4. Isolation and treatment of Waste Oils. Efficient and timely operation of treatment equipment.
	5. Solid wastes from construction and operation phases will be transported to local landfill.
	Monitoring
	1. Operation of Oily waste treatment will continue to be monitored, audited and maintained for efficiency.
	2. Undertake an audit of waste management procedures and practices for operation of T3. An audit of waste carrier and landfill site will be undertaken. Prescribe mitigation measures.
8.ECOLOGICAL EFFECTS	**Mitigation Measures**
	1. All operations will remain within the existing site fence line. Areas already cleared of vegetation for the construction lay down sites during construction of T1 and T2 will be used during T3.
	2. Re-vegetation of areas following construction.
	3. Landscape screen planting will be undertaken using appropriate native species.
	4. Restoration of borrow areas by contractor, using native species for planting.
	5. Specific routes for construction vehicles to avoid off-road vehicle movements.
	Monitoring
	1. Brief annual ecological walkover survey to assess ecological effects.
	2. Restoration of borrow areas will be periodically assessed.

Table 7.1 Summary of Provisional Environmental Management Plan (EMP) (Continued)

EMP ISSUE	DESCRIPTION OF ACTION
9. LANDSCAPE AND VISUAL EFFECTS	**Mitigation Measures**
	1. Ensure that no disturbance/ encroachment occur in areas not previously affected by T1/T2.
	2. Design landscape scheme including suitable native trees and other local species.
	3. Implement planting scheme as quickly as practically possible.
	Monitoring
	1. Ensure planting program is effective by monitoring tree health and replanting as necessary.
10. RISK MANAGEMENT	**Mitigation Measures**
	1. Staff will be educated as to spillage and explosion risks, prevention and response.
	2. Review of existing contingency plans for incident management, updated as required.
	Monitoring Measures
	1. Check accident records and the procedures which are used to record incidents.
	2. Audit clean up operations for any spills that occur.
	3. 5-monthly checks on storage facilities, general housekeeping with repair or upgrade as needed.

The provisional Environmental Management Plan (EMP) for T3 is presented in tabular form in this section.

The objective of the EMP is to:

- Detail work programs to prevent or reduce adverse environmental effects; and
- Confirm financial commitment to environmental management through budget estimates, schedules, staffing and training requirements and other necessary support services to implement the mitigation measures.

The provisional EMP covers the following environmental issues which have been identified as issues requiring mitigation and monitoring:

- Generic issues;
- Air quality;
- Social Issues;
- Water and wastewater issues;
- Noise;
- Access and traffic;
- Land Uses and waste management;
- Ecology; and
- Landscape and Visual Character.

For each of the key issues, the following information is provided:

1. A description of the mitigation or monitoring action;
2. Details of the individual (s) responsible for undertaking the action;
3. The standards or guidelines are described which must be met for the action;
4. The approximate timing of the action;
5. The details of the Responsible Authority/Agency for the action;
6. The financial commitment to the action in the form of a budget to be made available by the VRA.

TRAINING

Formal training programs in all aspects of plant operation, maintenance and management will be developed and implanted for T3 staff. These programs will be comprehensive and include training in environmental, health and safety procedures. This will ensure safe and efficient operation of the plant.

Table 7.2 Provisional Environmental Management Plan (EMP)

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
1. GENERIC RESPONSIBILITIES AND ROLES	**Mitigation Measures and Monitoring**					
	1. **Setting up the EMP** Define job descriptions for and appoint staff to positions of : a) Environmental Manager (EM) b) Assistant to Environmental Manager (AEM)	TBD	TBD	Prior to commencement of site preparation/construction phase	Ghana/VRA	Budget for salaries and overheads and support staff $30,000
	2. VRA Environmental Policy Draft and agree environmental Policy	TBD	TBD	Prior to commencement of site preparation/ construction phase	Ghana/VRA	Budget for policy included in above
	3. Complete EMP Modify and expand on provisional EMP provided in contract documents	TBD	TBD	For submission at commencement of operation phase	Ghana/VRA	Budget for EMP completion $1,000

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
1. GENERIC RESPONSIBILITIES AND ROLES	**Mitigation Measures and Monitoring**					
	4. **Annual Environmental Report (AER).** Develop report structure for AER which links environmental team into operational and administrative activities.	TBD	TBD	During site preparation/ construction phase	Ghana/VRA	Budget included in 1 above
	5. Environmental technical training. Technical training for environmental staff (AEM and others) on *inter alia;* 1. use of monitoring equipment 2. data collection 3. data interpretation and reporting 4. maintenance of equipment	TBD	TBD	During site preparation/ construction phase	Ghana/VRA	Budget included in 1 above
	6. Awareness training. Provide environmental awareness training for all management staff and site staff teams in the implementation aspects of the EMP	TBD	TBD	During site preparation/ construction phase	Ghana/VRA	Budget included in 1 above

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
1. GENERIC RESPONSIBILITIES AND ROLES	**Mitigation Measures and Monitoring**					
	7. Documentation Ensure environmental manager and EPC contractor have copies of EIA, EMP, site plans, contractual documents and the EMP is copied to site office and site manager(s)	TBD	TBD	At commencement of site preparation work	Ghana/VRA	Budget included in 1 above
	8. Record site conditions prior to any construction work. Take photographic records of site prior to site preparation work and notes	TBD	TBD	Prior to commencement of site preparation work	Ghana/VRA	Budget included in 1 above
	9. Prepare site plans and restoration plans Ensure site plans available which show environmental sites/issues/risks and restoration/landscape plan produced	TBD	TBD	At start of site preparation/ construction and during all phases	Ghana/VRA	Budget within construction budget

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
1. GENERIC RESPONSIBILITIES AND ROLES	**Mitigation Measures and Monitoring**					
	10. Public and Authority/ Agency Liaison. Set up liaison meetings with community and authorities. These will cover construction and operational management of environmental issues and emergency response preparedness, response plans and communication	TBD	TBD	Prior to and during each phase	Ghana/VRA	Budget included in 1 above
	11. Development of an Environmental Management System (EMS) to implement the EMP on a day to day basis throughout the organization. Develop simple operational procedures/guidance for staff undertaking or responsible for key tasks related to implementation of EMP.	TBD	TBD	Prior to and during early stages of site preparation/ construction phase	Ghana/VRA	Budget included in 1 above

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
1. GENERIC RESPONSIBILITIES AND ROLES	**Mitigation Measures and Monitoring**					
	12. Audit Review Program. Set up an audit and review program covering all activities to assess compliance with contract requirements and ensure meeting requirements of EMP, and other stakeholders including the general public. The program may include two types of components: 1. internal review – undertaken by VRA staff reporting internally; and /or 2. external audit – undertaken by independent consultants reporting to VRA.	TBD	TBD	At commencement of site preparation work	Ghana/VRA	Budget included in 1 above

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
2. AIR QUALITY	**Mitigation Measures**					
	1. Ensure measures taken to control dust emissions	TBD	TBD	At commencement of site preparation phase to operation phase	Ghana/VRA	Budget included in 1 above
	2. Ensure measures taken to install and efficiently operate NOx control equipment	TBD	TBD	Prior to commencement of site preparation/ construction phase	Ghana/VRA	Budget made available for NOx control equipment within EPC contract
	3. Ensure stack height is adequate for dispersion of emissions from turbines determined from air quality modeling	TBD	TBD	Prior to purchase of equipment	Ghana/VRA	Budget made available for stack of 27m
	4. Ensure sufficient emission controls and adequate maintenance of plant vehicles	TBD	TBD	Prior to commencement of site preparation phase, and ongoing during construction	Ghana/VRA	Budgeted within construction budget

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
2. AIR QUALITY (Continued)	**Monitoring**					
	1. Design monitoring program. Set up monitoring sites for ambient monitoring and boundary/off site monitoring tests and meteorological data collection for parameters: PM_{10}, NOx and SO_2. Review will be based on modeling results for T3.	TBD	TBD	During site preparation/ construction work	Ghana/VRA	Budgeted within construction budget
	2. Purchase and install air emissions monitoring equipment for T3.	TBD	TBD	During site preparation/ construction work	Ghana/VRA	Budget made available for NOx control equipment within EPC contract
	3. Develop air quality monitoring procedures to include appropriate calibration and maintenance	TBD	TBD	During site preparation/ construction work	Ghana/VRA	Budgeted
	4. Undertake staff training	TBD	TBD	During site preparation/ construction work	Ghana/VRA	Budget within construction budget
	5. Undertake air quality monitoring at sources and boundary and off site where appropriate, in accordance with methods and procedures	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Staff time in construction budget. Budget will be made available to allow for stack testing.

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible For Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
2. AIR QUALITY (Continued)	**Monitoring**					
	6. Tabulate emission and air quality data and interpret ready for inclusion in AER	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Budget included in construction budget
	7. Provide commitment to preventative maintenance of monitoring equipment (3 monthly intervals) and consider holding spare parts and good communication with service engineers to avoid down time	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Budgeted into commissioning and operation.
3. SOCIO-ECONOMIC AND PUBLIC HEALTH ISSUES	**Mitigation Measures**					
	1. **Public Health**. Ensure air quality mitigation measures are adequately controlled, in particular, control of dust and efficiency of NOx control, so that Ghanaian air quality guidelines are not exceeded.	TBD	TBD	At commencement of site preparation/ construction phase to end operation phase	Ghana/VRA	Budget covered under provisions for air quality
	2. Socio-economics 1. Maintain the Community Impact Agreement set up under T1/T2 and provide for construction of playground for Aboadze complex of school and scholarship for local students.	TBD	TBD	At commencement of site preparation/ construction phase to end of operation phase	Ghana/VRA	Budget in T3 construction and operations and maintenance budget.
	2. Raise the awareness of the risk posed by HIV /AIDS with respect to prostitution. Education programs to inform workers of the possible consequences of their actions.	TBD	TBD	At commencement of site preparation/ construction phase	Ghana/VRA	Budget in T1/TT2 construction budgets

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible For Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
3. SOCIO-ECONOMIC AND PUBLIC HEALTH ISSUES (Continued)	**Monitoring**					
	1. Public health. 1. Ensure air quality monitoring programme is operating efficiently and results are within EPA guidelines.	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Budget covered by air quality mitigation
	2. Socio-economics 1. VRA to continue with current monitoring programs to ensure the mitigation measures in place for T1/T2 are sufficient to cope with the demands of T3. This will comprise reviewing available local social statistics and assessing feedback from the community meetings; the objective being to ensure no decline in living standards is occurring due to TTPP (T1/T2+T3).	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Budget with T1/T2 construction and operations and maintenance budgets
	2. Monitor local traffic accident and health statistics for change in traffic related accidents. Monitor attendance and success of awareness raising measures with public consultation.	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Budget with T1/T2 construction and operations and maintenance budgets
	3. Monitor the land use in the area immediately surrounding the site. Check that farmland is not damaged or encroached on by construction related activities and that squatter camps are not established	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Budget from T1/T2

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
4. WATER AND WASTEWATER ISSUES	**Mitigation Measures**					
	1.Water supply. Potable water for Phase 1 of the plant will be supplied by the existing TTPP. The VRA has confirmed that the water capacity is sufficient to meet T3's demand.	TBD	TBD	TBD	Ghana/VRA	-
	2. Waste water treatment facilities. Wastewater treatment facilities to treat the domestic effluents from the plant. These include the sewage lagoons already installed for T1 and T2, which are suitable for combined operation of T1/T2 and T3. Effluents are discharged to local surface waters (Anankwari River feeder stream) initially, and then into the ocean upon completion of the seawater discharge pipeline to be installed under contract T1 (estimated completion mid 1999).	TBD	TBD	TBD	Ghana/VRA	Budget made available for installation of T1 facilities Maintenance will be provided by TTPP Operations

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
4. WATER AND WASTEWATER ISSUES (Continued)	**Mitigation Measures**					
	3. Stormwater site drainage. This is collected by the drainage channel at the site boundary. This drainage water is released to the marsh land to the west of the site. Drains will be maintained and cleared of silt and other obstructions as appropriate. If a spillage occurs, waters are not released to marshland and are held within drainage channel for treatment until cleaned.	TBD	TBD	Prior to commencement of site preparation and during construction and operation.	Ghana/VRA	Budget for maintenance in T3
	4. **Wastewaters from the plant effluents**. These include the water from desalination, cooling towers, oil water drains and demineralization of water (for NOx minimization), which will be collected and discharged into the Final Discharge Sump of the existing T1/T2 blowdown system.	TBD	TBD	Ongoing during commissioning and operation phase. Systems were provided under T1/T2 construction.	Ghana/VRA	Budgeted

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible For Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
4. WATER AND WASTEWATER ISSUES (Continued)	**Monitoring**					
	1. VRA to continue Established Monitoring Program which will comprise monitoring of both the effluents and also the local surface waters. T3 will not discharge any wastewater to the local bodies of water. a) Monitoring locations are as follows: (a) On-site • Oxidation ponds effluent • Water sump prior to discharge • Neutralisation sump • Oily water separator • Surface drainage channel at point of discharge (b) Offsite • In sea waters after dispersion • At three locations to be decided, west of site • At two locations within the Anankwari feeder streams Parameters analyzed include pH, coliform, Oil and grease, total suspended solids, temperature increase of sea for cooling water releases, (Daily Beach Sea Temperature monitoring), turbidity, Iron, Copper, Magnesium, Lead and conductivity. c) frequency of monitoring include monitoring prior to discharge or every 3 months (if no discharge) for onsite sampling for effluents, and every 6 months for offsite sampling.	TBD	TBD	Prior to site preparation work	Ghana/VRA	Budget/Yearly

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible For Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
4. WATER AND WASTEWATER ISSUES (Continued)	**Monitoring**					
	2. Purchase water effluent monitoring equipment and install as necessary in laboratory (already covered by T1 and T2)	TBD	TBD	Already completed during T1/T2 construction	Ghana/VRA	Budgeted
	3. Observe water effluent quality monitoring procedures in accordance with parameters and testing requirements of current guidelines.	TBD	TBD	Prior to site preparation work	Ghana/VRA	Budget in T1/T2 construction budgets
	4. Undertake staff training	TBD	TBD	Prior to site preparation work	Ghana/VRA	Budgeted in T1
	5. Undertake water quality monitoring at agreed locations. This will include visual inspection of the storm water drains on a daily basis.	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Budgeted for baseline monitoring at the three off site monitoring stations Budget per year included in operational budget

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
4. WATER AND WASTEWATER ISSUES (Continued)	**Monitoring**					
	6. Provide commitment to maintenance including spare parts and service engineers to avoid down time of laboratory equipment.	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Within operational and maintenance budget for T3.
5. NOISE	**Mitigation Measures**					
	1. Ensure measures taken to select plant components and site plant/vehicles using noise specifications. Ensure that plant type and condition is checked before delivery to site and that it meets specification.	TBD	TBD	Prior to commencement of site preparation/ construction phase	Ghana/VRA	Budget part of EPC Engineering costs
	2. Ensure sufficient noise controls at source.	TBD	TBD	Prior to commencement of site preparation/ construction phase, and ongoing during construction	Ghana/VRA	Budget will be made available for noise abatement of turbines
	3. Ensure noise bund is as required	TBD	TBD	During first month of site preparation/ construction phase	Ghana/VRA	Included in Budget
	4. Ensure that construction work is only carried out during designated working days and times.	TBD	TBD	Throughout site preparation/ construction phase	Ghana/VRA	In EPC construction budget

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
5. NOISE (continued)	5. Necessary mitigative measures agreed upon consultation with the VRA will be determined after further studies are performed.	TBD	TBD	Prior to operation phase.	Ghana/VRA	TBD
	Monitoring					
	1. Continue to observe monitoring program already in place for noise source compliance tests and boundary tests.	TBD	TBD	During commissioning and testing phase	Ghana/VRA	Budget part of EPC contract
	2. Purchase noise monitoring equipment (part of start up and testing effort) if required. Some noise monitoring equipment already purchased under T1 is beyond repair. Check the condition of this equipment and make sure it is regularly calibrated.	TBD	TBD	During site preparation/ construction work	Ghana/VRA	Budget part of EPC contract
	3. Enhance noise monitoring procedures and actions in the event of a non-compliance.	TBD	TBD	During site preparation/ construction work	Ghana/VRA	Included in Budget
	4. Undertake/continue staff training. Some staff training already done under T1/T2.	TBD	TBD	During site preparation/ construction work	Ghana/VRA	Included in Budget

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
5. NOISE (Continued)	**Monitoring**					
	5. Undertake monthly 24hour noise monitoring at Aboadze monitoring station, Aboadze near Lorry Park, VRA township, and the North, South, East and West boundaries. Also at various onsite locations in relation to key plant weekly for five minute periods equipment, in accordance with methods and procedures	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Budgeted in 1above
	6. Monitor site operations to identify where careless practices are contributing to noise emissions. For example, doors left open in plant housing or maintenance hatches left open on machinery.	TBD	TBD	During site preparation/ construction, commissioning and operation	Ghana/VRA	Budget to be made available

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
6. ACCESS AND TRAFFIC	**Mitigation Measures**					
	1. Existing access and haul routes will be used for transport of construction materials.	TBD	TBD	At commencement of site preparation/ construction phase and ongoing through operation phase.	Ghana/VRA	Budget included in EPC contract
	2. Careful loading of materials on and off vehicles. Measures taken to ensure vehicles are not overloaded and loads are safe as vehicles leave to and from the site.	TBD	TBD	At commencement of site preparation/ construction phase and ongoing through operation phase.	Ghana/VRA	Budget included in EPC construction contract
	3. Appropriate Speed Limits will be set on all roads used by plant traffic. These will be agreed with National Road Safety Committee.	TBD	TBD	At commencement of site preparation/ construction phase and on going throughout the operation	Ghana/VRA	Budget included in EPC contract
	4. Proper maintenance of site vehicles.	TBD	TBD	At commencement of site preparation/ construction phase and on-going throughout the operation	Ghana/VRA	Budget included in EPC contract

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
6. ACCESS AND TRAFFIC (Continued)	**Mitigation Measures**					
	5. Provision of bus service bringing construction workers to the site during peak construction period to reduce road traffic.	TBD	TBD	At commencement of site preparation/ construction phase and ongoing through operation phase.	Ghana/VRA	Budget in EPC construction Contract
	6. Measures to control vehicle speeds on the access road to the plant, the haul roads within the plant site and feeder roads from the plant to local villages will be agreed through negotiation and discussion with the National Road Safety Committee. These will include road signs, traffic calming measures and improved enforcement by transport police. Brief education programs will inform workers of hazards of speeding/drink driving.	TBD	TBD	At commencement of site preparation/ construction phase and ongoing through operation phase.	Ghana/VRA	Budget included in EPC construction contract
	Monitoring No monitoring proposed					

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
7. LAND ISSUES AND WASTE MANAGEMNENT	**Mitigation Measures**					
	1. Rehabilitation of Borrow Areas. Local borrow areas will be rehabilitated to former condition by contractor. Details of rehabilitation to be written into contractors contracts and an audit of contractors activities will be undertaken by EM.	TBD	TBD	After materials have been extracted from borrow pits, during site preparation/ construction phase..	Ghana/VRA	Budget included in EPC construction budget.
	2. Waste Management procedures. Waste management procedures will be developed for the site and a waste management manual produced. This will include segregation of wastes, storage, handling, on-site management of hazardous waste, personal protective equipment. The waste management procedures will include initiatives for waste reduction, re-use and recycling and treatment of hazardous wastes.	TBD	TBD	At commencement of site preparation/ construction phase. .	Ghana/VRA	Budget included in EPC contractor budget. Hazardous waste to be handles by VRA.
	3. Training of staff. All site personnel involved in waste management will be trained in the implementation of the waste management procedures. Staff will be provided with appropriate personal protective equipment and given guidance on environmental hazards associated with on-site wastes.	TBD	TBD	At commencement of site preparation/ construction phase	Ghana/VRA	Budget in construction budget

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
7. LAND ISSUES AND WASTE MANAGEMNENT (Continued)	**Mitigation Measures**					
	4. Treatment of Waste Oils. The waste oils are isolated from the surface drainage system and stored in an oil water lagoon, which will be removed offsite via road tanker by waste oil reuse companies.	TBD	TBD	During operation	Ghana/VRA	Budget in T1 contract sum
	5. Sludge Waste from Oxidation Ponds (Monitored by T1/T2). Sewage sludge will be generated from the oxidation ponds which will be dredged every 10 years. This will be landfilled or used locally for agriculture. The disposal option of the sludge will be carefully selected and monitored.	TBD	TBD	At 10 year intervals.	Ghana/VRA	Budget to be determined when dredging is required
	6. Solid wastes from construction and operation phases. These will include wood, metals, glass and plastic etc. The solid waste will be collected by Shama Ahanta East Metropolitan Authority and transported to its local landfill site	TBD	TBD	Construction and operation phases.	Ghana/VRA	Budget included in T1/T2 contracts and then in annual operations and maintenance budget

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
7. LAND ISSUES AND WASTE MANAGEMNENT (Continued)	**Monitoring**					
	1. Audit waste management procedures and practices. An audit of waste management procedures and practices will be undertaken focussing on the operation of T3. An audit of waste carrier and landfill site will be undertaken to ensure satisfactory disposal at appropriately regulated landfill site. Where mitigation measures or changes in waste management practices are required, then mitigation measures will be developed.	TBD	TBD	Waste management audit will be undertaken and repeated annually.	Ghana/VRA	Budget included in T3 operational and maintenance budget

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
8. ECOLOGICAL EFFECTS	**Mitigation Measures**					
	1. All operations will remain within the existing site fence line. Additional encroachment into the wetland area west of the site will be avoided. Areas already cleared of vegetation for the construction lay down sites during construction of T1/T2 will be used during T3.	TBD	TBD	At commencement of site preparation/ construction phase and ongoing through operation phase.	Ghana/VRA	Budget in T1 contract sum
	2. Revegetation of areas following construction.	TBD	TBD	Revegetation of T1/T2 areas ongoing. Any T3 areas will be addressed during the construction phase.	Ghana/VRA	Budget included in EPC contract
	3. Landscape screen planting will be undertaken using appropriate native species.	TBD	TBD	During construction phase	Ghana/VRA	Budget included in EPC contract
	4. Restoration of borrow areas by contractor. Selection of appropriate native species for planting.	TBD	TBD	During construction phase	Ghana/VRA	Budget included in EPC contract
	5. Specific routes for construction vehicles will be established, to avoid any off-road vehicle movements for site plant and vehicles	TBD	TBD	At commencement of site preparation/ construction phase and throughout project life	Ghana/VRA	Budget included in EPC contract

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
8. ECOLOGICAL EFFECTS	**Monitoring**					
	1. Brief annual ecological walkover survey to assess ecological effects. This will cover the plant site and the wetland area to a distance of 2km from the western boundary.	TBD	TBD	During construction work, commissioning and operation.	Ghana/VRA	Annual budget
	2. Borrow areas will be periodically assessed to ensure effective restoration has been undertaken.	TBD	TBD	Following completion of construction	Ghana/VRA	Budget included in EM staff salaries

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
9. LANDSCAPE AND VISUAL EFFECTS	**Mitigation Measures**					
	1. Ensure that no vegetation clearance or other disturbance/ encroachment occurs in areas not previously effected by T1/T2.	TBD	TBD	During site preparation/ construction phase	Ghana/VRA	Budget included in EPC contract
	2. Design landscape scheme including suitable native trees and other local species. This will include native grass species for proposed grassed areas of the site.	TBD	TBD	At commencement of construction phase and ongoing into operation phase	Ghana/VRA	Budget included in EPC contract
	3. Implement planting scheme for site and adjacent areas. Planting will be carried out as quickly as practically possible.	TBD	TBD	At commencement of construction phase and ongoing into operation phase	Ghana/VRA	Budget included in EPC contract
	Monitoring					
	1. Commitment to tree planting maintenance. Ensure planting program is effective by monitoring tree health and replanting as necessary	TBD	TBD	During construction work, commissioning and operation. The monitoring will be undertaken on a 6 monthly basis.	Ghana/VRA	Budget included in EPC contract

TABLE 7.2 Provisional Environmental Management Plan (EMP) – cont.

EMP Issue	Description of Action	Individual (s) Responsible for Action	Standards and Guideline Documents	Timing of Action	Responsible Authority/Agency	Financial Commitment
10. RISK MANAGEMENT	**Mitigation Measures**					
	1. Staff will be made aware of the risks posed by oil spillage, chemical spillage, fire and explosion. Staff will be educated on how to minimise risks by using good practice and on how to respond to an incident. Training program to include. • Fire fighting practice • Precautions for safe storage and handling of fuels and hazardous chemicals. • A mock Oil Spill Response exercise and details of the Oil Spill Contingency Plan (OSCP). T1/T2 current OSCP will be revised and extended to accommodate T3 operation.	TBD	TBD	During construction and ongoing through operational phase.	Ghana/VRA	Budget included in EPC contract
	2. Review of existing contingency plans for incident management. This is to be updated as required.	TBD	TBD	During construction and ongoing through operational phase.	Ghana/VRA	Budget included in EPC contract
	Monitoring					
	1. Check accident records and the procedures which are used to record incidents. 2. Audit clean up operations for any spillages that occur. 3. Check standard and integrity of storage facilities. Repair facilities and upgrade as required. Inspection will be carried out every 6 months.	TBD	TBD	During construction and ongoing through operational phase.	Ghana/VRA	Budget included in operational and maintenance costs

8 Monitoring Plan for T3

8.1 Air Quality

Continuous emissions monitoring equipment will be installed on the T3 units to ensure that emission concentrations remain within emission limit values. Emission test results will be summarized in an Annual Emissions Report (AER) for the plant.

Ambient air quality monitoring will continue at the three monitoring stations located at TTPP, Aboadze and Beposo for SO_2 and NO_X. The location of these stations is still considered appropriate to identify potential air quality impacts on the local communities.

These stations will continue to be supplemented by PM_{10} monitoring at the existing sites in Aboadze and in the VRA township for the duration of the construction period.

Monitoring stations will also be equipped with appropriate spare parts to minimize data loss due to equipment malfunction.

8.2 Social Issues

Additional monitoring will be carried out to ensure that the assumptions made concerning the ability of the current transport/community infrastructure to cope with the demands placed on it remain the same during T3. This will comprise a review of available local social statistics produced by other organizations, and assessing the feedback from the community meetings; the objective of which will be to ensure that no decline in living standards occurs due to T3 operation and TTPP as a whole.

The monitoring of road safety issues are covered in Section 8.5.

If the monitoring shows that the mitigation measures in place for T1/T2 or those additional measures put in place for T3 are not effective, additional measures may be required or those in existence will be strengthened. It is outside the scope of this EIA to suggest what additional measures may be necessary should those in place for T1/T2 or those put in place for T3 fail. These issues will be addressed as required.

8.3 Water and Wastewater

There is no additional monitoring proposed for T3 since the discharge locations are into the existing T1/T2 systems. Monitoring of the effluents and the local surface water quality will continue and an annual environmental report will be produced to ensure compliance with current environmental, health and safety guidelines.

8.4 Noise

The noise program with T3 is very much based on the existing monitoring program. Monitoring at the Aboadze village, adjacent to the Lorry Park, VRA township and plant boundaries will continue to be monitored. Periods over which the monitoring is to be undertaken are detailed.

Table 8.1 Proposed Noise Monitoring Locations and Frequency of Monitoring

Location	Frequency	Period
PLANT FENCE LINES		
Monitoring Points Northern Fence Southern Fence Eastern Fence Western Fence	 Weekly Weekly Weekly Weekly	 24 hours 24 hours 24 hours 24 hours
GAS TURBINE AREAS (T3)		
Monitoring Points Gas Turbines Control Rooms Step Up Transformers Auxiliary Transformers	 Weekly Weekly Weekly Weekly	 5 minutes 5 minutes 5 minutes 5 minutes
FUEL TREATMENT ROOM		
Monitoring Points Centrifuge Skids LCO & DFO Forwarding Pumps LCO & DFO Transfer Pumps Operators Desk	 Weekly Weekly Weekly Weekly	 5 minutes 5 minutes 5 minutes 5 minutes
Cooling Tower		
Monitoring Points Cooling Tower Cooling Water Fans Cooling Water Pumps	 Weekly Weekly Weekly	 5 minutes 5 minutes 5 minutes
NOISE SENSTIVE RECEPTORS		
Aboadze village, Environmental Monitoring Station *Aboadze village, adjacent Lorry Park VRA township *Amuzu	Weekly Weekly Weekly Weekly	24 hours 24 hours 24 hours 24 hours

The purpose of the noise monitoring program will be to demonstrate compliance with the noise limits set and to provide information for any necessary mitigation measures. Results of monitoring will be circulated to senior management on the site on where results indicate noise levels are a problem.

Staff will be trained in the use of sound level meters and interpretation of results. An integrated sound level meter will be purchased as this will allow the downloading of data direct to the computer for detailed analysis, when required.

The excessive noise levels predicted by the preliminary noise levels assessment will be further analyzed and appropriate mitigative measures will be discussed with the VRA and undertaken prior to T3 operation.

When plant is commissioned noise measurements will be undertaken to ensure that noise emissions are acceptable.

8.5 Access and Traffic

Traffic composition, density and proper use of designated access routes will be periodically surveyed by the Environmental Manager on and off site during the site preparation/construction and operation of T3. In particular, monitoring of the procedures set up to manage the transport of wide/unusual loads will be undertaken to assess their effectiveness and identify any further requirements need to limit traffic disruption during such journeys.

Road safety issues will be monitored through feedback from other authorities and training of TTPP staff will be amended accordingly to ensure maximum awareness of implications of speeding is achieved. The attendance at road safety awareness meetings by TTPP staff and other target groups will be monitored and their success at getting road safety information across to staff will be assessed using group interview and individual questionnaire methods.

8.6 Land Issues and Waste Management

Borrow Areas

The re-vegetation of borrow areas will be monitored to assess the success of restoration to former conditions. Where re-vegetation is not successful, further measures will be taken to reinstate the area to prevent unsightly scaring and long-term erosion problems.

Solid Waste

The monitoring of waste management practices and procedures will cover both T1/T2 and T3 and will be incorporated into a site EMS.

Inspections of site waste collection areas will be undertaken and recorded. Actions will be taken where good housekeeping is not observed.

An audit of the site waste management practice and procedures, the waste carrier and the disposal site(s) will be undertaken on a six-monthly basis to ensure satisfactory measures are in place and there are no pollution or health concerns. Where significant issues are found, the audit will recommend measures to improve the situation and appropriate actions will be taken.

8.7 Ecology

Brief, ecological walkover surveys will be undertaken annually during operation, to assess ecological changes. The survey will include assessment of species populations and their abundance and will extend for a distance of approximately 2 km from the site.

8.8 Visual and Landscape Character

Once the landscape planting proposals have been fully implemented after construction of T3 has been completed, the plants will be regularly assessed to check that successful rooting has taken place, and any damaged or dead plants will be replaced.

Table 7.2 covers the mitigation and monitoring plan for the T3 project in more detail.

9 Conclusions

The T3 Takoradi Thermal Plant will have overall benefits to the country. It will provide additional power to relieve Ghana's energy needs in the near future. Locally, citizens of Aboadze will have new employment opportunities, especially for skilled tradesmen in the Sekondi-Takoradi area. Furthermore, T3's budget allow for the provision of scholarship for local students and the construction of a playground for the Aboadze school complex. Public participation is a requirement of the local regulatory agencies responsible for issuing project applicable licences and permits; as such, the CCC has posted a public notice of the proposed T3 expansion and the VRA will help coordinate meetings with the local community.

The equipment comprising T3 is to be prefabricated, and will therefore minimize the need for a large construction labor force and extensive construction facilities. Generally, on site activities will be directed to site preparation, plant assembly, commissioning and start-up services. The plant will use equipment designed with available proven technology that minimizes many of the potential impacts on the environment and will incorporate best available technology options to mitigate the adverse impacts resulting from the operation of T3. Reliable fresh water supply and demineralized water supply for the operation of T3 will be made available by the existing TTPP and the VRA confirmed that its capacity will be sufficient to accommodate the additional water requirements. By careful site selection of certain features (i.e., utilization of water injection and sprint to minimize Nox emissions) it will be possible to further minimize impacts. An extensive monitoring plan has been outlined to gather the required baseline data, as well as fulfill long-term monitoring needs. The plan also indicates the appropriate time frame during which this monitoring must be undertaken.

The air dispersion model presented on Appendix C predicts that ground level concentrations resultants from the addition of T3 will meet Ghana EPA and World Bank air quality standards and guidelines in all cases. It is predicted that the operation of T3 concurrently with T1 and T2 will achieve acceptable levels considering tha the contribution of T3 to ground level concentrations is negligible compared to the maximum allowable limits and to the existing T1/T2 operational emissions.

The preliminary environmental sound level assessment performed by Hoover & Keith Inc indicated that the operation of T3 would exceed World Bank and Ghana EPA criteria and guidelines at only one location (VRA clinic located approximately 250 meters from the proposed T3 site). As discussed in section 6 further investigation and additional studies will be conducted in a timely manner to confirm the current predictions and any necessary mitigative measures will be discussed with the VRA and implemented as necessary to ensure compliance.

Ghanaian worker's rights legislation does not permit the use of child or forced labor and the Contractor's EPC Agreement enforces this requirement. No such practices will occur on the TTPP site (operations and construction).

The VRA has stated that the fuel supply and availability are sufficient and reliable to accommodate the operation of T3. Furthermore, considering that the fuel supply will be provided by T1/T2 and T3 will share the existing facilities, it is concluded that there is no adverse effect on this issue.

In terms of addressing the changes that have occurred since the preparation of the 2001 SEIS, it is considered that overall, there is minimal significant adverse change to the environmental impacts (beneficial and adverse) described in the 2001 SEIS, and any impact identified will be addressed by the mitigation plans outlined in this report and Environmental Management Plan already in place. The plant during normal operation is expected to meet relevant environmental guidelines.

Overall, it can be concluded that on account of T3 representing an extension of an existing facility, the scale of environmental impact is significantly reduced compared to a situation where a new power station were built. Further benefits are achieved through the sharing of facilities between T1/T2 and T3 such that the required infrastructure for T3 is largely readily available. The implementation of appropriate management policies and procedures during T3's operation, environmental quality monitoring and pollution prevention and response procedures, and health and safety frameworks, it is expected that any residual environmental effects will be kept to a minimum, under normal operating conditions. The recommendations laid out in the Provisional Environmental Management and Monitoring Plan for T3 should also ensure a high level of environmental protection is maintained.

Table 9.1 Environmental Impact Conclusion – Site Preparation and Construction Stage

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Air Quality	Dust Generation	Potential moderate to significant highly localized adverse effect. Dust generation from T3 earthworks, transport of fill material between borrow areas and TTPP and erosion may result.	Mitigation measures include controlling vehicle speeds, providing covers for vehicles, using hard surfaced roads where possible, covering or planting up stockpiled topsoil, maintaining plant equipment to limit emissions, and using dust collectors/water spray systems to limit dust from batching processes.	No residual effect expected with mitigation measures in place.
Social Effects	Pressure on the Community Infrastructure	No significant adverse effect. The T3 workforce requirements will be accommodated within T1/T2 arrangements.	Regularly held meetings between T3 management, the EPC contractor and local communities will provide the forum to raise and solve any issues that may arise. Provision for scholarship for local students and construction of playground for Aboadze school complex.	The Community Impact Agreement already in place and meetings will limit any residual effect from both occurring and/or remaining of minor significance.
	Community Disruption	No significant adverse effect. No record of anti-social behavior/disruption has been observed with T1/T2 – it is unlikely to occur with T3 given smaller workforce required.	No mitigation required.	The Community Impact Agreement already in place and meetings will limit any residual effect from both occurring and/or remaining of minor significance

Table 9.1 Environmental Impact Conclusion – Site Preparation and Construction Stage – cont.

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Social Effects (continued)	Employment Opportunities	Slight to moderate temporary benefit due to the requirement of up to approximately 300 workers.	No mitigation required.	-
	Migrant Influx and Squatter Camps	No significant adverse effect. As the influx of migrant job seekers for T1/T2 did not lead to formation of squatter camps - it is unlikely to occur for T3. T3 will also require a significantly smaller workforce.	No mitigation required.	Regular meetings to be held with local communities to address any concerns that may arise
	Food Supply Competition	No significant adverse effect was observed with T1/T2 and therefore is unlikely to occur with T3.	The food service outlets provided with T1/T2 will be sufficient to accommodate T3 requirements.	No residual effect.
	Public Health: • HIV/AIDS & STDs	Potential risk of exposure/ incidence to HIV/AIDS and other STDs. However, fewer workers will be required in T3 comparedo T1/T2.	Awareness training & education programmes on risks and consequences of prostitution will be run through the TTPP Infirmary.	Some residual effect may remain irrespective of mitigation measures; the significance of which is beyond the scope of this document.
	• Malaria Risk	No significant change to risk of new mosquito breeding grounds will occur.	Existing areas will continue to be sprayed regularly.	N/A

Table 9.1 Environmental Impact Conclusion – Site Preparation and Construction Stage

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Water and Wastewater	Water Supply	No significant adverse effects as water requirements for T3 will be minimal and met by the existing TTPP.	No mitigation required	No residual effects expected.
	Wastewater Issues	No effect as T1/T2 arrangements will be sufficient to accommodate T3.	No mitigation required.	No residual effects expected.
	Water Contamination	A potential adverse effect may result through accidents, the significance of which will depend on the incident.	Training in the handling, storing and disposal of hazardous materials will be provided. Emergency spill containment material and cleanup equipment will be provided and stored appropriately.	The emergency contingency plans/procedures for containing spills and water pollution control measures will reduce the significance of any residual effects.
Noise	Nuisance and disturbance to local communities	No significant cumulative adverse effect over that observed for T1/T2. Predicted noise levels at selected noise sensitive receptors are not expected to exceed acceptable noise criteria.Steam blows during commissioning will have a short term adverse effect.	Mitigation measures will include fitting noise reducing fixtures to vehicles and plant equipment, limiting night-time activities, providing noise awareness training, and monitoring noise levels to ensure compliance with acceptable criteria. Steam blows will be carefully scheduled to limit disturbance, advance warnings will be provided and the build up of debris in the pipework during construction will be limited to reduce length of steam blows.	Residual effects, albeit of slight significance, will last the duration of the site preparation/ construction or commissioning periods only.

Table 9.1 Environmental Impact Conclusion – Site Preparation and Construction Stage – cont.

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Access and Traffic	Access	No effect. No new access routes are required and no road closures/traffic diversions will be required.	No mitigation required	No residual effect
	Construction Traffic – general	No significant changes as T3 traffic will be lower than T1/T2.	Site preparation/construction traffic will be carefully managed, programmed and controlled to limit disruption to traffic flow.	The slight residual effects will last the duration of the site preparation/construction period only.
	Construction Traffic – wide/unusual loads	Potential short term slight adverse effect. Frequency of such journeys is low and impact should last the length of the journey only.	Appropriate liaison with local police and authorities will be undertaken to apply acceptable traffic management during such journeys.	No residual effect expected once site preparation/construction stage is complete.
	Changes to Air Quality & Noise Levels	Potential short-term adverse effect within 50 –100 m of access roads.	Regular maintenance of site vehicles, worker buses and other T3 related vehicles will be provided to limit emissions and noise.	Any residual effects will last the duration of site preparation/construction period only. Proportion of T3 related traffic relative to non-T3 traffic will be low, and therefore the significance of the potential impact will be diluted.

Table 9.1 Environmental Impact Conclusion – Site Preparation and Construction Stage

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Access and Traffic (continued)	Driving Conditions & Risks of Accidents	Short-term moderate adverse impact. Slow moving construction traffic may compound the risk of accidents observed on local roads.	Site preparation/construction traffic will be carefully managed, programmed and controlled to limit disruption to traffic flow.	Some slight residual effect may result despite mitigation, but will, in terms of construction traffic, be limited to the site preparation/ construction stage.
Land Use and Waste Management	Land Acquisition	No effect as no further land is required for T3.	N/A	N/A
	Earthworks: • Vegetation loss • Soil erosion • Traffic movements	No effect. T3 fill requirements will be sourced from T1/T2 borrow areas. Potential significant long-tern adverse effect may result. Short term adverse effect during movement of material, but highly localized.	Borrow areas will be graded and replanted where required. Borrow areas will be graded and replanted where required.	No residual effects.
	Solid Waste • Land contamination • Visual impact • Public Health Issue	Potentially significant effect if wastes are not properly controlled, allowing leakage to contaminate land Improperly stored wastes can unsightly. Wastes may harbour pests or cause disease when stored too long and allowed to degrade prior to disposal.	The local authority will be contracted to regularly remove waste off site and will be taken to an approved disposal facility. This will limit incidence of land contamination, prevent unsightly dumping and reduce likelihood of a public health issue arising.	Waste will continue to be generated on site – waste management procedures, site inspections and auditing will limit the significance of any adverse residual effects to slight.

Table 9.1 Environmental Impact Conclusion – Site Preparation and Construction Stage

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Ecology	Habitat Loss Land-take Borrow Areas	No effect associated with fill requirements as T1/T2 borrow areas will be used for T3.	Existing T1/T2 construction storage/lay down areas will be utilized. Extend landscape planting proposals to restore and enhance former construction areas and borrow areas. Native plant species will be used.	No residual effects.
	Wildlife Disturbance	Slight adverse effect, although T3 is smaller scale than T1/T2.	No mitigation required.	No residual effects.
	Habitat Contamination	Potential minor cumulative adverse effect.	See 'Air Quality', and 'Water and Waste Water' mitigation measures.	No residual effects.
Landscape and Visual Effects	Landscape Effects: • Vegetation loss and land use change • New structures & Features	No significant adverse effect – given small area of land affected and its position adjacent to T1/T2. Potential minor adverse effect associated with borrow areas. Slight cumulative adverse effect due to addition of T3structures to area already affected by T1/T2 structures.	Ensuring no further vegetation clearance/ disturbance or encroachment into areas not previously disturbed during T1/T2 Continue to implement the T1/T2 planting proposals to maximize screening benefits as soon as possible. Extend the landscape planting proposals as listed in 'Ecology' above.	For residual effects see section 8.8.
	Visual Effects: New views opened up Changes to existing views	No effect. Slight cumulative, incremental adverse effect due to new T3 structures.	As above.	Some residual effect experienced during construction phase.

Table 9.2 Environmental Impact Conclusion – Operation

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Air Quality	Local Effects: • CTG Emissions	No significant adverse effect overall. NO_2 and SO_2 concentrations are predicted to be within Ghana EPA and World Bank acceptable limits.	Emissions control has been achieved through design, such as: • High power generation efficiencies mean less pollution per unit of electricity produced; • Stack design will facilitate more effective dispersion.	While a residual effect will remain, this is expected to be of minor.
	National/ Global Context - CO_2 Emissions.	Relative cumulative adverse effect in Ghana with T3 in operation. Minimal global effect given Ghana's CO_2 emissions represents less than 1/30 of 1% of global emissions.	T3 has been designed to generate power efficiently	There will inevitably be a residual effect. The effect will vary with fuel used - less CO_2 will be produced with natural gas compared to LCO.
Social Effects	Community Disruption	No adverse effect. See section 6.2.2. Some slight benefit relative to site preparation/construction stage.	See Sections 6.3.2 and 6.4.2	See Section 6.5.2

Table 9.2: Environmental Impact Conclusion – Operation – cont.

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Social Effects (continued)	Employment Opportunities	Slight cumulative benefit. 25 –30 permanent workers will be required for T3.	No mitigation.	No mitigation.
	Public Health: HIV/AIDS & STDs	A potential adverse effect remains during operation of T3, however there will potentially be fewer single workers in the permanent workforce	See Sections 6.3.2 and 6.4.2.	See Section 6.5.2.
Water and Wastewater	Water Supply	No effect. Water supply requirements will be accommodated by the existing TTPP 6" supply line and Demin Water facility and discharged via T1/T2 discharge points.	No mitigation.	No residual effect.
	Wastewater Issues – general	No effect. Non industrial waste generation will be minimal and wastewater from the demineralization plant and cooling water system blowdown will be discharged to the Final Discharge Sump of the existing T1/T2 blowdown system.	No mitigation.	No residual effect.
	Wastewater Issues – thermal discharges	No significant adverse effect is expected over than that described in 1995 EIA Report.	No mitigation.	No residual effect.

Table 9.2: Environmental Impact Conclusion – Operation – cont.

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Water and Waste Water (continued)	Contamination Issues	Potential increase for contamination to occur with more frequent delivery of fuel. The existing Oil Spill Contingency plan together with training and equipment maintenance will be sufficient to cover additional risk.	All storage facilities are in a bermed area with impermeable liners and of a greater capacity than the storage facilities.	Residual impacts will be reduced to a minimum through the contamination control procedures and Oil Spill Contingency plan.
Noise	Nuisance and Disturbance of Local Communities	Current predicted levels are shown to be above acceptable guidelines. Further studies will be conducted and necessary mitigative measures will be implemented, in consultation with the VRA, prior to plant operation.	Upon completion of additional studies alternatives to mitigate possible adverse effects to the local community will be discussed with the VRA. An addendum to this report may be prepared to descrive the agreed upon measures taken, if necessary, to minimize the impact resultant from T3 operation. Closure of doors for noisy plant areas will be enforced. Noise measurements will be regularly.	A potentially slight negligible residual effect may result. As previously discussed in section 6, additional studies and mitigative measures will be implemented to minimize any residual effect associated with noise levels outside the plant boundaries.
Access and Traffic	Operational Traffic – general	Potential slight adverse effect associated with transport of waste, equipment and/or esources. However this will be a relative improvement on onstruction stage. No adverse effect associated with commuter traffic – the majority of T3 workers will be housed in the VRA township. Potential benefit relative to construction stage may result.	See Sections 6.3.5 and 6.4.5.	Any residual effects are expected to be negligible.

Table 9.2: Environmental Impact Conclusion – Operation – cont.

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Access and Traffic (continued)	Operational Traffic – wide/unusual loads	Short-term adverse effect – however the frequency for such journeys will be less than that associated with construction.	See Sections 6.3.5 and 6.4.5.	Any residual effects are expected to be negligible.
	Changes to roadside Air Quality and Noise Levels	Negligible adverse effect. Proportion of T3 related traffic in total traffic flows will be low. Likely benefit relative to construction stage will result due to less T3 related traffic present on roads.	See Sections 6.3.5 and 6.4.5.	Any residual effects are expected to be negligible.
	Driving Conditions & Risk of Accidents	Minimal to negligible adverse effect - operational traffic will be less than that with site preparation/construction. Potential slight benefit relative to site preparation/construction stage – due to absence of slow moving traffic.	Awareness/education programmes on the hazards of speeding/drink driving will be provided to T3 workers and other regular users. Traffic management features will be introduced as necessary.	Some slight residual effect may result despite mitigation.
Land Use and Waste Management	Solid Waste: • Land contamination • Visual impact • Public Heath Issues	See Section 6.2.6	T1/T2 procedures for handling solid waste will be incorporated into the T3 EMP. These include commitments to reduce, recycle and use recycled materials where practically possible. Will also safely dispose of residual waste.	See section 6.5.6.

Table 9.2: Environmental Impact Conclusion – Operation – cont.

Environmental Topic	Potential Impact	T3 Environmental Effects	T3 Mitigation Measures	Residual Effects and Comments
Ecology	Habitat Loss	No effect.	N/A	N/A
	Wildlife Disturbance	Slight benefits expected whereby noise and site activity will be reduced relative to site preparation/construction stages.	N/A	Residual effects are expected to be negligible as local wildlife will continue to acclimatise to the presence of TTPP.
	Habitat Contamination • Stack emissions • Dust generation	Potential slight adverse effects – due to settling of stack. Negligible effect once construction is finished and exposed areas have been revegetated.	No other mitigation measures relevant, other than those associated with air quality, water and waste water and landscape/visual issues.	Any residual effects associated with air emissions are not expected to be significant, especially once natural gas becomes available. The emergency contingency plans/procedures for containing spills and water pollution control measures will reduce the significance of any residual effects.
Landscape and Visual Effects	Landscape Effects	No further adverse effects. Some slight improvements expected with maturing of planting proposals.	T1/T2 planting proposals will be extended for T3.	Despite the mitigation measures there will inevitably be a moderate residual adverse effect resulting from TTPP as a whole. This residual effect would decrease with time as the planting proposals mature and local people become accustomed to the change.

Appendix A – Maps and Figures

Figure 1.1 T3 Site Location

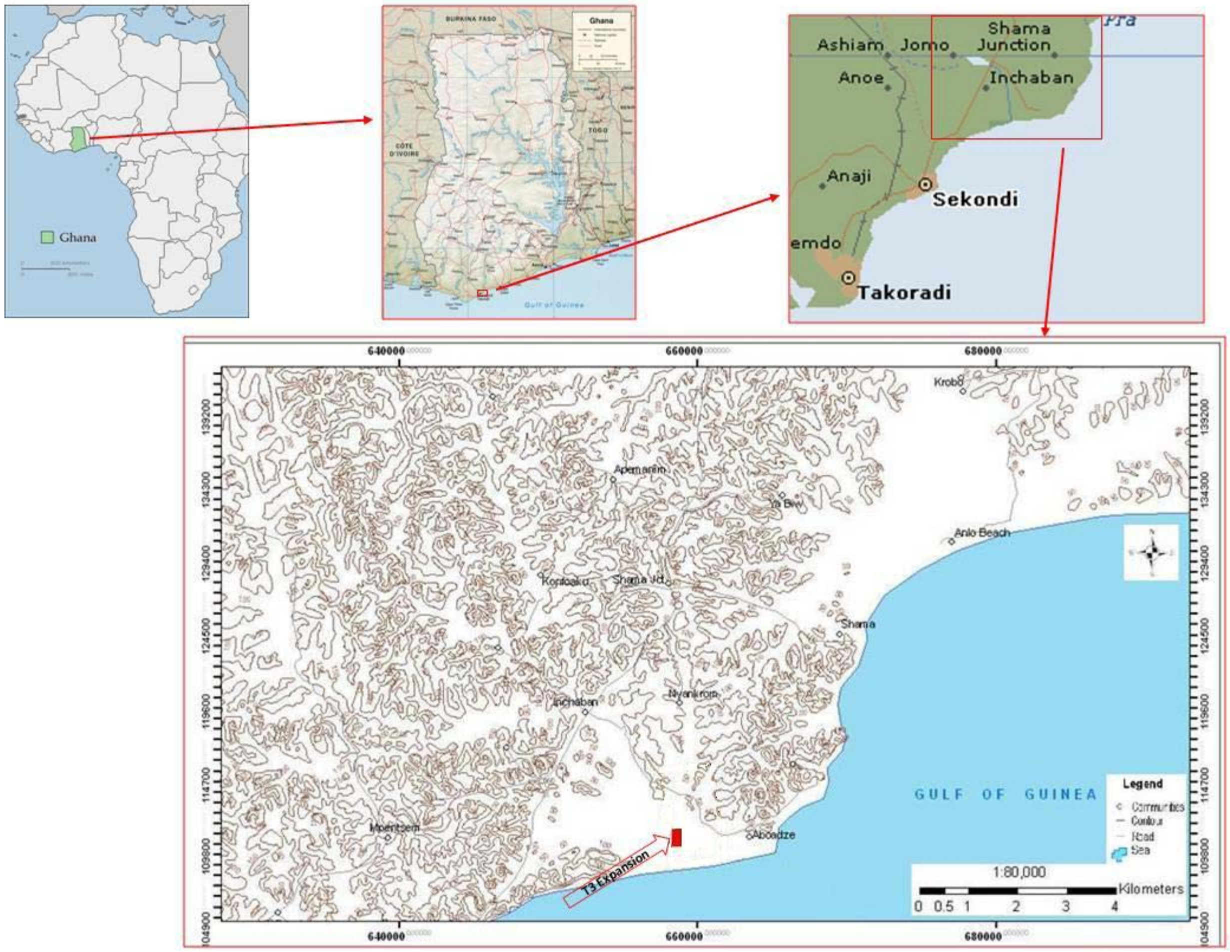


Figure 3.1 TTPP and T3 Expansion Site Location

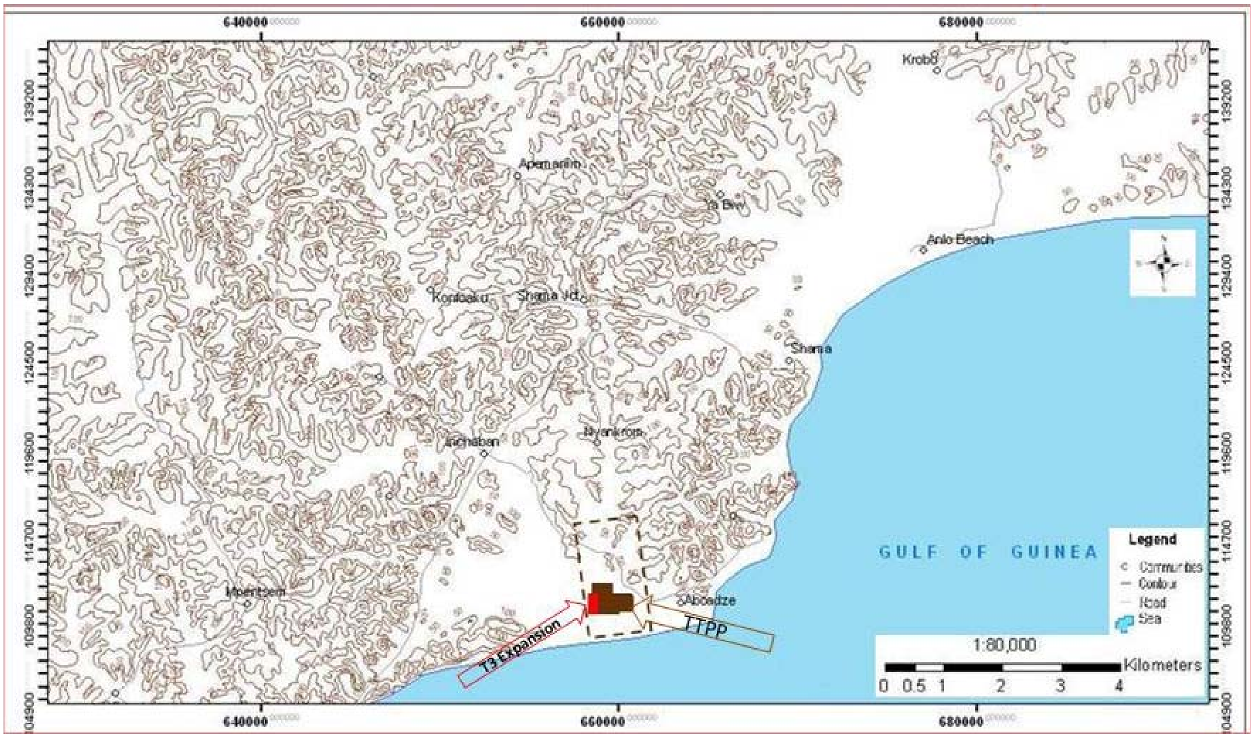


Figure 3.2 VRA Township Location

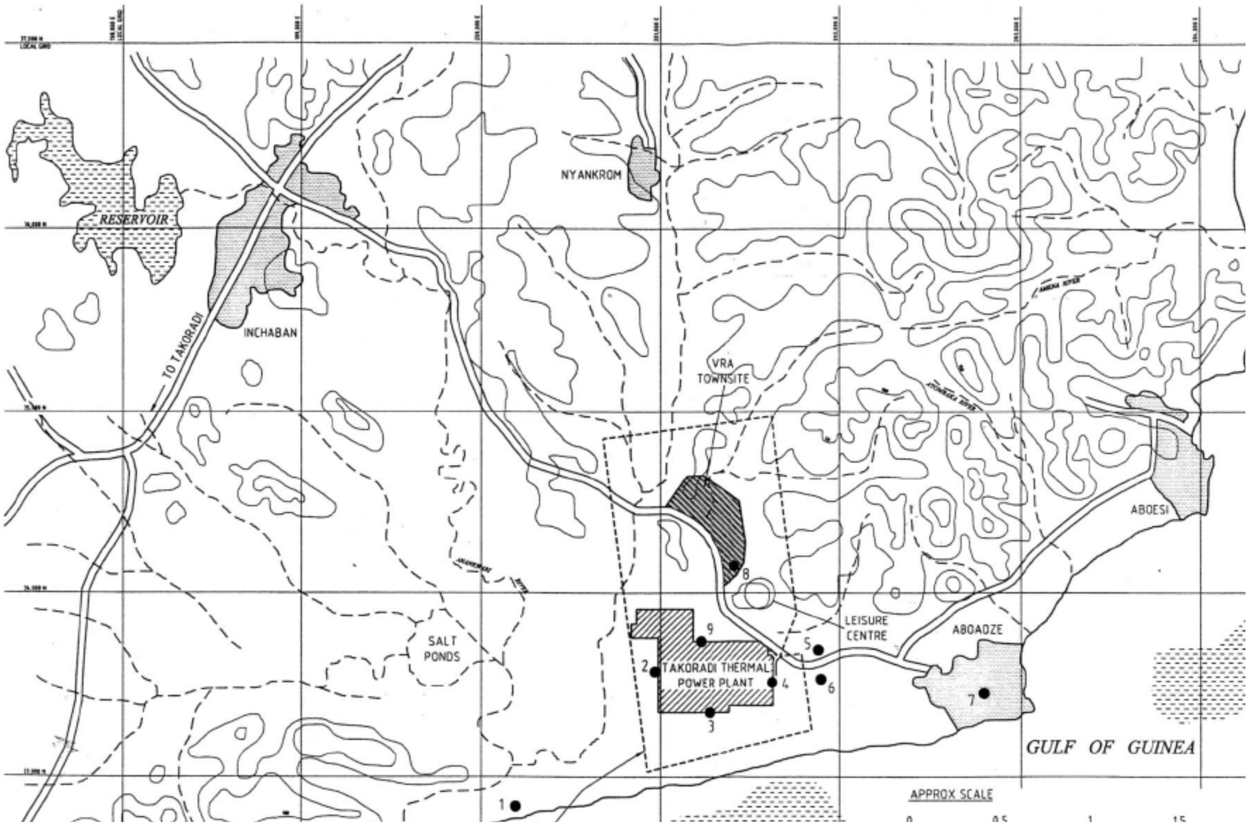


Figure 3.3 T3 Location With Respect to TTPP

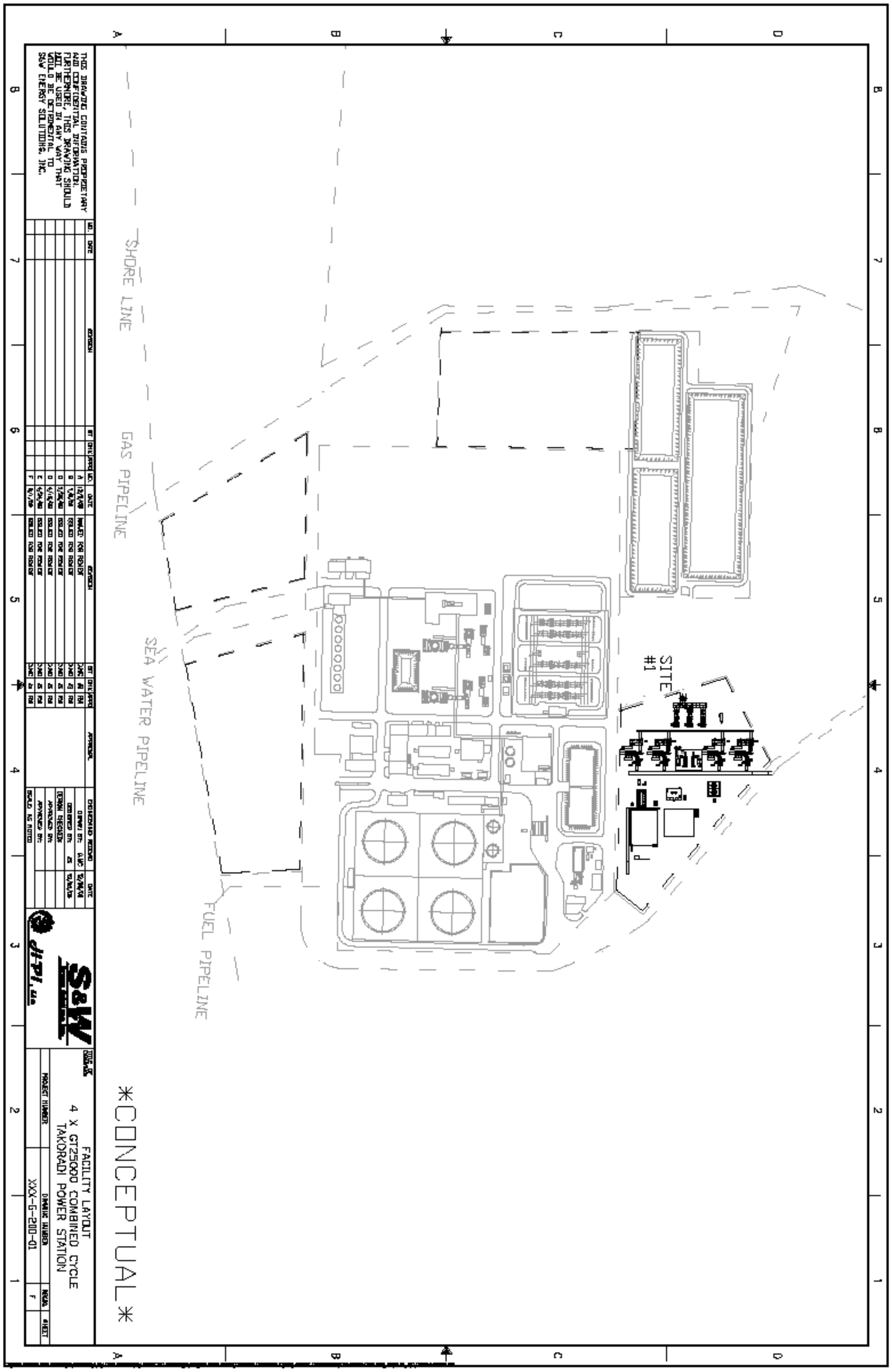


Figure 3.4 T3 Plot Plan (Reference Appendix E Drawings)

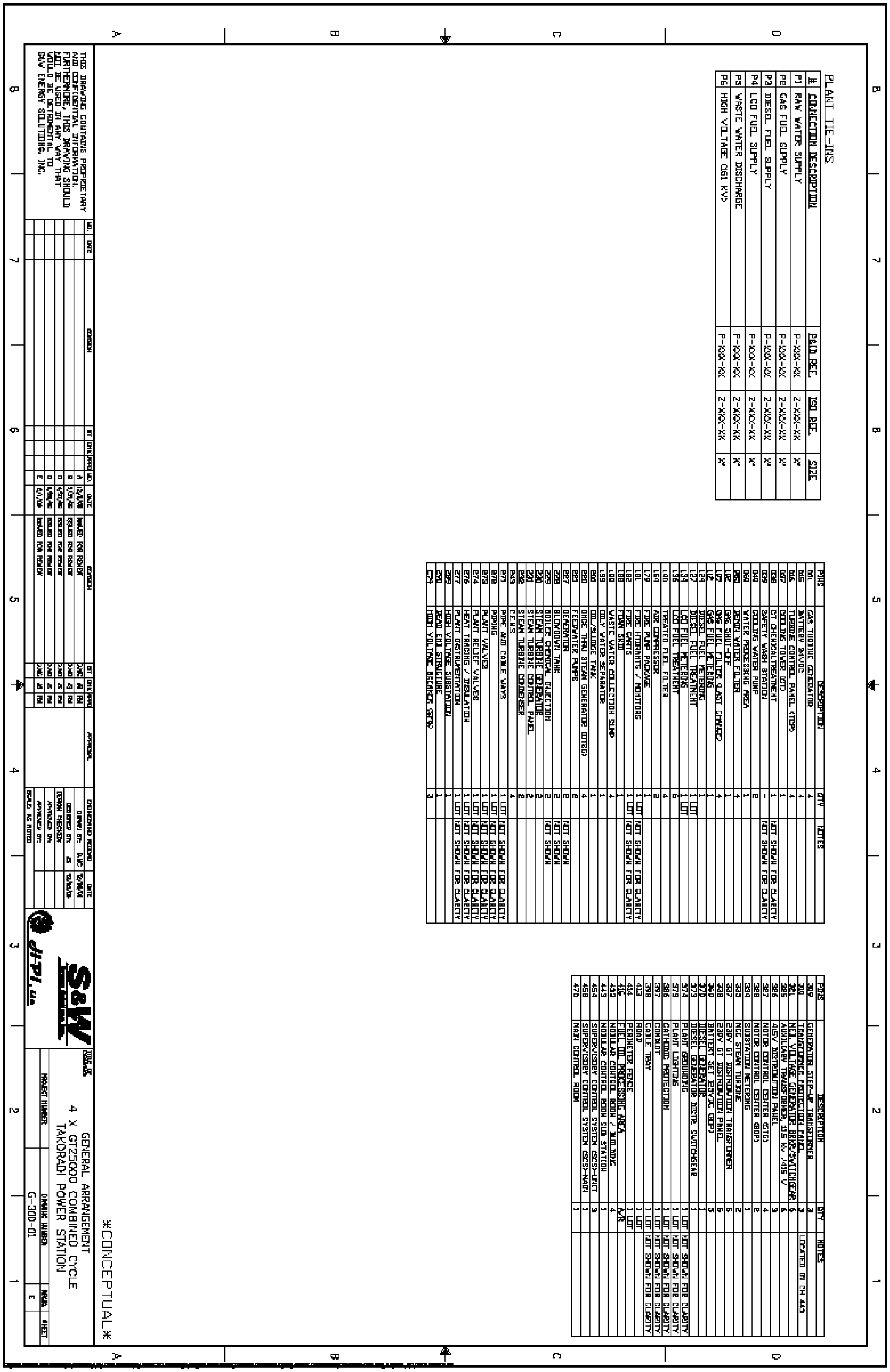


Figure 3.4 T3 Plot Plan (Reference Appendix E Drawings)

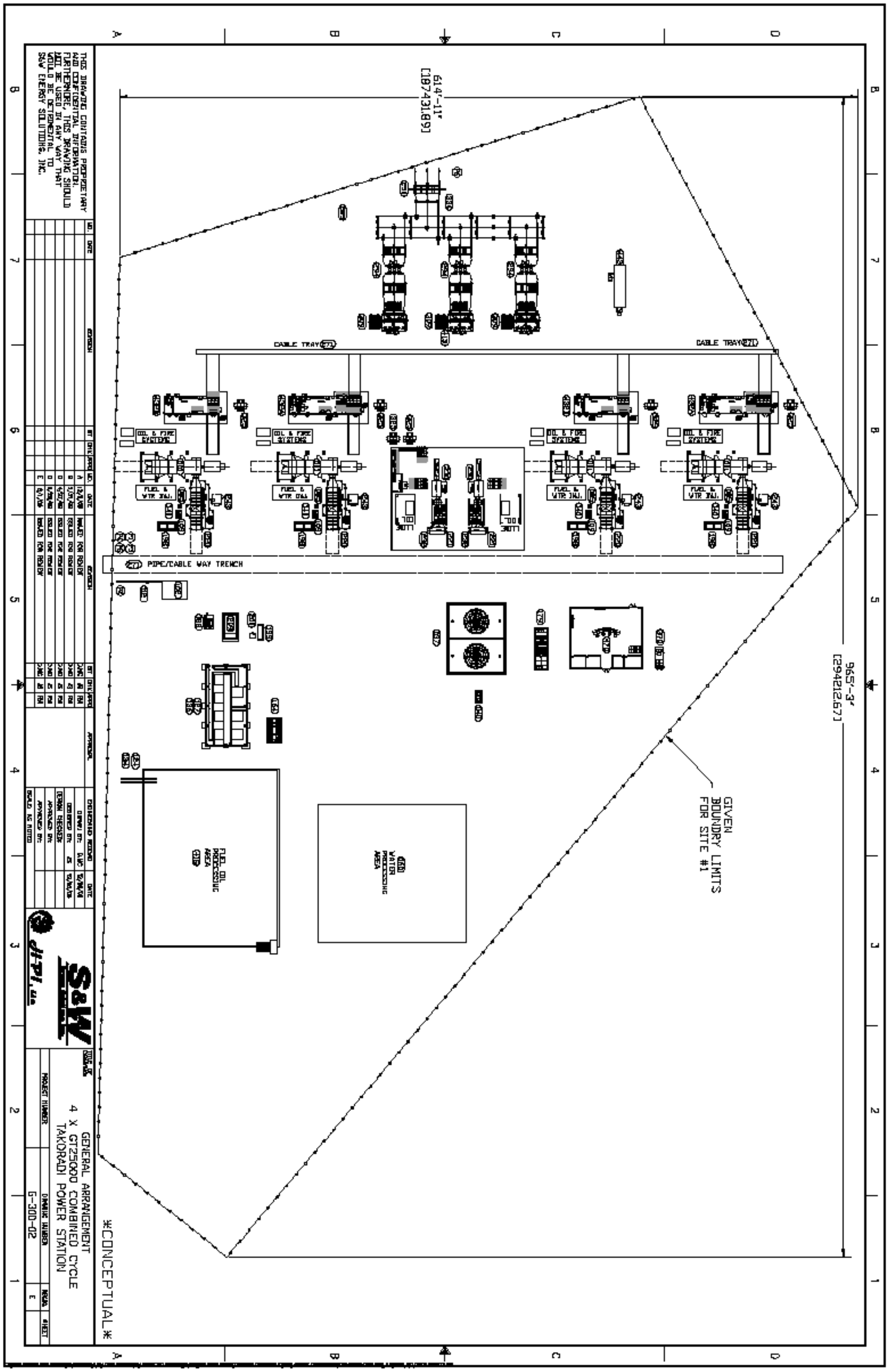


Figure 3.4 T3 Plot Plan (Reference Appendix E Drawings)

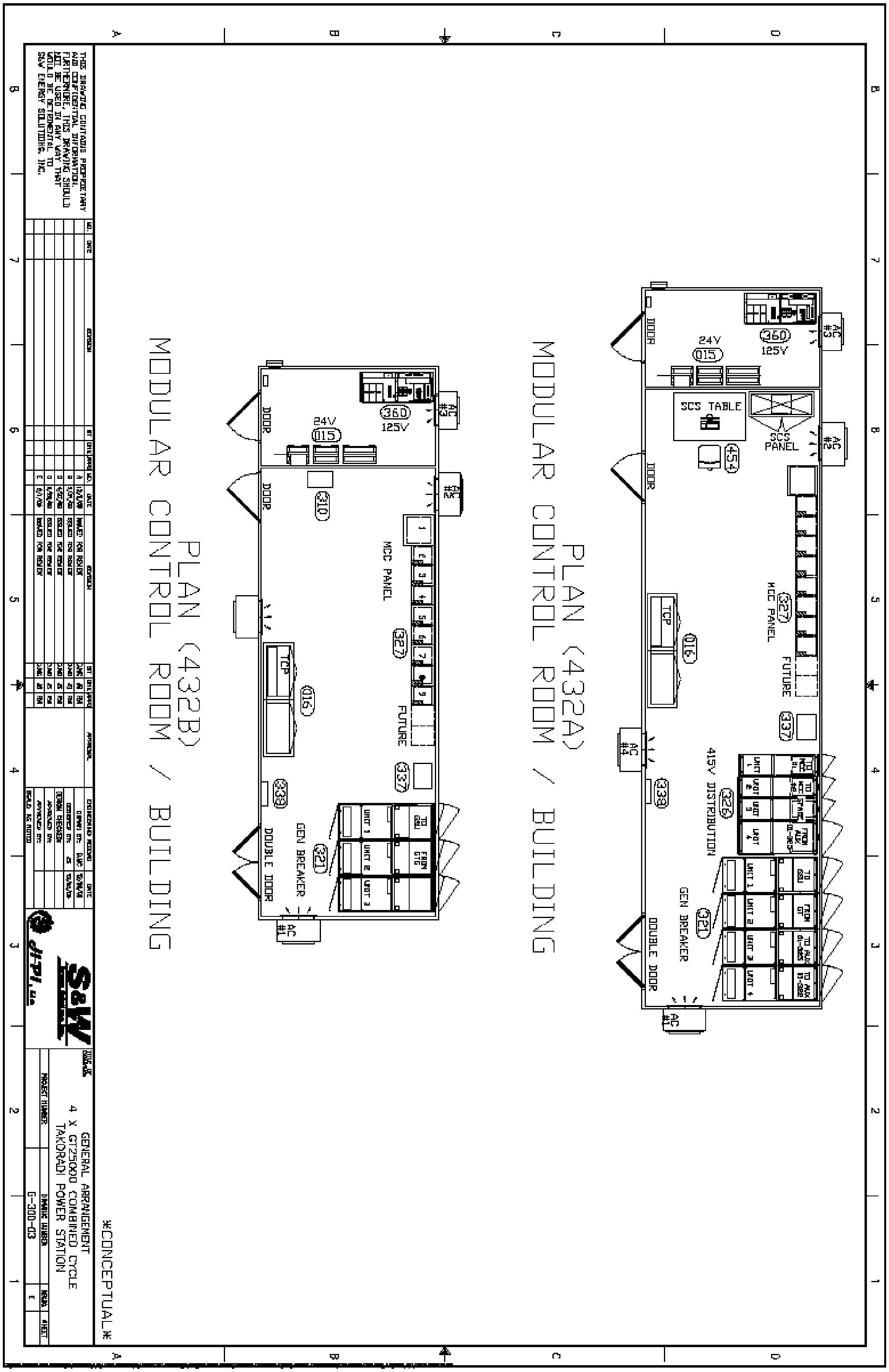


Figure 3.4 T3 Plot Plan (Reference Appendix E Drawings)

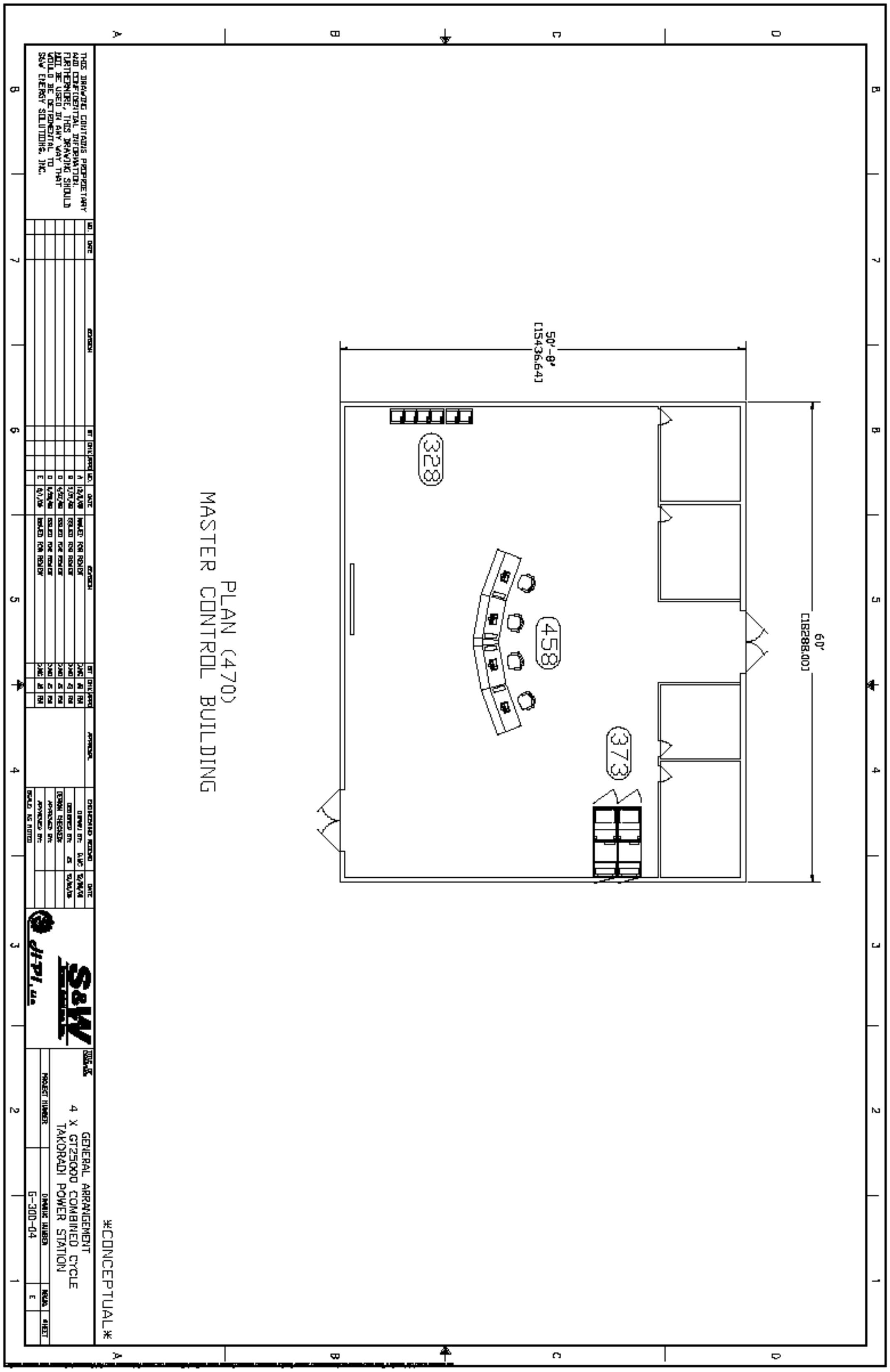
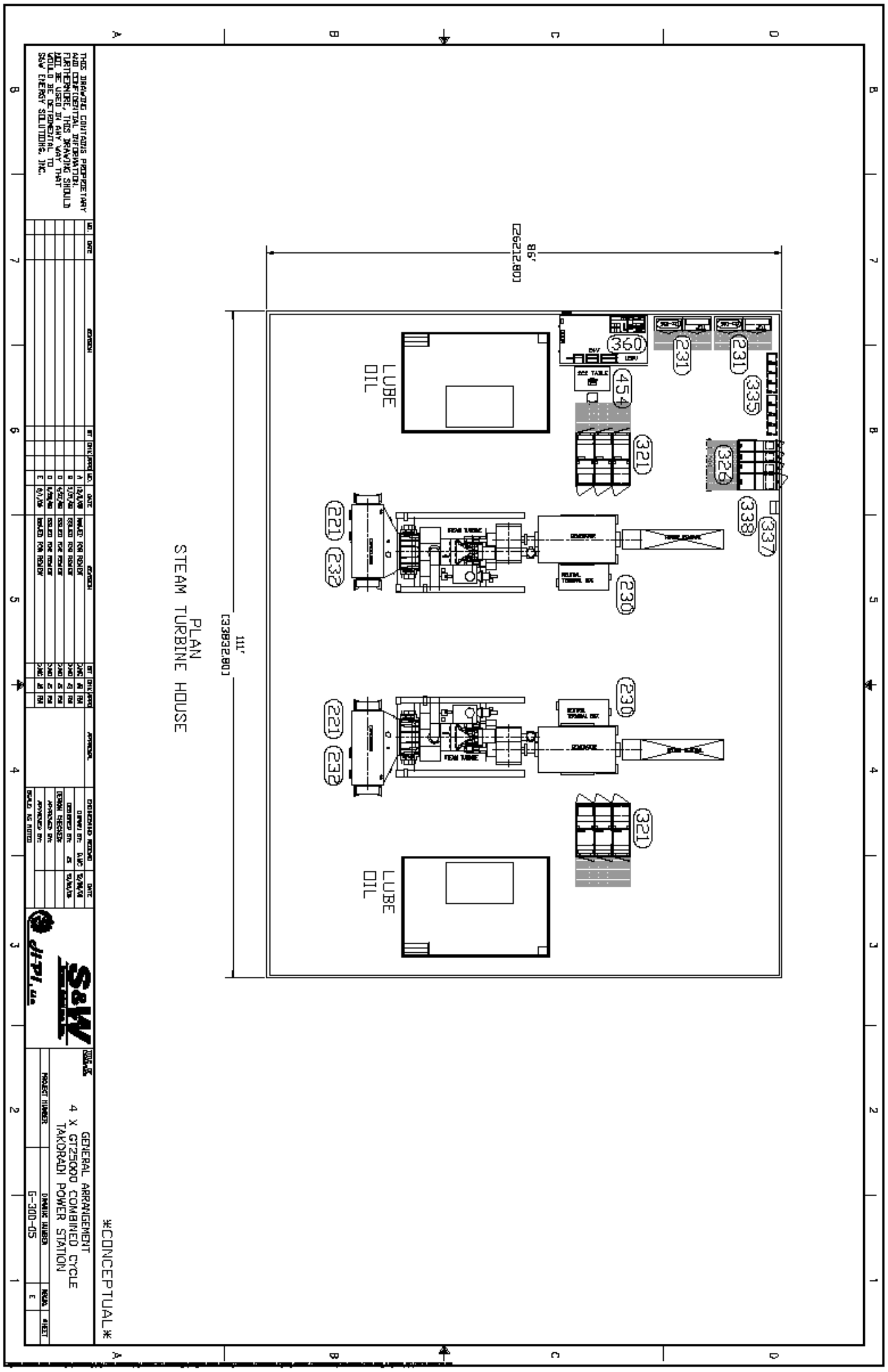


Figure 3.4 T3 Plot Plan (Reference Appendix E Drawings)

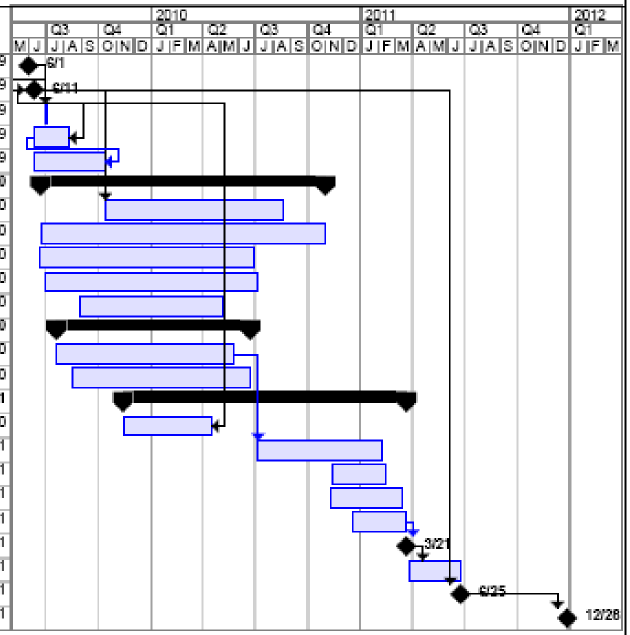


b

Figure 3.5 Construction, Commissioning and Startup Schedule

The Government of the Republic of Ghana
Contract No. 61738

ID	Task Name	Duration	Start	Finish
1	Effective Date	0 days	Mon 6/1/09	Mon 6/1/09
2	Commencement Date	0 days	Thu 6/11/09	Thu 6/11/09
3	Appoint Employer's Rep.	1 day?	Wed 7/1/09	Thu 7/2/09
4	Preliminary Engineering	2 mons	Thu 6/11/09	Wed 8/12/09
5	Detailed Engineering	4 mons	Thu 6/11/09	Tue 10/13/09
6	**Major Equipment Procurement**	**497 days**	**Mon 6/22/09**	**Mon 11/1/10**
7	GTG	10 mons	Tue 10/13/09	Thu 8/19/10
8	STG (2)	16 mons	Tue 6/23/09	Mon 11/1/10
9	HRSG (4)	12 mons	Mon 6/22/09	Tue 6/29/10
10	Condenser	12 mons	Mon 6/29/09	Tue 7/6/10
11	GSU	8 mons	Mon 8/31/09	Thu 5/6/10
12	**Balance of Plant Equipment**	**338 days**	**Mon 7/20/09**	**Wed 6/23/10**
13	Mechanical	10 mons	Mon 7/20/09	Wed 5/26/10
14	Electrical	10 mons	Mon 8/17/09	Wed 6/23/10
15	**Construction**	**493.38 days**	**Fri 11/13/09**	**Mon 3/21/11**
16	Civil Works	5 mons	Fri 11/13/09	Sat 4/17/10
17	Equipment Erection	7 mons	Wed 7/7/10	Wed 2/9/11
18	Piping	3 mons	Sat 11/13/10	Mon 2/14/11
19	Electrical	4 mons	Wed 11/10/10	Mon 3/14/11
20	I&C	3 mons	Sat 12/18/10	Mon 3/21/11
21	Mechanical Completion	0 days	Mon 3/21/11	Mon 3/21/11
22	Start-Up & Commissioning	90 days	Sat 3/26/11	Fri 6/24/11
23	Commercial Operation	0 days	Sat 6/25/11	Sat 6/25/11
24	Final Completion	0 days	Wed 12/28/11	Wed 12/28/11

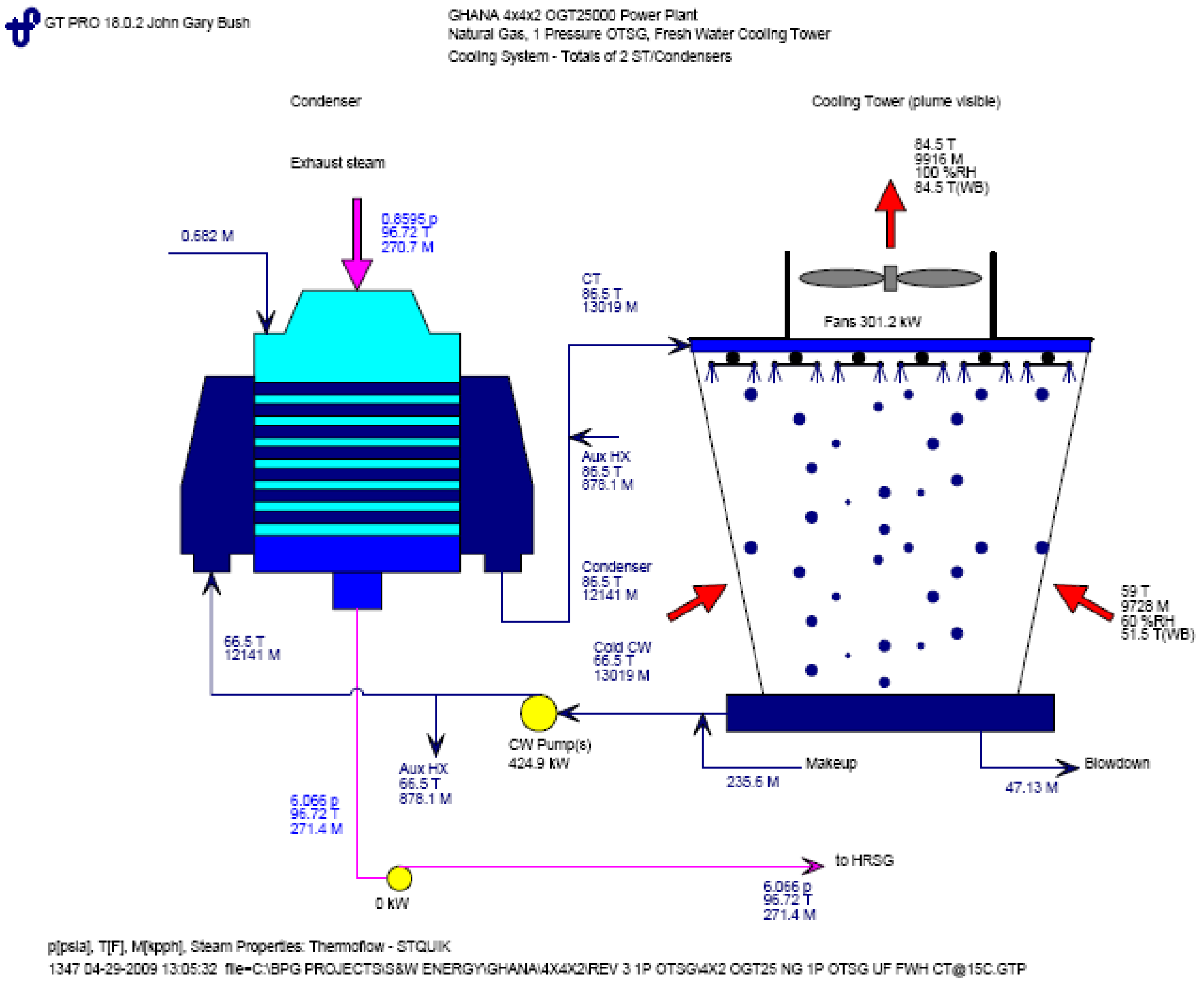


Project: Schedule - Rev 01
Date: Fri 5/1/09

Task		Milestone	◆	External Tasks	
Split		Summary		External Milestone	◆
Progress		Project Summary		Deadline	⇩

Page 1

Figure 3.6 T3 Cooling Water System Balance



**Note: An additional 80 gpm will be utilized for emission control of NOx.*

Source: Bush Power Group LLC

Figure 4.1 Approximate Area Encompassed by the Study

Figure 4.2 Transmission Line Topography

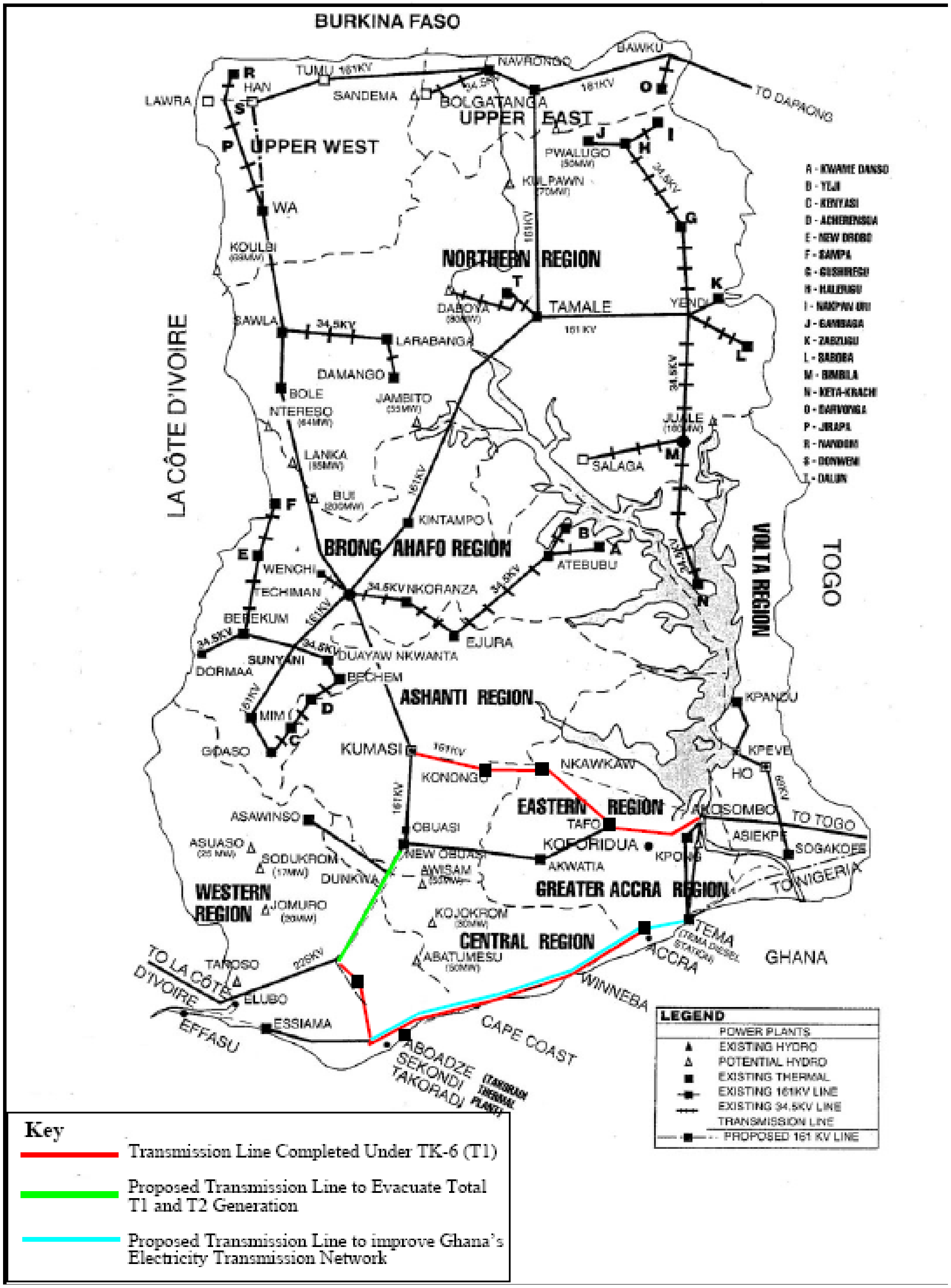


Figure 4.3 Portion of Anakwari Lagoon with Mangrove Vegetation (West of the Plant)

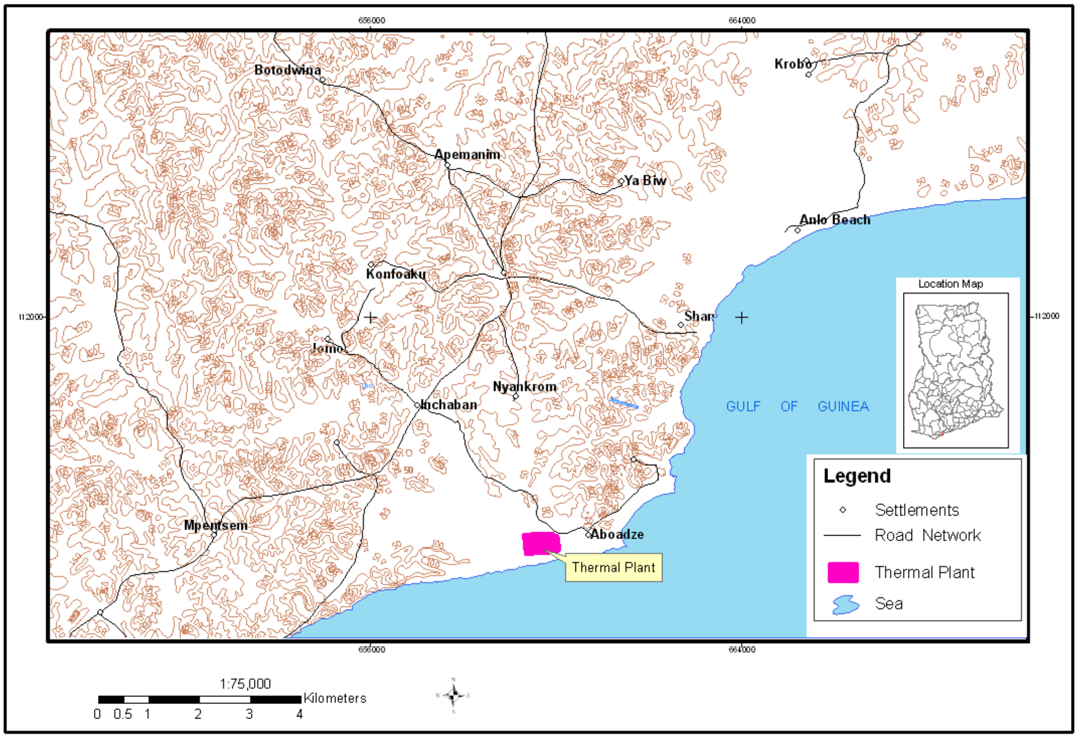
Figure 4.4 VRA's Scrap Yard & Storm Drain

Figure 4.5 Area Surrounding T3 Site

Figure 4.6 Coastline Erosion at Aboadze

Figure 4.7 Topographic Map of Ghana

Figure 4.8 Topographic Map of Aboadze Area



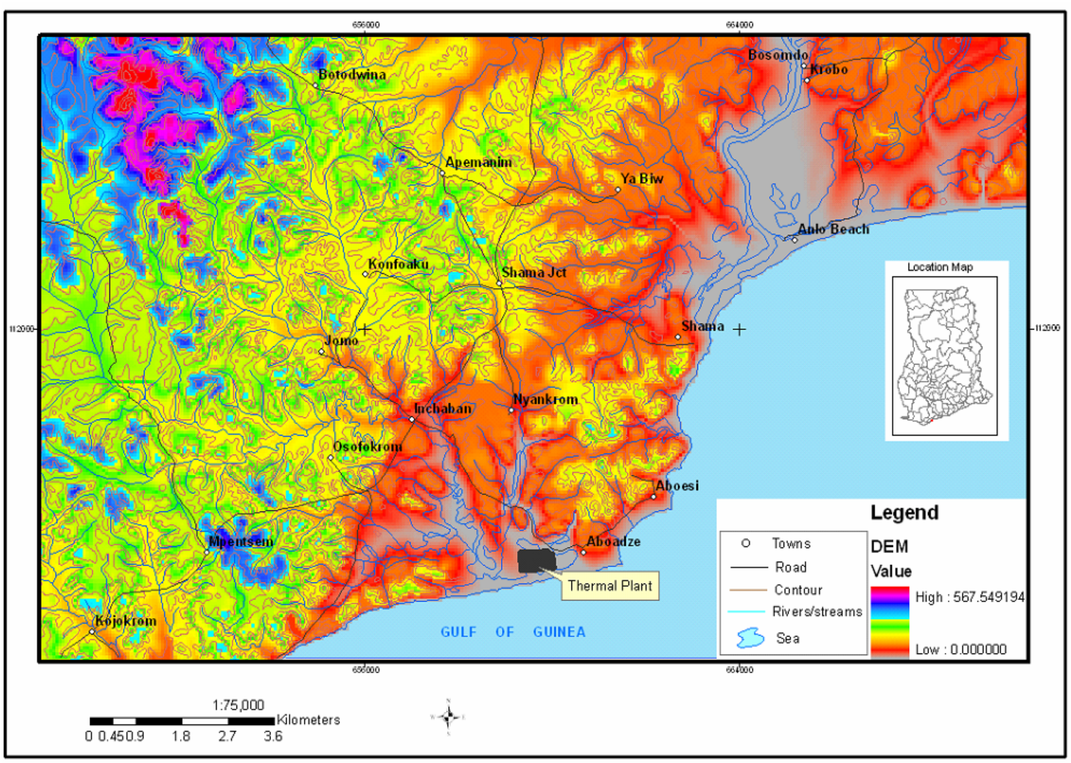


Figure 4.9 Satellite Imagery of Aboadze Area

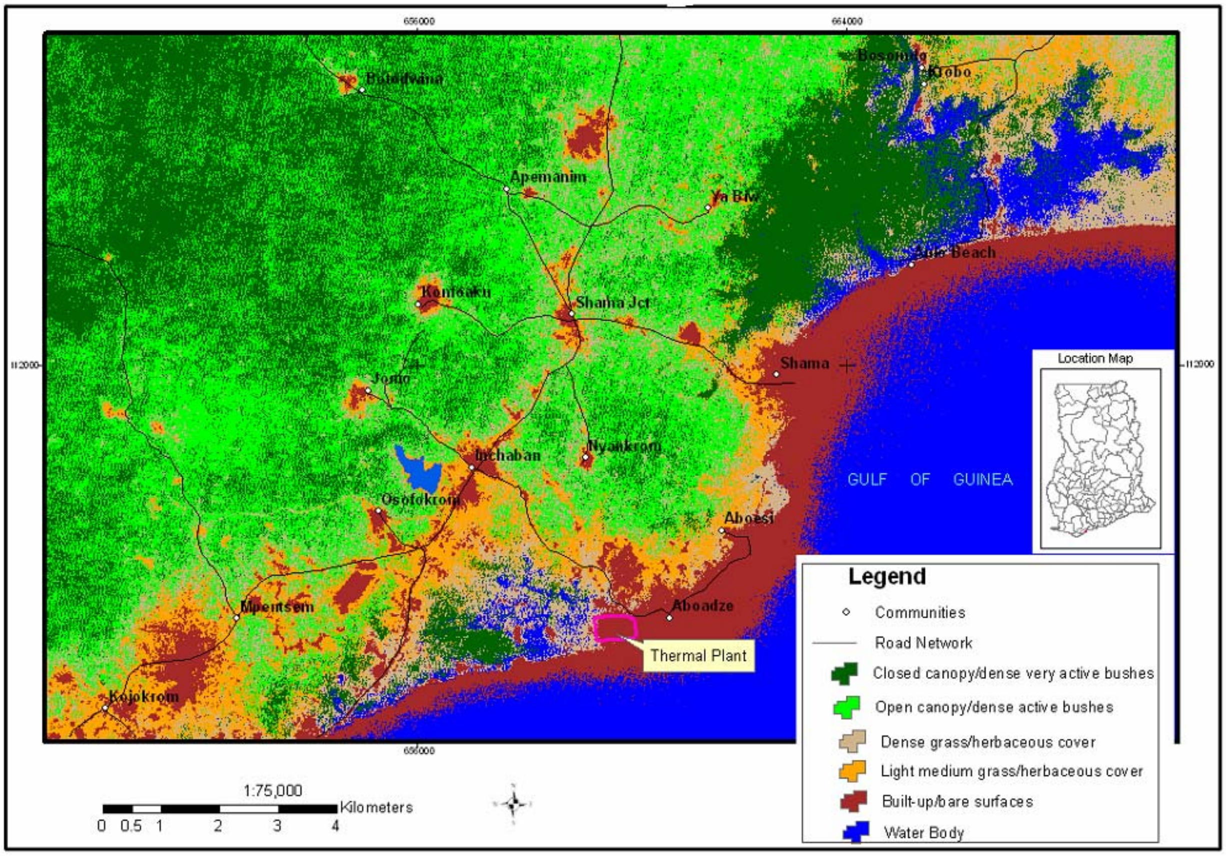


Figure 4.10 Ghana Geology Map

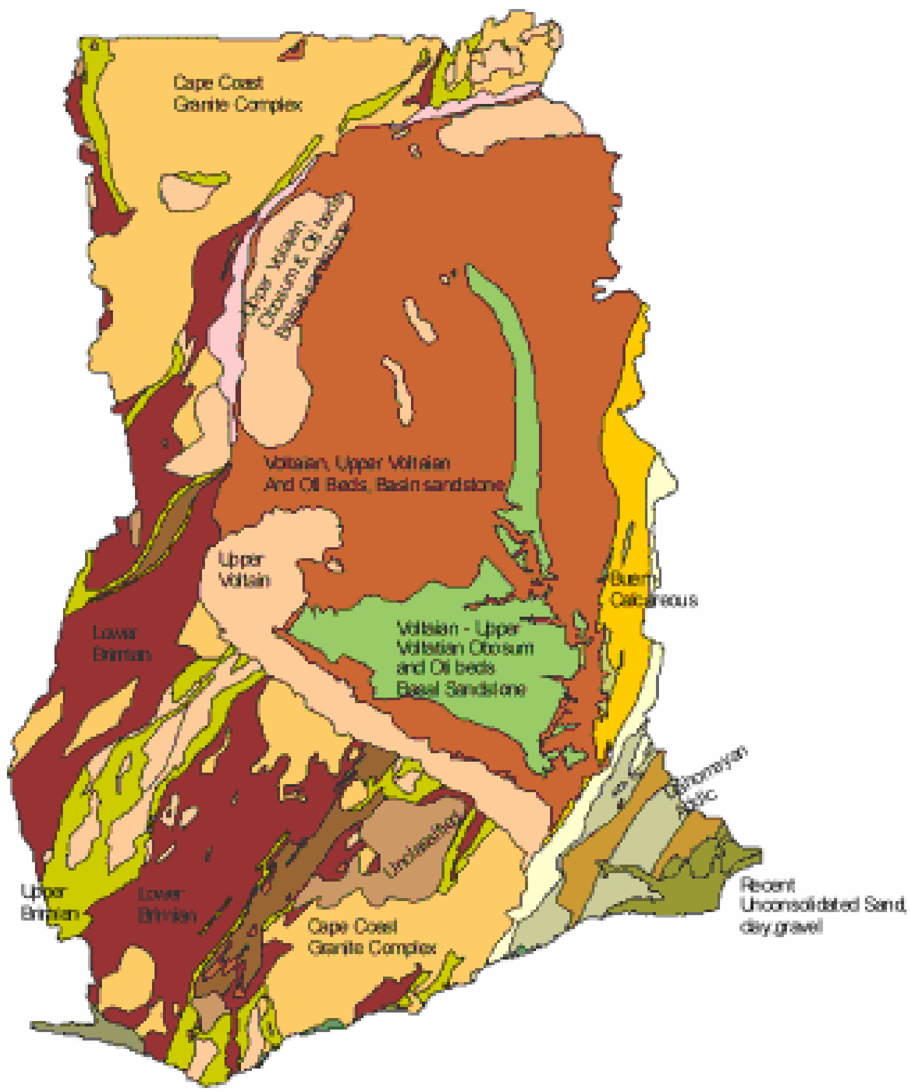


Figure 4.11 Ghana Soil Map

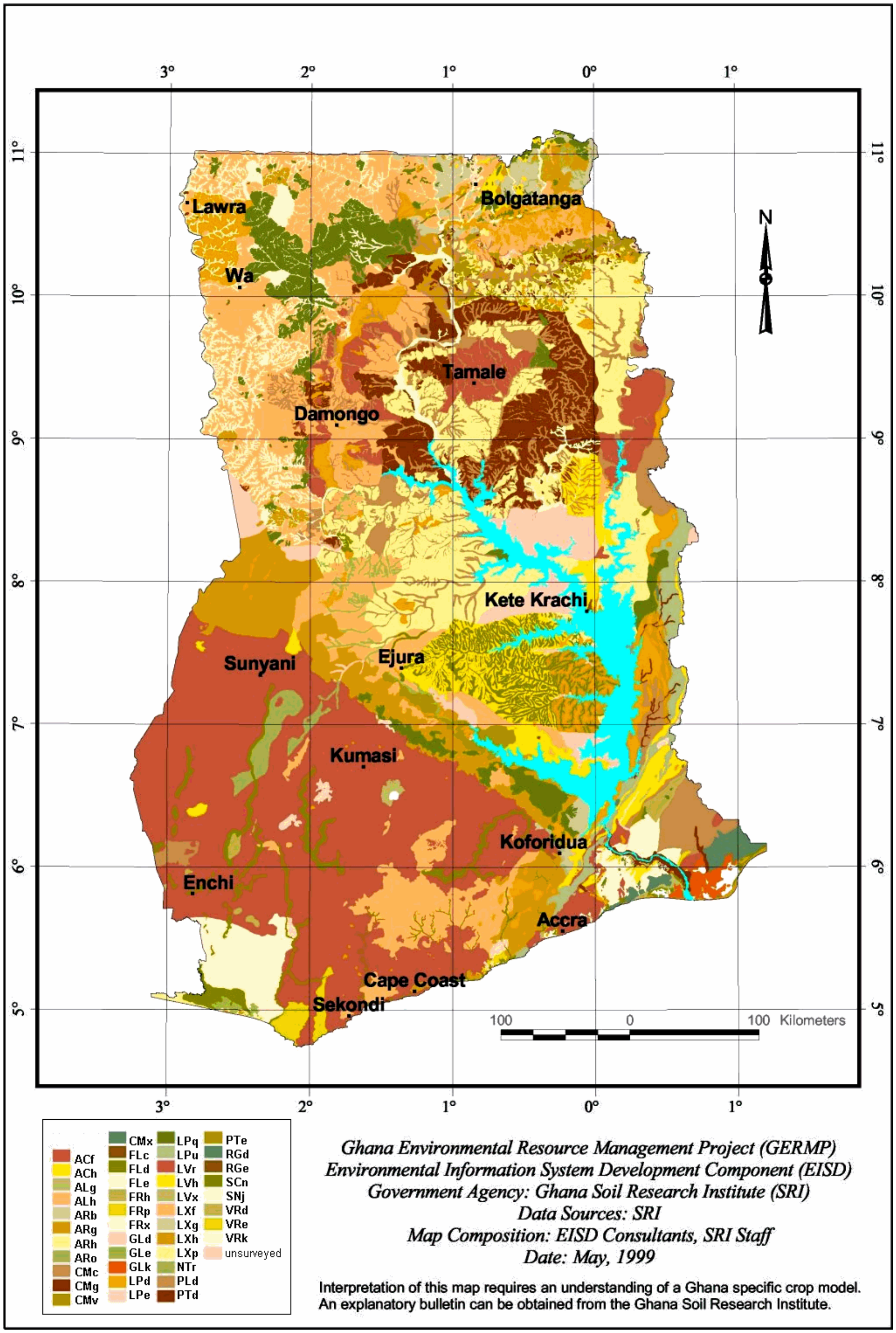
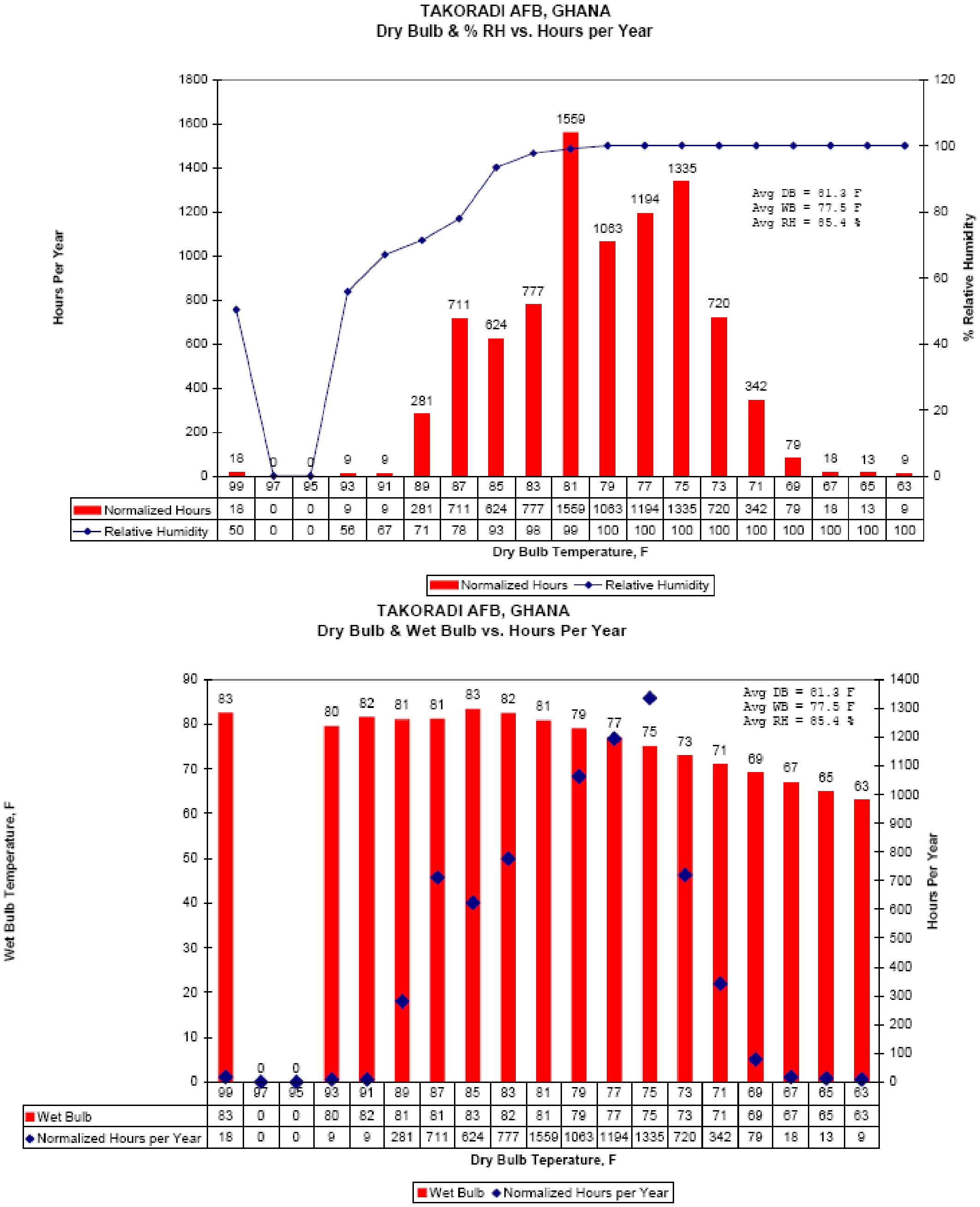


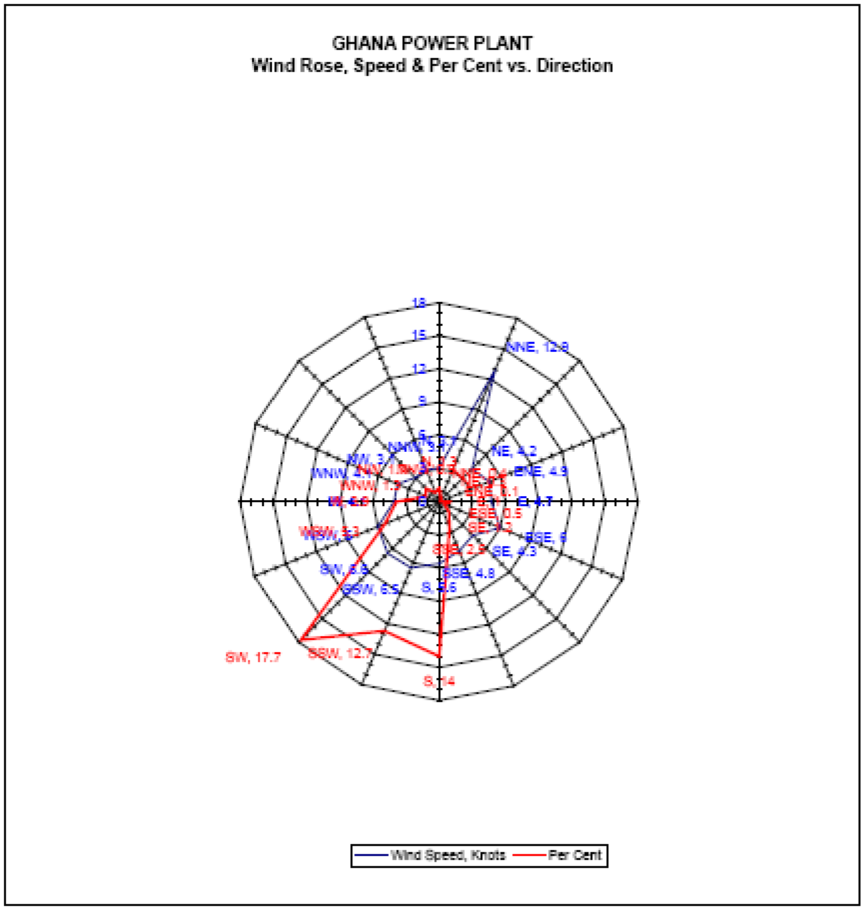
Figure 4.12 Takoradi Weather Profile (1973-1994)



Source: Bush Power Group LLC

Figure 4.13 Takoradi Wind Rose and Speed (1973-1994)

Direction	Mean Speed Knots	Per Cent
N	3.1	1.3
NNE	12.9	0.4
NE	4.2	0.3
ENE	4.9	0.1
E	4.7	1
ESE	6	0.5
SE	4.3	1.2
SSE	4.8	2.5
S	5.6	14
SSW	6.5	12.7
SW	6.6	17.7
WSW	6	5.3
W	4.1	3.9
WNW	4.1	1.3
NW	3.1	1.7
NNW	3.1	0.9



Source: Bush Power Group LLC

Figure 4.14 Mean Annual Rainfall

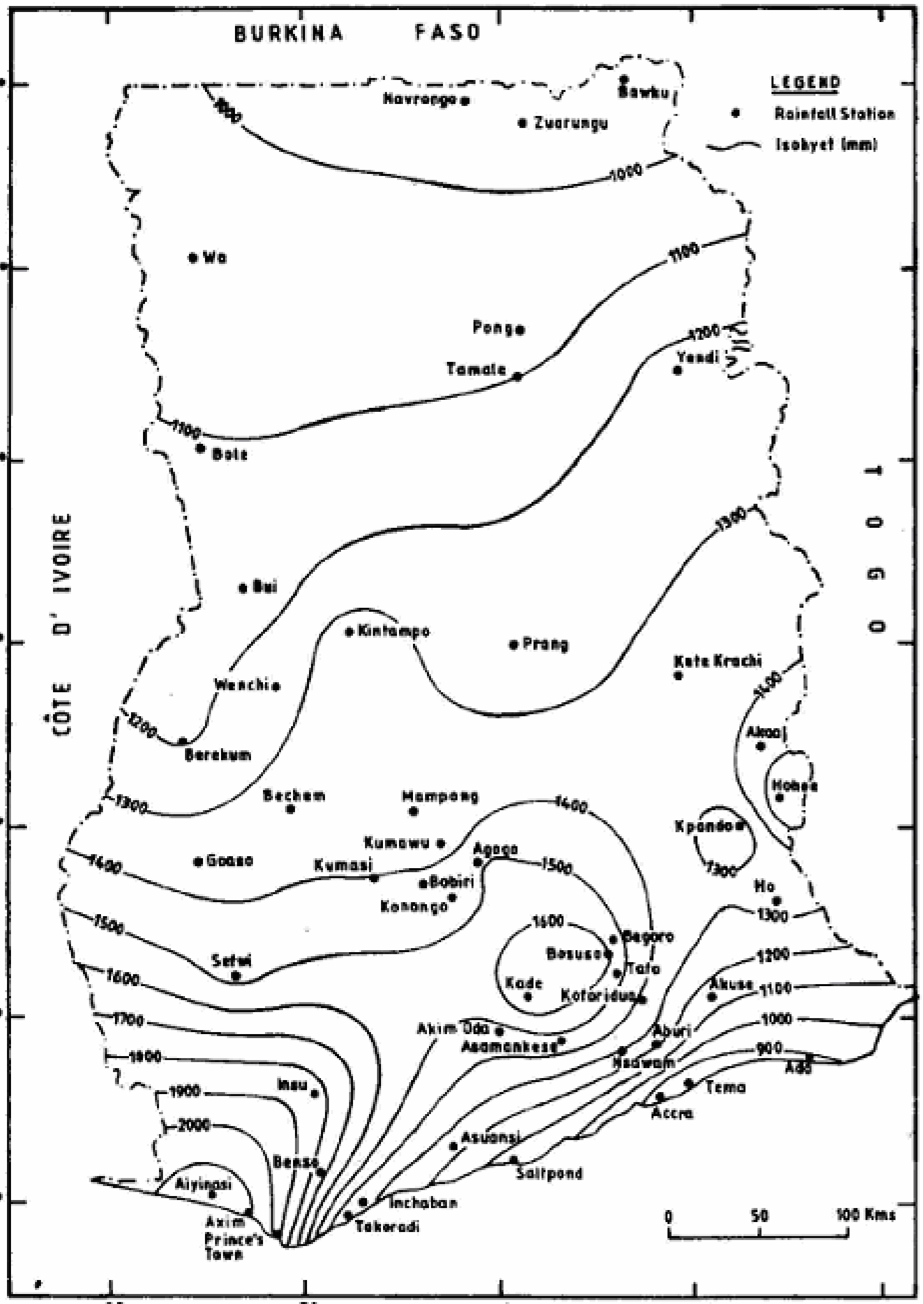


Figure 4.15 Ghana Representative Basins and Drainage Map

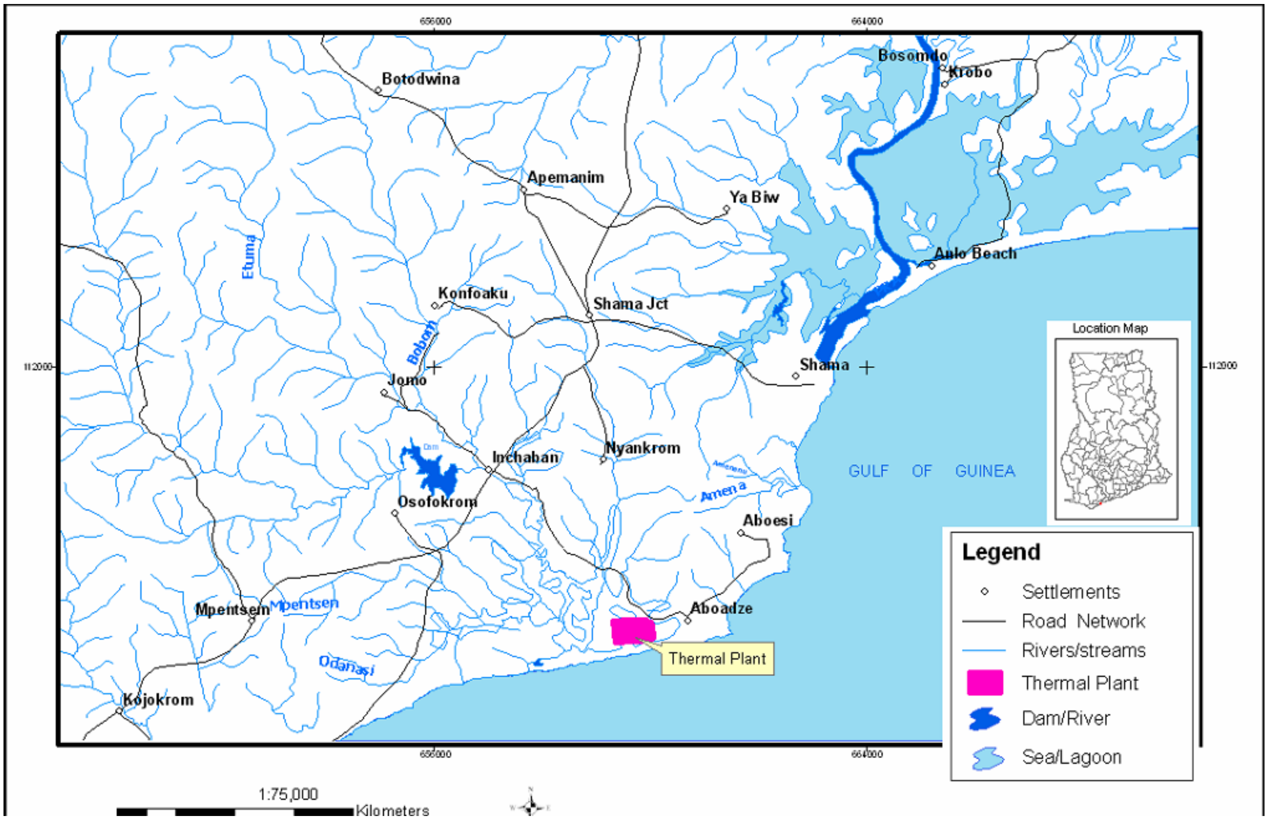


Figure 4.16 Ghana Coastal Zone

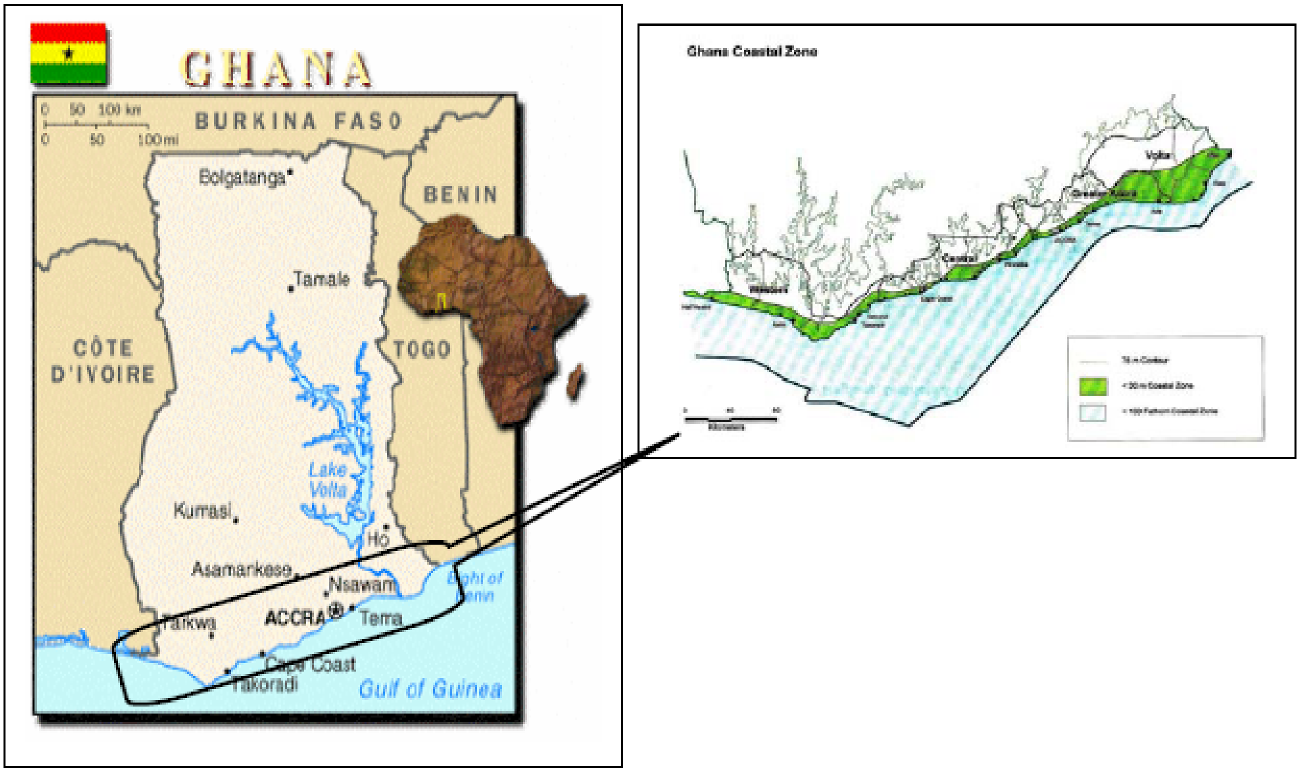


Figure 4.17 Open Coastal Lagoons at the Western Region of Ghana

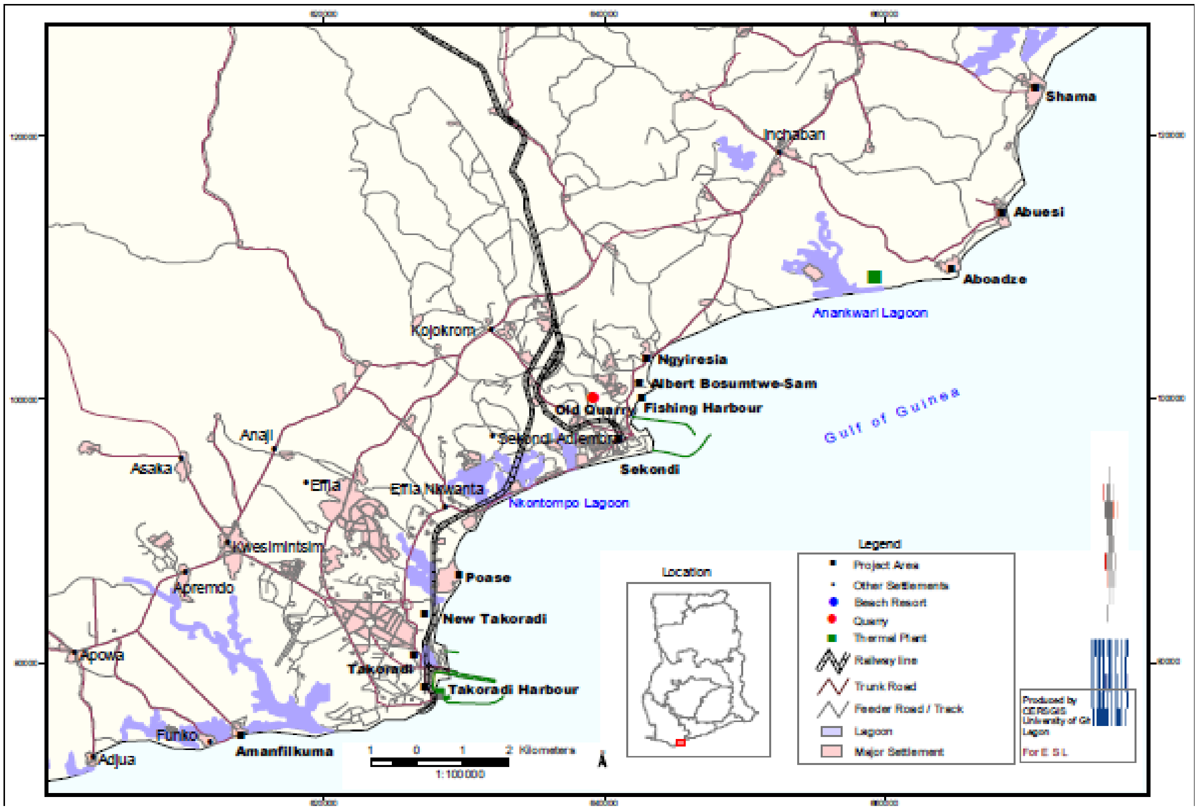


Figure 4.18 Shoreline at Aboadze/Takoradi

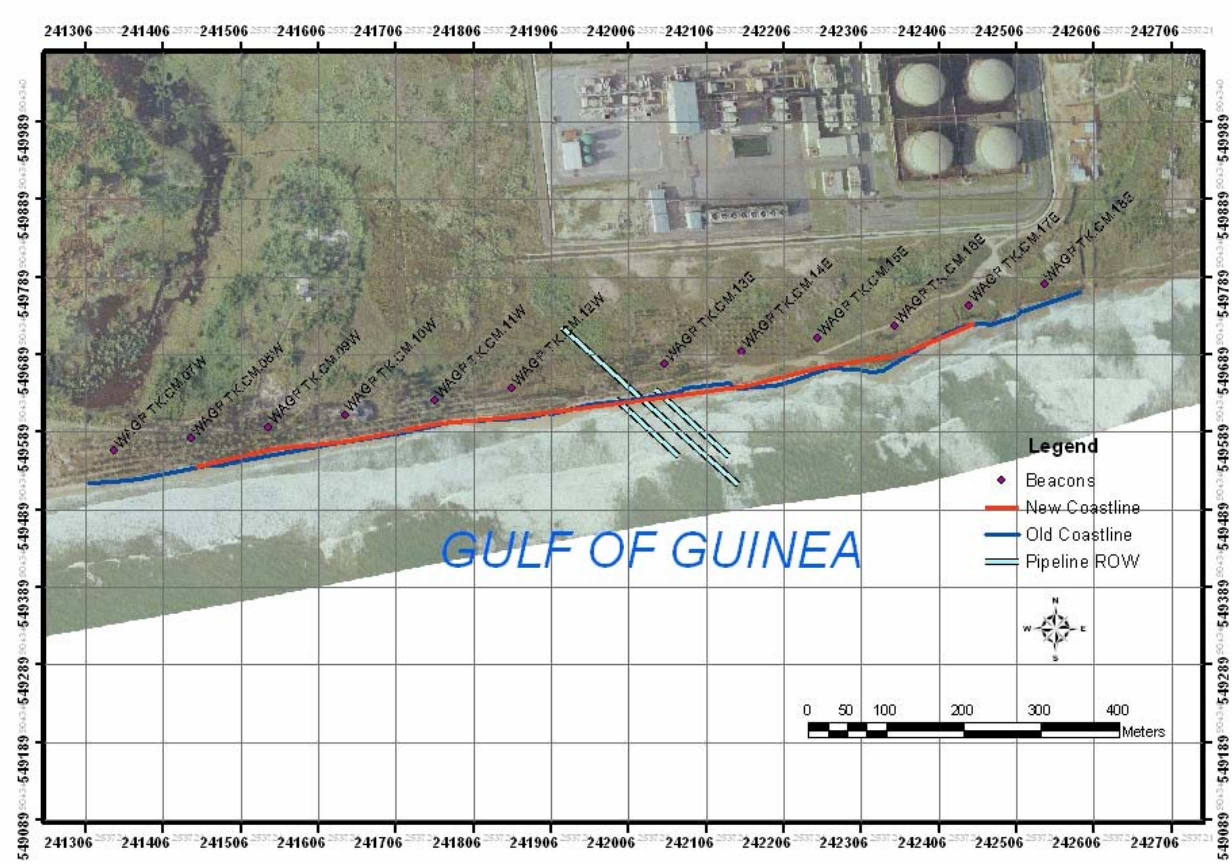


Figure 4.19 Ghana Ecological Zones

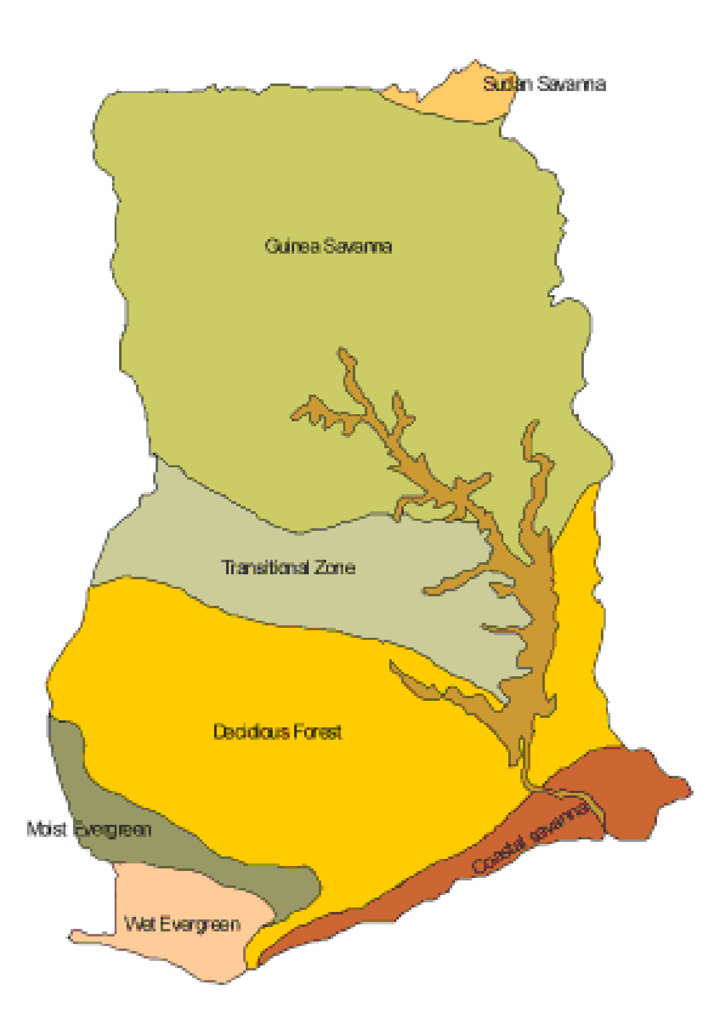


Figure 4.20 Typical Vegetation Around TTPP

Figure 4.21 20 Meter Belt Transect at Aboadze

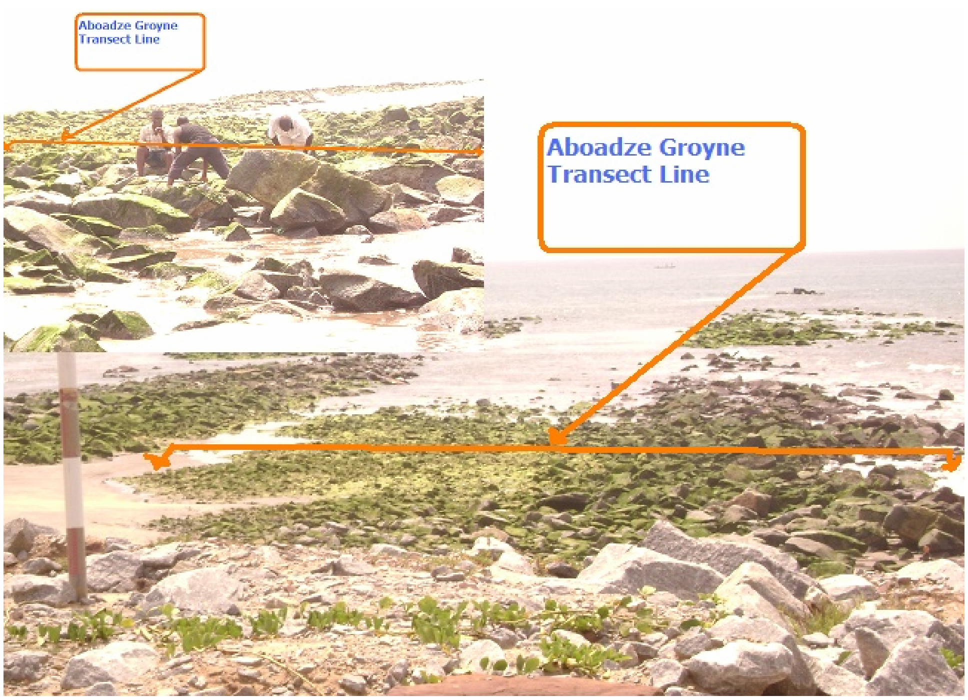


Figure 4.22 Quadrant Analysis of Rocky Shore Biota

Figure 4.23 Distribution and Abundance of Soft-Bottom Macrobenthic Fauna at Aboadze

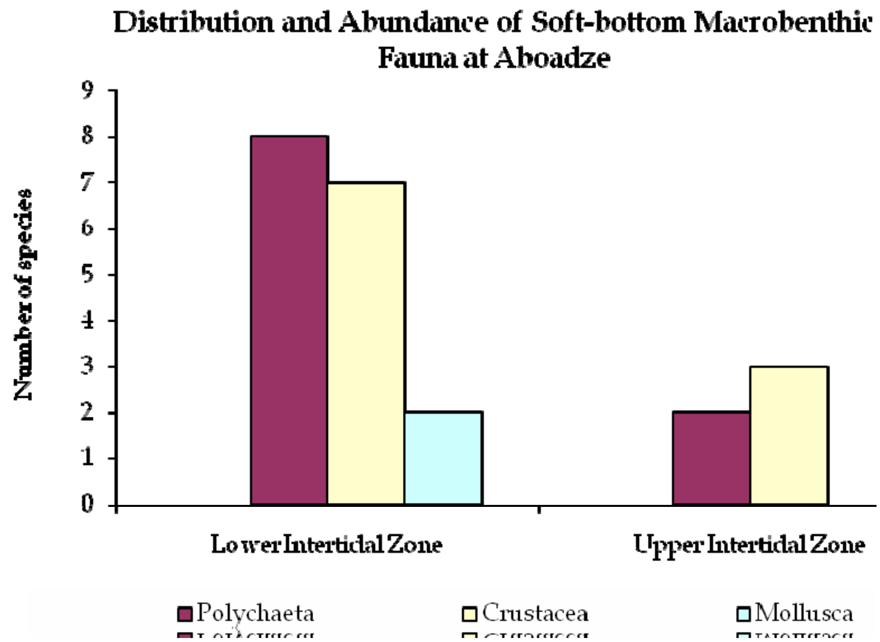


Figure 4.24 Distribution of Major Macrobenthic Species off Aboadze Subtidal Environment

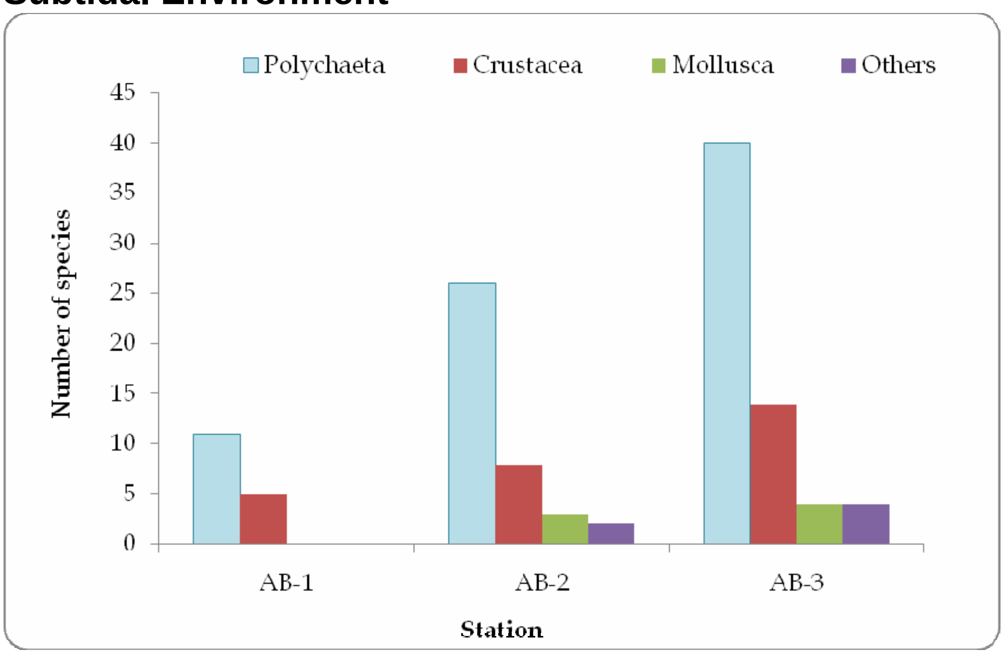


Figure 4.25 Ghana Population Density

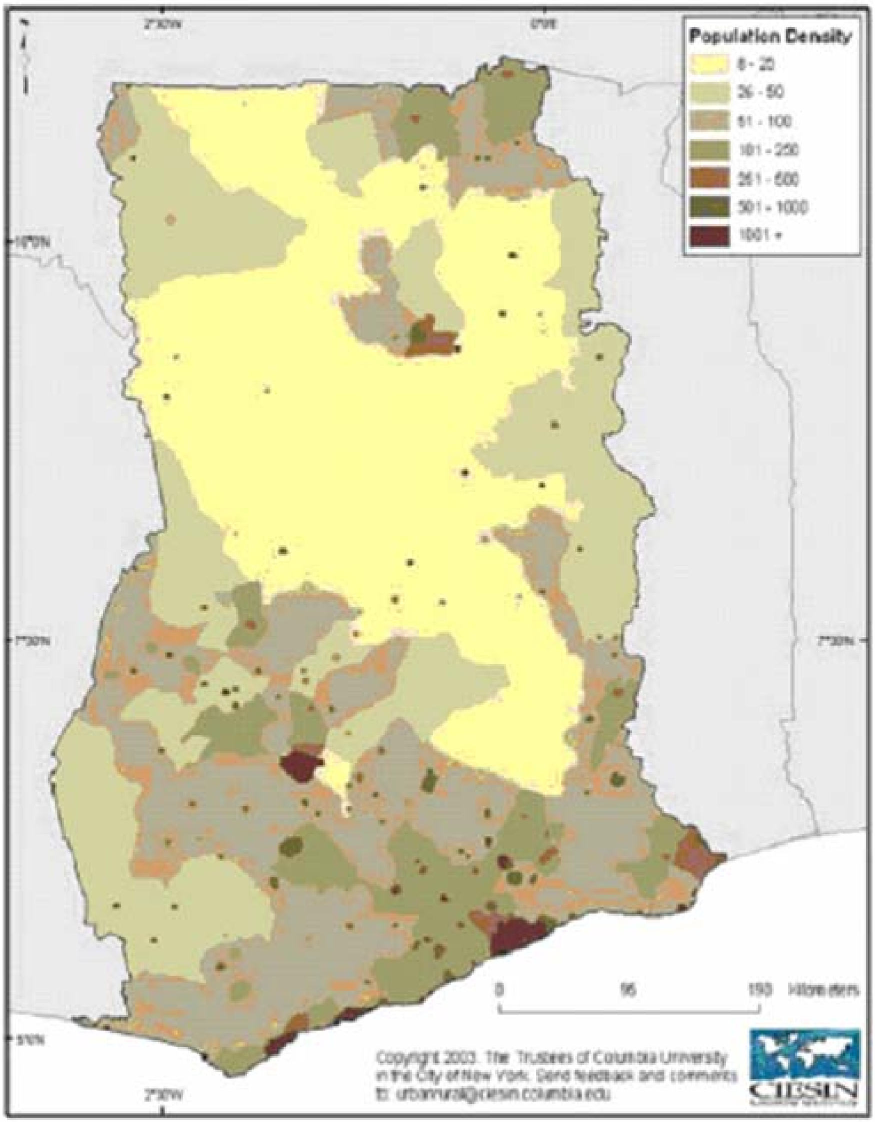


Figure 4.26 Population Density (2003-2008)

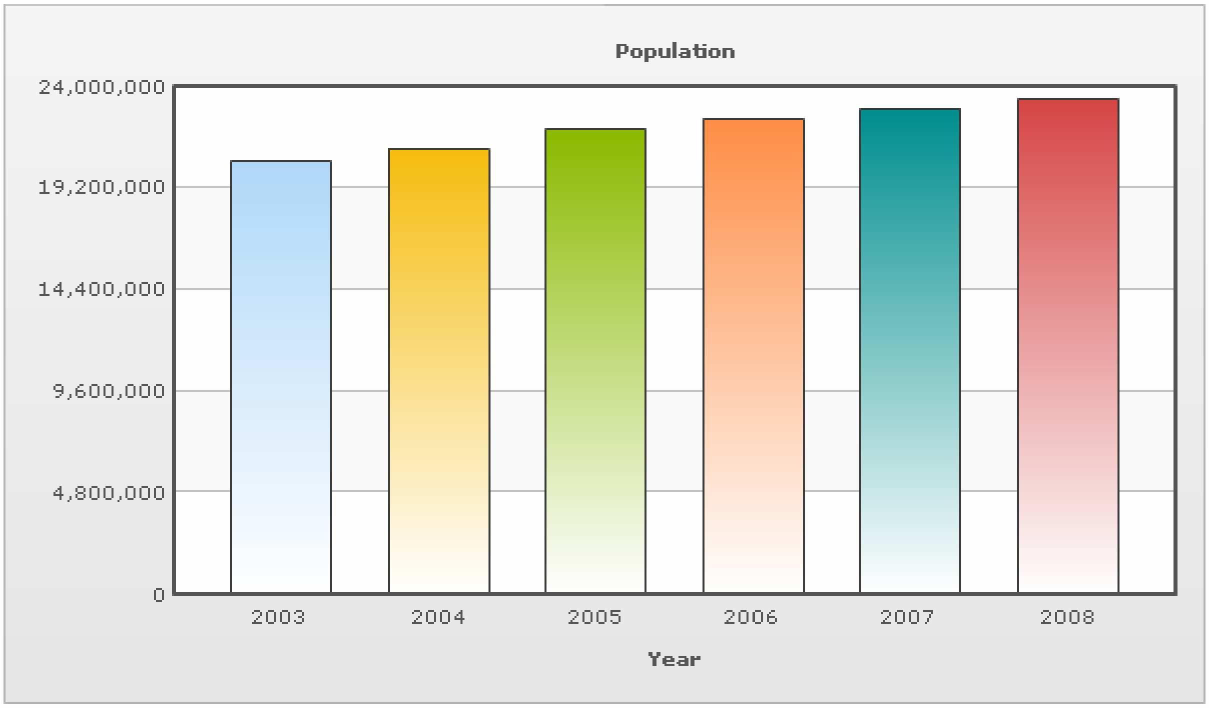


Figure 4.27 Aerial Map of TTPP

Figure 4.28 Aboadze Primary School

Figure 4.29 Land Use Map of Ghana

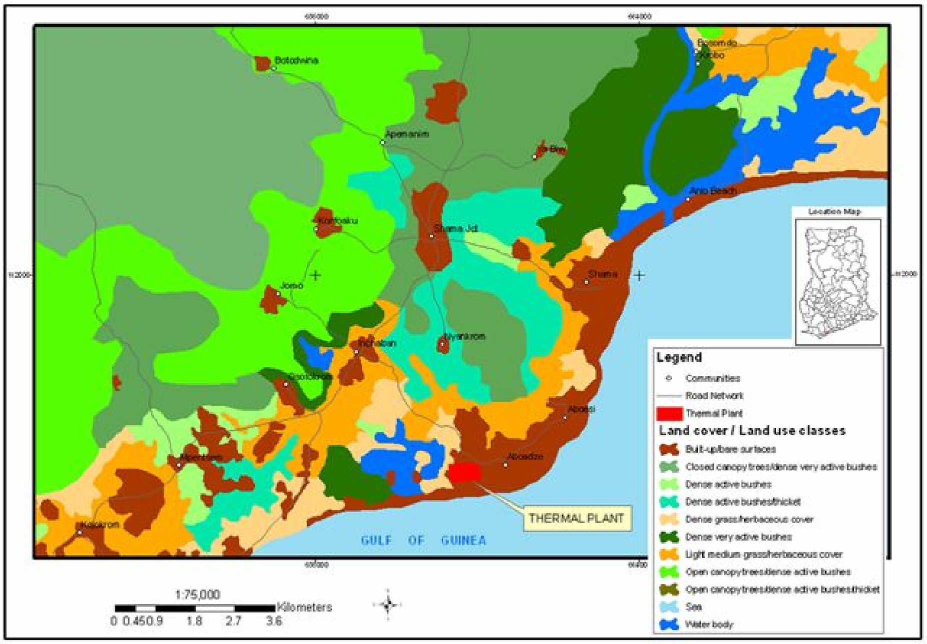


Figure 4.30 Monthly Catches of Fish Landings (2006-2008)

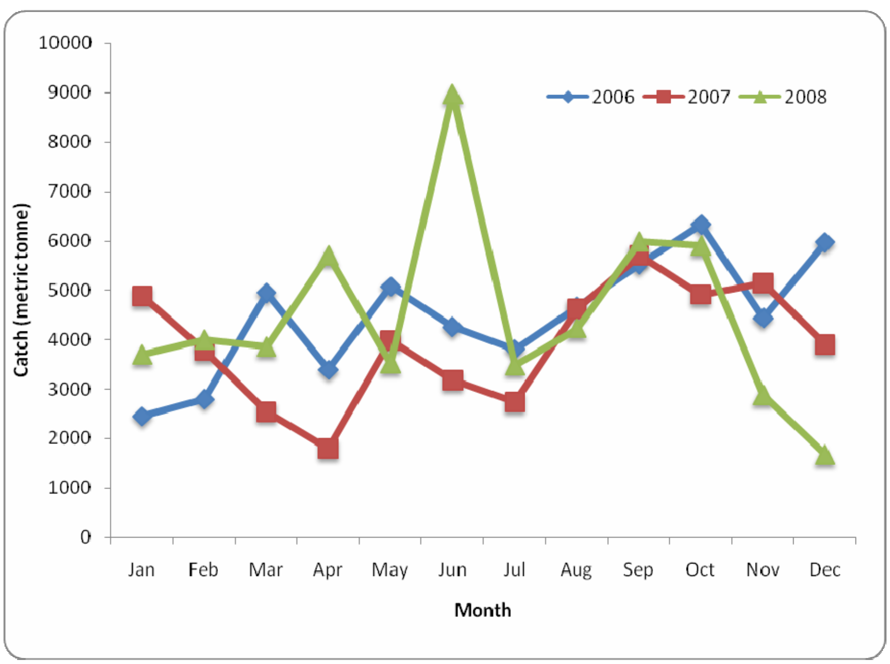


Figure 4.31 Annual Total Fish Landings in the SAEMA

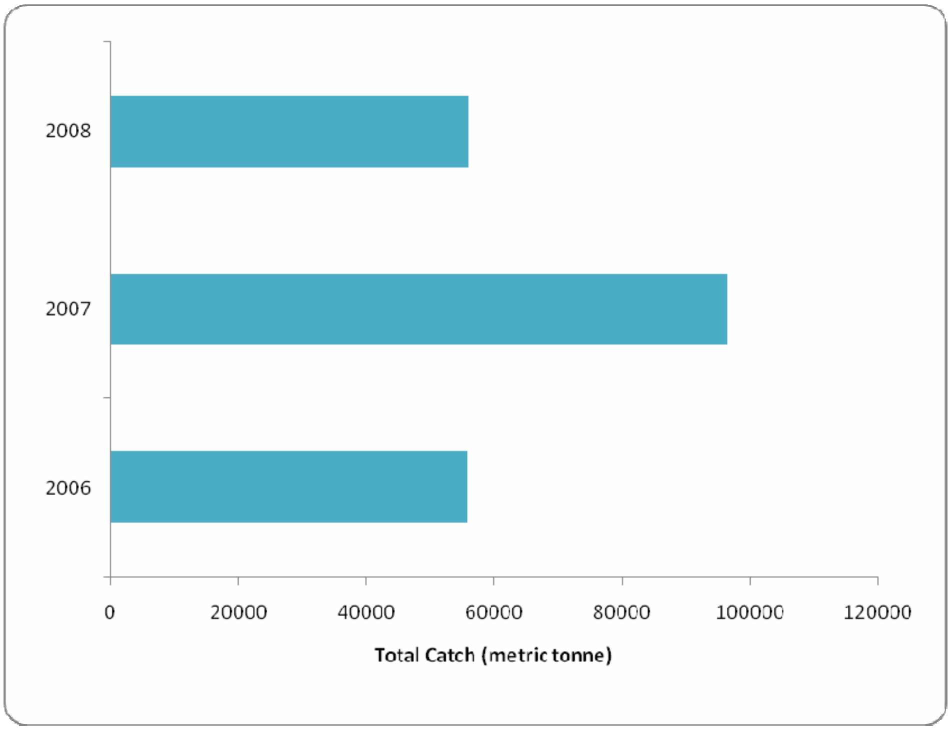


Figure 4.32 Dominant Fish Species in SAEMA (2006-2008)

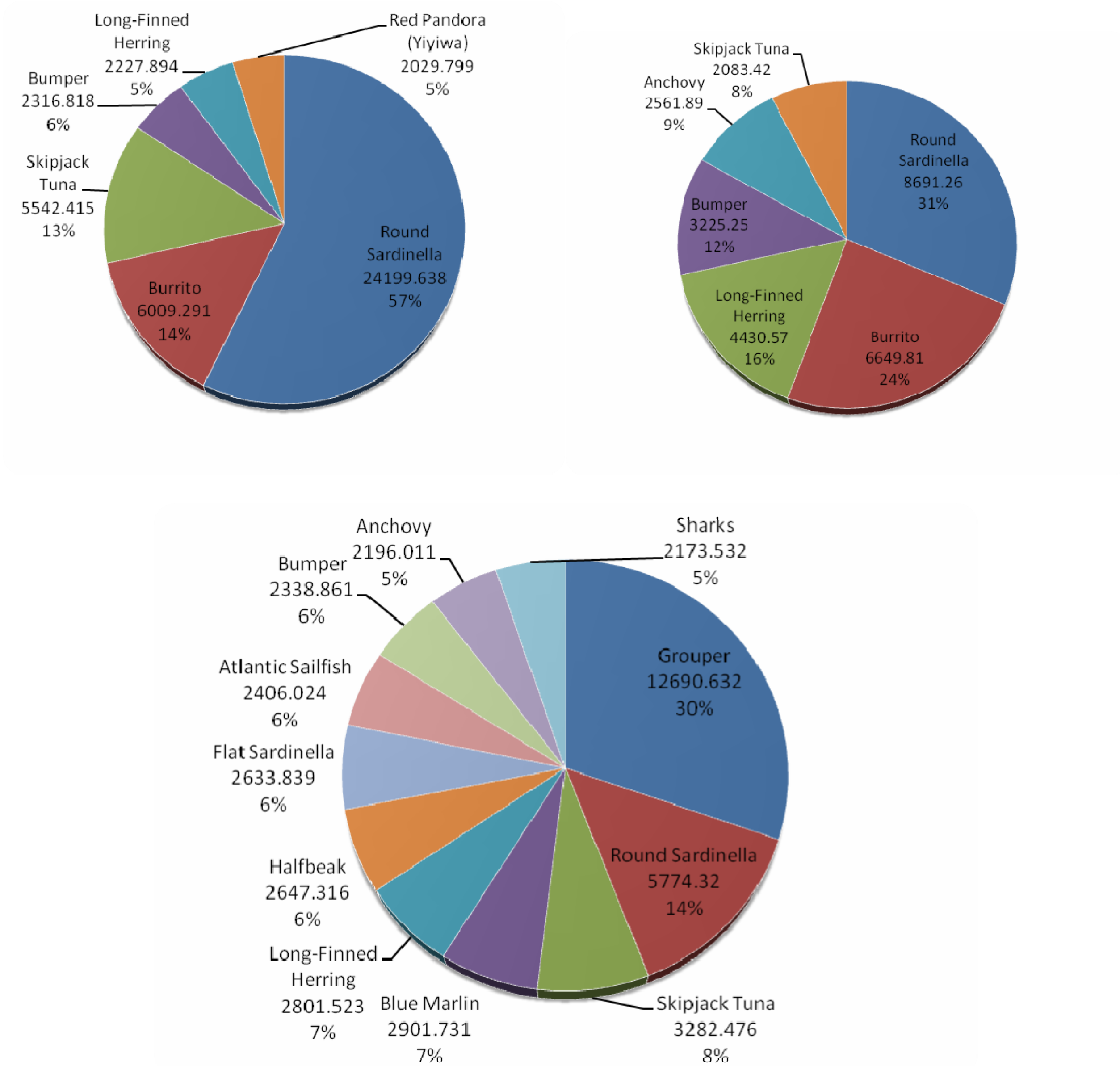
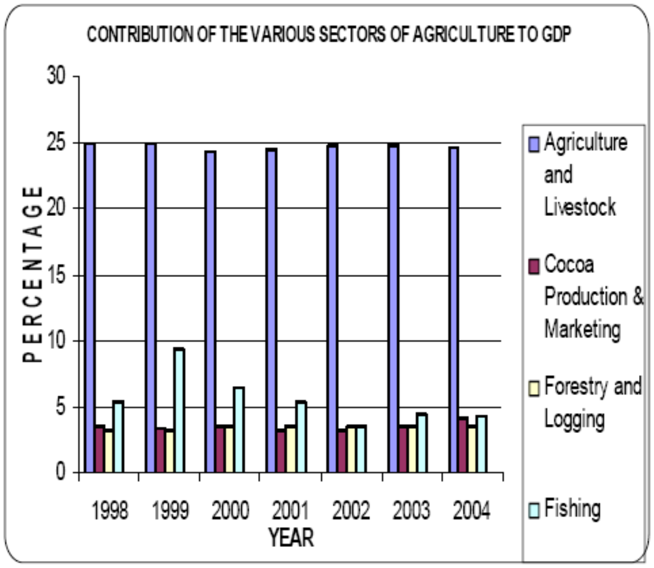


Figure 4.33 Agriculture Contribution to Ghana's National GDP (State of Ghanaian Economy)



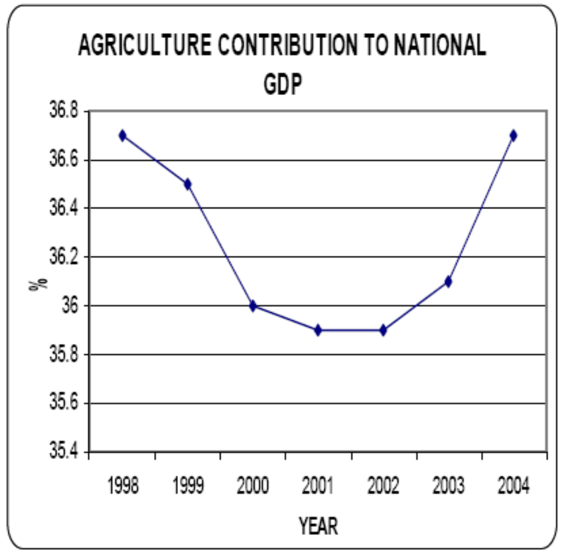


Figure 5.1 Load Demand According to the VRA

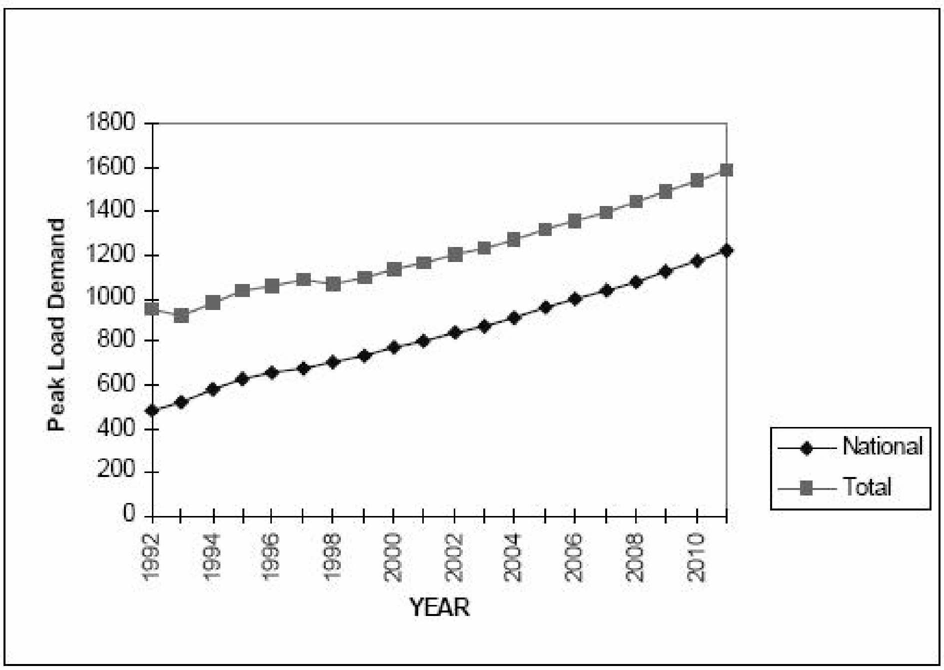
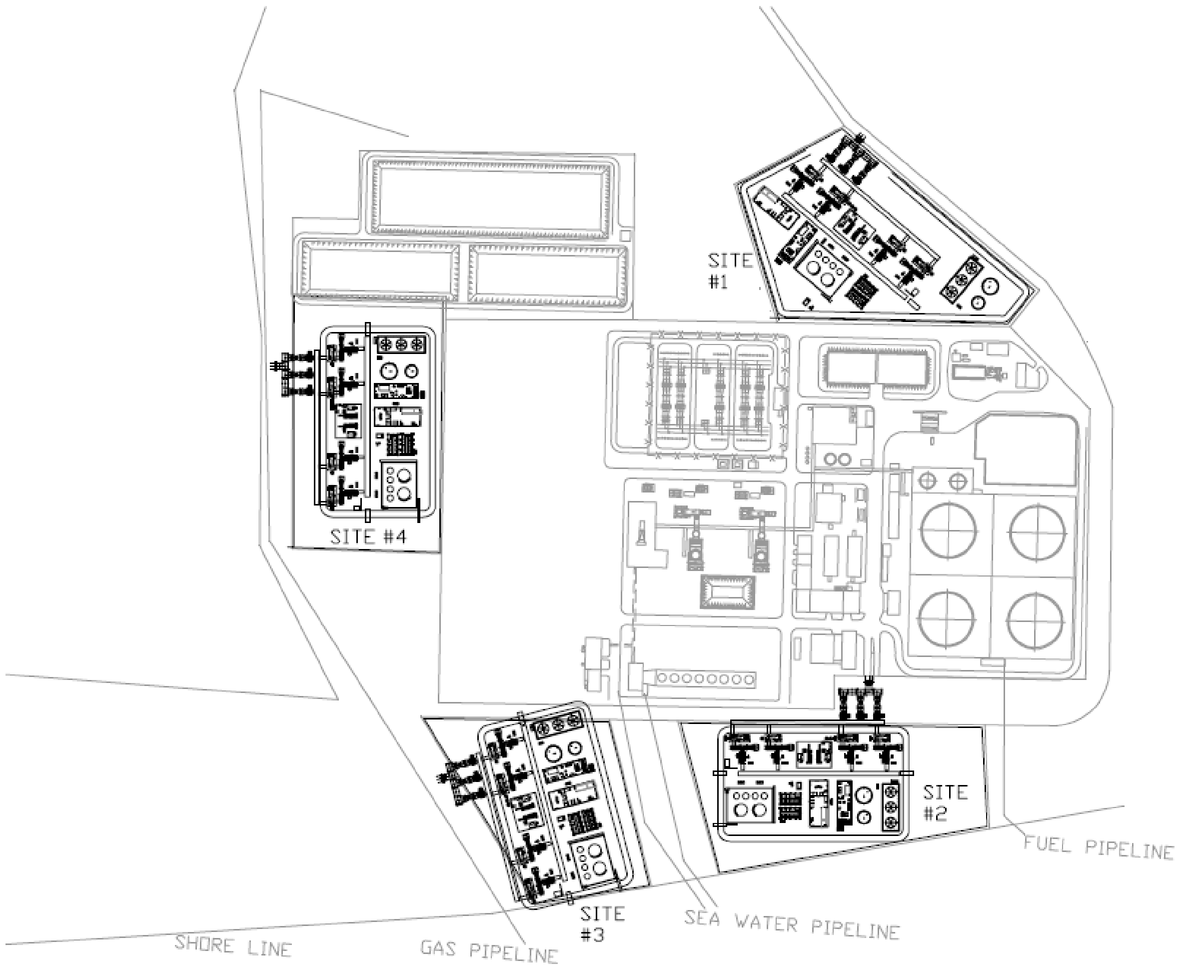


Figure 5.2 Alternative T3 Site Locations



Appendix B – Data Tables

Table 3.1a T3 Cooling Water System Requirements and Discharges

Plant Water Accounting	Current flow	% included		
Total Water Consumption	473 gpm		236.3	kpph
Evaporative cooler	0	100	0	kpph
Fogger	0	100	0	kpph
External water to GT injection	0	100	0	kpph
Steam cycle makeup	0.682	100	0.682	kpph
Cooling tower makeup	235.6	100	235.6	kpph
Wet air-cooled condenser makeup	0	100	0	kpph
Total HRSG water addition	0	0	0	kpph
Condensate addition	0	0	0	kpph
Addition before LTE (FW Tank)	0	0	0	kpph
Addition at deaerator	0	0	0	kpph
Auxiliary cooling tower makeup	0	100	0	kpph
Total Water Discharge	94 gpm		47.13	kpph
HRSG blowdown	0	100	0	kpph
Cooling tower blowdown	47.13	100	47.13	kpph
Wet air-cooled condenser blowdown	0	100	0	kpph
Total HRSG water bleed	0	100	0	kpph
Deaerator bleed	0	100	0	kpph
IPE bleed	0	100	0	kpph
HPE bleed	0	100	0	kpph
Condensate bleed	0	100	0	kpph
Bleed before LTE (FW Tank)	0	100	0	kpph
Water condensed from GT inlet chilling	0	100	0	kpph
Auxiliary cooling tower blowdown	0	100	0	kpph

Table 3.1b Turbine Water Injection Requirements for Emission Control (NOx)

NOx Water Supply Equivelent to: 80 gpm	Current Flow	% included		
Water Injection (20 gpm/turbine)	40.11	100	40.11	kpph

Table 3.2 Chemicals and Volumes Required for T3

Area of Use	Chemical	Approximate Volume Required (Design Capacities)
Cooling Water Treatment	Sodium Hypochlorite	100 Gallons/Year
	Sodium Hypobromide	100 Gallons/Year
	H2SO4	100 Gallons/Year
	Corrosion Inhibitor	100 Gallons/Year
	Sodium Monosulfate	100 Gallons/Year
Demineralization System Treatment	Hydrochloric Acid	100 Gallons/Year
	Sodium Hydroxide	100 Gallons/Year
Closed Steam System	Phosphates	200 Gallons/Year
	Amines	200 Gallons/Year
	O2 Scavenger	300 Gallons/Year
Gas Turbine Chemicals	GT Compressor Cleaning Agent	300 Gallons/Year

Table 3.3 Estimated Fuel Consumption for T3

Fuel Type Alternatives	Fuel Heating Value (MJ/KG)	Heat Rate (KJ/KWHR)[LHV]	Output (KW)	Fuel Burn Rate (kg/hr)
LCO	43	10,876	23,500	5,944
Diesel	-	-	-	-
Natural Gas	50	10,714	24,700	5,293

Table 3.4 OGT25000 Emission Rates

OGT 25000 Emission Rates	
Fuel	HFO/LCO
Ambient Temperature, °C	32
NOx ppmvd Ref 15% O2	146
NOx as NO2, lb/hr	124
CO ppmvd Ref 15% O2	80
CO, lb/hr	41
CO2, lb/hr	35060
HC ppmvd Ref 15% O2	84
HC, lb/hr	25
SOX as SO2, lb/hr	45

Table 3.5 IFC Emissions Guidelines for Combustion Turbines

Table 6 (B) - Emissions Guidelines (in mg/Nm³ or as indicated) for Combustion Turbine

Note:

- Guidelines are applicable for new facilities.
- EA may justify more stringent or less stringent limits due to ambient environment, technical and economic considerations provided there is compliance with applicable ambient air quality standards and incremental impacts are minimized.
- For projects to rehabilitate existing facilities, case-by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.
- EA should demonstrate that emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards, and more stringent limits may be required.

Combustion Technology / Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO_2)		Nitrogen Oxides (NOx)	Dry Gas, Excess O_2 Content (%)
Combustion Turbine			NDA/DA		NDA/DA	
Natural Gas (all turbine types of Unit > 50MWth)	N/A	N/A	N/A	N/A	51 (25 ppm)	15%
Fuels other than Natural Gas (Unit > > 50MWth)	50	30	Use of 1% or less S fuel	Use of 0.5% or less S fuel	152 (74 ppm)ᵃ	15%

General notes:

- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; S = sulfur content (expressed as a percent by mass); Nm³ is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to single units; Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- If supplemental firing is used in a combined cycle gas turbine mode, the relevant guideline limits for combustion turbines should be achieved including emissions from those supplemental firing units (e.g., duct burners).
- (a) Technological differences (for example the use of Aeroderivatives) may require different emissions values which should be evaluated on a cases-by-case basis through the EA process but which should not exceed 200 mg/Nm3.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):

- Natural Gas-fired Combustion Turbine – NOx
  - Guideline limits: 51 (25 ppm)
  - EU: 50 (24 ppm), 75 (37 ppm) (if combined cycle efficiency > 55%), 50*η / 35 (where η = simple cycle efficiency)
  - US: 25 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 15 ppm (> 850 MMBtu/h (≈ 249 MWth))
  - (Note: further reduced NOx ppm in the range of 2 to 9 ppm is typically required through air permit)
- Liquid Fuel-fired Combustion Turbine – NOx
  - Guideline limits: 152 (74 ppm) – Heavy Duty Frame Turbines & LFO/HFO, 300 (146 ppm) – Aeroderivatives & HFO, 200 (97 ppm) – Aeroderivatives & LFO
  - EU: 120 (58 ppm), US: 74 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 42 ppm (> 850 MMBtu/h (≈ 249 MWth))
- Liquid Fuel-fired Combustion Turbine – SOx
  - Guideline limits: Use of 1% or less S fuel
  - EU: S content of light fuel oil used in gas turbines below 0.1% / US: S content of about 0.05% (continental area) and 0.4% (non-continental area)

Source: EU (LCP Directive 2001/80/EC October 23 2001), EU (Liquid Fuel Quality Directive 1999/32/EC, 2005/33/EC), US (NSPS for Stationary Combustion Turbines, Final Rule – July 6, 2006)

Table 4.1 Soil Sample Analysis

Microbial parameter	A-Composite (0-15 cm)	A-Composite (15-50 cm)	B-Composite (0-15 cm)	B-Composite (15-50 cm)
Total coliform (g^{-2})	14620	154000	154000	150000
Fecal coliform (g^{-2})	< 1	110	< 1	< 1
Total heterotrophic	680	560	720	800
Bacteria (g^{-1})				
Pseudomonas spp. (g^{-1})	9	24	18	154
Clostridium spp. (g^{-1})	960	520	800	400
Desulphovibrio spp. (g^{-1})	< 1	< 1	< 1	< 1
Hydrocarbon oxidizers (g^{-1})	126	27	18	115
Hydrocarbon degraders (g^{-1})	80	44	90	110
Moulds (g^{-1})	640	440	480	70
Yeasts (g^{-1})	50	14	8	4

Table 4.2 Climatic Data (2000-2008)

Takoradi Monthly Rainfall Total (mm)												
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	27.2	0.0	68.0	145.1	195.1	296.3	24.7	34.1	33.3	42.1	30.2	152.2
2001	tr	40.0	21.6	174.9	271.9	206.4	190.0	19.9	11.9	106.5	50.4	3.0
2002	13.7	35.8	17.3	181.9	181.5	307.6	247.6	67.4	5.2	88.8	67.2	6.8
2003	37.3	40.0	76.1	192.2	182.2	79.2	6.5	18.6	11.3	234.8	30.1	9.6
2004	59.3	77.2	96.2	14.0	189.4	132.3	98.9	15.2	135.8	251.2	24.5	13.2
2005	2.3	55.4	136.7	50.4	269.7	103.0	3.3	4.8	37.0	190.9	41.3	26.2
2006	4.3	6.8	11.2	22.6	360.4	228.4	132.2	30.9	23.9	85.4	22.8	4.6
2007	0.2	7.9	83.2	102.9	125.0	197.2	255.0	60.7	161.9	210.6	33.1	11.9
2008	28.7	1.6	41.9	104.0	220.1	352.0	107.7	103.8	54.8	58.6	102.9	52.3
Mean Daily Maximum Temperature (°C)												
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	30.5	31.7	31.7	31.1	31.1	29.0	27.9	27.3	27.9	29.7	31.2	30.7
2001	30.5	31.7	31.7	31.5	30.8	29.2	27.8	27.0	27.6	29.9	31.0	31.2
2002	31.4	32.1	31.7	31.6	31.5	29.2	27.6	27.4	28.2	29.7	31.1	31.7
2003	31.2	31.9	32.4	31.5	31.1	29.4	29.0	27.9	28.7	30.0	31.5	31.7
2004	31.2	31.8	32.3	31.4	30.6	28.5	27.7	27.2	28.5	29.8	31.0	31.2
2005	31.4	31.8	31.9	32.1	30.5	28.8	27.8	27.3	28.6	30.1	31.3	31.7
2006	31.2	31.9	32.0	32.7	30.7	29.9	28.5	27.8	28.6	29.8	31.1	31.6
2007	31.6	31.8	31.8	31.7	31.3	29.3	28.5	28.2	28.3	29.7	30.9	31.5
2008	31.3	32.1	32.1	31.8	31.4	30.1	29.3	28.6	29.0	30.5	31.2	31.8
Mean Daily Minimum Temperature (°C)												
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	23.4	23.3	24.8	24.0	23.7	23.4	21.9	21.9	22.4	22.9	23.6	23.5
2001	23.2	23.9	24.0	23.9	24.3	23.4	22.9	22.1	22.4	23.5	23.9	24.1
2002	23.5	24.4	24.8	24.6	24.6	23.5	23.2	22.1	22.6	23.5	23.5	22.7
2003	23.7	24.5	24.7	24.3	24.4	23.5	22.5	22.3	23.5	24.0	23.9	23.8
2004	24.0	24.5	24.8	25.0	24.3	23.4	22.6	22.5	23.4	23.7	24.1	24.3
2005	22.3	25.1	24.9	25.5	24.4	24.3	22.7	22.0	23.4	23.7	24.2	23.9
2006	24.2	24.7	24.3	25.3	24.1	23.5	23.4	22.9	23.2	22.6	23.9	23.8
2007	22.4	24.7	24.9	24.7	24.6	23.9	23.1	22.6	23.0	22.9	23.4	23.7
2008	21.1	24.3	24.3	24.5	24.1	23.8	23.3	22.6	23.1	23.8	24.0	24.0

Table 4.2 Climatic Data (2000-2008) –cont.

Mean Daily Relative Humidity (%) at 0600 hours

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	96	94	93	95	95	96	96	96	96	96	95	95
2001	97	94	94	94	95	96	95	96	96	95	94	96
2002	95	94	95	94	95	95	97	97	96	96	96	96
2003	96	97	95	96	96	96	96	97	95	96	95	95
2004	96	94	90	95	95	96	97	96	97	96	96	96
2005	94	95	94	95	96	94	96	96	96	96	95	96
2006	97	97	95	93	95	99	96	96	97	96	96	96
2007	92	95	94	95	95	96	95	97	99	96	96	96
2008	93	94	95	95	95	95	94	97	97	96	96	96

Mean Daily Relative Humidity (%) at 1500 hours

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	75	66	72	76	77	82	81	83	82	79	73	74
2001	76	71	74	74	77	81	83	84	82	75	75	76
2002	69	72	74	75	75	80	87	83	81	78	74	71
2003	74	75	75	76	76	81	76	80	81	78	73	72
2004	75	71	70	77	76	83	83	84	83	79	76	75
2005	66	76	75	76	80	82	82	81	81	76	74	74
2006	78	74	72	70	78	80	82	82	83	82	75	76
2007	60	75	75	77	76	82	82	82	85	80	76	73
2008	69	74	73	75	77	78	79	81	82	77	76	75

Mean Daily Wind Direction

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	SW	SW	SW	SW	S	SW	SW	SW	SW	SW	SW	SW
2001	SW	SW	SW	SW	S	SW	SW	SW	SW	SW	SW	SW
2002	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2003	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2004	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2005	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2006	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2007	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2008	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW

Table 4.2 Climatic Data (2000-2008) – cont.

Mean Daily Wind Speed (knots)												
Year	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
2000	2.5	3.2	3.5	3.2	3.1	2.9	3.1	3.7	4.5	2.9	4.3	2.3
2001	2.5	3.2	4.3	3.7	3.0	3.3	2.5	4.5	5.3	5.1	3.3	2.8
2002	2.3	4.7	4.6	4.0	3.9	3.7	3.4	4.5	5.3	5.1	3.3	2.8
2003	3.3	4.4	3.7	4.9	3.8	3.1	4.8	5.1	5.9	3.8	3.5	2.9
2004	2.3	3.6	4.0	3.7	4.3	3.9	3.3	4.7	5.1	4.8	3.5	3.8
2005	3.9	4.3	4.4	4.6	3.1	4.8	4.2	4.6	4.1	4.4	2.8	2.5
2006	3.2	4.7	4.4	4.6	3.3	3.5	3.9	4.5	4.4	4.0	2.5	2.5
2007	2.0	4.2	4.2	4.1	3.1	2.5	4.0	4.0	3.8	4.1	2.3	2.1
2008	1.8	3.3	3.7	3.4	3.0	3.3	3.6	4.1	3.8	4.1	2.9	2.8
Mean Daily Duration of Bright Sunshine (hours)												
Year	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
2000	6.3	7.3	6.1	7.4	6.7	4.9	6.6	4.4	4.8	7.4	8.9	6.5
2001	6.6	6.7	6.8	6.9	5.8	4.8	4.8	2.8	5.1	7.7	7.9	8.1
2002	4.5	6.6	6.8	6.8	7.4	3.5	3.1	4.1	5.3	7.1	8.2	7.4
2003	6.1	7.6	6.8	6.9	7.2	4.9	6.7	4.6	5.1	7.3	7.8	6.8
2004	6.0	6.1	6.6	6.4	7.0	3.6	5.4	3.7	5.3	6.4	8.7	7.7
2005	4.9	6.8	6.7	7.3	6.4	4.6	4.6	4.5	4.9	7.2	7.6	7.7
2006	6.8	7.2	6.9	6.6	5.5	5.5	4.9	5.1	4.0	6.3	7.3	7.3
2007	4.0	7.0	6.4	7.8	6.5	3.7	5.8	5.2	4.3	5.9	7.9	7.3
2008	6.7	6.0	7.0	6.3	5.9	5.3	5.5	6.2	5.0	7.9	7.1	7.6

Source: AERC Limited

Table 4.3 Takoradi Hourly Weather Summary (1973-1994)

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------------------INTERNATIONAL STATION METEOROLOGICAL CLIMATE SUMMARY-------------------

 :STA 654670 | DGTK | TAKORADI AFB , ,GH-Telecom Summary
:LAT 04 53N :LONG 001 46W :ELEV 30(ft) 9(m) :TYPE NAVY SMOS V3 28051996
42 - Foreign STATION CLIMATIC SUMMARY (Derived from Hourly Data)


POR: (HOURLY): 1973-1994

      TEMPERATURE (DEG F)|REL HUM|VAP|DEW| PR |WIND (KTS) |TOT|     MEAN NO. OF DAYS WITH (&)
        MEANS    |EXTREME|PERCENT|PR |PT.| ALT|           |SKY| TEMP (DEG F) |      PRECIPITATION          |        OBSTR TO VISION  |
         |   |   |   |   | (LST) |IN.|(F)| FT.|PREVAIL|MAX|CVR|MAX|MAX|MIN|MIN|    |FRZ |    |HAIL|    |TH |FOG|SMOK|BLOW|DUST| OBS|
      MAX|MIN|AVG|MAX|MIN|   |   |HG.|   |  $ |DIR|SPD|SPD| + | >=| >=| <=| <=|R/DZ|R/DZ|SNOW|/SLT|PRCP|STM| * |HAZE|SNOW|SAND| VIS|
                         | 06| 15|                               | 95| 85| 75| 65|

 JAN  83  77  80  99  62  95  73 .85  74  30   S   5  21 SCT  #  16  15   1   1   0   0   0   1   3  17   9   0   #  22
 FEB  84  79  82 102  70  96  74 .92  77  25  SW   7  46 BRK  #  16   8   0   1   0   0   0   1   4  10   3   0   0  12
 MAR  85  79  83 102  64  96  72 .92  77  25  SW   8  64 BRK  #  20   9   #   2   0   0   0   2   7   7   2   0   1   9
 APR  85  79  82 102  71  95  76 .92  77  25  SW   7  40 BRK  #  18   9   0   3   0   0   0   3  11   4   #   0   #   4
 MAY  84  78  81 100  68  95  79 .91  76  25   S   5  32 BRK  #  15  11   0   6   0   0   #   6  11   1   #   0   #   2
 JUN  81  77  79 102  68  95  83 .88  75  15   S   5  66 BRK  #   5  12   0  10   0   0   0  10   8   2   0   0   1   3
 JUL  79  75  77 100  64  96  83 .83  73  15  SW   6  45 BRK  #   1  20   #   7   0   0   #   7   1   7   #   0   #   7
 AUG  78  74  77  92  66  96  84 .81  73  15  SW   6  65 BRK  0   #  23   0   8   0   0   #   8   #   7   #   0   #   7
 SEP  79  75  77  98  69  96  84 .84  74  15  SW   7  33 BRK  #   1  20   0   9   0   0   0   9   2   4   #   0   #   5
 OCT  81  77  79 100  68  96  80 .86  74  20  SW   8  60 BRK  #   6  17   0   7   0   0   0   7   7   3   0   0   #   3
 NOV  84  78  81 103  70  96  75 .89  76  25   S   6  60 BRK  #  16  16   0   2   0   0   0   2   7   8   1   0   #   9
 DEC  83  77  80 100  59  96  74 .88  75  25   S   5  16 BRK  #  15  14   #   1   0   0   0   1   4  16   6   0   #  18
 ANN  82  77  80 103  59  96  79 .87  75  25  SW   6  66 BRK  3 128 174   1  57   0   0   #  57  65  86  21   0   2 101
 POR  14  14  14  14  14   7   4   4   4   4   4   4  22   1 14  14  14  14  11  11  11  11  11  11  11  11  11  11  11


T = TRACE AMOUNTS ( < .05  < .5 INCHES
# = MEAN NO. DAYS < .5 DAYS
$ = PRESSURE ALTITUDE IN TENS OF FEET (I.E.  50 = 500 FEET)
@ = NAVY STATIONS REPORT HAIL AS SNOWFALL; ALSO NWS FROM JULY,1948-DEC.,1955
+ = THE PREDOMINANT SKY CONDITION
* = VISIBILITY IS NOT CONSIDERED
& = ANN TOTALS MAY NOT EQUAL SUM OF MONTHLY VALUES DUE TO ROUNDING
^ = 24 HR MAX PRECIP AND SNOWFALL ARE DAILY TOTALS (MID-NIGHT TO MID-NIGHT)
I = EXCESSIVE MISSING DATA - VALUE NOT COMPUTED
" = INCHES


----------------------------FEDERAL CLIMATE COMPLEX ASHEVILLE----------------------------
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Source: Bush Power Group LLC

Table 4.4   Annual Rainfall (1950-1991)

ANNUAL RAINFALL		
	1st Period (1950-1970)	2nd Period (1971-1991)
Mean (mm)	1394.0	1106.9
Max (mm)	2033.5	1656.2
Min (mm)	815.1	470.8
Climatic Variability (CV)	20%	30%

Table 4.5 Air Quality Standards and Guidelines

	Ghana EPA		World Bank	
Pollutant	Averaging Time	Time Weighted Average	Averaging Time	Time Weighted Average
Sulphur Dioxide (SO_2)	24hrs	150 µg/m³	24hrs	150 µg/m³
	1yr	80 µg/m³	1yr	80 µg/m³
Oxides of Nitrogen (NO_x)	24hrs	150 µg/m³	24hrs	150 µg/m³
	1yr	-	1yr	100 µg/m³
Particulate Matter (PM_{10})	24hrs	70 µg/m³	24hrs	150 µg/m³
	1yr	-	1yr	50 µg/m³

Table 4.6 Takoradi Thermal Power Plant (T1) Emissions Compliance Data

NO_x Emissions Compliance data

2001	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of NO_x data	**223**	**525**	**444**	**533**	**604**	**352**	**307**	**42**	**22**	**180**	**223**	**264**	**3719**
Hours of MAL compliance	208	516	437	532	602	350	307	42	18	179	223	264	**3678**
% Compliance	**93**	**98**	**98**	**100**	**100**	**99**	**100**	**100**	**82**	**99**	**100**	**100**	**98.9**

2002	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of NO_x data	**630**		**458**	**601**	**670**	**663**	**89**				**553**	**600**	**4632**
Hours of MAL compliance	609	350	434	589	613	640	79				553	600	**4467**
% Compliance	**97**	**95**	**95**	**98**	**91**	**97**	**89**				**100**	**100**	**96.4**

2003	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of NO_x data	**837**	**328**	**190**	**89**	**189**	**295**	**291**	**303**		**30**			**2552**
Hours of MAL compliance	823	328	190	89	189	267	238	303		30			**2457**
% Compliance	**98**	**100**	**100**	**100**	**100**	**91**	**82**	**100**		**100**			**96.3**

SO_2 Emissions Compliance Data

2001	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of SO_2 data	**223**	**525**	**444**	**533**	**604**	**352**	**307**	**42**	**22**	**180**	**223**	**264**	**3719**
Hours of MAL compliance	223	525	444	533	604	352	307	42	22	180	223	264	**3719**
% Compliance	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

2002	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of SO_2 data	**630**	**368**	**458**	**601**	**670**	**663**	**89**				**553**	**600**	**4632**
Hours of MAL compliance	630	368	458	601	670	663	89				553	600	**4632**
% Compliance	**100**	**100**	**100**	**100**	**100**	**100**	**100**				**100**	**100**	**100**

2003	J	F	M	A	M	J	J	A	S	O	N	D	*Total*
Total hours of SO_2 data	**837**	**328**	**190**	**89**	**189**	**295**	**291**	**303**		**30**			**2552**
Hours of MAL compliance	837	328	190	89	189	295	291	303		30			**2552**
% Compliance	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**		**100**			**100**

Table 4.6 Takoradi Thermal Power Plant (T1) Emissions Compliance Data – cont.

PM_{10} monitoring data ($\mu g/m^3$)

	VRA TOWNSHIP					ABOADZE			
	1999	**2000***	**2001***	**2002**	**2003**	**1999**	**2001***	**2002**	**2003**
Jan	40.9	30.5		355.5	132.6	57.1		432.6	147.1
Feb	54.9	60.8		51.2	18.8	81.4		84.1	55.8
Mar	41.2			45.9	34.1	70.1		77.3	69.4
Apr	32.1			48.2	20.4	32.1		65.8	58.6
May	23.4			39.5	12.3	41.8		58.7	16.0
Jun	18.4			36.8	30.4	33.8		45.6	
Jul	26.1			28.1	30.6			70.7	60.8
Aug	41.0			37.5	48.8			168.7	66.4
Sep				11.4	13.7			323.0	18.8
Oct	73.8		27.5	14.0	21.4		29.0	43.4	35.5
Nov	70.7		32.5	29.6	40.5		29.5	40.5	67.0
Dec			35.0	60.8	32.2		50.0	67.1	44.9
% Compliance	**90**	**100**	**100**	**92**	**92**	**83**	**100**	**58**	**91**
MAL ($\mu g/m^3$)	**70**								

Notes
* Data gaps are due to periods of equipment breakdown
Non compliance in August and September 2002 at Aboadze was due to daytime activities of school children on football field adjacent to monitoring site.
Non compliance in January attributable to the effect of the dust laden harmattan wind
MAL = Maximum allowable limit (70 $\mu g/m^3$ for 24hr readings, and 50-100$\mu g/m^3$ for annual average)

Ambient GLC for SO_2 measured at Beposo and Aboadze

BEPOSO (SO_2)	1997	1998	1999	2000	2001	2002
Annual average GLC (ppm)		0.0010	0.0005	0.0013	0.0002	0.0001
Max allowable limit (ppm)*		0.028	0.028	0.028	0.028	0.028
Compliance, %		100	100	100	100	100

ABOADZE (SO_2)	1997**	1998	1999**	2000**	2001	2002
Annual average GLC/ppm		0.001			0.0005	0.0002
Max allowable limit/ppm*		0.028			0.028	0.028
Compliance, %		100			100	100

** The World Bank Group Pollution and Abatement Handbook 1998 pg 424*
*** No sampling due to equipment breakdown*
Annual max allowable limit = 80 $\mu g/m^3$ (0.028 ppm), based on 1 ppm SO_2 = 2.86 mg/m^3

Table 4.6 Takoradi Thermal Power Plant (T1) Emissions Compliance Data – cont.

Ambient GLC for NO_x measured at Beposo and Aboadze

BEPOSO (NO_x)	1997	1998	1999	200	2001	2002
Annual average GLC/ppm	0.009	0.003	0.011	0.011	0.021	0.002
Max allowable limit/ppm*	0.048	0.048	0.048	0.048	0.048	0.048
Compliance, %	100	100	100	100	100	100

ABOADZE (NO_x)	1997 **	1998	1999 **	2000	2001	2002
Annual average GLC (ppm)		0.016		0.007	0.012	0.005
Max allowable limit/ppm*		0.048		0.048	0.048	0.048
Compliance, %		100		100	100	100

** The World Bank Group Pollution and Abatement Handbook 1998 pg 424*
*** No sampling due to equipment breakdown*
Annual max allowable limit = 100 μg/m^3 (0.048 ppm), based on 1 ppm NO_x = 2.05 mg/m^3

Table 4.7 Estimated Ambient Background Concentrations in Takoradi

Pollutant	Assumed Background Ambient Concentration (μg/m^3)
NO_2	7
SO_2	35
PM_{10}	84

Table 4.8 Surface Water Quality Near TTPP

Parameter	Estuary of Anakwari Lagoon	Middle of Anakwari Lagoon	Wetland 1	Wetland 2	Intertidal Zone 1	Intertidal Zone 2
pH	7.18	7.12	6.07	6.23	8.03	7.86
Cond.(uS/cm)	6360	3690	1792	1699	61780	58398
TDS (mg/L)	3220	1836	901	889	30900	29773
Sal (ppt)	4	3	1	1	34	34.5
Turb. (NTU	200	180	33	41	27	26
TSS (mg/L)	215	184	35	46	34	34
Nitrate (mg/L)	0.4	0.6	0.9	0.76	0.6	0.1
Phosphate (mg/L)	0.37	0.24	0.15	0.19	0.08	0.07
Sulfate (mg/L)	575	625	185	184	3450	3500
Iron (ppm)	1.718	1.982	2.609	1.974	0.224	0.231
Copper (ppm)	0.004	0.007	0.015	0.011	0.052	0.034
Lead (ppm)	0	0	0	0	0.141	0.366
Zinc (ppm)	0	0	0	0	0	0
Sample Locations						
Latitude	N 04 57 58 . 8	N 04 58 02. 9	N 04 58 07.4	N 04 58 07.9	N 04 58 04.9	N 04 58 04.9
Longitude	W 001 40 20.9	W 001 40 20.9	W 001 39 43. 6	W 001 39 45.	W 001 39 42 .5	W 001 39 42 .5

Source: AERC Limited

Table 4.9 Tidal Range for Selected Area of the Coast of Ghana (in meters)

Location	Neap	Mean	Spring	Phase
Takoradi/Aboadze	0.58	0.90	1.22	107º
Accra	0.62	0.94	1.26	107º
Tema	0.64	0.96	1.28	107º
Aflao	0.68	1.00	1.32	108º

Table 4.10 Sediment Granulometric Analysis for Samples from Aboadze Beach

Station	Intertidal Zone	Mean Grain Size (φ)	Sorting Coefficient	Sand Type	Sorting Class
West of the Thermal Plant	Upper	1.60	1.20	Medium sand	Poorly Sorted
	Middle	1.28	1.31	Medium sand	Poorly Sorted
	Lower	0.89	1.08	Coarse sand	Poorly Sorted
Groyne Area	Upper	1.26	1.30	Medium sand	Poorly Sorted
	Middle	0.67	1.23	Coarse sand	Poorly Sorted
	Lower	0.71	1.31	Coarse sand	Poorly Sorted
East of the Thermal Plant	Upper	1.07	1.20	Medium sand	Poorly Sorted
	Middle	1.24	1.31	Medium sand	Poorly Sorted
	Lower	0.95	1.11	Coarse sand	Poorly Sorted

Table 4.11 Average Monthly Sea Surface Temperatures at Takoradi (1968-1971)

Month	Average Temperature
January	25.7
February	26.8
March	26.8
April	27.3
May	27.1
June	26.0
July	23.1
August	21.1
September	21.3
October	24.9

Table 4.12 Monthly Sea Surface Temperatures at Takoradi (1999-2000)

Month	Temperature Range (ºC)	Average Temperature (ºC)
May 1999	27.5 – 29.0	28.4
June 1999	-	-
July 1999	22.0 – 25.5	23.3
August 1999	21.0 – 23.5	22.2
September 1999	21.5 – 24.0	22.3
October 1999	21.5 – 28.0	25.3
November 1999	27.5 – 29.0	28.5
December 1999	27.0 – 30.0	28.7
January 2000	24.0 – 28.0	26.0
February 2000	26.0 – 29.0	27.4
March 2000	28.0 – 30.5	29.5
April 2000	26.5 – 29.7	28.4

Table 4.13 Composition and Conservation Significance of Wildlife at TTPP

Species	Common Name	Recorded Species	Conservation Significance	
		Aboadze	CITES	National
AMPHBIA				
Bufo regularis	Common Toad	X		
Hylarana galamensis	Common Frog	X		
REPTILIA				
Squamata: Lacertilia				
Agama agama	Rainbow Lizard	X		
Lygodactylus conraui	Gecko	X		
Mabuya affinis	Skink	X		
M. Perroteti	Orange-flanked skink	X		
Squamata: Serpentes				
Psammophis sibilans	Hissing Sand Snake			
AVES				
Accipitricidae				
Milvus migrans	Black Kite	X	II	I
Neophron monachus	Hooded vulture	X	II	I
Columbidae				
Streptopelia semitorquata	Red-eyed Dove			II
Alcedinidae				
Halcyon malimbicus	Blue-breasted Kingfisher	X		
Corvidae				
Corvus albus	Pied Crow	X		
Estrildidae				
Lonchura cucullata	Bronze Mannikin	X		II
Ploceidae				
Ploceus cucullatus	Village Weaver	X		II
MAMMALIA				
Rodentia				
Lemniscomys striatus	Spotted Zebra Mouse	X		

Note: CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna publishes a list of three Appendices (CITES Appendices, 1975) which limits global trade of certain categories of animal species.

- *Appendix I species are threatened species which cannot be traded in*
- *Appendix II species are species for which levels of trade are limited*
- *National Criteria (Ghana Wildlife Conservation Regulations)*

Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971, and Ghana Wildlife Conservation (Amendment) Regulations, 1988; 1995) also categorise animal species into two main Schedules based on the level of protection required for a particular species

- *Schedule I species are completely protected (i.e., their hunting, capture or destruction is prohibited at all times)*

Schedule II species are partially protected (i.e., their hunting capture or destruction is absolutely prohibited between 1st August and 1st December of any season, and the hunting, capture and destruction of any young animal, or adult accompanied by young, is absolutely prohibited at all times).

Table 4.14 Species Composition and Shorebirds at Aboadze

Common Name	Scientific Name	Location	
WADERS		**Swampy Area**	**Intertidal area**
Black-winged stilt	*Himantopus himantopus*	1	1
Whimbrel	*Numenius phaeopus*		1
Grey plover	*Pluvialis squatarola*		2
Common sandpiper	*Tringa hypoleucos*	9	2
Sanderling			1
Ringed plover	*Charadrius hiaticula*		2
Total Waders		10	9
OTHERS			
Grey heron	*Ardea cinera*	3	
Little egret	*Egretta garzetta*		4
Western reef heron	*Egretta gularis*		1
Purple heron	*Ardea pupurea*	2	
Great-white egret	*Egreta alba*	1	
Pied kingfisher	*Ceryle rudis*	1	
Black kite	*Milvus migrans*	4	
Total Others		11	5

Table 4.15 Rocky Shore Species at Aboadze

Species	Aboadze Groyne Transect			Aboadze Transect (west of groyne)		
	Total	Density	F (%)	Total	Density	F (%)
MACROALGAE						
Lithothamnia						
Ralfsia expansa						
Hydropuntia dentata						
Hypnea musciformis						
Ulva fasciata	56	2.8	40	274	10.54	62
Caulerpa taxifolia						
Centrocera clavulatum				68	2.62	31
Chaetomorpha antennina						
Gelidiopsis variabilis						
Padina durvillaei				240	9.23	35
Chaetomorpha linum	916	45.8	100	16	0.62	23
Sargassum vulgare				253	9.73	27
Enteromorpha flexuosa	24	1.2	30	76	2.92	31
Dictyota ciliolate				24	0.92	23
EPIFAUNA						
Anthopleura spp.				21	0.81	27
Patella safiana	664	33.2	60			
Cthamalus dentata	2.5	0.125	25			
Nerita atrata	9	0.45	25			
Planaxis lineatus	4	0.2	20			
Fissurella nubecula						
Thais heamastoma	85	4.25	80			
Llittorina cingulifera						
Pagrus sp.						
Siphonaria pectinata	8	0.4	30	73	2.81	23
Cerithium atratum						

Note: Density and frequency of occurrence (F) of rocky shore species from transects at Tema and Aboadze. Density of macro algae are given as percent cover per meter square, and epibenthic fauna as individuals per meter square except for Cthamalus dentate. Only species with > 20% Frequency of Occurrence (F) are presented.

Table 4.16 Intertidal Macrobenthic Fauna

SPECIES	ABOADZE	
	Lower Intertidal Zone	Upper Intertidal Zone
Polychaeta		
Cirriformia afer	+	-
Diopatra monroi	++	-
Eunice vitata	+	-
Eurythoe sp	++	+
Marphysa sanguinea	+	-
Nereis sp.	+++	-
Polydora antennata	+	-
Syllis gracilis	++	+
Crustacea		
Aorid sp.	++	+
Talitrus sp.	-	-
Cirolana spp	+	-
Exocirolana sp.	-	++
Mysid sp.	++	-
Phoxocephalid sp.	+	-
Ocypoda cursor	-	+
Mollusc		
Terebra sp.	+	
Oliva sp.	+	

Abundance range:
- = 0, + = 1 – 5, ++ = 6 – 10, +++ = 11 – 15, ++++ = 16 – 20, +++++ = 21+

Table 4.17 Correlation Between Macrobenthic Community and Environmental Variables

Variable	Abundance	No. Species	%Clay	%Silt	%Sand	TOC	Depth
Abundance	1.00						
No.Species	0.55	1.00					
%Clay	0.57	-.038	1.00				
%Silt	0.33	0.97	-.059	1.00			
%Sand	-0.99	-0.40	-0.70	-0.17	1.00		
TOC	0.64	0.99	-0.27	0.94	-0.5	1.00	
Depth	0.58	0.99	-0.34	0.96	-0.44	0.99	1.00

Table 4.18 Population Size of Selected Towns

Towns	Population	Locality
Shama	9,855	Urban
Abuesi	9,873	Urban
Aboadze	9,399	Urban
Inchaban	5,486	Urban
Supomu Dunkwa	3,540	Urban
Beposo	1,661	Semi Urban

Table 4.19 Population Statistics

Region	Area (Sq Km)	Population	Density	Growth Rate (%)
Western	23,921	1,924,577	80.5	3.2
Central	9,826	1,593,823	162.2	2.1
Greater Accra	3,245	2,905,726	895.5	4.4
Volta	20,570	1,635,421	109	1.4
Eastern	19,323	2,106,696	79.5	1.9
Ashanti	24,389	3,612,950	148.1	3.4
Brong Ahafo	39,557	1,815,408	45.9	2.5
Northern	70,384	1,820,806	25.9	2.8
Upper East	8,842	920,089	104.1	1.1
Upper West	18,476	576,583	31.2	1.7
Total Country	**238,533**	**18,912,079**	**79.3**	**2.7**

Table 4.20 2000 Census Summary

Area	Male	Female	Total
Takoradi Sub – Metro	86,794	88,642	175,436
Sekondi Sub – Metro	56,697	57,460	114,157
Shama Sub – Metro	39,278	40,295	79,573
Total	**182,769**	**186,397**	**369,166**

Table 4.21 Population Structure

Age Group	Percent
0-14	44.8
15-64	51.9
≥ 65	3.3

Source: Ghana Statistical Service, 2000

Table 4.22 Ghana International Tourist Arrivals and Receipts

Year	Arrivals	Receipts (US$ M)
1995	286,000	233.2
1996	304,860	248.8
1997	325,435	265.59
1998	347,925	283.96
1999	372,653	304.12
2000	399,000	386
2001	439,833	447.83
2002	482,643	519.57
2003	530,827	602.8

Source: Ghana Tourist Board

Table 4.23 School Enrollment

Level/Type	1999/2000		2000/2001		2001/2002		2002/2003		2002/2003		2002/2003	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Pre-School	63,740	62,086	65,134	62,449	355,385	346,919	389,299	379,519	413,034	404,643	480,216	468,434
Public	23,714	23,469	26,368	25,828	230,778	226,819	260,706	256,028	262,019	257,938	276,214	271,736
Private	40,026	38,617	38,766	36,621	124,607	120,100	128,593	123,491	151,015	146,705	204,002	196,698
Kindergarten	276,411	270,605	263,398	258,686					320,939	316,176	369,019	362,312
Public	204,565	201,933	192,789	190,638					227,953	225,608	242,592	239,659
Private	71,846	68,672	70,609	68,048					92,986	90,568	126,427	122,653
Primary	1,352,992	1,207,888	1,302,405	1,175,252	1,359,150	1,227,284	1,323,320	1,200,917	1,403,913	1,282,220	1,525,548	1,403,988
Public	1,123,394	991,587	1,081,569	966,327	1,116,801	996,948	1,116,691	1,004,748	1,153,228	1,043,546	1,217,099	1,111,225
Private	229,598	216,301	220,836	208,925	242,349	230,336	206,629	196,169	250,685	238,674	308,449	292,763
Junior Secondary	455,154	377,865	437,006	367,239	468,514	397,122	468,923	396,285	498,686	420,548	548,156	462,090
Public	405,486	330,765	382,918	316,649	404,860	337,035	404,906	335,847	423,943	350,039	450,597	371,608
Private	49,668	47,100	54,088	50,590	63,654	60,087	64,017	60,438	74,743	70,509	97,559	90,482

Table 4.24 Fish Landings in Shama, Aboesi and Aboadze Area (in metric tons)

Year	Shama	Abuesi	Aboadze	Total
1989	1690	1290	965	4205
1990	2895	1960	1770	6625
1991	2003	1945	1490	5438
1992	2500	2156	1893	6649

Table 4.25 Diversity Indices for Fish Species from 2006-2008 in the SAEMA

Year	Number of Species	Margale'f Species Richness	Pielou's Evenness	Shannon-Wierner Diversity
2006	38	3.189	0.4765	1.733
2007	42	3.372	0.4678	1.748
2008	33	2.757	0.5929	2.073

Table 4.26 Breakdown by Occupation for the Western Region, Sekondi-Takoradi and Shama Local Authorities

Occupation	Western Region	Sekondi-Takoradi	Percentage	Shama	Percentage
All occupations (Over 15 years) -Total -Male -Female	530,228 285,884 264,384	71,219 36,305 34,914	13 14 13	23,321 10,769 12,552	4 4 5
Professional, technical and related workers -Total -Male -Female	20,294 13,248 7,046	5,759 3,483 2,276	28 26 32	609 407 202	3 3 3
Clerical and Related Workers -Total -Male -Female	12,417 9,481 2,936	6,359 4,437 1,922	51 47 65	223 177 46	2 2 2
Wholesale and retail trade -Total -Male -Female	58,199 3,860 54,339	19,852 1,440 18,412	34 37 34	5,831 130 5,681	10 3 10
Agriculture, animal husbandry, forestry workers and hunters -Total -Male -Female	354,742 173,726 172,016	8,735 4,968 3,757	3 3 2	12,882 7,832 5,050	4 5 3
Agriculture, animal husbandry -Total -Male -Female	223,506 77,456 146,050	6,093 2,473 3,620	3 3 2	7,322 2,796 4,526	3 4 3
Fisherman, hunters and related workers -Total -Male -Female	12,759 12,642 117	1,976 1,951 25	15 15 2	3,522 3,491 31	28 28 26
Production, transport, equipment operators, labourers and related workers -Total -Male -Female	79,156 54,518 24,608	23,820 16,927 6,899	30 31 28	3,546 2,032 1,514	5 4 6

Table 4.27 Employment for Select Communities

Number in Employment							
Locality	Sex	Total Aged 15 and Over	Total	Agriculture Hunting Fishing Forestry	Unemployed	Homemaker	Other
Shama	M	1927	1641	1199	135	16	235
	F	2269	1735	72	69	245	219
Aboadzi	M	715	567	455	41	9	98
	F	903	759	14	18	44	82
Aboasi	M	621	526	450	12	3	80
	F	648	564	15	14	48	22
Sekondi	M	9433	6363	285	842	84	1942
	F	8932	5135	95	646	2122	1029
Inchaban	M	738	579	134	70		89
	F	764	615	232	21	61	63

Table 4.28 Fish Production in Ghana (1993-2004)

Year	Marine Fisheries Landings (MT)	Inland Fisheries Landing (MT)	Total Fish Landing (MT)
1993	316,680.3	40,000	356,680.3
1994	276,165.50	42,000	318,165.5
1995	273,672.40	52,400	326,072.4
1996	301,907.2	60,500	362,407.2
1997	295,223.8	62,700	357,923..8
1998	278,663.7	63,800	342,463.7
1999	268,885.1	81,900	350,785.1
2000	354,566.6	82,500	437,066.6
2001	370,952.9	81,000	451,952.9
2002	290,008.1	81,000	371,008.1
2003	331,412.0	82,000	413,412.0
2004	352,405.1	81,500	533,905.1

Table 4.29 Agricultural Land (In Hectares)

Total Land Area	23,853,900
Agricultural Land Area	13,628,179
Area under cultivation	4,320,000
Area under irrigation	7,500
Area under inland waters	1,100,000
Total Land Area	23,853,900

Source: Ministry of Food and Agriculture

Table 4.30 Livestock Population

Type of Livestock	2000	2001	2002	2003
Poultry	1,940	2,080	2,270	2,500
Sheep	1,270	1,280	1,350	1,400
Goats	1,400	1,460	1,470	1,620
Cattle	1,090	1,090	1,110	1,130
Pigs	710	690	680	670
Poultry	1,940	2,080	2,270	2,500

Source: Ministry of Food and Agriculture

Table 4.31 Crop Production (Metric Tonnes)

Crop	2001	2002	2003	2004	2005
Maize	738	845	880	1,616	1,790
Rice	107	162	160	215	224
Cassava	16,999	19,265	19,270	19,492	22,298
Yam	112	143	140	165	125
Cocoyam	483	495	500	569	432
Plantain	1,083	1,170	1,190	2,804	3,051

Source: Metro Agric Directorate, SAEMA

Table 4.32 Yield per Hectare (Metric Tonnes)

Crop	2001	2002	2003	2004	2005
Maize	1.26	1.39	1.42	1.40	1.41
Rice	1.11	1.15	1.14	1.17	1.16
Cassava	8.13	8.78	8.80	8.82	8.81
Yam	4.00	3.97	3.50	4.02	3.80
Cocoyam	4.09	3.69	3.57	4.12	3.93
Plantain	4.77	3.45	2.70	8.20	8.50

Source: Metric Agric Directorate, SAEMA

Table 4.33 Area for Crop Production (Hectares)

Crop	2001	2002	2003	2004	2005
Maize	586	608	620	1,154	1,270
Rice	96	141	140	184	193
Cassava	2,091	2,194	2,190	2,210	2,531
Yam	28	36	40	41	33
Cocoyam	118	134	140	138	110
Plantain	227	339	440	342	359

Source: Metric Agric Directorate, SAEMA

Table 4.34 Top 10 Diseases in Shama Ahanta Metropolitan District (1991)

Disease	Cases	% of Population
Malaria	35,616	10.0
Upper Respiratory Infection	7,652	2.3
Acute Eye Infection	6,750	2.0
Accidents and Fractures	4,730	1.4
Diseases of the skin	4,031	1.2
Diseases of the oral cavity	3,262	1.0
Diarrhoeal disease	3,207	0.9
Ear Infection	2,986	0.9
Hypertension heart disease	2,048	0.6
Intestinal worms	1,298	0.4
Total	**71,580**	**21**

Table 4.35 Three Year Trend of Selected Diseases of Public Health Importance

Incidence/ Cases By Year	2004		2005		Mid 2006	
	Cases	Incidence	Cases	Incidence	Cases	Incidence
Guinea Worm	0	0	0	0	0	0
Malaria	34,399	81.9	54,516	126.1	34,308	77.1
< 5 yr Malaria	18,619	257.9	19,452	261.7	4,175	54.4
Malaria in Preg.	N/A	0	804	46.5	286	16.0
TB	N/A	N/A	103	0.20	80	0.17
CSM	0	0	1	0.2	0	0
Cholera	0	0	0	0	229	51.3
Y/F	0	0	4	0.9	3	0.6
AFP	3	0.7	2	0.4	5	1.12
Measles	93	22.1	44	10.1	15	33

Table 4.36 Trace Metal Concentrations in the Ghanaian Marine Environment

	Mercury	Lead	Cadmium	Zinc	Copper
Sea water (ng/L)	<20	-	-	-	-
Sediment (mg/kg)	0.002 – 0.04	6 – 35	-	1 – 80	2 – 20
Algae (mg/kg)	0.02 – 20	1 – 2	<0.1	2 – 5	1 – 2
Shrimp (mg/kg)	<0.02	0.9 – 2	<0.1	5.6 – 6.3	2 – 6
Fish (mg/kg)	<0.02 – 0.3	<0.2 – 0.65	<0.1 – 0.3	0.5 – 16	<0.2 – 5.6
WHO Concentration for fish flesh limit (mg/kg)	0.5	-	-	-	-

Table 6.1 Summary of Emissions and Air Dispersion Modeling

Compound Name	Compound Molecular Wt.	Background Conc. ug/m3	Modeling Conc. ug/m^3	Model+Background Conc. ug/m3	Modeling Conc. ppm	Modeling Conc. ppb	World Bank Standard ug/m3	NAAQS Standard ppb	NAAQS Standard ppm	NAAQS Averaging Period
NO_x	46.0000	0.0108	3.20	3.2058	0.0016	1.5611	100.00	54.00	0.0540	Annual
NO_x	46.0000	0.0108	12.04				150.00			24-hour
CO	28.0000	0.0000	51.10	51.0960	0.0409	40.8768	**	35,500.00	35.5000	1-hour
CO	28.0000	0.0000	10.93	10.9320	0.0087	8.7456	**	9,500.00	9.5000	8-hour
SO2	64.0000	0.0007	1.07	1.0657	0.0004	0.3730	80.00	35.00	0.0350	Annual
SO2	64.0000	0.0007	1.28	1.2763	0.0004	0.4467	150.00	145.00	0.1450	24-hour
PM_{10}***		30.2850	1.14	31.4213			50.00			Annual
PM_{10}							150.00			24-hour

* No background data available for CO.
** No World Bank Standards estblished for CO
*** The background levels for PM10 are skewed and are probably too high because the monitor is next to a dusty soccer field!

Table 6.2 Noise Monitoring Results at T1 Boundaries [dB(A)] – Jan-March 2009

Area	EPA Limit (dBA)	Noise Levels (dBA)			Remarks
		Jan 2009	Feb 2009	Mar 2009	
Eastern Fence	70	53.0-55.0	52.0-54.0	54-55	Compliant with allowable limit
Northern Fence	70	64.3-66.0	64-66	60-62	Compliant with allowable limit
Southern Fence	70	58.2-62.8	57.1-60.5	59-61	Compliant with allowable limit
Western Fence	70	69.0-70.0	69.5-73.3	68-72	2-3 dBA above compliance limit due to TICO GTs
Aboadze Village (day)	55	50-54	50-54	51-53	Compliant with allowable limit
VRA Township (day)	55	53-55	53-55	54-55	Compliant with allowable limit
Aboadze village (night)	48	43-47	43-47	44-47	Compliant with allowable limit
VRA Township (night)	48	46-48	46-48	45-47	Compliant with allowable limit

NOTES:

a) Eastern fence corresponds to the fence east of the crude oil storage tanks
b) Northern fence refers to the fence dividing T1 from T3 and land adjacent to the raw water tank
c) Southern fence is next to the T1 cooling tower
d) Western fence is west of the T2 gas turbines

Table 6.3 Summary of Sound Pressure Levels at the NSA (VRA clinic - 250 m.)

Description	Octave Band Center Frequency - Hz									Awt
	31.5	63	125	250	500	1000	2000	4000	8000	
CT Enclosure	63	61	62	64	54	52	50	46	38	59
CT Intake	74	68	68	47	30	7	20	37	38	53
OTSG Exhaust Stack	71	66	65	63	58	50	38	24	13	59
OTSG Shell	84	74	74	68	59	47	44	39	23	63
Steam Turbine Generator (STG)	62	65	65	60	54	51	46	34	34	57
Total	**85**	**76**	**76**	**70**	**63**	**56**	**52**	**48**	**41**	**66**

Table 6.4 Ghana EPA and World Bank Noise Level Criteria

Zone	Description of Area of Noise Reception	Permissible Noise Level [dB(A)]	
		Day 06.00-22.00	Night 22.0-06.00
A	Residential areas with negligible or infrequent transportation.	55	45
B1	Educational (School), and health (Hospital, clinic) facilities.	55	50
B2	Areas with some commercial or light industry.	60	55
C1	Areas with some light industry, places of entertainment or public assembly, and places of worship such as churches and mosques.	65	60
C2	Predominantly commercial areas.	75	65
D	Light industrial areas.	70	60
E	Predominantly heavy industrial areas.	70	70

Table 8.1 Proposed Noise Monitoring Locations and Frequency of Monitoring

Location	Frequency	Period
PLANT FENCE LINES		
Monitoring Points Northern Fence Southern Fence Eastern Fence Western Fence	 Weekly Weekly Weekly Weekly	 24 hours 24 hours 24 hours 24 hours
GAS TURBINE AREAS (T3)		
Monitoring Points Gas Turbines Control Rooms Step Up Transformers Auxiliary Transformers	 Weekly Weekly Weekly Weekly	 5 minutes 5 minutes 5 minutes 5 minutes
FUEL TREATMENT ROOM		
Monitoring Points Centrifuge Skids LCO & DFO Forwarding Pumps LCO & DFO Transfer Pumps Operators Desk	 Weekly Weekly Weekly Weekly	 5 minutes 5 minutes 5 minutes 5 minutes
Cooling Tower		
Monitoring Points Cooling Tower Cooling Water Fans Cooling Water Pumps	 Weekly Weekly Weekly	 5 minutes 5 minutes 5 minutes
NOISE SENSTIVE RECEPTORS		
Aboadze village, Environmental Monitoring Station *Aboadze village, adjacent Lorry Park VRA township *Amuzu	Weekly Weekly Weekly Weekly	24 hours 24 hours 24 hours 24 hours

Appendix C – Emissions and Air Dispersion Modeling

Sound Environmental Solutions, Inc.

AIR DISPERSION MODELING FOR PROPOSED

TAKORADI THERMAL POWER PLANT EXPANSION

Introduction

HPI Technologies is in the process of designing and constructing an expansion module at the Takoradi Thermal Power Plant. The expansion will include the installation of four skid mounted, Zorya-Mashproekt GT25000 turbines, with a nominal power output 25 megawatts per unit. As part of the review process the international lender has asked HPI Technologies to conduct dispersion modeling of the air emissions from the proposed units to evaluate the potential impacts, in order to be able to assess what additional investigations, if any, are warranted and determine any mitigation measures that may be required. HPI Technologies retained Sound Environmental Solutions, Inc. (SES) to conduct the modeling. The purpose of this report is present the results of the modeling along with the assumptions that were used.

Model

There are a number of dispersion models commercially available that can be used to determine potential air impacts. The model selected for this project was AERMOD atmospheric dispersion modeling system, which was developed for the US Environmental Protection Agency, and is internationally accepted as an effective modeling option.

AERMOD is a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain through the use of three modules:

- A steady-state dispersion model designed for short-range (up to 50 kilometers) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data preprocessor (AERMET) that accepts surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as

atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.

- A terrain preprocessor (AERMAP) whose main purpose is to provide a physical relationship between terrain features and the behavior of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

Inputs and Assumptions

The Emissions and Air Dispersion Modeling was carried out by Sound Environmental Solutions utilizing the following baseline date:

- Turbines and Stack Emission Data (Tables C1 and C2);
- Site specific layout (Figures 3.3 and C1);
- Current available meteorological data (Tables 4.2 and C3, Figures 4.12 and 4.13).

At this time LCO is the principal fuel source. The design of the CTGs allows for the conversion of natural gas, once it becomes available. The vendor provided emission data did not include particulates and so AP-42 emission factor for particulates were used.

The model requires that the meteorological data be based on hourly readings. An extensive search confirmed that there is no readily available meteorological data available for the location or surrounding area. Eventually some suitable data were located for a meteorological station in neighboring Cote D'Ivoire at Abidjan and Doloa. The Abidjan station is located at a similar latitude and distance from the coast, and the Doloa station is only a little to the north and so provide the best available data for use in the model.

Results

The model was set-up to represent the current facility and the inclusion of the four new units in the northeast section of the site. The calculated emissions of NOx, CO, Particulates and SO_2 for projected estimated operational scenario of water injection enabled, Light Crude Oil (<0.2% sulphur content) as the primary source of fuel and local average ambient temperature of 32ºC were used to calculate the offsite maximum concentrations. The results are summarized in Table C4 and include the World Bank and EPA National Ambient Air Quality Standards (NAAQS) for comparison purposes. Complete model run data are presented on Tables C5 thru C8.

Results for criteria pollutants were compared against Ghana EPA and World Bank Air Quality Guidelines (Table 4.6) and show that the calculated offsite concentrations are much lower than the maximum allowable limits (MAL) for SO_2 and NO_x (0.11% and 0.25%, respectively).

Table C1: OGT25000 Turbine Emission Levels at Rated Output Power

Zorya-Mashproekt (Orenda) OGT25000 Turbine Emission Levels	
Fuel	**DFO/LCO**
Water injection	**ON**
Ambient temperature (ºC)	32
NOx, mg/Nm³ (Ref 15% O_2; 1.013 bar; dry)	300
NOx, kg/hr	56.19
CO mg/Nm³ (Ref 15% O_2; 1.013 bar; dry)	100
CO, kg/hr	18.73
CO_2, kg/hr	15903
CxHy mg/Nm³ (Ref 15% O_2; 1.013 bar; dry)	60
CxHy, kg/hr	11.23
SO_x as SO_2, kg/hr	20.19

Table C2: Stack and Exhaust Emission Data

Stack and Exhaust Emission Data	
Number of stacks	4
Diameter and height of each stack (feet)	11.19 X 88
Exhaust flow per stack (lb/hr)	1,217,480
Turbine Exhaust Temperature (F)	930
CO_2	2.82% (vol)
N_2	73.44% (vol)
O_2	14.12% (vol)
H_2O	8.74% (vol)
Air	0.88% (vol)

Figure C1: T3 Exhaust Stack Location Coordinates

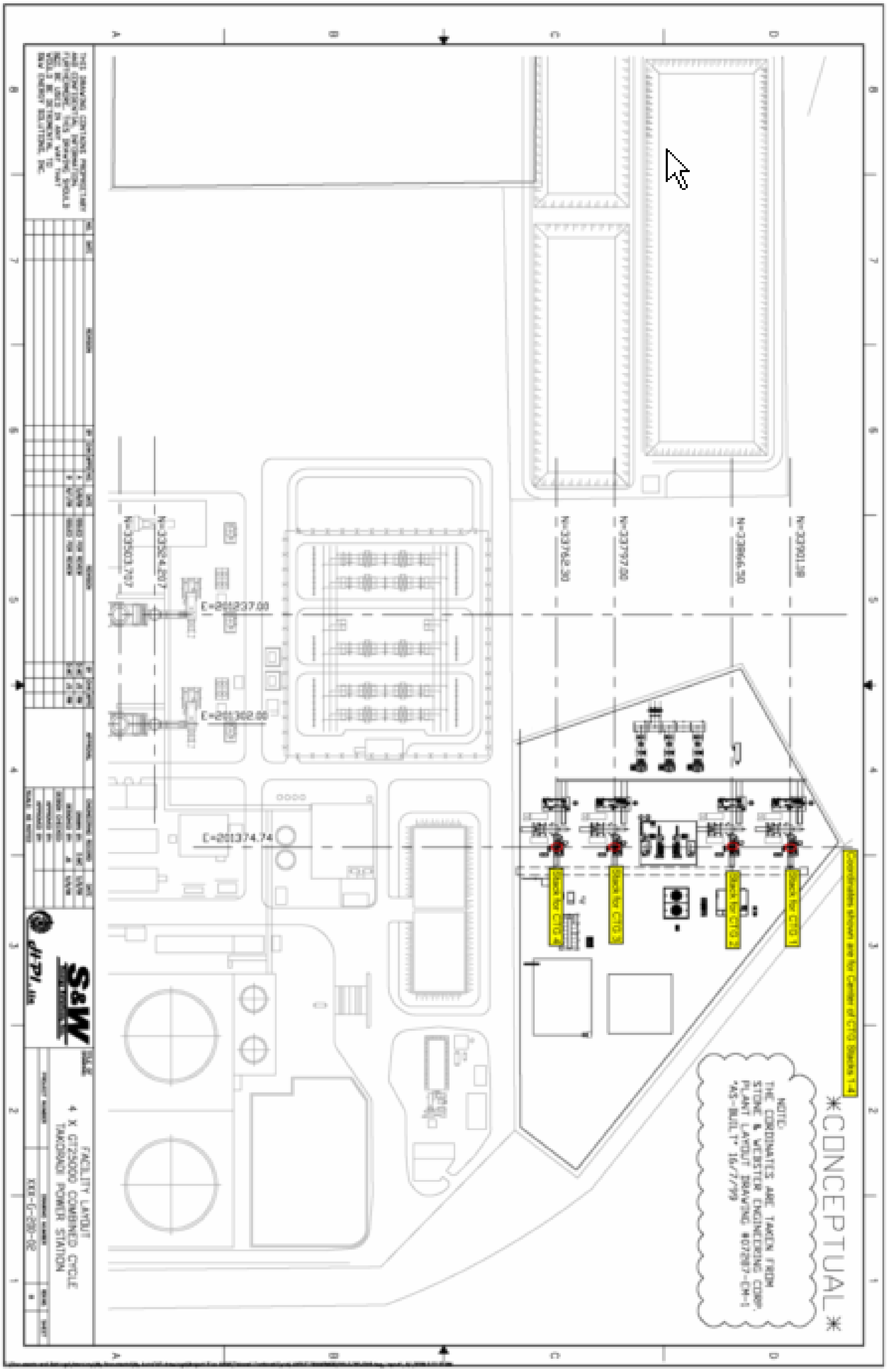


Table C3: Daily Climatic Data for 4th Quarter of 2008

STATION: TAKORADI				MONTH: OCTOBER			YEAR: 2008				
DATE	RAINFALL (MM)	TEMPERATURE		WIND			RELATIVE HUMIDITY				SUNSHINE
		MAX	MIN	RUN	DIRECTION	SPEED	600	900	1200	1500	DURATION
		°C	°C	9H TO 9H		KTS	%	%	%	%	HOURS
1	0.2	29.6	23.6	61.29	SW	5	96	86	78	81	7.5
2	0	29.6	23.7	61.55	SW	3	97	94	77	81	7.5
3	0.1	29.6	22.9	65.98	SW	4	98	88	79	81	8.8
4	0	29.8	24	68.53	SW	4	96	85	78	78	9
5	0.7	30.1	22.9	69.92	SW	4	97	81	77	79	7.5
6	0	29.8	24	88.95	SW	4	96	90	78	76	8.9
7	0.3	30.2	23.7	121.13	SW	7	97	81	77	85	7.3
8	4.5	29.1	24	85.88	SW	5	97	85	92	81	3.7
9	1.1	30.5	23.6	124.11	SW	7	97	86	82	83	8.3
10	0.2	29.7	24	107.73	SW	6	96	92	81	81	8.4
11	0	29.5	23.6	89.82	SW	6	96	85	78	78	9.1
12	TR	29	23.3	34.27	SW	4	96	86	82	787	3.1
13	0	31	23.2	72.55	SW	5	98	85	69	79	8.1
14	0	29.6	24	70.1	SW	4	96	81	78	78	8.3
15	0	30.5	23.6	48.11	SW	3	96	78	69	73	10
16	TR	30.5	23.6	84.41	SW	4	96	81	78	75	9.2
17	0	31	23.5	64.88	SW	4	93	78	72	75	5.4
18	0	31.7	24.5	59.33	SW	2	96	75	69	72	9.9
19	0	31.1	23.5	74.94	SW	3	94	78	66	72	8.5
20	4.1	31.5	24.7	101	SW	5	96	81	73	76	9.6
21	2.6	31.2	23.5	106.83	SW	5	97	80	77	80	7.6
22	4.2	30.5	24.4	53.98	SW	3	96	96	96	72	3.9
23	0	31	22.5	64.13	SW	2	96	81	75	75	8.3
24	0	31	24	68.87	SW	3	97	81	72	75	10
25	0	31	24	104.27	SW	5	97	80	77	79	9.8
26	0	31.4	25	112.2	SW	5	96	82	75	76	9.7
27	3.6	32	24	68.5	SW	3	97	81	74	64	8.2
28	0	31.5	24.6	41.75	SW	2	96	81	75	73	8.6
29	0	31.5	24	53.71	SW	2	96	78	70	72	9.4
30	34.8	31.7	24	64	SW	4	96	78	72	72	9.3
31	2.2	29.5	25	39.54	SW	3	98	98	93	89	1.6
TOTAL	58.6	945.7	738.9	2332.26		126	2986	2592	2389	3098	244.5
MEANS		30.5064516	23.8354839	75.23419355	SW	4.064516129	96.32258	83.6129	77.064516	99.93548	7.88709677

Table C3: Daily Climatic Data for 4th Quarter of 2008 (continued)

STATION: TAKORADI				MONTH: NOVEMBER			YEAR: 2008				
DATE	RAINFALL (MM)	TEMPERATURE		WIND			RELATIVE HUMIDITY				SUNSHINE
		MAX	MIN	RUN	DIRECTION	SPEED	600	900	1200	1500	DURATION
		°C	°C	9H TO 9H		KTS	%	%	%	%	HOURS
1	0	31	23.9	44.34	VAR	3	96	88	79	89	3.1
2	6.8	31	24.5	56.1	SW	3	96	86	77	75	6.7
3	1	30.6	23	73.5	SW	4	96	89	82	82	4
4	TR	29.8	23.5	36.08	SW	2	97	94	90	85	1.1
5	0	31.5	24.5	40.03	SW	3	97	92	73	75	7.5
6	0	31.5	24.5	58.2	SW	3	96	78	69	72	9.6
7	TR	31.1	24	39.53	SW	3	96	81	69	72	6.2
8	12.1	31.3	23.8	69.1	SW	5	96	88	75	75	8.1
9	0	31.5	22.5	48.32	SW	3	96	78	73	72	8.9
10	73.6	31	24	73.84	SW	3	96	88	75	78	4.2
11	0	31.3	22.2	46.67	SW	2	96	84	69	71	7.9
12	0	31.2	22.2	41.01	SW	2	96	78	72	72	9.5
13	1.1	31.5	24	48.05	SW	2	96	81	72	69	8.9
14	0	31.5	22.2	29.72	S	1	96	85	72	72	7.5
15	0	31.9	24	43.47	SE	2	96	81	72	75	7.5
16	0	31.1	24.2	43.79	SW	1	94	78	72	72	8.4
17	0	31.5	24.4	87.42	SW	5	94	82	73	75	8.5
18	7.4	31.5	25.6	55.2	SW	5	93	85	73	91	4.7
19	0	28.7	23.5	19.79	SW	2	96	88	84	81	0
20	0	31.1	23.5	37.89	SW	3	96	78	71	72	9.1
21	0	31	24.2	35.03	SW	2	96	82	75	75	9.3
22	0	31.5	23.7	39.57	SW	3	96	82	73	72	9.9
23	0	31.6	24	40.88	SW	3	96	82	74	72	9.6
24	0	31.5	25.5	51.53	SW	3	96	82	75	75	9.6
25	0	32	25.5	43.19	SW	3	96	82	73	76	9.6
26	0	30.5	25.2	23.3	SW	2	94	88	82	82	1.8
27	0	31.9	24.5	50.86	SW	5	96	78	73	72	9.9
28	0	31.7	25	60.29	SW	4	96	82	78	75	9.8
29	0	32	24.9	53	SW	5	96	82	73	73	9.7
30	0.9	31	24.7	40.68	SW	3	96	82	79	74	2.3
31	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
TOTAL	102.9	936.3	721.2	1430.38		90	2873	2504	2247	2271	212.9
MEANS		31.21	24.04	47.6793333	SW	3	95.76667	83.46667	74.9	75.7	7.096666667

Table C3: Daily Climatic Data for 4th Quarter of 2008 (continued)

STATION: TAKORADI				MONTH: DECEMBER					YEAR:	2008	
DATE	RAINFALL (MM)	TEMPERATURE		WIND			RELATIVE HUMIDITY				SUNSHINE
		MAX	MIN	RUN	DIRECTION	SPEED	600	900	1200	1500	DURATION
		^0C	^0C	9H TO 9H		KTS	%	%	%	%	HOURS
1	2.5	317	230	64.91	SW	4	96	91	81	76	5.1
2	0	320	245	71.11	SW	4	96	82	74	73	93
3	14.1	320	240	88.88	SW	5	92	81	73	73	10.4
4	0	314	240	54.45	SW	3	97	92	75	82	5.8
5	30.6	321	240	100.95	VR	3	96	88	73	96	4.2
6	0	292	218	38.06	S	3	95	93	80	78	0.5
7	0	306	219	49.15	SW	1	96	85	66	68	9.8
8	0	315	245	42.9	SW	1	96	88	77	77	5.3
9	0	311	235	51.14	SW	3	95	85	73	74	9.7
10	0	31.5	23.5	62.71	SW	4	97	86	76	75	9.3
11	TR	316	245	61.05	SW	2	96	82	72	73	74
12	0	317	241	68.4	SW	3	96	85	73	72	9.5
13	0	324	240	53.72	SW	3	97	85	70	75	9.3
14	0	320	236	58.26	SW	2	97	85	73	73	9.1
15	0	320	232	44.87	SW	4	97	85	74	76	93
16	TR	317	246	48.19	SW	3	96	85	75	75	58
17	0	326	239	60.05	SW	3	97	84	73	75	70
18	0	320	239	63.89	SW	3	97	89	76	75	7.9
19	0	320	245	48.43	SW	3	96	85	76	76	9.1
20	0	325	244	46.43	SW	3	98	91	76	76	9.5
21	0	326	242	45.1	SW	2	98	88	73	73	9.2
22	0	327	243	63.48	SW	3	98	88	70	73	8.8
23	0.1	32.1	25	58.76	SW	3	96	92	76	79	8.2
24	0	323	240	45.17	S	2	97	92	75	76	6.8
25	0	32.1	230	44.47	S	1	97	81	69	73	8.5
26	0	315	240	61.69	SE	1	97	88	72	69	7.3
27	0	316	25	41.72	SE	1	98	92	70	70	4.4
28	0	320	237	41.99	SW	2	97	88	72	72	6.9
29	0	318	237	55.64	SW	3	96	88	74	73	7.1
30	TR	320	255	64.3	SW	4	96	82	74	73	87
31	5	318	251	60.44	SW	3	96	85	79	74	74
TOTAL	52.3	8999.7	6767.5	1760.31		85	2989	2691	2290	2323	730.7
MEANS		290.312903	218.306452	56.78419		2.741935	96.41935	86.80645	73.87097	74.93548	23.57096774

Table C4: Air and Emissions Dispersion Modeling Results Summary

Compound Name	Compound Molecular Wt.	Background Conc. ug/m3	Modeling Conc. ug/m^3	Model+Background Conc. ug/m3	Modeling Conc. ppm	Modeling Conc. ppb	World Bank Standard ug/m3	NAAQS Standard ppb	NAAQS Standard ppm	NAAQS Averaging Period
NO_x	46.0000	0.0108	3.20	3.2058	0.0016	1.5611	100.00	54.00	0.0540	Annual
NO_x	46.0000	0.0108	12.04				150.00			24-hour
CO	28.0000	0.0000	51.10	51.0960	0.0409	40.8768	**	35,500.00	35.5000	1-hour
CO	28.0000	0.0000	10.93	10.9320	0.0087	8.7456	**	9,500.00	9.5000	8-hour
SO2	64.0000	0.0007	1.07	1.0657	0.0004	0.3730	80.00	35.00	0.0350	Annual
SO2	64.0000	0.0007	1.28	1.2763	0.0004	0.4467	150.00	145.00	0.1450	24-hour
PM_{10}***		30.2850	1.14	31.4213			50.00			Annual
PM_{10}							150.00			24-hour

* No background data available for CO.
** No World Bank Standards estblished for CO
*** The background levels for PM10 are skewed and are probably too high because the monitor is next to a dusty soccer field!

Table C5: SO_2 Emissions Model Run

```
                                                TAKO_04_SO2.USF
*** AERMOD - VERSION 07026 ***
*** TAKORADI POWER PLANT -     CONC. LEVEL                             ***
*** Model Executed on 06/11/09 at 16:04:26 ***
 Input File - P:\GHANA AIR DISPERSSION MODELING\TAKO_04_SO2.DTA

Output File - P:\GHANA AIR DISPERSSION MODELING\TAKO_04_SO2.LST

   Met File - p:\GHANA AIR DISPERSSION MODELING\tacoradi-04.SFC

      Number of sources -          4
Number of source groups -          1
    Number of receptors -       4161
```

*** POINT SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS.	EMISSION RATE (GRAMS/SEC)	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	STACK HEIGHT (METERS)	STACK TEMP. (DEG.K)	STACK EXIT VEL. (M/SEC)	STACK DIAMETER (METERS)	BLDG EXISTS	URBAN SOURCE	CAP/ HOR	EMIS RATE SCALAR VARY BY
TG_100	0	0.52028E+01	201350.0	33910.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	
TG_400	0	0.52028E+01	201350.0	33865.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	
TG_200	0	0.52028E+01	201350.0	33800.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	
TG_300	0	0.52028E+01	201350.0	33760.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID	SOURCE IDs
ALL	TG_100 , TG_400 , TG_200 , TG_300 ,

Page 1

Table C5: SO_2 Emissions Model Run (Continued)

TAKO_04_SO2.USF

*** THE SUMMARY OF MAXIMUM ANNUAL (1 YRS) RESULTS ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

GROUP ID		AVERAGE CONC		RECEPTOR (XR,	YR,	ZELEV,	ZHILL,	ZFLAG)	NETWORK GRID-ID OF TYPE
ALL	1ST HIGHEST VALUE IS	1.06503	AT (	201550.00,	34300.00,	10.00,	10.00,	0.00)	DC
	2ND HIGHEST VALUE IS	1.06080	AT (	201500.00,	34250.00,	10.00,	10.00,	0.00)	DC
	3RD HIGHEST VALUE IS	1.06057	AT (	201500.00,	34300.00,	10.00,	10.00,	0.00)	DC
	4TH HIGHEST VALUE IS	1.05719	AT (	201550.00,	34250.00,	10.00,	10.00,	0.00)	DC
	5TH HIGHEST VALUE IS	1.05458	AT (	201550.00,	34350.00,	10.00,	10.00,	0.00)	DC
	6TH HIGHEST VALUE IS	1.04270	AT (	201500.00,	34350.00,	10.00,	10.00,	0.00)	DC
	7TH HIGHEST VALUE IS	1.03541	AT (	201525.00,	34200.00,	10.00,	10.00,	0.00)	DC
	8TH HIGHEST VALUE IS	1.03528	AT (	201500.00,	34200.00,	10.00,	10.00,	0.00)	DC
	9TH HIGHEST VALUE IS	1.03480	AT (	201600.00,	34300.00,	10.00,	10.00,	0.00)	DC
	10TH HIGHEST VALUE IS	1.03419	AT (	201600.00,	34350.00,	10.00,	10.00,	0.00)	DC

*** THE SUMMARY OF HIGHEST 1-HR RESULTS ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

NETWORK GROUP ID OF TYPE GRID-ID	AVERAGE CONC	DATE (YYMMDDHH)	RECEPTOR (XR, YR, ZELEV, ZHILL, ZFLAG)

Page 2

Table C5: SO_2 Emissions Model Run (Continued)

```
                                        TAKO_04_SO2.USF
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - -
ALL       HIGH  1ST HIGH VALUE IS      47.40272  ON 04121402: AT (  201600.00,    34150.00,     10.00,     10.00,
    0.00)  DC
          HIGH  2ND HIGH VALUE IS      15.77314  ON 04052413: AT (  201550.00,    34250.00,     10.00,     10.00,
    0.00)  DC

                                        *** THE SUMMARY OF HIGHEST  3-HR RESULTS ***

                                    ** CONC OF SO2       IN MICROGRAMS/M**3                           **

                                              DATE
    NETWORK
GROUP ID                          AVERAGE CONC      (YYMMDDHH)             RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)
  OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - -
ALL       HIGH  1ST HIGH VALUE IS      15.80091m ON 04121403: AT (  201600.00,    34150.00,     10.00,     10.00,
    0.00)  DC
          HIGH  2ND HIGH VALUE IS      12.52936  ON 04051715: AT (  201500.00,    34300.00,     10.00,     10.00,
    0.00)  DC

                                        *** THE SUMMARY OF HIGHEST 24-HR RESULTS ***

                                    ** CONC OF SO2       IN MICROGRAMS/M**3                           **

                                              DATE
    NETWORK
GROUP ID                          AVERAGE CONC      (YYMMDDHH)             RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)
  OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - -
ALL       HIGH  1ST HIGH VALUE IS       4.01404b ON 04080224: AT (  201500.00,    34350.00,     10.00,     10.00,
    0.00)  DC
          HIGH  2ND HIGH VALUE IS       3.54586m ON 04031924: AT (  201300.00,    34500.00,     10.00,     10.00,
    0.00)  DC

                                              Page 3
```

Table C5: SO_2 Emissions Model Run (Continued)

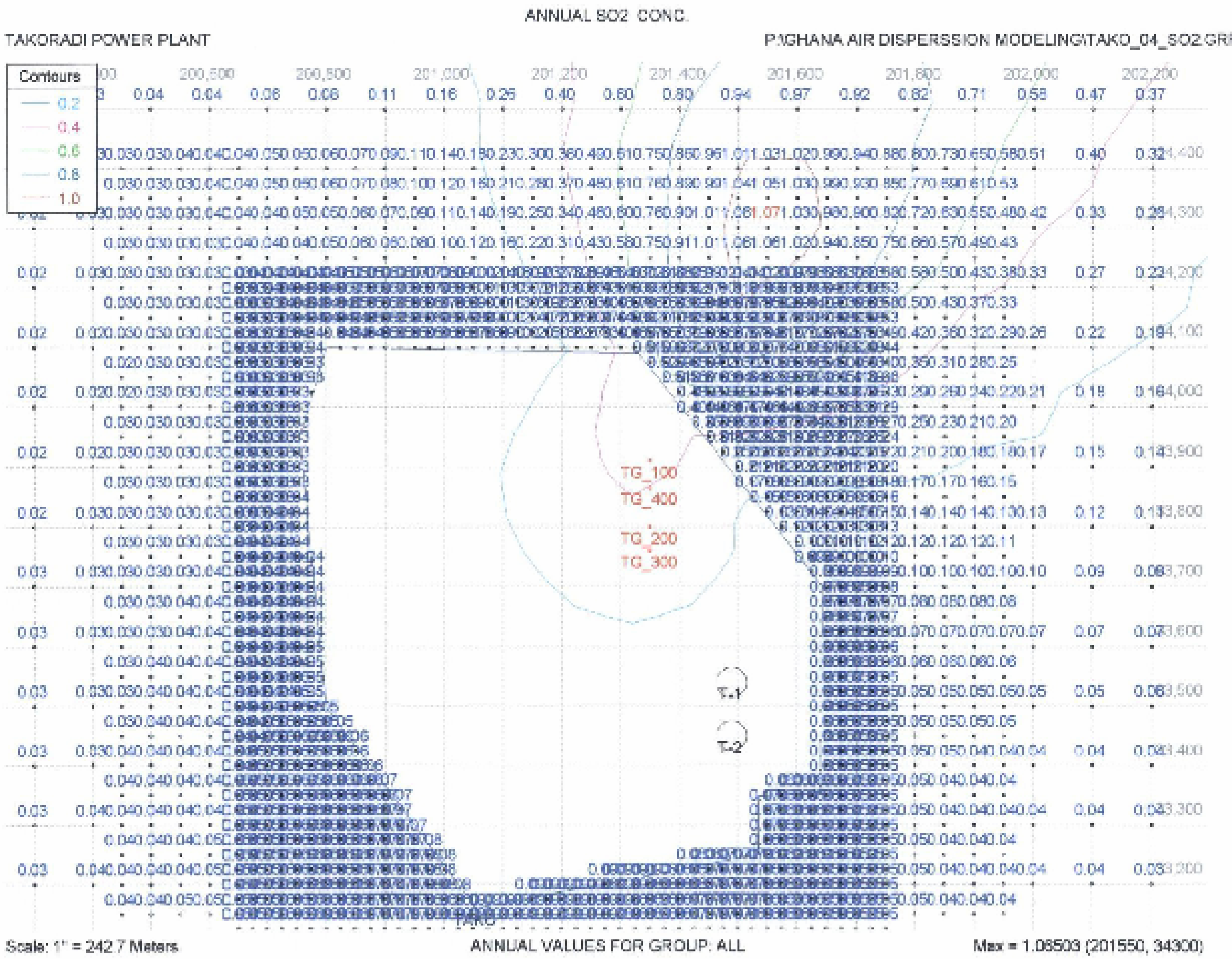


Table C5: SO_2 Emissions Model Run (Continued)

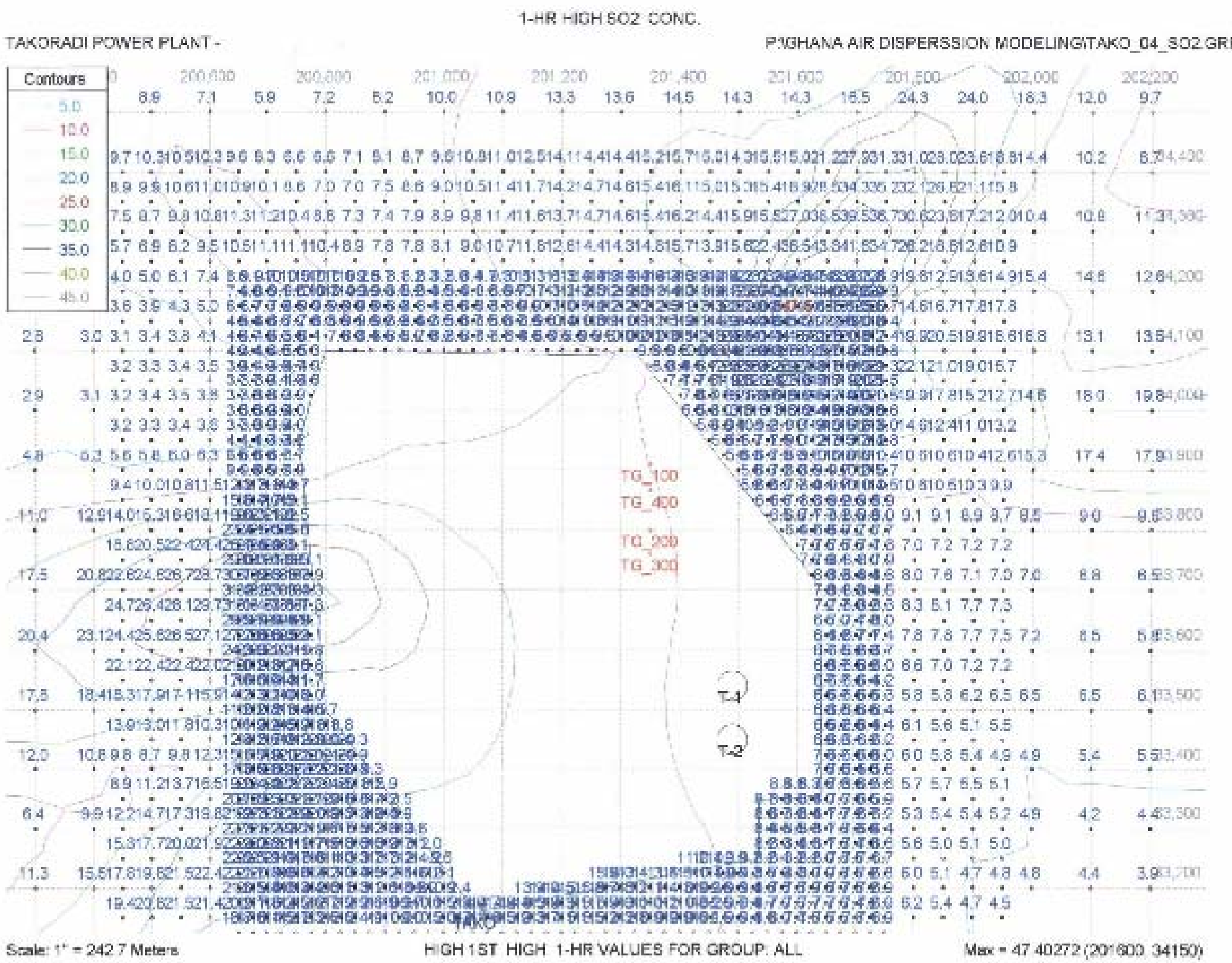


Table C5: SO_2 Emissions Model Run (Continued)

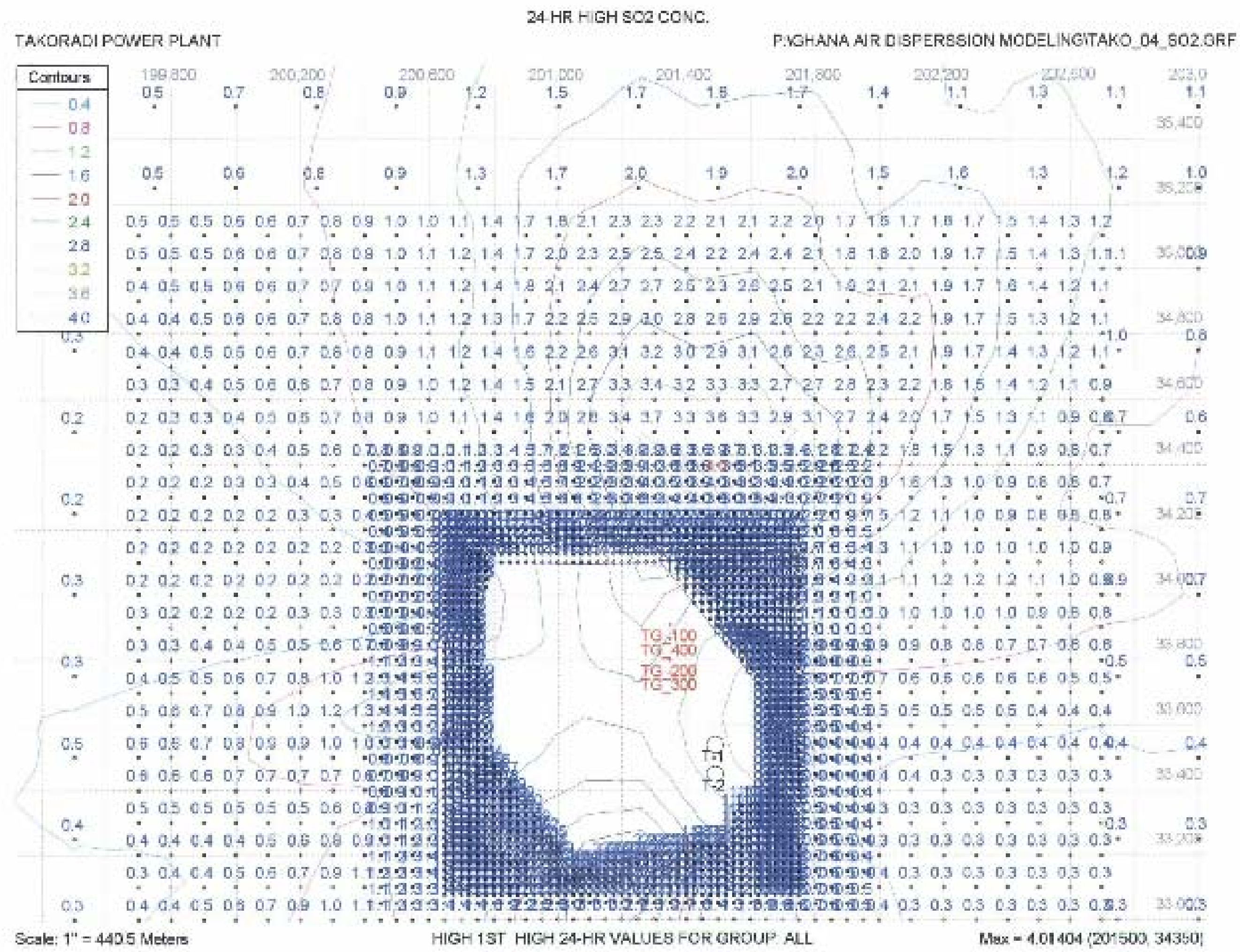


Table C6: NO_x Emissions Model Run

```
                                                TAKO_04_NOX.USF
*** AERMOD - VERSION 07026
*** TAKORADI POWER PLANT -                                                        ***
*** Model Executed on 06/11/09 at 15:39:22 ***
 Input File - P:\GHANA AIR DISPERSSION MODELING\TAKO_04_NOX.DTA

Output File - P:\GHANA AIR DISPERSSION MODELING\TAKO_04_NOX.LST

   Met File - p:\GHANA AIR DISPERSSION MODELING\tacoradi-04.SFC

      Number of sources -           4
Number of source groups -           1
    Number of receptors -        4161
```

*** POINT SOURCE DATA ***

URBAN SOURCE ID	CAP/ HOR	NUMBER PART. CATS.	EMISSION RATE (GRAMS/SEC)	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	STACK HEIGHT (METERS)	STACK TEMP. (DEG.K)	STACK EXIT VEL. (M/SEC)	STACK DIAMETER (METERS)	BLDG EXISTS	SOURCE	EMIS RATE SCALAR VARY BY
TG_100		0	0.15608E+02	201350.0	33910.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO
TG_400		0	0.15608E+02	201350.0	33865.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO
TG_200		0	0.15608E+02	201350.0	33800.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO
TG_300		0	0.15608E+02	201350.0	33760.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID	SOURCE IDs
ALL	TG_100 , TG_400 , TG_200 , TG_300 ,

*** THE SUMMARY OF MAXIMUM ANNUAL (1 YRS) RESULTS ***

Page 1

Table C6: NO_x Emissions Model Run (Continued)

TAKO_04_NOX.USF

** CONC OF NOX IN MICROGRAMS/M**3 **

NETWORK GROUP ID		AVERAGE CONC		RECEPTOR (XR,	YR,	ZELEV,	ZHILL,	ZFLAG)	OF TYPE GRID-ID
ALL	1ST HIGHEST VALUE IS	3.19504	AT (	201550.00,	34300.00,	10.00,	10.00,	0.00)	DC
	2ND HIGHEST VALUE IS	3.18233	AT (	201500.00,	34250.00,	10.00,	10.00,	0.00)	DC
	3RD HIGHEST VALUE IS	3.18164	AT (	201500.00,	34300.00,	10.00,	10.00,	0.00)	DC
	4TH HIGHEST VALUE IS	3.17152	AT (	201550.00,	34250.00,	10.00,	10.00,	0.00)	DC
	5TH HIGHEST VALUE IS	3.16368	AT (	201550.00,	34350.00,	10.00,	10.00,	0.00)	DC
	6TH HIGHEST VALUE IS	3.12803	AT (	201500.00,	34350.00,	10.00,	10.00,	0.00)	DC
	7TH HIGHEST VALUE IS	3.10616	AT (	201525.00,	34200.00,	10.00,	10.00,	0.00)	DC
	8TH HIGHEST VALUE IS	3.10576	AT (	201500.00,	34200.00,	10.00,	10.00,	0.00)	DC
	9TH HIGHEST VALUE IS	3.10435	AT (	201600.00,	34300.00,	10.00,	10.00,	0.00)	DC
	10TH HIGHEST VALUE IS	3.10249	AT (	201600.00,	34350.00,	10.00,	10.00,	0.00)	DC

*** THE SUMMARY OF HIGHEST 1-HR RESULTS ***

** CONC OF NOX IN MICROGRAMS/M**3 **

GROUP ID		AVERAGE CONC	DATE (YYMMDDHH)		RECEPTOR (XR,	YR,	ZELEV,	ZHILL,	ZFLAG)	NETWORK OF TYPE GRID-ID
ALL	HIGH 1ST HIGH VALUE IS	142.20451	ON 04121402:	AT (	201600.00,	34150.00,	10.00,	10.00,	0.00)	DC
	HIGH 2ND HIGH VALUE IS	47.31822	ON 04052413:	AT (	201550.00,	34250.00,	10.00,	10.00,	0.00)	DC

Page 2

Table C6: NO_x Emissions Model Run (Continued)

```
                                   TAKO_04_NOX.USF

                                    *** THE SUMMARY OF HIGHEST  8-HR RESULTS ***

                               ** CONC OF NOX       IN MICROGRAMS/M**3                          **

                                                     DATE
          NETWORK
 GROUP ID                        AVERAGE CONC      (YYMMDDHH)             RECEPTOR  (XR, YR, ZELEV, ZHILL,
ZFLAG)     OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - -
 ALL      HIGH  1ST HIGH VALUE IS     30.42634m ON 04031516: AT (  201250.00,    34350.00,     10.00,
10.00,      0.00)  DC
          HIGH  2ND HIGH VALUE IS     28.36973m ON 04031916: AT (  201300.00,    34400.00,     10.00,
10.00,      0.00)  DC

                                    *** THE SUMMARY OF HIGHEST 24-HR RESULTS ***

                               ** CONC OF NOX       IN MICROGRAMS/M**3                          **

                                                     DATE
          NETWORK
 GROUP ID                        AVERAGE CONC      (YYMMDDHH)             RECEPTOR  (XR, YR, ZELEV, ZHILL,
ZFLAG)     OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - -
 ALL      HIGH  1ST HIGH VALUE IS     12.04181b ON 04080224: AT (  201500.00,    34350.00,     10.00,
10.00,      0.00)  DC
          HIGH  2ND HIGH VALUE IS     10.63730m ON 04031924: AT (  201300.00,    34500.00,     10.00,
10.00,      0.00)  DC

                                        Page 3
```

Table C6: NO_x Emissions Model Run (Continued)

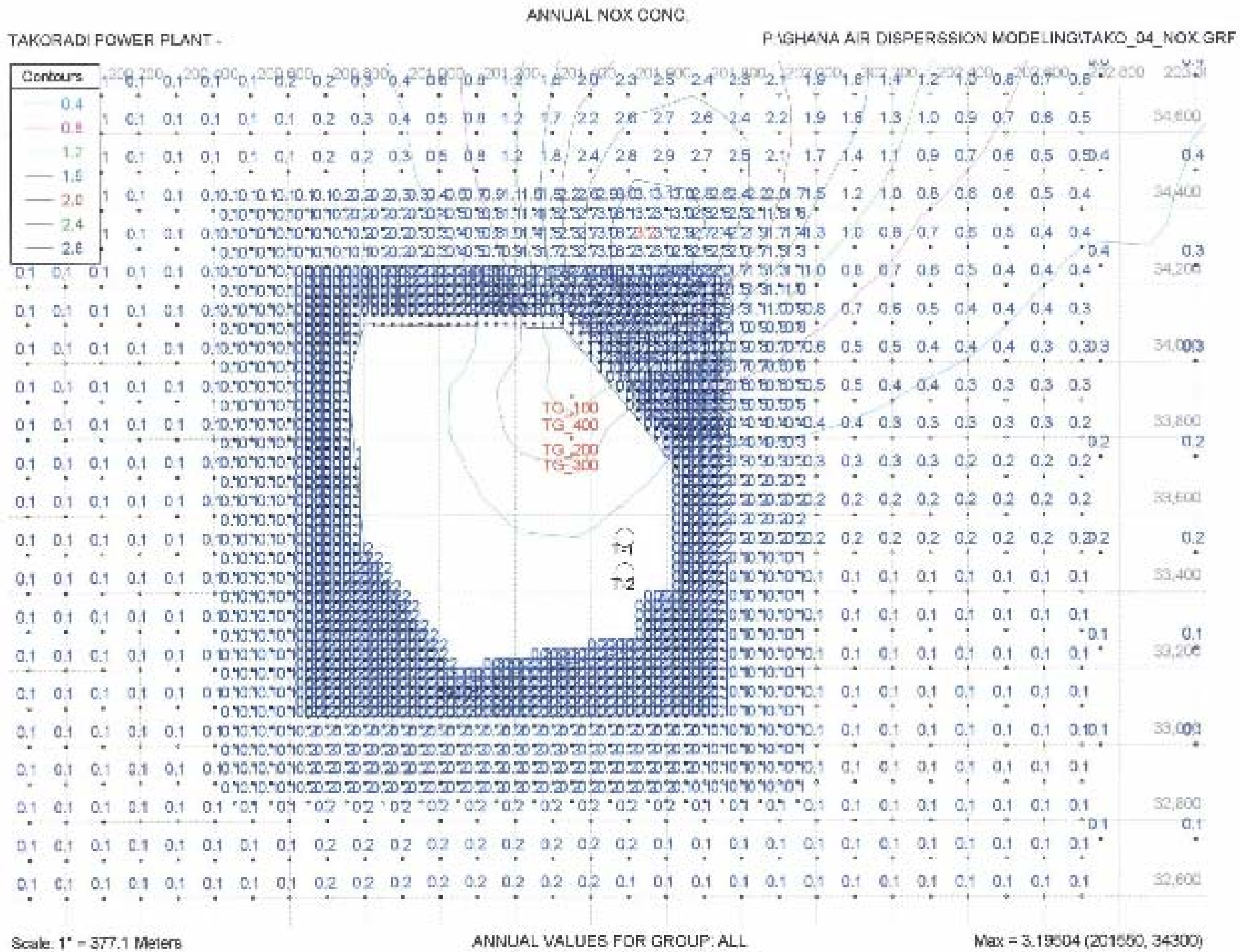


Table C6: NO_x Emissions Model Run (Continued)

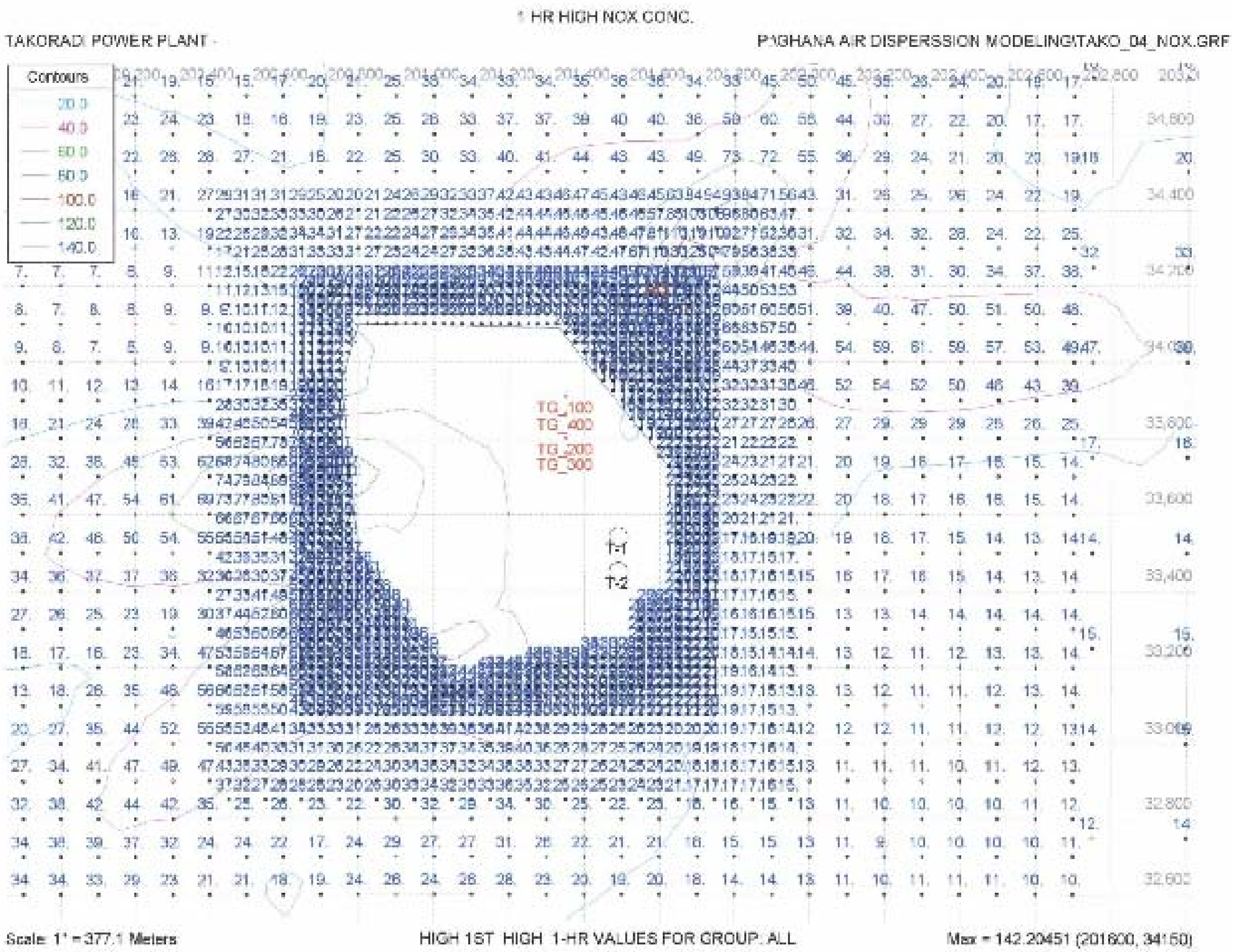


Table C6: NOx Emissions Model Run (Continued)

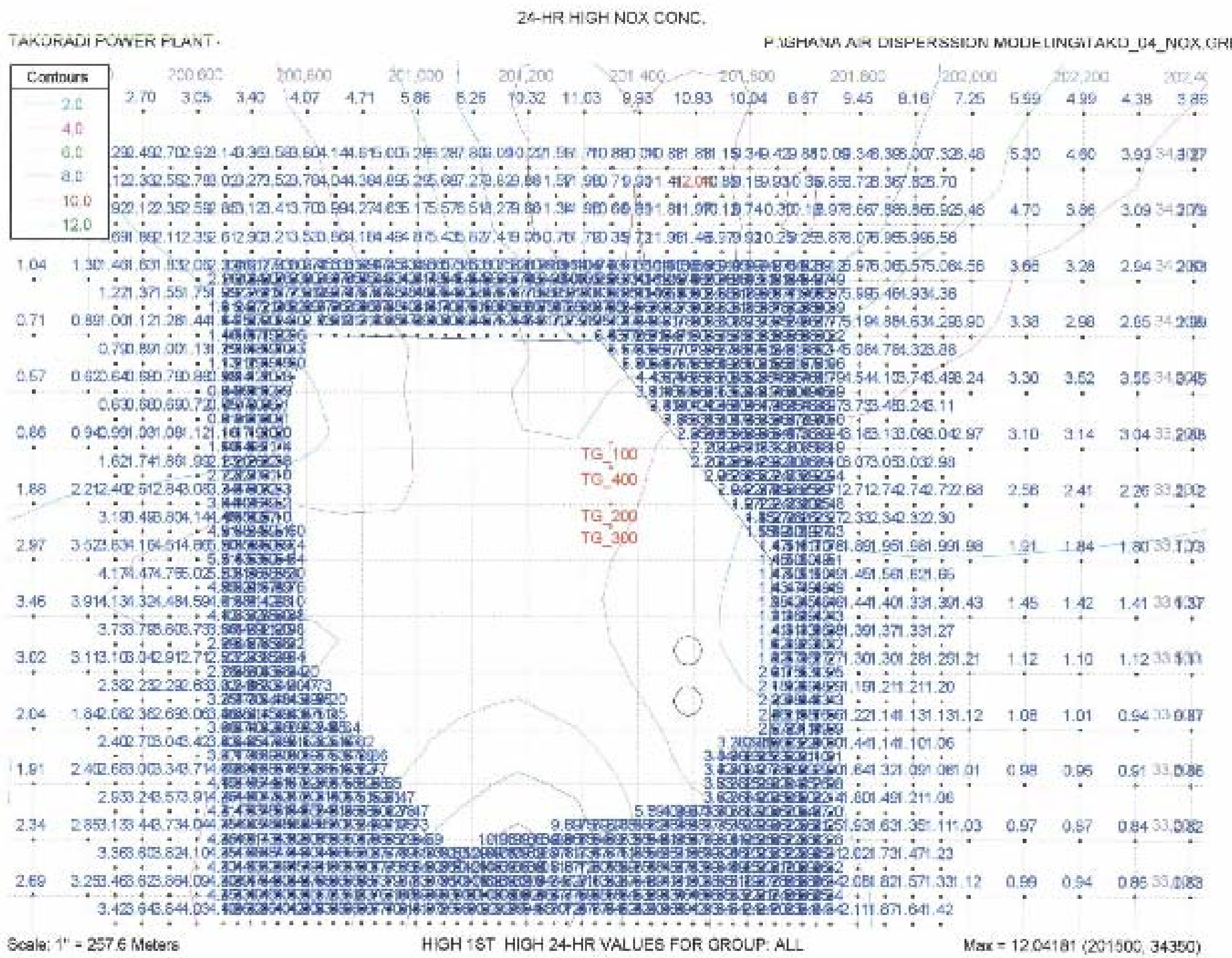


Table C7: CO Emissions Model Run

TAKO_04_CO.USF

*** AERMOD - VERSION 07026 ***
*** TAKORADI POWER PLANT - CO CONC. LEVEL ***
*** Model Executed on 06/11/09 at 16:25:18 ***
Input File - P:\GHANA AIR DISPERSSION MODELING\TAKO_04_CO.DTA

Output File - P:\GHANA AIR DISPERSSION MODELING\TAKO_04_CO.LST

Met File - p:\GHANA AIR DISPERSSION MODELING\tacoradi-04.SFC

Number of sources - 4
Number of source groups - 1
Number of receptors - 4161

*** POINT SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS.	EMISSION RATE (GRAMS/SEC)	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	STACK HEIGHT (METERS)	STACK TEMP. (DEG.K)	STACK EXIT VEL. (M/SEC)	STACK DIAMETER (METERS)	BLDG EXISTS	URBAN SOURCE	CAP/ HOR	EMIS RATE SCALAR VARY BY
TG_100	0	0.56082E+01	201350.0	33910.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	
TG_400	0	0.56082E+01	201350.0	33865.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	
TG_200	0	0.56082E+01	201350.0	33800.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	
TG_300	0	0.56082E+01	201350.0	33760.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID	SOURCE IDs
ALL	TG_100 , TG_400 , TG_200 , TG_300 ,

*** THE SUMMARY OF MAXIMUM ANNUAL (1 YRS) RESULTS ***

Page 1

Table C7: CO Emissions Model Run (Continued)

```
                                   TAKO_04_CO.USF
                              ** CONC OF CO        IN MICROGRAMS/M**3                             **

 NETWORK
  GROUP ID                      AVERAGE CONC                 RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)   OF TYPE
  GRID-ID
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - -

  ALL      1ST HIGHEST VALUE IS      1.14802 AT (  201550.00,    34300.00,     10.00,     10.00,      0.00)
 DC
           2ND HIGHEST VALUE IS      1.14346 AT (  201500.00,    34250.00,     10.00,     10.00,      0.00)
 DC
           3RD HIGHEST VALUE IS      1.14321 AT (  201500.00,    34300.00,     10.00,     10.00,      0.00)
 DC
           4TH HIGHEST VALUE IS      1.13957 AT (  201550.00,    34250.00,     10.00,     10.00,      0.00)
 DC
           5TH HIGHEST VALUE IS      1.13675 AT (  201550.00,    34350.00,     10.00,     10.00,      0.00)
 DC
           6TH HIGHEST VALUE IS      1.12394 AT (  201500.00,    34350.00,     10.00,     10.00,      0.00)
 DC
           7TH HIGHEST VALUE IS      1.11609 AT (  201525.00,    34200.00,     10.00,     10.00,      0.00)
 DC
           8TH HIGHEST VALUE IS      1.11595 AT (  201500.00,    34200.00,     10.00,     10.00,      0.00)
 DC
           9TH HIGHEST VALUE IS      1.11543 AT (  201600.00,    34300.00,     10.00,     10.00,      0.00)
 DC
          10TH HIGHEST VALUE IS      1.11477 AT (  201600.00,    34350.00,     10.00,     10.00,      0.00)
 DC


                                        *** THE SUMMARY OF HIGHEST  1-HR RESULTS ***

                              ** CONC OF CO        IN MICROGRAMS/M**3                             **
                                                DATE
          NETWORK
 GROUP ID                        AVERAGE CONC     (YYMMDDHH)             RECEPTOR  (XR, YR, ZELEV, ZHILL,
ZFLAG)     OF TYPE   GRID-ID
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - -
 ALL       HIGH  1ST HIGH VALUE IS      51.09632  ON 04121402: AT (  201600.00,    34150.00,     10.00,
10.00,       0.00)  DC
           HIGH  2ND HIGH VALUE IS      17.00218  ON 04052413: AT (  201550.00,    34250.00,     10.00,
10.00,       0.00)  DC

                                        Page 2
```

Table C7: CO Emissions Model Run (Continued)

```
                                        TAKO_04_CO.USF

                                         *** THE SUMMARY OF HIGHEST  8-HR RESULTS ***

                                    ** CONC OF CO        IN MICROGRAMS/M**3                              **

                                                    DATE
               NETWORK
 GROUP ID                         AVERAGE CONC      (YYMMDDHH)              RECEPTOR  (XR, YR, ZELEV, ZHILL,
ZFLAG)     OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - -
 ALL      HIGH  1ST HIGH VALUE IS      10.93266m ON 04031516: AT (  201250.00,    34350.00,     10.00,
10.00,      0.00)  DC
          HIGH  2ND HIGH VALUE IS      10.19369m ON 04031916: AT (  201300.00,    34400.00,     10.00,
10.00,      0.00)  DC

                                         *** THE SUMMARY OF HIGHEST 24-HR RESULTS ***

                                    ** CONC OF CO        IN MICROGRAMS/M**3                              **

                                                    DATE
               NETWORK
 GROUP ID                         AVERAGE CONC      (YYMMDDHH)              RECEPTOR  (XR, YR, ZELEV, ZHILL,
ZFLAG)     OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - -
 ALL      HIGH  1ST HIGH VALUE IS       4.32681b ON 04080224: AT (  201500.00,    34350.00,     10.00,
10.00,      0.00)  DC
          HIGH  2ND HIGH VALUE IS       3.82215m ON 04031924: AT (  201300.00,    34500.00,     10.00,
10.00,      0.00)  DC



                                            Page 3
```

Table C7: CO Emissions Model Run (Continued)

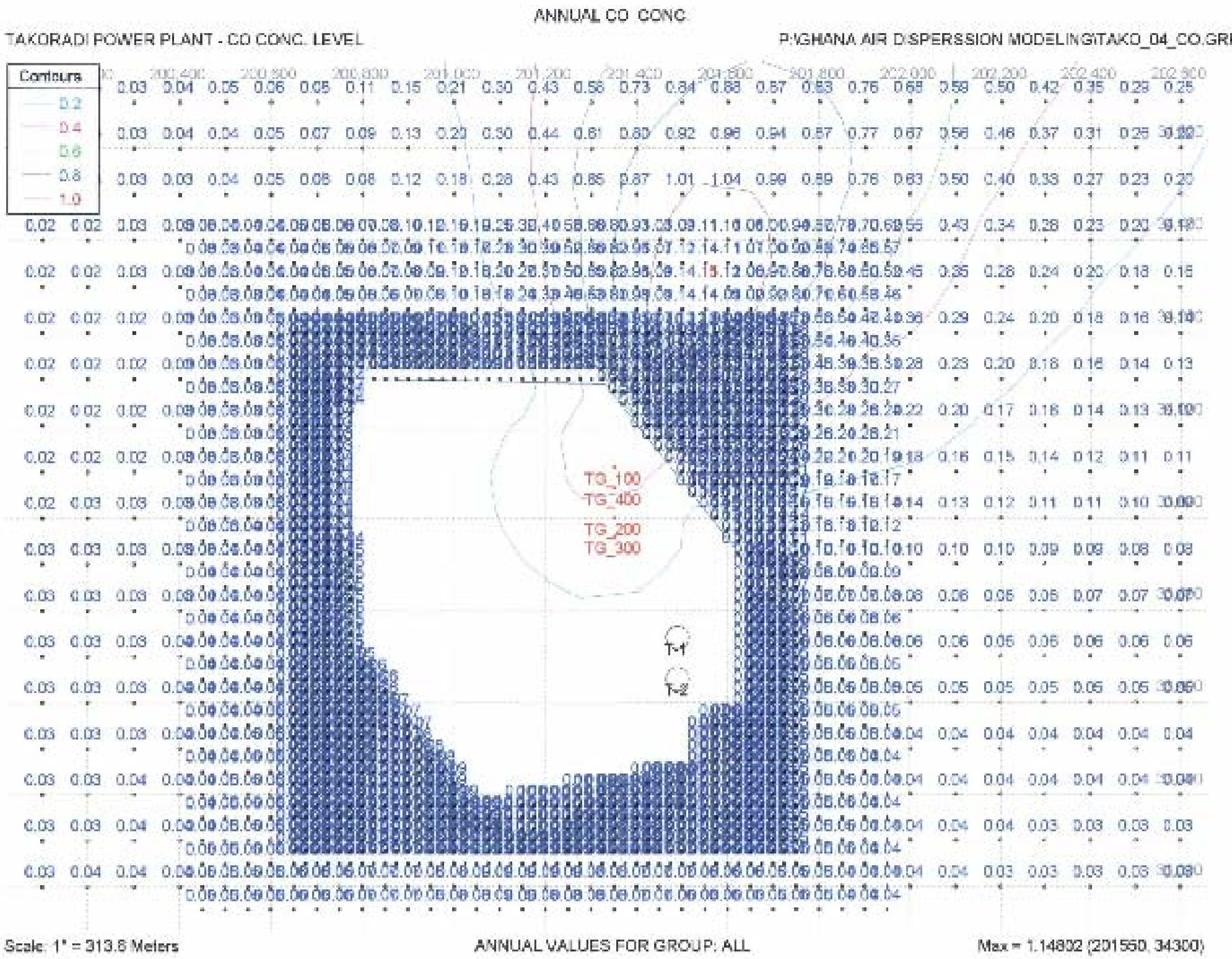


Table C7: CO Emissions Model Run (Continued)

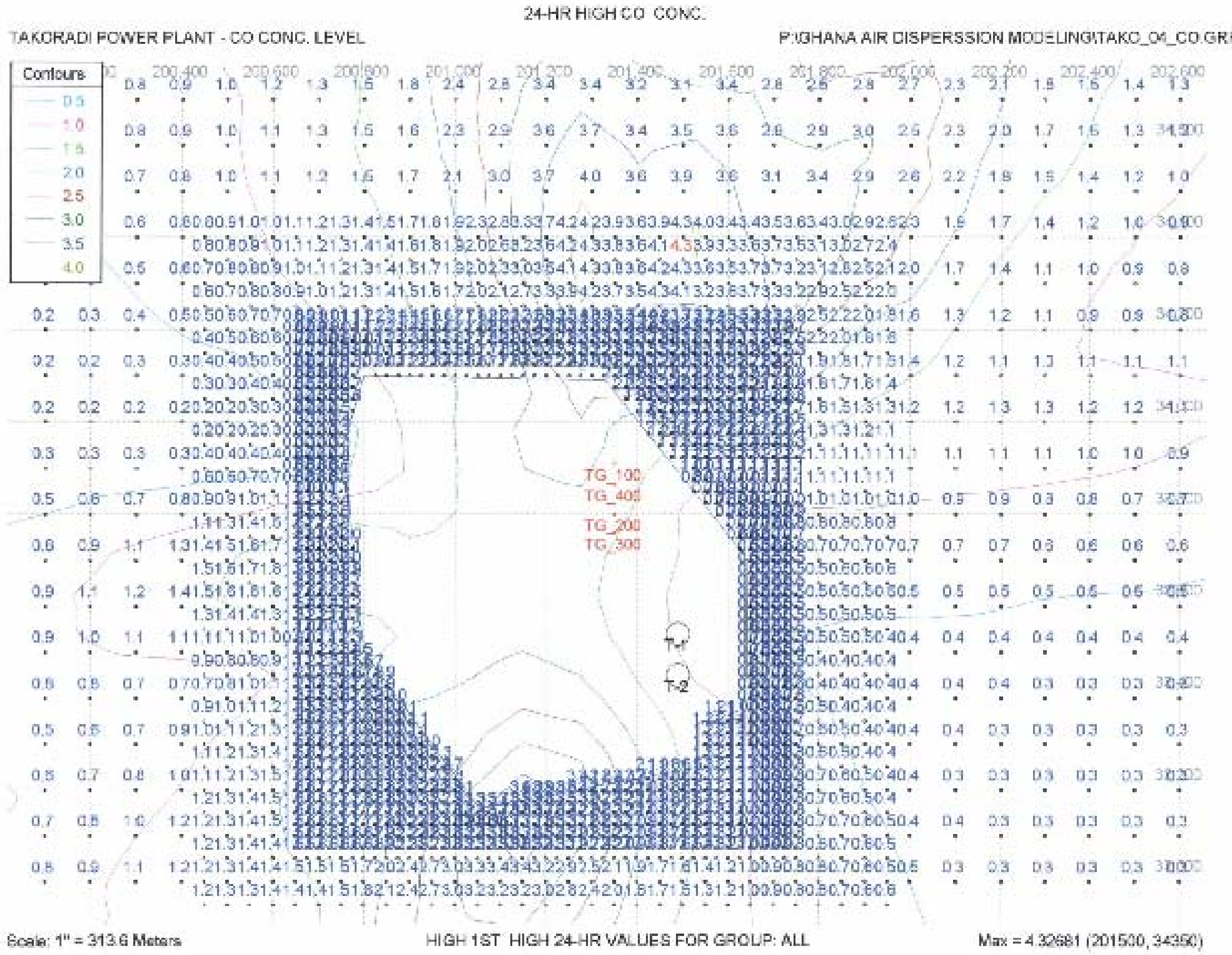


Table C7: CO Emissions Model Run (Continued)

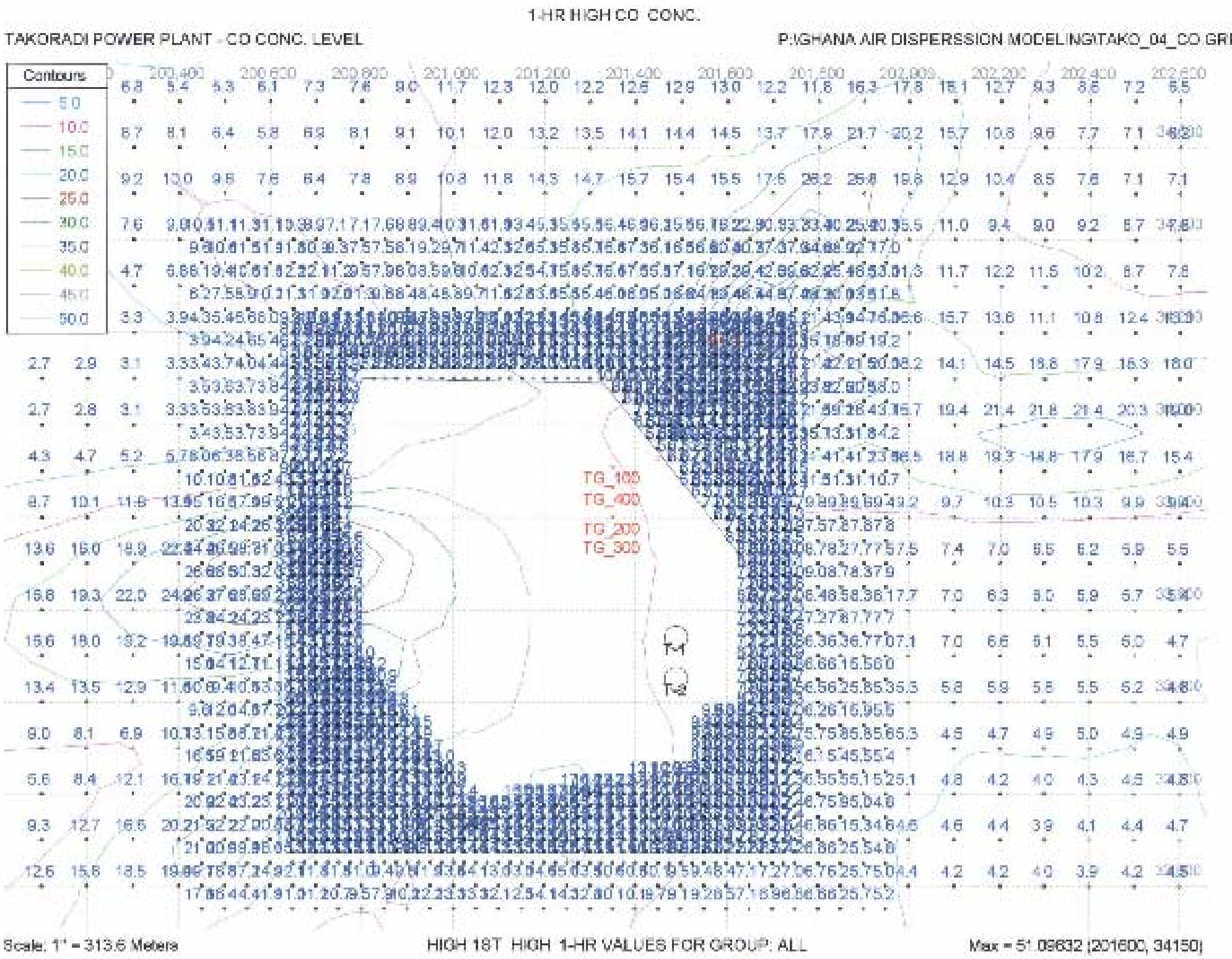


Table C8: PM_{10} Emissions Model Run

```
                                    TAKO_04_PM10.USF
*** AERMOD - VERSION 07026 ***
*** TAKORADI POWER PLANT - PM CONC. LEVEL                                   ***
*** Model Executed on 06/12/09 at 08:01:41 ***
 Input File - P:\GHANA AIR DISPERSSION MODELING\TAKO_04_PM10.DTA

Output File - P:\GHANA AIR DISPERSSION MODELING\TAKO_04_PM10.LST

   Met File - p:\GHANA AIR DISPERSSION MODELING\tacoradi-04.SFC

      Number of sources -          4
Number of source groups -          1
    Number of receptors -       4161
```

*** POINT SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS.	EMISSION RATE (GRAMS/SEC)	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	STACK HEIGHT (METERS)	STACK TEMP. (DEG.K)	STACK EXIT VEL. (M/SEC)	STACK DIAMETER (METERS)	BLDG EXISTS	URBAN SOURCE	CAP/ HOR	EMIS RATE SCALAR VARY BY
TG_100	0	0.56000E+01	201350.0	33910.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	
TG_400	0	0.56000E+01	201350.0	33865.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	
TG_200	0	0.56000E+01	201350.0	33800.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	
TG_300	0	0.56000E+01	201350.0	33760.0	10.0	26.82	772.04	35.36	3.41	NO	NO	NO	

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID	SOURCE IDs
ALL	TG_100 , TG_400 , TG_200 , TG_300 ,

*** THE SUMMARY OF MAXIMUM ANNUAL (1 YRS) RESULTS ***

Page 1

Table C8: PM10 Emissions Model Run (Continued)

```
                                   TAKO_04_PM10.USF
                               ** CONC OF PM10      IN MICROGRAMS/M**3                              **

NETWORK
 GROUP ID                   AVERAGE CONC               RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)  OF TYPE
 GRID-ID
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - -

 ALL     1ST HIGHEST VALUE IS        1.14634 AT ( 201550.00,    34300.00,    10.00,    10.00,     0.00)
DC
         2ND HIGHEST VALUE IS        1.14179 AT ( 201500.00,    34250.00,    10.00,    10.00,     0.00)
DC
         3RD HIGHEST VALUE IS        1.14154 AT ( 201500.00,    34300.00,    10.00,    10.00,     0.00)
DC
         4TH HIGHEST VALUE IS        1.13790 AT ( 201550.00,    34250.00,    10.00,    10.00,     0.00)
DC
         5TH HIGHEST VALUE IS        1.13509 AT ( 201550.00,    34350.00,    10.00,    10.00,     0.00)
DC
         6TH HIGHEST VALUE IS        1.12230 AT ( 201500.00,    34350.00,    10.00,    10.00,     0.00)
DC
         7TH HIGHEST VALUE IS        1.11446 AT ( 201525.00,    34200.00,    10.00,    10.00,     0.00)
DC
         8TH HIGHEST VALUE IS        1.11432 AT ( 201500.00,    34200.00,    10.00,    10.00,     0.00)
DC
         9TH HIGHEST VALUE IS        1.11380 AT ( 201600.00,    34300.00,    10.00,    10.00,     0.00)
DC
        10TH HIGHEST VALUE IS        1.11314 AT ( 201600.00,    34350.00,    10.00,    10.00,     0.00)
DC


                                     *** THE SUMMARY OF HIGHEST  1-HR RESULTS ***

                               ** CONC OF PM10      IN MICROGRAMS/M**3                              **
                                                  DATE
          NETWORK
 GROUP ID                        AVERAGE CONC    (YYMMDDHH)              RECEPTOR  (XR, YR, ZELEV, ZHILL,
ZFLAG)    OF TYPE  GRID-ID
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - -
 ALL      HIGH  1ST HIGH VALUE IS     51.02161  ON 04121402: AT ( 201600.00,    34150.00,     10.00,
10.00,      0.00)  DC
          HIGH  2ND HIGH VALUE IS     16.97732  ON 04052413: AT ( 201550.00,    34250.00,     10.00,
10.00,      0.00)  DC

                                          Page 2
```

Table C8: PM_{10} Emissions Model Run (Continued)

```
                                   TAKO_04_PM10.USF

                                     *** THE SUMMARY OF HIGHEST 24-HR RESULTS ***

                              ** CONC OF PM10      IN MICROGRAMS/M**3                          **
                                                        DATE
         NETWORK
 GROUP ID                    AVERAGE CONC      (YYMMDDHH)              RECEPTOR  (XR, YR, ZELEV, ZHILL,
ZFLAG)    OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - -
 ALL      HIGH  1ST HIGH VALUE IS       4.32049b ON 04080224: AT (  201500.00,    34350.00,     10.00,
10.00,      0.00)  DC
          HIGH  2ND HIGH VALUE IS       3.81656m ON 04031924: AT (  201300.00,    34500.00,     10.00,
10.00,      0.00)  DC
```

Page 3

Table C8: PM_{10} Emissions Model Run (Continued)

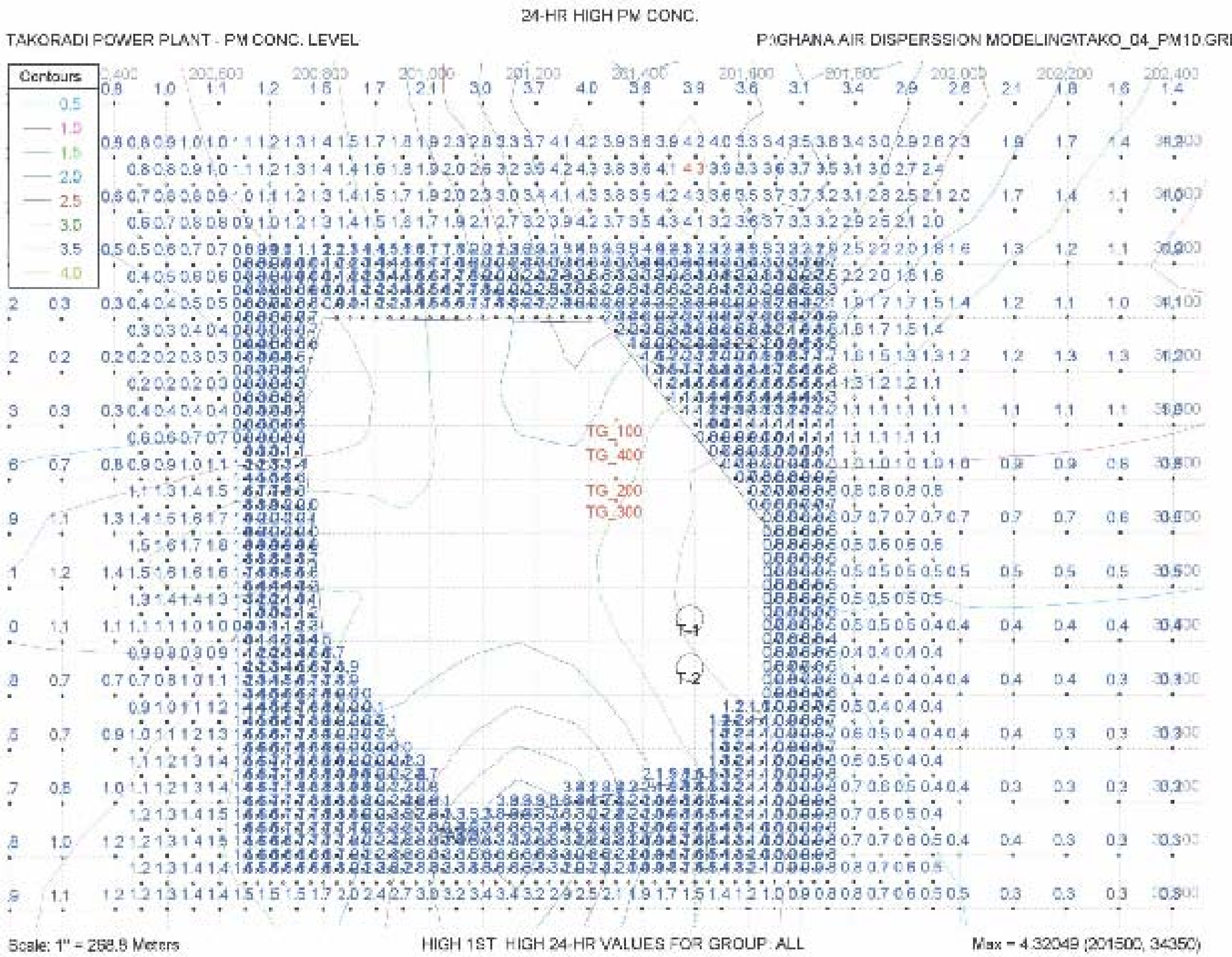
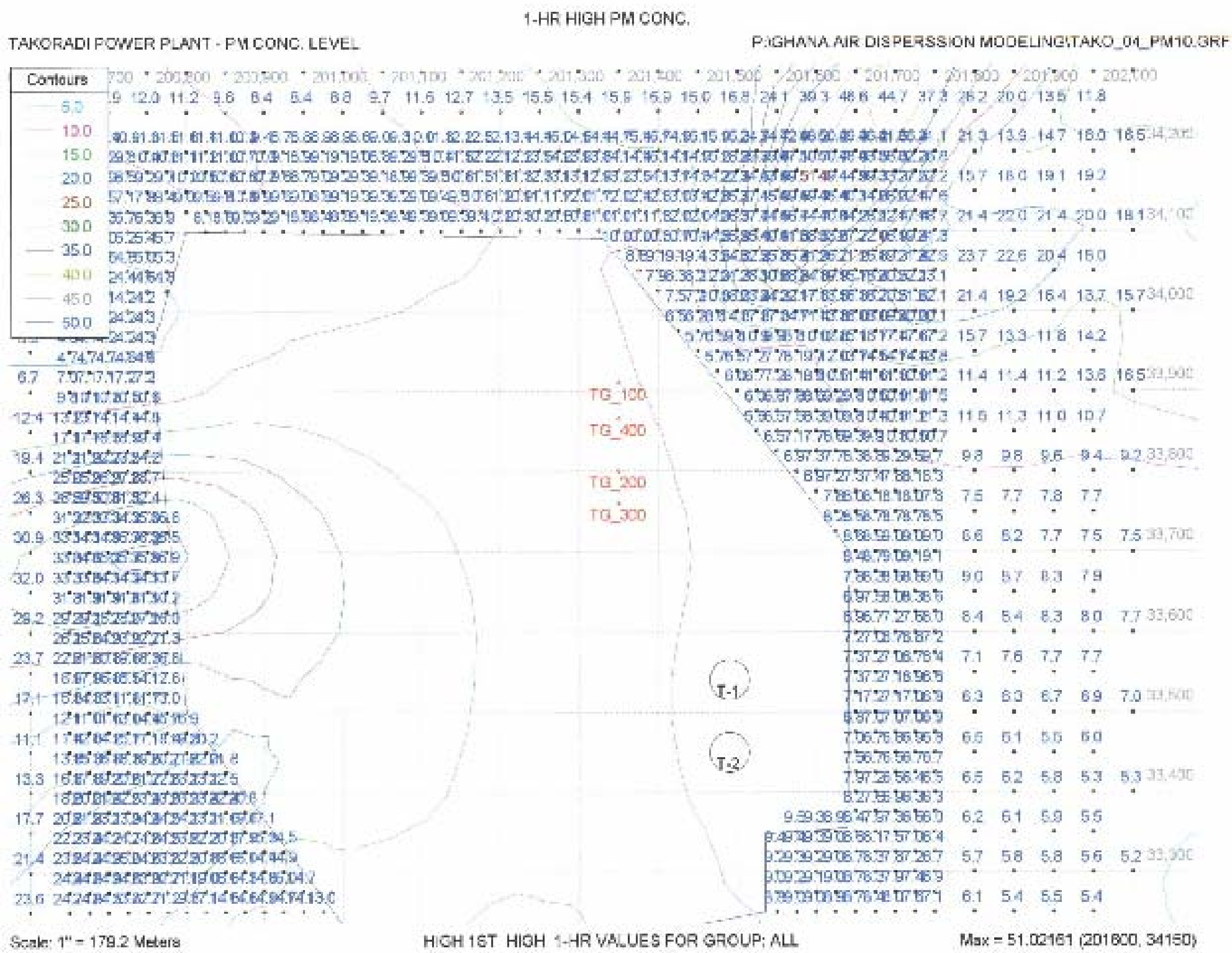


Table C8: PM_{10} Emissions Model Run (Continued)



Appendix D – Environmental Sound Level Assessment

HOOVER & KEITH INC. | Acoustics & Noise Control Engineering | 11391 MEADOWGLEN, SUITE D HOUSTON, TEXAS 77082 281-496-9876 (Fax. 281-496-0016) | h&k

11 June 2009

Rachel Pappworth
Sound Environmental Solutions
11111 Katy Freeway, Suite 1004
Houston, TX 77079

Subject: Preliminary Environmental Sound Level Assessment for the T3 Expansion at the Takoradi Thermal Power Station, Adoadze, Ghana. H&K Job No. 4178

Dear Ms. Pappworth

In this letter we provide the results of our preliminary environmental sound level assessment for the T3 Expansion at the Takoradi Thermal Power Station.

It is our understanding that the T3 Expansion will consist of:

- Four (4) Zorya-Mashproekt GT25000 skid mounted Combustion Turbine (CT) driven generator sets. We assumed that the each CT generator set would be contained in an enclosure that would limit the exterior sound level to 85 dB(A) at a distance of 1 m. In addition we assumed that the CT intake would be equipped with a filter and a 4-foot (1.2 m) long muffler.

- Four (4) One Through Steam Generators (OTSG); one for each of the CT driven generator sets. These units have the capability to run in a "normal" mode (i.e. producing steam) or run "dry" (i.e. not producing steam). For the purpose of our study we assume the OTSG would be operated in the normal mode and there is no muffler in the ducting between the CT and OTSG or the OTSG exhaust stack.

- Two Steam Turbine Generator (STG) sets with enclosures containing the steam turbine, gear and electrical generator. We assumed that the each STG set would be contained in an enclosure that would limit the exterior sound level to 85 dB(A) at a distance of 1 m.

In addition we also understand that nearest off-site noise sensitive area (NSA) is an existing clinic located approximately 820 feet (250 m) east of the proposed T3 Expansion site.

We utilized the information on the equipment provided by Mr. Paul DePan (S&W Energy Solutions) to estimate the sound emission levels for each of the equipment items listed above. The estimated sound levels are shown on Table 1.

h&k

The sound level impact, due to the T3 Expansion only, were estimated at the NSA assuming simple hemispherical spreading and air absorption (86 °F & 90% RH). For this preliminary sound level assessment we did not consider attenuation due to barriers, buildings or vegetation. The results of our sound level estimate are shown on Table 2. In this table we show the sound pressure estimates for each individual item for each octave band from 31.5 through 8,000 Hz; as well as the overall A-Weighted sound level (dB(A)). The final row of Table 1 shows the summation of the individual items. Our analysis indicates that the total A-weighted sound level due to the T3 Expansion only will be approximately 66 dB(A).

To our knowledge we know of no studies that have documented the existing sound levels at the NSA. We were provided with the results of sound level surveys that were conducted in the vicinity of the existing facility in January, February, and March of 2009. From this data we would estimate that the existing ambient sound levels at the NSA is approximately 55 to 60 dB(A). Therefore our analysis would indicate that the operation of the T3 Expansion would increase the ambient sound levels at the NSA by approximately 6 to 11 dB(A).

We hope this information is beneficial and if questions arise please do not hesitate to contact us.

Sincerely
Hoover and Keith Inc.

Reginald H. Keith
President

h&k

Table 1 – Summary of Equipment Sound Power Levels (PWL or L_w in dB re 10^{-12}W)

Description	Octave Band Center Frequency - Hz 31.5	63	125	250	500	1000	2000	4000	8000	Awt	Notes
CT Enclosure	113	111	112	114	105	104	103	103	98	111	1
CT Intake	124	118	118	97	81	59	73	94	98	104	2
OTSG Exhaust Stack	121	116	115	113	109	101	90	80	74	110	3
OTSG Shell	134	124	124	118	110	99	97	96	84	135	
Steam Turbine Generator (STG)	115	118	118	113	107	105	102	93	97	111	4

Notes –

1. Assumes enclosure that can achieve 85 dB(A) average at 1 m.
2. Assumes attenuation due to an intake filter and a 4-ft (1.2 m) long silencer in the CT intake.
3. Assumes no additional attenuation other than that provided by the OTSG internal components during "normal" operation.
4. Assumes enclosure that can achieve 85 dB(A) average at 1 m

Table 2 – Summary of Sound Pressure Levels (SPL or L_p in dB re 20 μPa)
At the NSA – 820 Feet (250 m) East

Description	Octave Band Center Frequency - Hz 31.5	63	125	250	500	1000	2000	4000	8000	Awt
CT Enclosure	63	61	62	64	54	52	50	46	38	59
CT Intake	74	68	68	47	30	7	20	37	38	53
OTSG Exhaust Stack	71	66	65	63	58	50	38	24	13	59
OTSG Shell	84	74	74	68	59	47	44	39	23	63
Steam Turbine Generator (STG)	62	65	65	60	54	51	46	34	34	57
Total	**85**	**76**	**76**	**70**	**63**	**56**	**52**	**48**	**41**	**66**

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