AMANDI ENERGY LIMITED - GHANA

ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT VOLUME II - APPENDICES

190 MW COMBINED CYCLE POWER PLANT AT ABOADZE, GHANA

PARSONS BRINCKERHOFF

CONTENTS

APPENDIX 5A – AIR QUALITY CONSTRUCTION DUST ASSESSMENT

APPENDIX 6A – NOISE MODELLING REPORT

APPENDIX 7A – SUPPLIMENTARY OFFSHORE INFORMATION

APPENDIX 8A – ECOLOGY REPORT

APPENDIX 9A - COMPENSATION REPORT

APPENDIX 10A - PHASE 2 CONTAMINATION INVESTIGATION REPORT

APPENDIX X – ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

APPENDIX 5A

AIR QUALITY CONSTRUCTION DUST ASSESSMENT

Criteria for assessment of dust impacts (IAQM Guidance on the Assessment of Dust from Demolition and Construction– February 2014)

Table 5A.1: Criteria for defining sensitivity of receptors

Sensitivity of the Area	Human Receptor – Dust Soiling Effects	Human Receptor – Human Health Effects of PM_{10}	Ecological Receptor
High	- users can reasonably expect a enjoyment of a high level of amenity; or - the appearance, aesthetics or value of their property would be diminished by soiling; and the people or property would reasonably be expected a to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. - indicative examples include dwellings, museums and other culturally important collections, medium and long term car parks and car showrooms.	- locations where members of the public are exposed over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day). - Indicative examples include residential properties. Hospitals, schools and residential care homes should also be considered as having equal sensitivity to residential areas for the purposes of this assessment.	- locations with an international or national designation and the designated features may be affected by dust soiling; or - locations where there is a community of a particularly dust sensitive species such as vascular species included in the Red Data List For Great Britain. - indicative examples include a Special Area of Conservation (SAC) designated for acid heathlands or a local site designated for lichens adjacent to the demolition of a large site containing concrete (alkali) buildings.
Medium	- users would expect to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home; or - the appearance, aesthetics or value of their property could be diminished by soiling; or the people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. - indicative examples include parks and places of work. -	- locations where the people exposed are workers, and exposure is over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day). - indicative examples include office and shop workers, but will generally not include workers occupationally exposed to PM_{10}, as protection is covered by Health and Safety at Work legislation.	- locations where there is a particularly important plant species, where its dust sensitivity is uncertain or unknown; or - locations with a national designation where the features may be affected by dust deposition. - indicative example is a Site of Special Scientific Interest (SSSI) with dust sensitive features.
Low	- the enjoyment of amenity would not reasonably be expected; or	- locations where the people exposed are workers, and exposure is over a time period	- locations with a local designation where the features may be affected by dust deposition.

Sensitivity of the Area	Human Receptor – Dust Soiling Effects	Human Receptor – Human Health Effects of PM_{10}	Ecological Receptor
	- property would not reasonably be expected to be diminished in appearance, aesthetics or value by soiling; or - there is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. - indicative examples include playing fields, farmland (unless commercially-sensitive horticultural), footpaths, short term car parks and roads. a People's expectations will vary depending on the existing	relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day). - indicative examples include office and shop workers, but will generally not include workers occupationally exposed to PM_{10}, as protection is covered by Health and Safety at Work legislation.	- indicative example is a local Nature Reserve with dust sensitive features.

Table 5A.2: Criteria for determination of dust emission magnitude determination for demolition activities without mitigation

Demolition Criteria	IAQM Dust Emission Magnitude		
	Small	Medium	Large
Installation Volume	<20,000m^3	20,000m^3-50,000m^3	>50,000m^3
Material Dust Potential	Metal/timber cladding, demolition activity above <10m ground, during wetter months.	Potentially dusty demolition material, activities at 10-20m above ground.	Potentially dusty demolition material. Onsite crushing e.g. concrete and screening demolition activities >20m above ground level.

Table 5A.3 Criteria for dust emission magnitude determination for earthworks activities without mitigation

Earthworks Criteria	IAQM Dust Emission Magnitude		
	Small	Medium	Large
Site Area	<2,500m^2	2,500 – 10,000m^2	>10,000m^2
Soil/Material Type	Sand	Silt	Clay (dry)
Earthmoving equipment	<5 veh at a time	5 – 10 veh at a time	>10 veh at a time
Bunds / Stockpiles	<4m high	4 – 8m high	>8m high
Material Moved	<20,000 tonnes	20,000 -100,000 tonnes	>100,000 tonnes
Timing of Works	During wetter months	Various conditions	During drier months

Table 5A.4: Criteria for dust emission magnitude determination criteria for construction activities without mitigation

Construction Criteria	IAQM Dust Emission Magnitude		
	Small	Medium	Large
Installation Volume	<25,000m^3	25,000m^3-100,000m^3	>100,000m^3
Dust Potential of Construction Activities	Use of materials with low potential for dust release (e.g. metal cladding or timber)	e.g. use of dusty material such as concrete/ballast; piling	e.g. on-site concrete batching, sandblasting

Table 5A.5: Criteria for dust emission magnitude determination criteria for trackout activities without mitigation

Trackout Criteria	IAQM Dust Emission Magnitude		
	Small	Medium	Large
Number of HDV (>3.5t) per day	<10	10 – 50	>50
Extent of unconsolidated surfaces (i.e. unpaved road length)	<50m	50 – 100m	>100m
Surface material dust potential	Low	Moderately dusty i.e. some clay content	Potentially dusty i.e. high clay content

Table 5A.6: Criteria for determination of sensitivity of area to human health effects

Receptor Sensitivity	PM_{10} background concentration	Number of Receptors	Distance from the Source (m)				
			<20	<50	<100	<200	<350
High	>32 µg/m^3	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	28-32 µg/m^3	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	24-28 µg/m^3	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<24 µg/m^3	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	-	>10	High	Medium	Low	Low	Low
	-	10-10	Medium	Low	Low	Low	Low
Low	-	>1	Low	Low	Low	Low	Low

Table 5A.7: Criteria for determination of sensitivity of area to ecological impacts

Receptor Sensitivity	Distance from the Source (m)	
	<20	<50
High	High	Medium
Medium	Medium	Low
Low	Low	Low

Table 5A.8: Criteria for assessment of risk of dust impacts

Receptor Sensitivity	Dust Emission Magnitude		
	Large	Medium	Small
Demolition			
High	High Risk	Medium Risk	Medium Risk
Medium	High Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Negligible
Earthworks			
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Negligible
Construction			
High	High Risk	Medium Risk	Low Risk
Medium	Low Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Negligible
Trackout			
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Low Risk	Negligible
Low	Low Risk	Low Risk	Negligible

APPENDIX 6A

NOISE MODELLING REPORT

PARSONS BRINCKERHOFF

March 2015

AMANDI ENERGY COMBINED CYCLE POWER PLANT - BASELINE NOISE SURVEY REPORT

Amandi Energy Limited - Ghana

3513188A

[Issue 1]

Amandi Energy Limited - Baseline Noise Survey Report

3513188A

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CONTENTS **Page**

1	**INTRODUCTION**	**7**
1.1	Background	7
1.2	Published Guidance	7
1.3	Ambient Noise Levels - Discussion	7
2	**Methodology**	**8**
2.1	General	8
2.2	Short Term Sampling Measurements	8
2.3	Noise Measurements	8
3	**Results**	**10**
4	**References**	**11**

Annexes

A - Glossary of Acoustic Terminology **12**

B - Noise Monitoring Location map **14**

C - Calibration Certificates **16**

D - Noise Survey Forms **18**

1 INTRODUCTION

1.1 Background

1.1.1 Amandi Energy Limited, a Power Company in Ghana, proposes to build a nominal 240MW combined-cycled power plant. This plant will be situated on the acquired Amandi site which is situated approximately 1km west of the town of Aboadze The plant will include one gas turbine linked with a generator to produce electrical energy. Waste heat from the combustion chamber of the gas turbine will be routed into a Heat Recovery Stem Generator (HRSG) which will convert waste heat to energy by way of producing steam to feed a steam turbine.

1.1.2 Parsons Brinckerhoff has been commissioned by Amandi Energy Limited in Ghana Takoradi, to undertake an assessment of the existing noise levels at noise sensitive receptor (NSR) locations around the proposed Amandi site.

1.1.3 This report details the methodology and approach of the attended noise survey, and presents the full set of recorded measurements.

1.1.4 A glossary of acoustics terminology is provided in Annex A to assist the reader with technical aspects of this survey report.

1.1.5 The results of the noise measurements provide baseline noise information, which will be used to inform the updated Environmental & Social Impact Assessment (ESIA) for the proposed Amandi Energy combined power plant.

1.2 Published Guidance

1.2.1 The methodology detailed in British Standard (BS) 7445-1:2003[1] and BS 7445-3:1991[3], was followed during the surveys undertaken. BS 7445 defines and prescribes best practice during the recording and reporting of environmental noise.

1.3 Ambient Noise Levels - Discussion

1.3.1 During the noise survey exercise, it was noted that ambient noise levels, in the area of the Amandi site and the surrounding sensitive receptors, were dominated varying noise sources (depending on the NSR under consideration) which included road traffic noise from nearby roads, T1/T2/T3 plant (though T3 was running at half capacity and therefore produced less noise than T1 & T2), noise from the Volta River Authority (VRA) site, noise from overhead Pylons, sea splash noise from the Gulf of Guinea, noise from crickets and birds. The cricket noise was only at night.

2 METHODOLOGY

2.1 General

2.1.1 The noise survey was undertaken to quantify the existing ambient noise levels at NSR locations surrounding the Amandi site. There was a meeting on 31st January 2015 at the Amandi offices between Amandi and PB which included a site survey. Measurement locations and methodology was discussed and agreed. Due to the risks associated with carrying out unattended noise monitoring in unchartered terrain, attended monitoring approach was adopted for this exercise.

2.1.2 All noise measurements were carried out by persons deemed qualified and competent to carry out such noise measurements.

2.1.3 Short term attended noise measurements were taken at one location on the Amandi site and ten locations surrounding the site, to provide a description of the existing environmental noise levels on the site and in the local area of the site.

2.1.4 A Monitoring Location Map is attached in Annex B.

2.2 Short Term Sampling Measurements

2.2.1 Short term sampling measurements were conducted during the daytime, and night time. The measurement durations and time periods were as follows:

Weekday Daytime	– 0600hrs to 2200hrs	- 30 minute samples
Weekday Night time	– 2200hrs to 0600hrs	- 15 minute samples
Weekend Daytime	– 0600hrs to 2200hrs	- 60 minute samples
Weekend Night time	– 2200hrs to 0600hrs	- 15 minute samples

2.2.2 The following broadband values were recorded: L_{Aeq}, L_{A90}, L_{A10} ,L_{Amin} and L_{Amax}. The Fast time weighting and A-weighted frequency network were used.

2.3 Noise Measurements

2.3.1 All noise monitoring was conducted in accordance with the guidance set out in BS 7445:2003. Measurements were made using Class 1 Integrating-Averaging Sound Level Meters as defined in IEC 61672:2003. The noise meter was calibrated and checked before and after each measurement period, with negligible (0.1dBA) change in level noted. The sound level meter was placed in free field conditions at a height of 1.2 metres above ground level

2.3.2 The calibration certificate for the noise meter used is provided in Annex C, which also shows the serial number for the equipment used.

2.3.3 Measurements were undertaken during the day and night on a typical weekday and a weekend day. The weekend measurements were carried out on 1st February and 7th to 8th February 2015. The weekday measurements were carried out on Monday 2nd February through to Thursday 5th February 2015.

2.3.4 Weather conditions were conducive to successful monitoring; with wind speeds between 0-4m/s. where applicable, all roads were dry, and there was no significant rain at the time of measurement. The average ambient temperature was 32°C during

the daytime (though there was a high of 38°C), reducing to around 26°C during the night-time period. Though humidity was not measured it was perceived to be high.

2.3.5 The Parsons Brinckerhoff Acoustician was Samuel Miller CEng, FIOA.

3 RESULTS

3.1.1 Full results of the noise measurements are provided in the noise monitoring forms in Annex D.

3.1.2 Table 1 reports a summary of the measured L_{Aeq} noise levels, and Table 2 reports a summary of the measured L_{A90} noise levels.

Table 1 – Summary of Measured L_{Aeq} Noise Levels

Location ID		Measured $L_{Aeq,T}$ dB			
		Weekend		Weekday	
		Daytime T=30 mins	Night Time T=15 mins	Daytime T=1 hour	Night Time T= 15 mins
Location 1	Open Land (site)	44.9	52.5	46.2	57.6
Location 2	White Building	45.5	51.8	46.4	56
Location 3	VRA Hospital	55.8	55.7	58.4	56
Location 4	Brown Round Building	60.5	59	61.6	60.5
Location 5	T2 Expansion	54.2	N/A	N/A	N/A
Location 6	VRA Land (Car Park)	57.4	56.9	56.9	55.1
Location 7	WAGP	52.7	45.9	53.6	50.4
Location 8	Local Cuisine Restaurant	47.3	38.7	48.3	54.3
Location 9	Kwaku Anlo Village	44.4	41.8	55.3	50.9
Location 10	Town Houses (West of River Anakwari)	N/A	N/A	42.7	40.4
Location 11	Beach resort across the Anakwari Estuary	45.7	46.7	45.0	46.2

Table 2 – Summary of Measured L_{A90} Noise Levels

Location ID		Measured $L_{A90,T}$ dB			
		Weekend		Weekday	
		Daytime T=30 mins	Night Time T=15 mins	Daytime T=1 hour	Night Time T=15 mins
Location 1	Open Land (site)	41.6	51.7	44.4	55.5
Location 2	White Building	41.7	49.0	43.1	52.4
Location 3	VRA Hospital	53.9	54.0	55.2	54.8
Location 4	Brown Round Building	52.9	55.2	58.0	57.5
Location 5	T2 Expansion	53.4	N/A	N/A	N/A
Location 6	VRA Land (Car Park)	56.4	56.0	54.7	54.1
Location 7	WAGP	50.3	43.6	49.5	49.6
Location 8	Local Cuisine Restaurant	42.8	36.3	43.3	50.3
Location 9	Kwaku Anlo Village	42.0	37.6	41.3	47.8
Location 10	Town Houses (West of River Anakwari)	N/A	N/A	40.2	38.0
Location 11	Beach resort across the Anakwari Estuary	43.1	45.0	42.5	44.7

4 REFERENCES

1. BS 7445-1: 2003 “Description and Measurement of Environmental Noise: Guide to quantities and procedures", BSI

2. BS 7445-3: 1991 “Description and Measurement of Environmental Noise: Guide to application to noise limits ", BSI

3. IEC 61672:2003 "Electroacoustics - sound level meters", BSI

ANNEX A

GLOSSARY OF ACOUSTIC TERMINOLOGY

Glossary of Acoustics Terminology

Decibel (dB)	The decibel scale is used in relation to sound because it is a logarithmic rather than a linear scale. The decibel scale compares the level of a sound relative to another. The human ear can detect a wide range of sound pressures, typically between $2x10^{-5}$ and 200 Pa, so the logarithmic scale is used to quantify these levels using a more manageable range of values.
Sound Pressure Level (SPL)	The Sound Pressure Level has units of decibels, and compares the level of a sound to the smallest sound pressure generally perceptible by the human ear, or the reference pressure. It is defined as follows: $SPL\ (dB) = 20\ Log_{10}(P/P_{ref})$ where P = Sound Pressure (in Pa) P_{ref} = Reference Pressure $2x10^{-5}$ Pa An SPL of 0dB suggests the Sound Pressure is equal to the reference pressure. This is known as the *threshold of hearing*. An SPL of 140dB represents the *threshold of pain*.
A-Weighting	The human ear can detect a wide range of frequencies, from 20Hz to 20kHz, but it is more sensitive to some frequencies than others. Generally, the ear is most sensitive to frequencies in the range 1 to 4 kHz. The A-weighting is a filter that can be applied to measured results at varying frequencies, to mimic the frequency response of the human ear, and therefore better represent the likely perceived loudness of the sound. SPL readings with the A-weighting applied are represented in dB(A).
L_{90} or L_{A90} and other percentile measures	This represents the SPL which is exceeded 90% of the time, expressed in dB or dB(A). L_{A10} is used to quantify road noise levels. Other percentiles exist and are used for various types of noise assessment. These include L_{01}, L_{10}, L_{50}, L_{99}.
Noise	A noise can be described as an unwanted sound. Noise can cause nuisance.
Noise Sensitive Receptors (NSR's)	Any identified receptor likely to be affected by noise. These are generally human receptors, which may include residential dwellings, work places, schools, hospitals, and recreational spaces.
$L_{eq,\ T}$ or $L_{Aeq,\ T}$	The equivalent continuous sound level. It provides an “average” sound level over a defined period of time (T).
L_{Amax}	The maximum sound level measured.
L_{Amin}	The minimum sound level measured

ANNEX B

NOISE MONITORING LOCATION MAP

Figure 1 Monitoring Locations

ANNEX C

CALIBRATION CERTIFICATES

CERTIFICATE OF CALIBRATION

Date of Issue: 03 December 2013 **Certificate Number: TCRT13/1375**

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

M. Breslin [ ] K. Mistry [ ]

Customer	Parsons Brinckerhoff Ltd Amber Court, William Armstrong Newcastle Business Park Newcastle upon Tyne NE4 7YQ
Order No.	PB83176
Description	Sound Level Meter / Pre-amp / Microphone / Associated Calibrator

Identification

Manufacturer	*Instrument*	*Type*	*Serial No. / Version*
Rion	Sound Level Meter	NA-28	01070573
Rion	Firmware		1.8
Rion	Pre Amplifier	NH-23	70589
Rion	Microphone	UC-59	00367
Brüel & Kjær	Calibrator	4231	3002998
	Calibrator adaptor type if applicable		UC 0210

Performance Class 1

Test Procedure TP 2.SLM 61672-3 TPS-49

Procedures from IEC 61672-3:2006 were used to perform the periodic tests.

Type Approved to IEC 61672-1:2002 Yes Approval Number 21.21/07.01

If YES above there is public evidence that the SLM has successfully completed the applicable pattern evaluation tests of IEC 61672-2:2003

Date Received 29 November 2013 ANV Job No. TRAC13/11218

Date Calibrated 03 December 2013

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1:2002.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	16 November 2011	CAL111131	ANV Measurement Systems

CERTIFICATE OF CALIBRATION

Certificate Number
TCRT13/1375

Sound Level Meter Instruction manual and data used to adjust the sound levels indicated.

SLM instruction manual title	Sound Level Meter	NA-28
SLM instruction manual ref / issue		06-11
SLM instruction manual source		Manufacturer
Internet download date if applicable		N/A
Case corrections available		Yes
Uncertainties of case corrections		Yes
Source of case data		Manufacturer
Wind screen corrections available		Yes
Uncertainties of wind screen corrections		Yes
Source of wind screen data		Manufacturer
Mic pressure to free field corrections		Yes
Uncertainties of Mic to F.F. corrections		Yes
Source of Mic to F.F. corrections		Manufacturer
Total expanded uncertainties within the requirements of IEC 61672-1:2002		Yes
Specified or equivalent Calibrator		Specified
Customer or Lab Calibrator		Lab Calibrator
Calibrator adaptor type if applicable		UC 0210
Calibrator cal. date		11 November 2013
Calibrator cert. number		UCRT13/1183
Calibrator cal cert issued by Lab		ANV Measurement Systems
Calibrator SPL @ STP	94.12 dB	Calibration reference sound pressure level
Calibrator frequency	1000.00 Hz	Calibration check frequency
Reference level range	20 - 120 dB	

Accessories used or corrected for during calibration - Wind Shield
Note - if a pre-amp extension cable is listed then it was used between the SLM and the pre-amp.

Environmental conditions during tests	Start	End	
Temperature	22.03	22.18	± 0.20 °C
Humidity	41.5	41.5	± 3.00 %RH
Ambient Pressure	101.81	101.76	± 0.03 kPa

Response to associated Calibrator at the environmental conditions above.

Initial indicated level	94.4 dB		Adjusted indicated level	94.1	dB
The uncertainty of the associated calibrator supplied with the sound level meter ±				0.10	dB

Self Generated Noise	This test is currently not performed by this Lab.								
Microphone installed (if requested by customer) = Less Than						N/A	dB	A Weighting	
Uncertainty of the microphone installed self generated noise ±						N/A	dB		
Microphone replaced with electrical input device -				UR = Under Range indicated					
Weighting	A			C			Z		
	10.3	dB	UR	15.1	dB	UR	21.9	dB	UR
Uncertainty of the electrical self generated noise ±						0.12	dB		

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

For the test of the frequency weightings as per paragraph 12. of IEC 61672-3:2006 the Actual microphone free field response was used.

The acoustical frequency tests of a frequency weighting as per paragraph 11 of IEC 61672-3:2006 were carried out using an electrostatic actuator.

..... END .....

Calibrated by: A Patel

Additional Comments

None

Calibration Report

Certificate Number:-16651

Manufacturer:	**Rion**
Type:	**NC-74**
Serial no:	**00830766**

Customer:	**Parsons Brinckerhoff Ltd**
Department:	
Address:	**Queen Victoria House, Redland Hill, Bristol. BS6 6US.**
Order No:	
Contact Person:	**Adam Price.**

Measurement Results:

	Level: (dB)	P. Stab : (dB)	Frequency: (Hz)	F. Stab : (%)	Distortion: (% TD)
1:	93.91	0.06	1002.65	0.00	1.22
2:	93.90	0.01	1002.64	0.00	1.24
3:	93.91	0.01	1002.64	0.00	1.21
Result (Average):	**93.91**	**0.03**	**1002.64**	**0.00**	**1.22**
Expanded Uncertainty:	0.10	0.06	1.00	0.01	0.10
Degree of Freedom:	>100	4	>100	>100	>100
Coverage Factor:	2.00	3.31	2.00	2.00	2.00

The stated level is relative to 20µPa.

The stated level is valid at measurement conditions.
Reference microphone: WSM5 - B&K4192-2496459. Volume correction: 0.043 dB
Records:K:\C A\Calibration\Nor-1504\Nor-1018 CalCal\2014\RIONNC74_00830766_M1.nmf
Measurement procedure: TP-01
All results quoted are directly traceable to National Physical Laboratory, London

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA publication EA-4/02.

Environmental conditions:

Pressure:	Temperature:	Relative humidity:
101.461 ± 0.044 kPa	21.2 ± 0.2 °C	55.0 ± 0.9 %RH

Date of calibration: 23/07/2014
Date of issue: 23/07/2014

Supervisor : Darren Batten TechIOA
Engineer :

Michael Tickner
Software version: 6.0b

Campbell Associates
www.campbell-associates.co.uk

ANNEX D

NOISE SURVEY FORMS

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML1 - Open land (site)		
Equipment:	NA-28	**Engineers:**	Adam Price
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear
Post-Calibration:	94.0 dB	**GPS:**	4°58'4.80"N 1°39'55.70"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU0115	Weekend	Day	01/02/2015 11:46	15	2	S	32	44.5	74.1	58.4	37.8	48.5	46.7	44.1	41.4	Noise sources, t1 t2, noise from sea splash, birds. Sunny dry day.
AU0115	Weekend	Day	01/02/2015 12:01	15	2	S	32	45.3	74.9	60.8	38.2	50.7	47.2	44.8	41.8	
AU3615	Weekend	Night	08/02/2015 00:23	15	0	S	22	52.8	82.4	56.4	49.3	54.6	53.7	52.7	51.8	Crickets, sea splash distant t1t2. Generator off, construction noise
AU3615	Weekend	Night	08/02/2015 00:38	15	0	S	22	52.1	59.1	53.5	50.9	53.3	52.8	52.1	51.5	
AU2015	Week	Day	04/02/2015 10:14	15	2	S	22	46.2	75.8	54.9	41.8	49.7	47.8	45.9	44.3	Noise from t1 t2 sea waves bird noise
AU2015	Week	Day	04/02/2015 10:29	15	2	S	30	46.2	75.8	51.3	42.0	49.0	47.7	46.1	44.5	
AU2015	Week	Day	04/02/2015 10:44	15	2	S	30	46.0	75.6	59.9	42.1	48.9	47.4	45.7	44.1	
AU2015	Week	Day	04/02/2015 10:59	15	2	S	30	46.3	75.9	50.9	42.6	49.3	47.8	46.1	44.8	
AU1715	Week	Night	03/02/2015 23:25	15	2	S	22	57.6	87.2	60.0	51.8	59.3	58.7	57.9	55.5	noise from sea, crickets,faint t1

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML2 - White Building		
Equipment:	NA-28	**Engineers:**	Adam Price
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear * light drizzle for 2 minutes on 01/
Post-Calibration:	94.0 dB	**GPS:**	4°58'11.10"N 1°39'48.60"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU0215	Weekend	Day	01/02/2015 12:44	15	1.5	S	32	46.1	75.7	76.1	39.3	54.2	46.4	43.1	41.5	Noise sources distant plant noise (t1,2), water/sea noise, birds. Light drizzle two min.
AU0215	Weekend	Day	01/02/2015 12:59	15	1.5	S	32	44.9	74.5	67.4	39.3	51.1	45.8	43.4	41.8	
AU3415	Weekend	Night	07/02/2015 23:38	15	0.0	S	26	51.8	81.4	58.6	47.0	56.3	54.1	51.1	49.0	sea, Distant t1 t2, Cricket. Dog,
AU2115	Week	Day	04/02/2015 11:28	15	2	S	32	48.3	77.9	67.2	41.2	58.4	50.8	44.9	43.0	sea waves, birds, t1 t2 started 1127
AU2115	Week	Day	04/02/2015 11:43	15	2	S	32	44.5	74.1	55.2	41.4	48.9	45.7	44.1	43.1	040215 generator off for AQ 1207
AU2115	Week	Day	04/02/2015 11:58	15	2	S	32	45.5	75.1	57.6	40.9	52.5	47.2	44.6	43.2	distant aircraft. 1215 large bang - lid
AU2115	Week	Day	04/02/2015 12:13	15	2	S	32	46.4	76.0	66.0	41.6	54.4	48.1	44.5	43.2	closing from distance?
AU1515	Week	Night	03/02/2015 22:38	15	1	S	26	56.0	85.6	64.2	49.6	62.0	58.6	55.1	52.4	noise from t1 t2 & crickets

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML3 - VRA Hospital		

Equipment:	NA-28	**Engineers:**	Adam Price
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear
Post-Calibration:	94.0 dB	**GPS:**	4°58'27.10"N 1°39'18.10"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU0315	Weekend	Day	01/02/2015 14:20	15	2	S	32	56.0	85.6	67.9	51.8	62.3	57.6	55.2	53.7	Noise source, traffic noise from main road, t1 t2 plant
AU0315	Weekend	Day	01/02/2015 14:35	5	2	S	32	55.6	81.2	69.1	52.8	60.4	56.8	55.1	54.0	
AU3815	Weekend	Night	08/02/2015 01:31	15	0	S	26	55.7	85.3	62.7	52.5	59.2	57.2	55.4	54.0	t1 t2, pillions, air con.
AU2415	Week	Day	04/02/2015 17:29	15	0	S	26	57.5	87.1	73.8	53.5	64.0	59.2	56.5	55.3	t1 t2. Traffic noise from the main road .
AU2415	Week	Day	04/02/2015 17:44	15	1	S	28	57.2	86.8	71.9	53.9	61.8	58.7	56.7	55.4	Workmen ,Construction noise. air conditioning units . 1741 car horn. Overhead pylons.
AU2415	Week	Day	04/02/2015 17:59	15	1	S	28	56.5	86.1	73.2	53.2	60.5	57.6	56.1	54.8	
AU2415	Week	Day	04/02/2015 18:14	15	1	S	28	60.8	90.4	79.7	53.8	73.9	58.6	56.2	55.2	
AU2915	Week	Night	05/02/2015 22:18	15	1	S	26	56.0	85.6	70.5	53.0	60.7	56.9	55.7	54.8	t1 t2. Pylons , air con, RTN.

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML4 - Brown Round House		

Equipment:	NA-28	**Engineers:**	Adam Price	
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear	
Post-Calibration:	94.0 dB	**GPS:**	4°58'5.50"N	1°39'46.30"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU0415	Weekend	Day	01/02/2015 15:10	15	3	S	30	60.3	89.9	69.2	49.0	66.2	64.2	58.1	52.5	
AU0415	Weekend	Day	01/02/2015 15:25	15	3	S	30	60.7	90.3	71.3	49.7	66.4	64.3	59.1	53.3	Noise sources t1 t2, sea splash
AU3515	Weekend	Night	07/02/2015 23:59	15	3	S	26	59.0	88.6	66.7	48.5	63.5	61.4	58.3	55.2	Sea splash dominates. Generator off
AU2215	Week	Day	04/02/2015 12:42	15	2.5	S	32	61.7	91.3	71.4	54.0	65.5	63.8	61.5	58.7	
AU2215	Week	Day	04/02/2015 12:57	15	2.5	S	32	61.5	91.1	68.0	52.7	65.2	63.6	61.4	58.5	sea splash noise from sea dominates
AU2215	Week	Day	04/02/2015 13:12	15	2.5	S	32	61.3	90.9	73.6	52.4	64.9	63.6	61.0	57.3	
AU2215	Week	Day	04/02/2015 13:27	15	2.5	S	32	61.8	91.4	68.0	51.8	65.6	64.2	61.6	57.6	
AU1615	Week	Night	03/02/2015 23:00	15	4	S	26	60.5	90.1	66.2	52.2	64.3	62.6	60.1	57.5	sea splash dominates

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML5 - T2 Expansion		

Equipment:	NA-28	**Engineers:**	Adam Price
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear
Post-Calibration:	94.0 dB	**GPS:**	4°58'16.20"N 1°39'38.80"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU0515	Weekend	Day	01/02/2015 15:55	15	3	S	30	54.3	83.9	71.8	52.1	57.7	54.8	54.0	53.4	Noise sources, west – pylons, generator plus turbines
AU0515	Weekend	Day	01/02/2015 16:10	15	3	S	30	54.1	83.7	59.9	52.6	56.4	54.9	54.0	53.4	

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML6 - VRA Land (Car Park)		

Equipment:	NA-28	**Engineers:**	Adam Price
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear
Post-Calibration:	94.0 dB	**GPS:**	4°58'14.70"N 1°39'21.40"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU0615	Weekend	Day	01/02/2015 16:56	15	2	S	32	57.0	86.6	70.6	54.0	59.3	58.0	57.0	55.8	
AU0615	Weekend	Day	01/02/2015 17:11	15	2	S	30	57.8	87.4	65.9	55.8	60.5	58.7	57.7	56.9	Noise sources t1 t2 plant, pillion noise.
AU3715	Weekend	Night	08/02/2015 01:06	15	3	S	32	56.9	86.5	60.6	55.0	58.6	57.9	56.8	56.0	Noise from t1 t2 & cooling tower
AU2815	Week	Day	05/02/2015 16:26	15	3	S	32	55.8	85.4	70.0	52.5	59.7	57.0	55.3	54.4	
AU2815	Week	Day	05/02/2015 16:41	15	3	S	32	57.0	86.6	71.7	53.5	64.6	58.2	55.8	54.8	Noise from main road construction
AU2815	Week	Day	05/02/2015 16:56	15	3	S	32	56.0	85.6	68.7	53.1	60.7	57.2	55.6	54.6	noise from nearby t1t2 pillion noise.
AU2815	Week	Day	05/02/2015 17:11	15	3	S	30	58.2	87.8	74.4	53.0	65.5	61.2	56.3	55.0	
AU1215	Week	Night	02/02/2015 23:57	15	0.5	S	26	55.1	84.7	66.2	52.7	57.3	56.1	55.0	54.1	Noise sources t1 t2 plant, pylons, crickets.

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML7 - WAGP, West African Gas Pipeline		

Equipment:	NA-28	**Engineers:**	Adam Price
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear
Post-Calibration:	94.0 dB	**GPS:**	4°58'32.60"N 1°39'33.20"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU0715	Weekend	Day	01/02/2015 17:37	15	2	S	26	52.4	82.0	73.2	48.5	60.6	52.9	51.2	50.0	Noise source t1 t2 plant
AU0715	Weekend	Day	01/02/2015 17:52	15	2	S	26	53.0	82.6	71.8	48.8	61.6	53.4	51.6	50.5	
AU3915	Weekend	Night	08/02/2015 01:52	15	3	S	26	45.9	75.5	58.4	42.5	50.1	48.3	44.3	43.6	Sources t1 t2 t3, crickets, pylons.
AU2715	Week	Night	05/02/2015 15:13	15	3	S	22	54.1	83.7	79.3	47.7	63.6	55.0	50.8	49.3	t1 t2, traffic off site, pylons,
AU2715	Week	Day	05/02/2015 15:28	15	3	S	22	54.2	83.8	72.6	48.1	64.2	55.7	51.4	50.1	construction works (men using
AU2715	Week	Day	05/02/2015 15:43	15	3	S	22	50.8	80.4	64.8	47.6	55.4	51.9	50.5	49.3	hammers,shouting) 1604 thunder slight
AU2715	Week	Day	05/02/2015 15:58	15	3	S	22	54.5	84.1	74.7	48.0	66.8	54.8	50.7	49.4	rumble.
AU1315	Week	Night	03/02/2015 00:18	15	2	S	22	50.4	80.0	56.3	48.1	52.5	51.4	50.3	49.6	Noise sources t1 t2 plant and substation behind t1 t2. T3 is not on

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML8 - Local Cuisine Restaurant		

Equipment:	NA-28	**Engineers:**	Adam Price
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear
Post-Calibration:	94.0 dB	**GPS:**	4°58'53.76"N 1°39'50.62"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU3115	Weekend	Day	07/02/2015 12:17	15	3	S	30	46.5	76.1	66.3	40.1	54.7	48.7	44.7	42.4	t1t2, trees, children playing in
AU3115	Weekend	Day	07/02/2015 12:32	15	3	S	30	48.0	77.6	77.7	41.0	54.2	49.2	45.5	43.2	orphanage , distant cock crowing,
AU4015	Weekend	Night	08/02/2015 02:13	15	3	S	30	38.7	68.3	57.4	34.5	43.9	41.1	37.9	36.3	Noise sources cricket, t1 t2 and
AU1415	Week	Day	03/02/2015 17:10	15	3	S	22	47.5	77.1	68.4	41.6	54.0	49.3	45.9	43.8	t1t2 plant, traffic noise from VRA road
AU1415	Week	Day	03/02/2015 17:25	15	3	S	22	48.8	78.4	69.5	40.0	57.0	50.3	46.8	43.7	(100m), Bird noise,1725hrs car horn in
AU1415	Week	Day	03/02/2015 17:40	15	3	S	22	48.1	77.7	62.7	38.0	55.8	50.8	46.5	43.5	distance, 1738&1800hrs motor cycle,
AU1415	Week	Day	03/02/2015 17:55	15	3	S	22	48.6	78.2	73.5	39.1	57.6	48.8	44.1	42.1	1745hrs orphanage.
AU1915	Week	Night	04/02/2015 00:17	15	0	S	22	54.3	83.9	65.2	47.5	59.9	57.1	53.3	50.3	plant noise, dog, crickets. 3 cars pass

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML9 - Kwaku Anlo Village		
Equipment:	NA-28	**Engineers:**	Adam Price
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear
Post-Calibration:	94.0 dB	**GPS:**	4°58'39.88"N 1°39'53.39"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU3015	Weekend	Day	07/02/2015 11:35	15	1.5	S	30	44.6	74.2	65.0	39.6	49.5	46.2	43.7	41.9	Distant rustling of trees, Bird noise
AU3015	Weekend	Day	07/02/2015 11:50	15	1.5	S	30	44.2	73.8	64.2	40.0	48.1	45.7	43.8	42.1	
AU4115	Weekend	Night	08/02/2015 02:30	15	1.5	S	26	41.8	71.4	57.8	35.7	48.0	46.2	39.5	37.6	cricket, t1 t2 and t3.
AU2315	Week	Day	04/02/2015 16:10	15	0	S	32	50.2	79.8	75.6	39.4	59.5	48.9	43.5	41.5	noise from distant plant plus chickens
AU2315	Week	Day	04/02/2015 16:25	15	0	S	32	53.6	83.2	76.7	38.8	67.5	47.4	42.4	40.9	walking around . Cock crowing.1648
AU2315	Week	Day	04/02/2015 16:40	15	0	S	32	59.2	88.8	83.7	39.4	74.1	52.2	43.4	41.3	Thunder sound but no rain dry sunny
AU2315	Week	Day	04/02/2015 16:55	15	0	S	32	52.8	82.4	78.5	39.0	63.6	49.0	43.0	41.4	hot.
AU2515	Week	Night	04/02/2015 22:43	15	0	S	26	50.9	80.5	71.7	45.8	54.3	52.4	49.3	47.8	dog,T1,T2 plant noise. Crickets.

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML10 - Town Houses (West of River Anakwari)		

Equipment:	NA-28	**Engineers:**	Adam Price	
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear	
Post-Calibration:	94.0 dB	**GPS:**	4°58'6.70"N	1°40'16.50"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU0915	Week	Day	02/02/2015 17:25	15	1	S	28	43.0	72.6	57.0	37.7	47.3	45.0	42.4	40.4	Noise sources Sea plus ships but fairly
AU0915	Week	Day	02/02/2015 17:40	15	1	S	28	42.3	71.9	56.3	37.6	46.5	44.2	41.9	39.9	quiet, couldn't hear plant noise from t1
AU2615	Week	Night	05/02/2015 07:05	15	0.5	S	29	40.4	70.0	57.9	35.4	44.8	42.0	39.7	38.0	sea splash, birds, t1 t2 very faint

Noise Monitoring Form

PARSONS BRINCKERHOFF

Project:	Amandi Ghana	**Job Number:**	3513188A
Location:	ML11 - Beach Resort across the Anakwari Estuary		
Equipment:	NA-28	**Engineers:**	Adam Price
Pre-Calibration:	94.0 dB	**Weather Description:**	Dry / Clear
Post-Calibration:	94.0 dB	**GPS:**	4°57'59.40"N 1°40'30.70"W

Measurement Period					Weather			Statistical Noise Levels / dB(A)								Description of Audible Noise
File name	Period	DAY/Night	Start Time & Date	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temp (°C)	L_{eq}	L_E	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}	
AU3215	Weekend	Day	07/02/2015 13:30	15	4	S	32	46.2	75.8	65.9	40.5	52.2	46.8	44.6	42.9	Noise sources Sea splash, car pass.
AU3215	Weekend	Day	07/02/2015 13:45	15	4	S	32	45.1	74.7	57.2	41.2	48.4	46.5	44.9	43.2	
AU3315	Weekend	Night	07/02/2015 22:36	15	4	S	26	46.7	76.3	59.2	42.9	49.8	48.1	46.4	45.0	crickets, sea splash, boat noise. 2248hrs – car door slam.
AU1015	Week	Day	02/02/2015 18:18	15	0.5	S	28	45.4	75.0	73.8	39.8	50.1	46.9	44.4	42.5	Noise sources Sea splash, cricket
AU1015	Week	Day	02/02/2015 18:33	15	0.5	S	28	45.0	74.6	57.3	40.1	49.2	46.8	44.6	42.8	
AU1115	Week	Night	02/02/2015 22:46	15	0.5	S	26	46.2	75.8	58.9	42.4	49.1	47.7	46.0	44.7	Cricket, sea splash, boat noise

SECTION 7A

SUPPLIMENTARY OFFSHORE INFORMATION

4.0 DESCRIPTION OF EXISTING ENVIRONMENT

4.1 Baseline Noise Level Studies

The statistical analysis of a one week beach front noise (L_{eq}) monitoring programme undertaken as part of the baseline noise survey for the main power plant project recorded noise levels between 55.5dBA – 103.8dBA as in Table 1 L_{min} and L_{max}) below, with background noise (L_{90}) from the sea waves and T1 operation between 68dBA and 104dBA.

The average noise levels measured at the beach front (proposed site for the seawater intake project) are however within the EPA allowable limit of 70dBA for industrial areas.

Table 1 Ten - Day Baseline Noise Data at Proposed Project Site

Noise Parameter	Lmax	L90	L50	L10	Lmin
	dBA	dBA	dBA	dBA	dBA
09-Sep	68.9	68.3	66.8	65.0	64.2
10-Sep	82.9	82.9	67.6	65.3	64.6
11-Sep	94.6	94.6	79.9	68.9	66.6
12-Sep	88.8	88.8	76.0	69.5	60.1
13-Sep	94.6	94.6	75.8	62.6	58.2
14-Sep	93.8	93.8	64.7	57.3	55.5
15-Sep	103.8	103.8	70.7	58.5	57.4
16-Sep	94.6	94.6	75.5	62.5	57.2
17-Sep	79.4	79.4	60.3	57.4	56.1
18-Sep	68.2	68.2	62.5	57.8	56.3

Taking into consideration background noise from the operation of the T1 Plant and noise from sea waves, the results indicate that general noise levels at the seawater intake project site is quite high hence there is the need to ensure worker health protection by provision of ear protection equipment to all workers during the construction phase.

4.2 Bathymetric Studies of the Marine Environment

Studies were carried out to clearly identify the bathymetric conditions currently existing in the marine environment establish seabed profile in the project area to facilitate the laying of undersea pipelines for intake and discharge of seawater. The methodology employed was the Single-Beam Echosounding Survey (SBES) and it provided a large-scale view of the submarine topography of the area.

Figure 1 Satellite Image of Bathymetric Survey Site

Figure 3 Contour (1m interval) Plot of the Bathymetry of the Seawater Intake Site

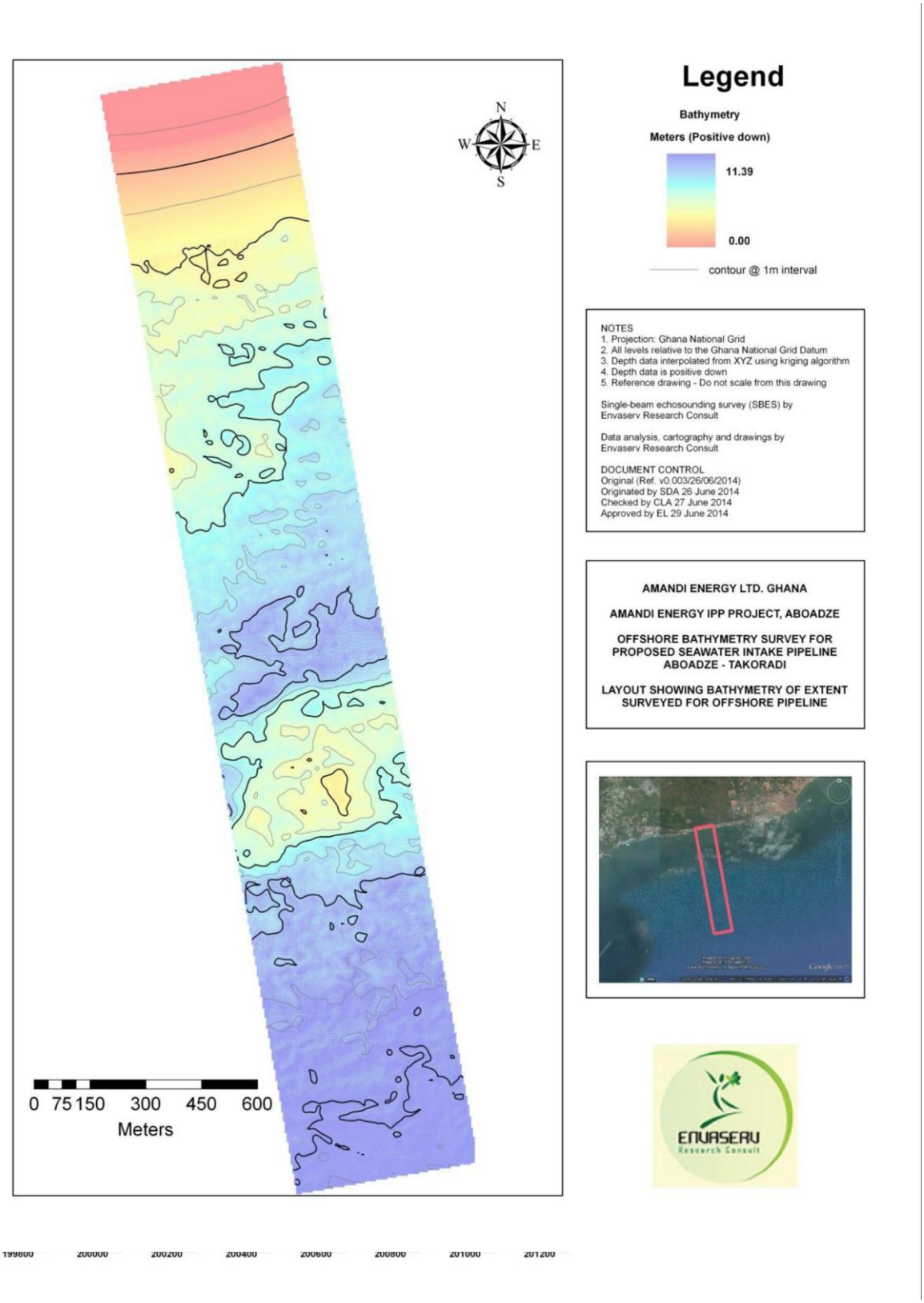
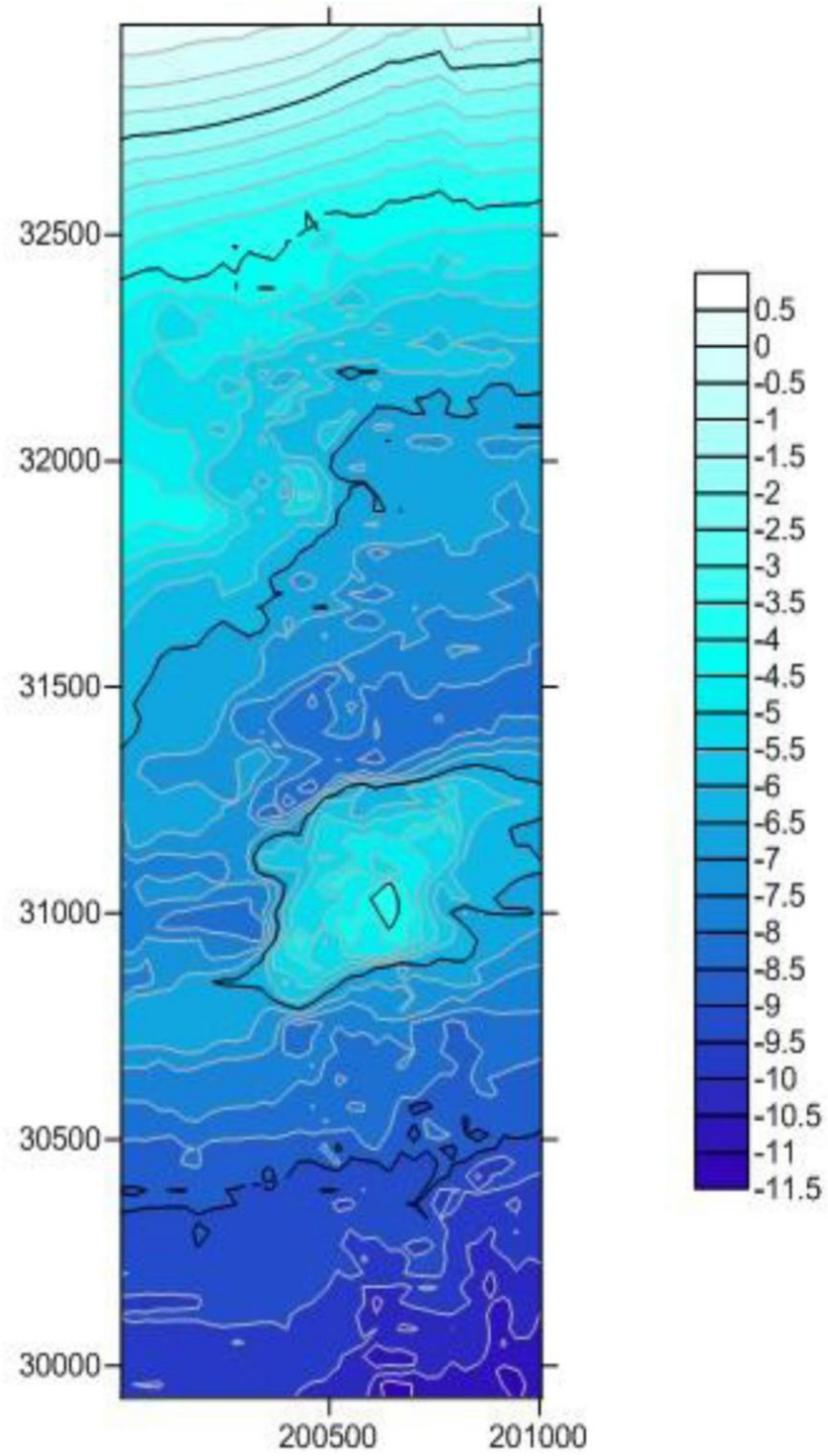
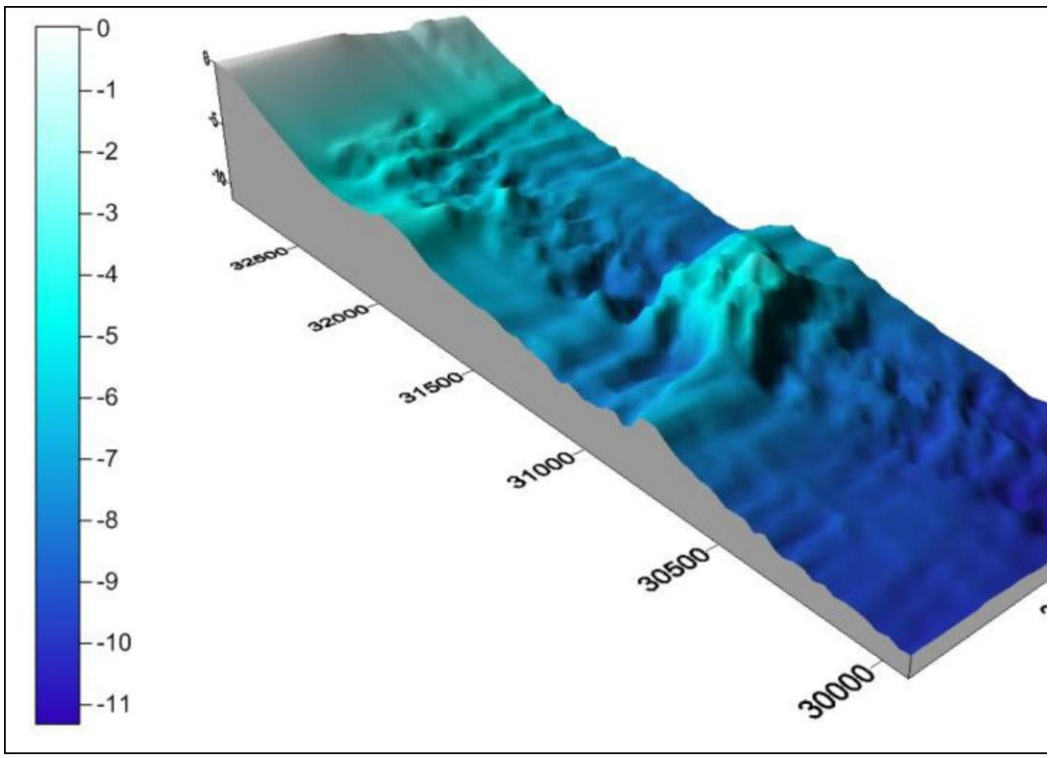


Figure 4 Contour (0.5m interval) Plot of the Bathymetry of the Seawater Intake Site



The results indicate that the near shore bathymetry showed a gentle profile of about 1:300 gradient, sloping seawards. The breaker zone extended to about 1000m seawards from the coast but may become closer to shore at high tides. The surf zone extends from the breaker zone to the shoreline and has secondary waves breaking close to shore (about 250m) after reforming from the breaker zone. A significant rise of about 5m was observed on the seafloor at about 2000m from the shoreline within the survey corridor. The rise in the seafloor seems to extend across most of the survey corridor, extending eastwards. On the whole, the topography of the seafloor was generally undulating and showed areas of depressions and elevations as exhibited on the surface plots. (Figures 6 and 9)

Figure 5: 3D Plot of Bathymetry Vertical Scale



This has implications for the choice of the pipeline ROW and the quantity of material to be excavated as well as the environmental aspects of the disposal of waste which will be examined in the impact mitigation section.

4.3 Metocean Study and Modeling

An accurate and in depth study of the wave regime (intertidal studies) in the project area was commissioned by Amandi Energy Ltd. to serve as input into the ESIA. The purpose is to gather all necessary data that will inform the risks associated with all sea based construction maintenance and operation activities and will help guide the necessary precautions that need to be put in place.

The report (Appendix www) presents the findings of a desk-based MetOcean study conducted for Amandi Energy Ltd along a defined corridor in the nearshore waters off Aboadze-Takoradi for an offshore intake water pipeline. The report shows results of analysis conducted on wind, waves, water quality, biota and sediment data available for the area. The report compared the existing data with data modeled for the area to present a clear picture of the meteorological and oceanographic conditions prevailing in the area.

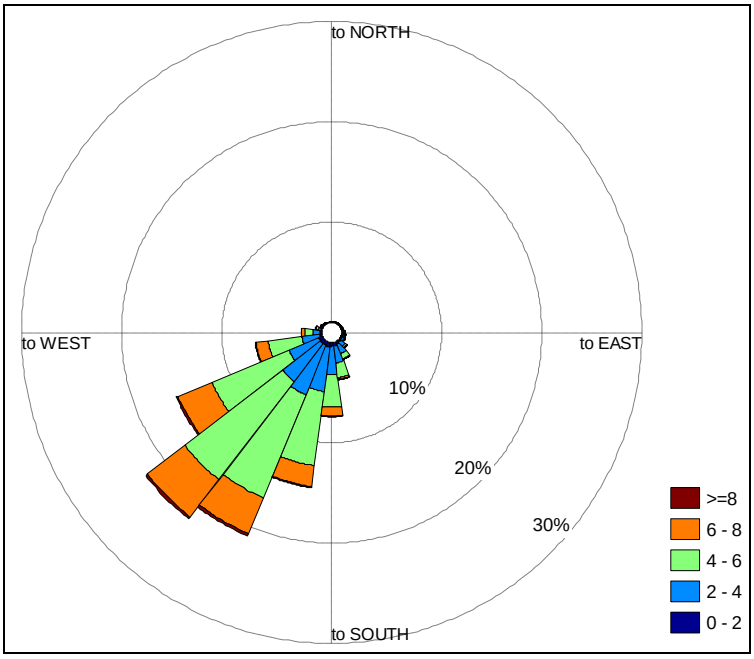
4.3.1 Winds

Atmospheric circulation within the Gulf of Guinea is influenced by the north and south trade winds, which converge in the Inter-Tropical Convergent Zone (ITCZ). The ITCZ is a low pressure system oscillating north and south of the equator, influencing seasonal variations in weather. Primary wind direction is southwest during the year. Extreme winds are caused by line squalls, usually moving from east to west. The squalls generate very strong winds at sea, but are thought to induce weak currents and low wave amplitudes as a result of limited fetch. There are two squall seasons, June to November when the ITCZ is north of the equator and in December to May when the ITCZ is usually south of the equator. Data is currently not available for the extreme squall winds conditions along the Takoradi coast.

Figure 10 below shows the predominant wind direction, speed and probability distribution in a rose plot, computed from 10-year wind data from 1997 to 2006 for the Takoradi shoreline. From the rose plot, the predominant wind direction is south-west with wind speeds rarely exceeding 8 meters per second. Winds were weak from the south and the west with less than 10% occurrence for each direction. The dominant wind speed is between 4 and 6 meters per second with wind speeds maxing at about 8 meters per second. Wind speeds up to 4 meters

per second and between 6 and 8 meters per second occurred at about 5% probability. It is also observed that wind speeds between 4m/s and 6m/s from about 225 nautical degrees had the highest probability of occurrence for the coast of Takoradi.

Figure 6 Wind rose showing predominant wind direction, speed and % of occurence for Takoradi coast



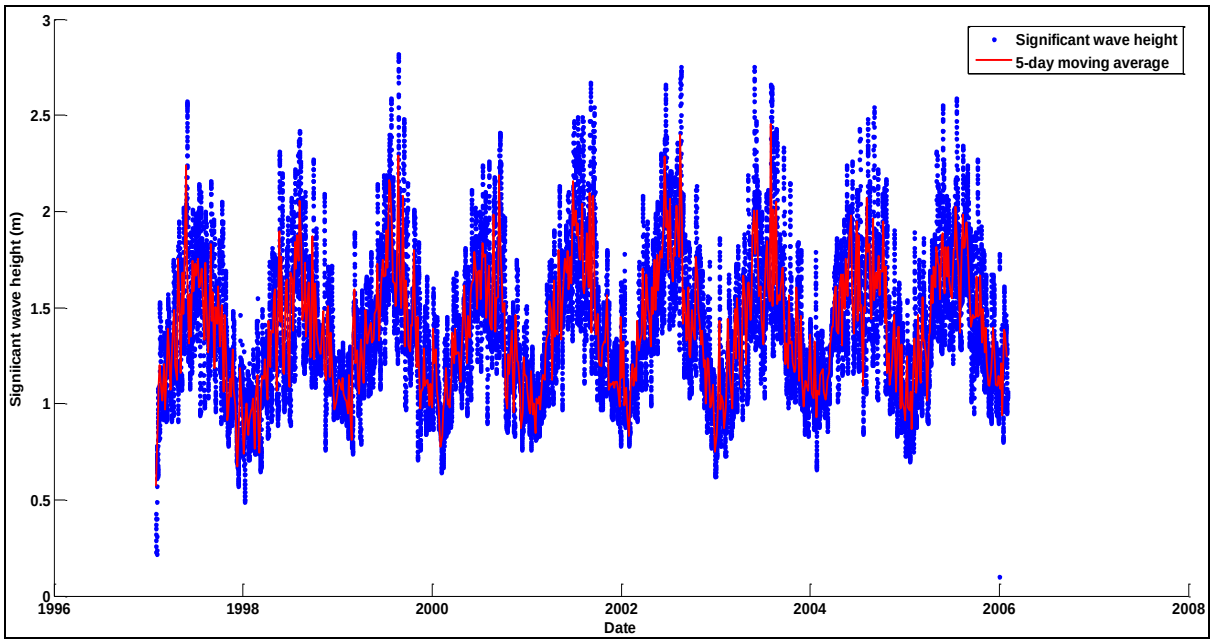
Note: The colored legend indicates wind speed while the percentages on the concentric circles within the rose plot indicate percent of occurrence of winds.

4.3.2 Waves

The wave climate along the Gulf of Guinea (including the study area) is dominated by extra-tropical storms from the South Atlantic, effects of trade winds south of West Africa and local storms. The South Atlantic extra-tropical storms and the storms induced by the trade winds south of West Africa arrive at the Gulf of Guinea as swells due to wave dispersion and this is mixed up with the seas generated by local storms, creating a dual-peak wave spectrum. The principal direction of the waves change slightly during the year with the direction predominantly being from the southwest from January to May and predominantly south from May to December. The wave climate off the Ghanaian coast is generally considered mild, but is not completely calm, with a swell of about 1 m present most of the time as a result of the persistent SE trades and/or southern swell.

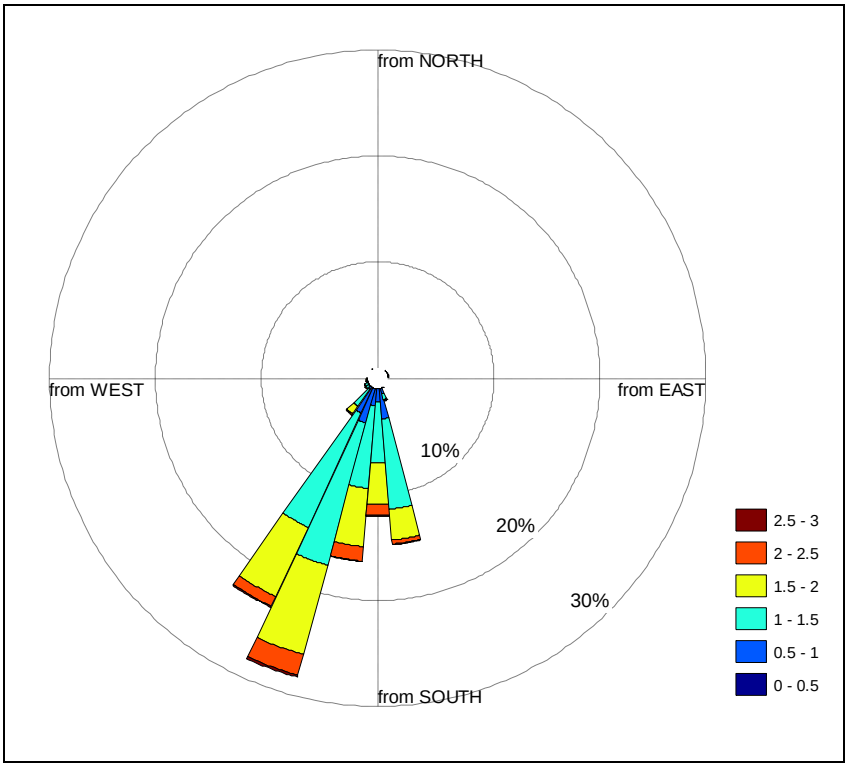
Figure 11 is a scatter plot of the significant wave height (Hs) and a 5-day moving averages of the Hs for the coast of Takoradi. Significant wave height values ranged from about 0.5 m to 2.8 m while the 5-day moving average ranged from 0.5 m to 2.5 m.

Figure 7 Five day moving average of wave height and significant wave height for Takoradi coast



A rose plot of the wave data is presented in Figure 12 below and shows also the % probability of Hs

Figure 8 Rose plot of wave spectra showing wave direction and significant wave height

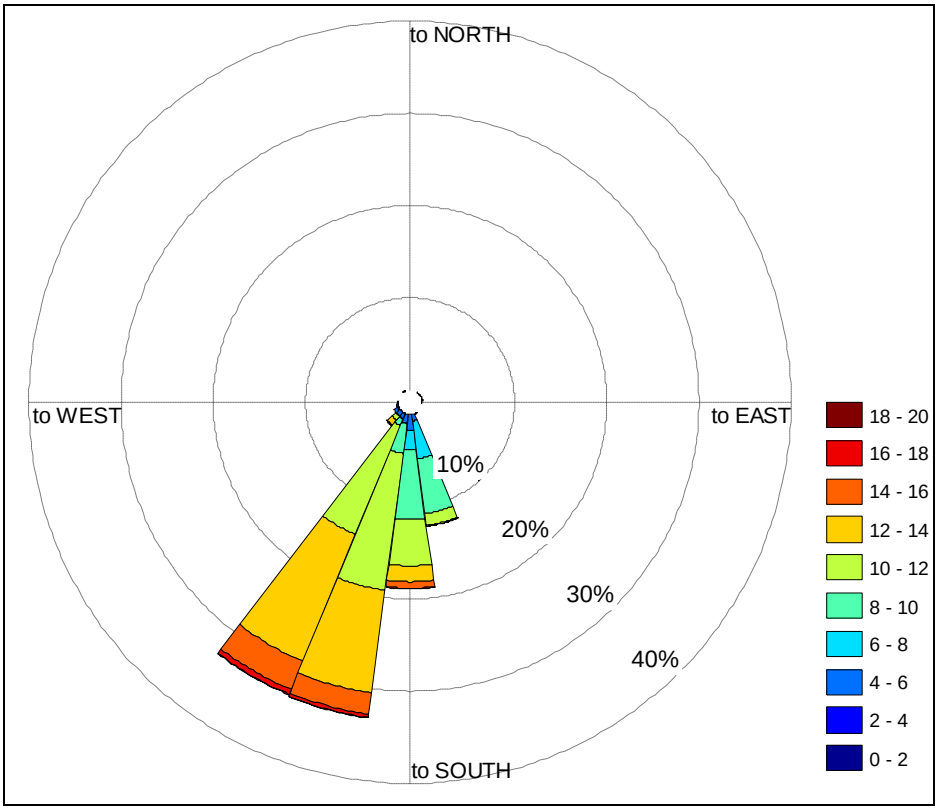


Note: The color legend shows values for significant wave height Hs and the concentric circles in the rose plot shows labels for occurrence of Hs

The figure shows the waves spreading from SSE to SSW, but mainly coming from SSW. The waves from SSE were dominated by Hs between 1m and 1.5m while waves from all other directions had waves with Hs ranging from 1m and 2m. Waves from SSE and S had less than 20% occurrence while waves from SSW had between 20% and 30% occurrence. The highest joint probability of Hs and wave direction occurring along the coast of Takoradi were waves with Hs between 1m and 1.5m from 200 nautical degrees.

Figure 13 is a rose plot of peak wave (Tp). The figure shows that Tp for waves coming from SE were predominantly between 6 and 10 seconds, from the south were predominantly between 8 and 12 seconds, and from the SSW predominantly between 10 and 14 seconds.

Figure 9 Rose plot of peak waves Tp for the takoradi coast



Note: The color legend shows the range of Tp and the concentric circles in the plot show percentage of occurrence.

Wave model studies with Delft3D suggest that the waves approach the shore from a SSW direction but refract close to shore and hit the coastline at almost shore normal.

4.3.3 Tides (Water Level)

The tidal cycle along the Takoradi coast is regular and semi-diurnal with an average tidal range of about 1.32 m (Wiafe et al. 2013). The tidal currents are sluggish and generally have reduced influence on coastal processes except within tidal inlets (AESC, 1997). Other possible sources of intermittent increases of local water levels include line squalls and the transfer of energy from internal to surface tides, resulting in additional increases of about 0.30 m (Longhurst, 1962).

Tidal data for the Takoradi coast was sourced from the GLOSS portal for the Takoradi port, one of the oldest ports along the West African coast. Figure 14 shows the tidal time series data obtained from January 2007 to January 2013. The time series shows significant data gaps where the tide gauge was not functional. Figure 15 shows a sample data set covering the

month of April 2008 from the data set. The result shows a diurnal tidal pattern ranging about 0.8m either side of a mean tidal level. It must be noted that the tidal data is related to survey benchmarks and is not connected in a real sense to any datum. Tidal constituents obtained from data analyses are presented in Table 3 below.

Table 2 Tidal parameters from water level analysis for Takoradi

Description	Abbreviation	Value (cm)
Mean Sea Level	MSL	114.24
Mean High Water Spring	MHWS	163.76
Mean Low Water Spring	MLWS	65.35
Highest Astronomical Tide	HAT	204.39
Lowest Astronomical Tide	LAT	27.33
Highest Water Level Tide	HWLT	214.1

Figure 10 Tidal times series (water level) January 2007 to January 2013 for Takoradi

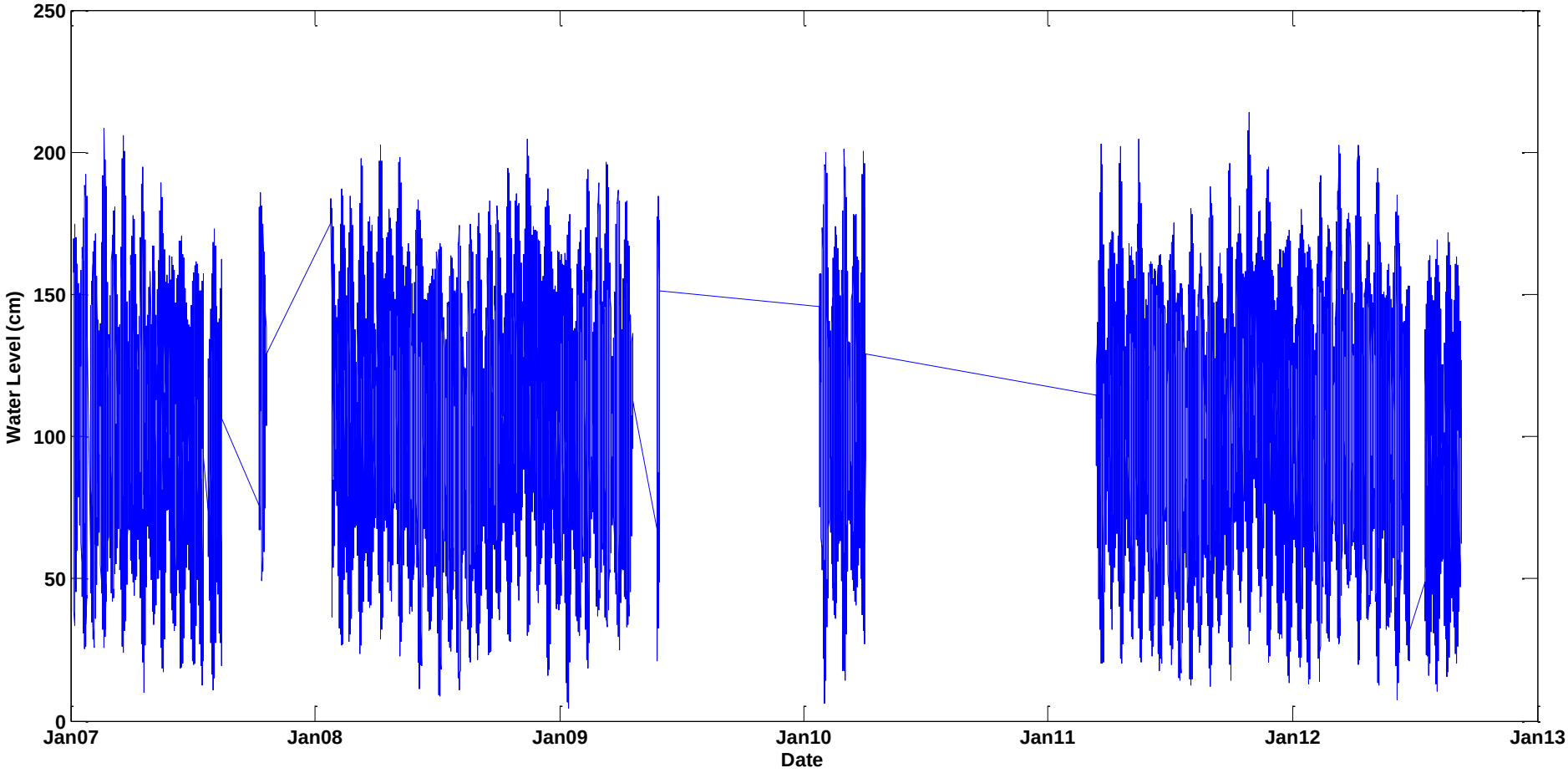
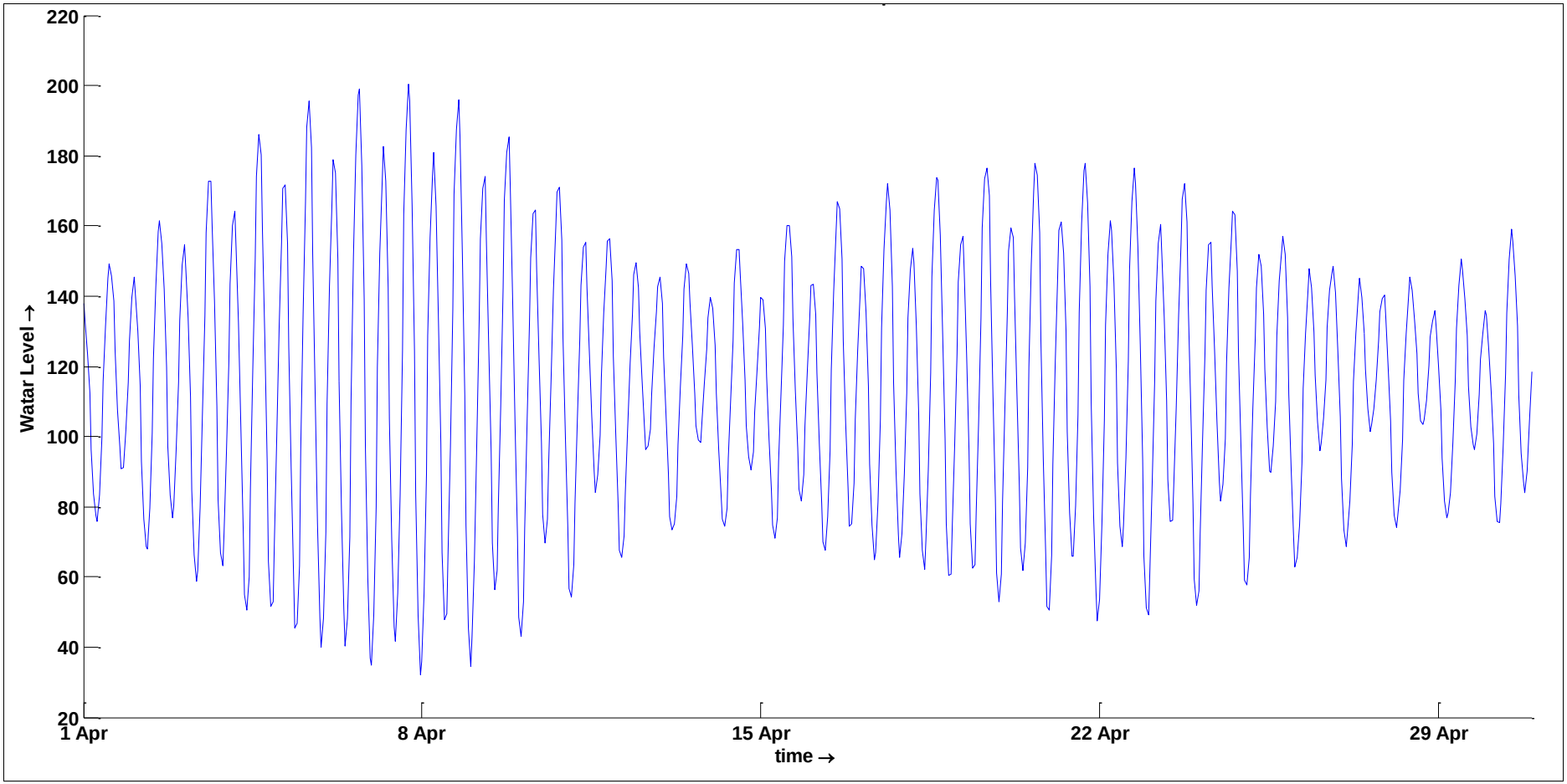


Figure 11 Sample tidal (water level) data April 2008 for Takoradi harbour


220
200
180
160
140
120
100
80
60
40
20
Watar Level →
1 Apr
8 Apr
15 Apr
22 Apr
29 Apr
time →

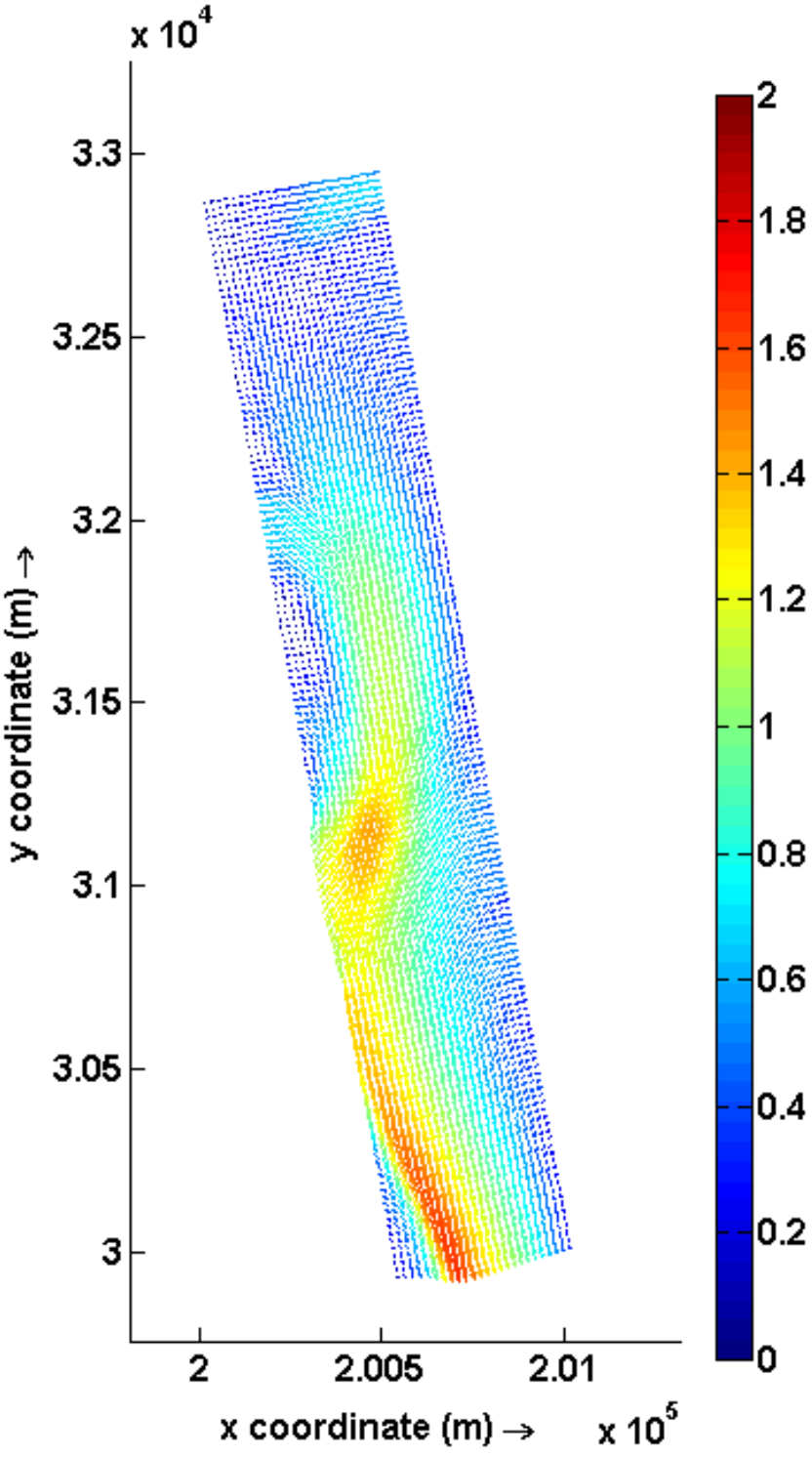
4.3.4 Currents

Two types of currents affect the coast of Takoradi, which are large-scale currents and local currents. The large-scale currents are surface currents and internal currents. The main large-scale current is the Guinea current. This is an offshoot of the Equatorial Counter Current (ECC), a current induced by the oceanic gyres of the North and South Atlantic Oceans that flows in an eastward direction (Mensah and Koranteng, 1988; Bernacsek, 1986; Longhurst, 1962). This ECC becomes known as the Guinea Current as it runs from Senegal to Nigeria. A small westward-flowing current, which is counter to the predominant direction of the Guinea Current, lies about 40 m beneath the Guinea Current and appears to turn to the southwest near the bottom (Binet et al., 1991; Longhurst, 1962).

Local currents in the area include longshore currents, onshore currents, rip currents and sub-surface flows peculiar to the specific project area. No current data was found for the area at this particular time, particularly current data at various depths.

However, for the purpose of this report, a near shore circulation model was initialized using the Delft 3D modeling software. The model output, which was depth averaged suggests that the currents flow towards the general direction of the shore then turn more or less eastwards along the shore at about 0.6 to 1.5 meters per second.

Figure 12 Nearshore current modelled along survey corridor



Note: The color bar legend indicates current velocities while the arrows show current direction

4.3.5 Seawater Quality

Data used in seawater quality assessment was a desk study of existing data augmented with in situ samples collected during the SBES survey. The survey involved CTD profile casts and water sampling with a Niskin water sampler along the pipeline corridor. Table 4 shows the coordinates for the various water sampling locations and Figure 17 is a Google image depicting the various stations sampled.

Table 3 Coordinates of Seawater sampling locations

Station Location	X-coordinates	Y-coordinates
A6	200444.50	30416.59
F2	200596.82	32474.36
E2.5	200530.46	32273.75
C3	200380.68	31920.21
A4	200268.63	31400.42
D5	200661.03	30958.61
E6	200832.63	30491.72
A6	200494.48	30426.41
C7	200724.3	30030.06
F7	201063.12	30089.62

Figure 13 Seawater quality sampling locations

Note: Stations are named as the intersection point between lines oriented normal to the shore (labeled A to F) and lines oriented parallel to the shore (labeled 1 to 7).

A summary of the seawater quality analysis shows the following

- The temporal pattern of the results indicated a fairly uniform salinity and pH from January to December with the temporal variations within a narrow unit.
- The pH levels were moderately basic as expected due to the buffering effects of CO_3^{2-}.
- The pH levels were lower between August and December than January to July, which again could be the influence of the season.
- The temporal patterns of composite CTD information including temperature, density and conductivity were generally uniform except that July, August and September depicted low temperatures and conductivity and higher water density. The observation could be the resultant influence of the rains since those periods coincided with the known rainy period in the country. There are two bimodal peaks in the rainy season, the major rainy season starts from May and gets maxima in July, whereas the minor season starts from September and ends in November.

- Electrical conductivity was slightly higher at surface water layers than bottom suggesting higher ion concentrations at the surface than bottom.
- However, the electrical conductivity profile indicated a declension with water depth.
- The pattern of the electrical conductivity mimics that of salinity. Salinity concentration ranged between 34.8 and 35.8 ‰.
- Water density showed increasing concentration with water depth and largely mimicked the pattern of salinity. Seawater density often varies with water temperature, salinity and depth.
- The seawater temperature showed decreasing levels with water depth notably from July to September. The temperature profile suggests the existence of a minor thermocline that may prevent mixing of bottom and surface water layers. Thermocline is thermally stratified seawater in which there is a rapid decrease in temperature with depth. When the thermocline breaks as a result of coastal upwelling, homogeneity in physicochemical variables occur.
- The near surface water temperature averaged 26.56±2.49^{0}C and the near bottom temperature was 25.34°C ± 2.70°C. The average CTD temperature profile measured in June 2014 ranged between 22.25°C and 25.75°C (Fig. 12).
- Turbidity portrayed irregular pattern. Moderately higher at the top 1m surface layer, which decreased slightly with water depth and increased afterwards at the 8 m depth
- Turbidity ranged between 6.6 ppm and 228.6 ppm averaging 45.60±48.93 ppm for the survey in June 2014 indicating substantial variability in turbidity regimes. The average temporal trend indicated the highest turbidity occurred at the bottom layers between October and November. Nonetheless, the temporal pattern was peaking and troughing between the months.

Table 4 Mean monthly levels and concentrations of seawater quality parameters

Month	Salinity (‰)	pH	Temperature (^{0}C)	Density (kg/m^3)	Conductivity (mS/cm)	Turbidity (mg/l)
January	35.62	7.80	25.22	23.76	53.96	2.50
February	35.51	7.78	26.46	23.30	55.80	2.65
March	35.45	7.73	27.70	22.91	56.54	3.10
April	35.33	7.77	27.83	22.73	56.52	5.10
May	35.48	7.80	28.15	22.73	57.08	18.90
June	35.05	7.81	27.69	22.56	55.96	8.90
July	35.78	7.81	24.27	24.18	53.34	2.60
August	35.82	7.75	24.27	25.20	49.73	5.95
September	35.90	7.53	24.44	25.35	49.47	3.96
October	35.77	7.55	27.41	23.19	56.69	15.20
November	35.01	7.59	27.77	22.23	56.82	9.60
December	35.20	7.62	24.80	22.96	56.01	5.80

Note: the means were calculated from a water column profile data but the monthly averages for the near surface, mid-depth and near bottom layers are presented in Appendix E. (MetOcean Report)

Levels of nutrients (nitrate and orthophosphate) vary moderately per season. The reported values were low compared to other coastal ecosystems, and may not present any concern of eutrophication. The distribution of ions (i.e., cations and anions) in the selected locations of the survey area is shown in Table 5.

Magnesium, calcium and sulfate showed general spatial uniformity. Concentrations of calcium and potassium levels were low. The average values for chloride (20385.5±144.22), sodium (9032.1±316.69), barium (0.00±0.00) and total dissolved solids (42,424.0±2648.74) at relatively shallow areas compares favorably well with relatively deep waters for chloride ((20208.3±204.67), sodium (9059.9±312.02), barium (0.00±0.00) and total dissolved solids (46,375.00±1701.71). This suggests lack of significant difference between shallow and deeper water waters of 1km interval.

Table 5 Distribution of some ions and TDS in relatively deeper and shallow locations

Parameter	Shallow water	Deep water
Chloride	20385.5	20208.3
Sodium	9032.1	9059.9
Barium	0.0	0.0
Total dissolved solids	42425.0	46375.0

4.3.6 Sediment Analysis

Analysis carried out on sediment was grain size distribution. In all, 10 locations along the proposed corridor were sampled, but only four stations returned adequate samples for grain size distribution analyses. No sediment sample was returned at locations F3, E2.5 and C3, all close to the shore. Rock samples were returned at locations A4 and D5, with the D5 samples being collected together with some shell fish. Sediment samples were returned for locations A6, E6, C7 and F7. The grain size distribution was skewed towards fines with greater than 80 percent of the sediment grains passing through the 125µm mesh (Table 5).

Table 5 Sediment grain size distribution

	Percent Sediment Retained			
Sieve Mesh Size	**A6**	**E6**	**C7**	**F7**
1000µm	0.05	0.62	0.68	0.09
710µm	0.14	0.65	2.48	0.31
500µm	0.15	0.83	2.20	0.49
355µm	0.13	1.08	2.76	0.70
180µm	0.74	2.92	4.68	2.34
125µm	2.79	6.61	8.85	4.60
63µm	63.99	62.51	61.28	64.82
less than 63µm	32.01	24.79	17.07	26.66

4.3.7 Marine Ecology

A summary of number of individuals and taxa within the main taxonomic groups is presented in Table 7. (Complete species list is in MetOcean Report). The species encountered and recorded both in the previous and current baseline assessment indicated a total of 79 species (mean=11 species) comprising 54 polychaete, 13 crustaceans and 6 molluscs, and 6 species placed in 'Others' category. The species designated as 'Others' comprise 5 different taxa namely ophiuroids, oligochaetes, sipunculids, nemertina and cnidaria. The macrobenthos were numerically dominated by the taxa polychaeta, accounting for more than 53% of sampled individuals (See Table 7). Crustacea contributed 24 %, while 'Others' category accounted for 18% and Mollusca made up 5 %.

The highest number of individuals (168 indi.) and taxa (61) were encountered at Station GC. The shallowest stations reported the lowest number of individuals and taxa possibly due to unfavorable condition. Species diversity was low at the shallowest areas (A6, C7, E6& F7). There were substantial numbers of rare species (species that occur possibly once in all grab samples). The four most numerically dominant species were Aricdeafauvelli, Ampelisca sp., and Sipuncula. There was no species that was encountered across each sampled station although oligochaetes and ophiuroids occurred in more than 3 sites.

Table 6 Abundance and richness on major macrobenthic faunal groups

Taxa	No. of Species	Abundance (No. of indi)	Percent Abundance
Polychaeta	54	125	53
Crustacea	13	55	24
Mollusca	6	11	5
Others	6	43	18

In terms of species assemblage pattern, Shannon-Wiener diversity indicates species diversity within the project area ranged from 0 to 4.091. Highest diversity was recorded at station GC. The recorded species diversity pattern is similar to trends observed for the species richness.

Remarkably, stations C7, E6 and F7 recorded low species richness and diversity and this may attributed to prevailing factors affecting the bottom dwelling organisms. Such factors include substrate type, water column productivity and hydrodynamic conditions. Per the diversity levels, 55% of the bottom communities within the sea bed of the project area can be described as "impacted".

4.3.8 Intertidal Ecology

The intertidal region within the project sphere is predominantly sandy with rocky outcrops on the eastern section of the beach which serves as substrate for colonization by rocky shore organisms. In addition, a groyne berm constructed to provide sheltered conditions is expected to enhance successful colonization by marine flora and fauna. The composition of the rocky intertidal with the project area comprises several epibenthic and macroalgal species. The epibenthic fauna consists of gastropods, crustaceans, echinoderm and cnidarians. Common fauna species found on the rocky intertidal of the project area are *Thais haemastoma*, *Siphonaria pectinata*, *Patella safiana*, *Fissurella nebecula*, Nerita atrata and *Cthalamus dentata*. Dominant flora species include *Chaetomorpha linum*, *Sargassum vulgare*, *Padina durvillaei*, *Ulva fasciata* and *Enteromorpha flexuosa*.

4.3.9 Fish Assemblage

Pelagic Species

The pelagic fish stocks are exploited commercially and comprise the small pelagics and the large pelagic resources. Major small pelagic fish resources account for approximately 80% of the total catch landed in the country and include sardinella species (Sardinella aurita & Sardinella maderensis), chub mackerel (Scomber japonicas), anchovy (Engraulis encrasicolus), horse mackerel (Trachurus sp.), African moon fish (Selene dorsalis), West African Illisha (Illisha African), Atlantic bumper (Chloroscombrus chrysurus), barracuda (Sphyraena sp). It is estimated that the maximum catch the small pelagic fishery can sustain is 180 000 tonnes.

Demersal Species

Demersal stocks are also commercially important with widespread distribution on the continental shelf of Ghana. The species composition of the demersal assemblage include members of the

sparidae family (e.g. blue spotted seabream *Pagrus caeruleostictus,* Angola dentex Dentex angolensis, Congo dentex Dentex congoensis); Sciaenidae family (croakers), Mullidae (Goatfishes), Lutjanjdae (snappers), Serranidae (Groupers). About eighteen (18) commercially fish species are described as "threatened" in Ghanaian waters due to heavy exploitation. These include the Blackchin guitarfish, dusky grouper, bottlenose skate (endangered), Thunnusobseus (vulnerable), Goliath grouper, Wide sawfish and Large tooth sawfish (critically endangered). A World Bank report in 2011 indicated a 40% increase in the reported number of threatened fish species from an initial number of 25 to 42.

4.4 Environmental Sensitivity Information

An on land field assessment was carried out to determine the presence or otherwise of any endangered or threatened flora and fauna species eg sea turtles and migratory birds and their habitats, such as sandy beaches and mangroves, as well as the presence of any archaeological finds, cultural or heritage items will be carried out.

Even though it is known that some migratory birds do visit the Takoradi area at certain times of the year, at the time of the study, no such endangered species were present at the site. No turtles were observed during a walk through of the beach adjacent to the project site and no fauna of either international or national significance were observed.

The study however revealed the presence of interspersed mangroves along the upper reaches of the Anankwari stream which empties its flood waters into the open ocean at the estuary. The project area lies east of the estuary and given the predominant wind and current direction of north easterly and eastwards respectively, there will not be any impact on these mangroves as a result of the construction of the seawater intake facility.

4.5 Socio-economic

Due to the flooding of the main project site by rainfall runoff from the Anankwari stream, the traditional economic activity of gathering of crabs from the flood plain had ceased as a result of the sand blockage of the river estuary by the eroded sea sand from the west –east movement of sea current typical of the Gulf of Guinea. Construction will therefore not entail the disruption of this economic activity at the project site by the local people.

4.6 Cultural Issues

In view of the pacification rites performed by the Volta River Authority during the construction of the T3 Project, there are no cultural issues of concern involved in the construction of the sea water intake facilities.

APPENDIX 8A

ECOLOGY REPORT

Report

Ecological Baseline Survey & Impact Assessment

Prepared for
Amandi Energy

Prepared by
Envaserv Research Consult
P.O. Box 3797, Accra
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February 2015

Technical Report

Ecological Baseline Survey and Impact Assessment

Prepared for

Amandi Energy

ENVASERV RESEARCH CONSULT Ltd.
P.O. Box 3797 Accra, Ghana
www.envaservconsult.com

February 2015

Document Control

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V2	20/02/2015	Client comments incorporated	EL	CLA	EL	AEL
V3	03/03/2015	V3 released to Client	EL	CLA	EL	AEL
V4	12/03/12	V4 released to client with comments incorporated	EL	CLA	EL	AEL

TABLE OF CONTENTS

Table of Contents ..... **II**

List of Tables ..... **V**

List of Figures ..... **V**

List of Plates ..... **VI**

Executive Summary ..... **I**

SECTION ONE: General Introduction

1.0 Introduction **3**

1.1 Background Information 3

1.2 Indicators Of Ecological Health 4

1.3 Terms Of Reference 5

1.4 Scope Of Study 6

1.5 Limitations To The Study 6

1.6 Structure of the Report 7

SECTION TWO: Legal & Regulatory Agreements on Biodiversity

2.0 Introduction 8

2.1 Convention on Biological Diversity 8

2.2 Convention on Wetlands of International Importance Especially as Waterfowls Habitats_Ramsar Convention 8

2.3 Convention on the Conservation of Migratory Species of Wild Animals 9

2.4 International Union for Conservation of Nature 10

2.5 African Convention on the Conservation of Nature & Natural Resources 10

2.6 World Bank Safeguard Policies 10

2.7 Status of Ghana in the Multinational Environmental Agreements (MEAs)... 11

SECTION THREE: Assessment Methodology

3.0 APPROACH AND METHODS **12**

3.1 Description of Site 12

3.2 Terrestrial Habitat Survey 14

3.2.1 Vegetation and Plant Species 14

3.2.1.1 Transects 14

3.2.2 GIS Analysis 15

3.2.3 Mammals and Herpetofauna 18

3.2.4 Bird Survey 19
3.3 Coastal Marine Ecology 21
3.3.1. Rocky Shore 21
3.3.2 Sandy Shore 22
3.3.2.1 Macro-invertebrates 22
3.3.2.2 Crab Ecology 22
3.4 Aquatic Ecology 23
3.4.1 Mangrove and Lagoon Macro-invertebrates 23
3.4.2 Aquatic Flora 23
SECTION FOUR: Results of the Assessments
4.0 RESULTS 26
4.1 Terrestrial Ecology 26
4.1.1 Vegetation and Plant Species 26
4.1.1.1 Plant Species Conservation Status 27
4.1.1.2 Plant of Economic Importance 27
4.1.1.3 Agricultural Plant 28
4.1.1.4 Spatial Land Cover 28
4.1.2 Distribution of Small Mammals and Herpetofauna 33
4.1.2.1 Conservation Status 37
4.1.2.2 Discussion 37
4.1.3 Avifauna Species Composition 38
4.2 Aquatic Ecology 39
4.2.1 Aquatic Plant Species 39
4.2.2 Macrobenthic Invertebrates 40
4.3 Coastal Marine Ecology 42
4.3.1 Rocky Shore 42
4.3.2 Sandy Shore 45
4.3.2.1 Macrobenthic Invertebrates 45
4.3.2.2 Crab Ecology 45
4.3.3 Shoreline Morphology 46

SECTION FIVE: Ecological Sensitivity
5.0 Impact Assessment Criteria 50

5.1 Assessment Methodology 50
5.2 Evaluation of Impact Significance 53
5.3 Impact and Mitigation Measures 53
5.4 Analysis of Project Compliance with IFC Policy 60

SECTION SIX: Conclusion and Recommendations
6.1 Conclusion 64
6.2 Recommendations 64

REFERENCES 67
APPENDICES 69

LIST OF TABLES

Table 4.1: List of Herpatofauna and Mammals recorded in the study area 34
Table 4.2: Small mammal abundance data based on catches from the Sherman traps 35
Table 4.3: A list of Herpetofauna and mammals likely to be regular users of the studied area 35
Table 4.4: Inventory of wet-land macro-invertebrates within the study area. 41
Table 4.5: Abundance, species richness and density of the macro-benthic fauna groups in the study area 41
Table 5.1: Summary of impact significance 53
Table 5.2: Analysis of compliance with IFC police 62

LIST OF FIGURES

Figure 3.1: Locality map indicating Amandi's Project Site 13
Figure 3.2: Map showing transects and quadrats for vegetation study 17
Figure 3.3: Map of site showing fauna trap points 20
Figure 3.4: Study area showing benthic sampling points 25
Figure 4.1: Map showing the extent of mangrove coverage of Amandi's Project site 30
Figure 4.2: Land cover-map of Amandi's project site in 2000 31
Figure 4.3: Land cover-map of Amandi's project site in 2011 32
Figure 4.4: Distribution of diversity indices across sampling stations of the study area 42
Figure 4.5: Beach profile of the east-point (top), mid-point (middle) and west-point (bottom) 48
Figure 4.6: Shoreline morphology 49
Figure 5.1: Superimposition of proposed project lay out on the mangrove forest to identify quantities affected for compensation 57

LIST OF PLATES

Plate 1: Line transect walk of for the vegetation survey....14
Plate 2: Establishment of quadrants and plant cover estimation....15
Plate 3: A setup of pitfall trap with drift fence (left) and Sherman collapsible live traps (right)...18
Plate 4: *Echinometra lacunter* dominated micro-habitat on the sheltered rocky shore 21
Plate 5: Rocky shore survey (top) sandy shore survey (bottom) 23
Plate 6: Macro-invertebrates sampling of wet-land Anakwari lagoon 24
Plate 7: Fauna of the wetland....24
Plate 8: Dominant plant species recorded....29
Plate 9: *Trachlepix species* (left) observed during refuge search and captured *Mastonys nathlensis* in a Sherman trap (right)....33
Plate 10: Little bee-eater (left) and common fiscal (right) observed during the bird survey 38
Plate 11: Aquatic plants within the Anakwari lagoon 39
Plate 12: Exposed rocky out-crops of Aboadze beach 44
Plate 13: *Patella safiana* (left) and the colonial *Zoanthus species* (right) encountered on rocky intertidal....44
Plate 14: Dense cover of green-algae *Ulva flexuosa* interspersed with *Chaetomorpha linum* (left) and red algae *Centroceras calvulatun* (right) 44

EXECUTIVE SUMMARY

Envaserv Research Consult (ERC) Ltd. was appointed by Amandi Energy Ltd. (AEL) to undertake ecological baseline and impact assessment for a proposed Combined Cycle Gas Turbine (CGT) facility at Aboadze with a generating capacity of approximately 190MW. The current assessment sought to update the permitted Environmental Impact Statement (EIS) to meet international donors' (e.g. IFC, OPIC and World Bank) requirements. The study settings were the terrestrial, aquatic and coastal ecosystems focusing on inventorying and quantifying the flora and fauna of these systems (e.g., plant species, mangrove wetland, small/mammals, avifauna, macrobenthic invertebrates, macro-algae). Further, the study assessed the global and national conservation significance of the biodiversity and habitats to elucidate and evaluate the potential impacts the facility would have on them.

Field surveys for the various ecological components were carried out from 26th January to 5th February 2015 employing acceptable/approved survey protocols. Species recorded were assessed for their conservation (international & national) and ecological significances. The terrestrial floristic composition (76 species from 37 families) showed plant species consisting mainly of herbaceous (41.4%), Shrubs (25%), trees (18.7%) and grasses (9.3%). The plant families of Fabaceae, Asteraceae, Malvaceae and Poaceae showed the highest frequency of occurrence, whilst Apocynaceae, Euphoribiaceae, Rutuceae showed the lowest occurrence. The common plant species were the *Zanthoxyloides zanthoxylem* and *Paspallum vaginatum*. However, mangrove forest coverage was over 60% with the main species being Rhizophora racemosa (red mangrove) and Avicennia germinans (black mangrove) with patches of Laguncularia racemosa (white mangrove), making the area one of the few wetlands where all the three mangrove species are present, although these species are of Least Concern according to the International Union for the Conservation of Nature and Natural Resources (IUCN) Redlist of threatened species. Also all the plant species encountered were yet to be assessed by the IUCN Red List.

Mammals (2 species) and herpetofauna (3 species) community was generally low with all the species being of Least Concern (IUCN) and not listed (Ghana wildlife regulation). The poor mammal and herpetofauna diversity could be due to the nature of the habitats. The avifauna survey recorded 91 species from 33 families and 70 genera. No species of global conservation significance was recorded at the site. At the national level, 17 of the species recorded are listed on schedule 1 of the wildlife conservation regulation and hence prohibited to be captured or hunted at any time of the year. Although the site is primarily a wetland, it has little significance in terms of birds and other valued biodiversity of national and international importance. The number of bird, mammal and herpetofauna species that are ecologically associated with the site was low. The aquatic invertebrates in the mangrove wetland yielded a total of 62 individuals,

made up of 7 species, which belong to 4 major taxonomic groups namely Polychaeta, Crustacea, Insecta and Mollsuca. The reported aquatic macro-invertebrates were of low conservation significance. The mudskipper (*Periophthalamus barbus)* formed a significant population of the wetland fauna. The diversity of the intertidal biodiversity was moderately high but with low conservation significance except the area is a type locality for *Griffithsia schousboei* (Rare macroalgae but not listed in the IUCN Red List).

The proposed Amandi's Power Plant is not likely to exert any adverse impact on the population of the fauna community on the basis of the results of the field survey. Nonetheless, clearing of vegetation to make way for the project would lead to habitat loss and may impact potential biodiversity associated with those habitats. Further, clearing of mangrove forest, which is a natural habitat, would adversely affect potential biodiversity and associated ecological services. Adverse ecological impacts of the proposed facility ranged between low to medium but with appropriate mitigation many of the impacts would be reduced to low. In sum, significant portions of the area of the proposed fall under critical natural habitat due primarily to the presence of mangrove forest as per the IFC policy guideline. However, of the 18.33% (0.044 km^2) mangrove coverage on the site boundary, 6.92% (0.017 km^2) that would be affected by the project development should be compensated at the non-mangrove areas (0.021 km^2) at northern portions of the site. The identified compensation site can potentially establish corridors with the existing mangrove species. However, the mangrove replanting should be done preferably during the dry season (i.e., March & April) to ensure that the species are firmly rooted before the onset of the rains due to the flooded nature of the site. In general, site clearing should be carried out at a period that will not coincide with overwintering season of the migrant waterbirds (Sept-Nov.). Vegetation in non-active area on the site should be left to provide haven for fauna species that may persist at the site. Clearing of mangrove forest should be done in a manner that will not degrade it and with the view of preserving the three mangrove species. Adequate monitoring mechanisms should be put in place during constructional and operational phases of the project with key ecological indicators that would let temporal impacts be realized.

SECTION ONE: General Introduction

1. INTRODUCTION

1.1 Background Information

The purpose of the terrestrial ecological baseline survey is to collect additional flora and fauna data to assist in evaluating potential impacts associated with Amandi Energy's proposed Combined Cycle Gas Turbine (CGT) facility at Aboadze with a generating capacity of approximately 190MW. The survey has been occasioned by the need to update the Ghana Environmental Protection Agency (EPA) permitted Environmental Impact Statement (EIS) to meet international lenders requirements. This document thus details the scientific methods that were employed in conducting the ecological baseline survey and impact assessment. The primary aim of the study was to document the diversity of flora and fauna of the critical habitats and ecosystem in the study area, and elucidate their conservation significance.

Components of biodiversity are usually grouped into four ecological systems: terrestrial, freshwater, marine and agro-biodiversity systems. Each system has an individual set of processes that are the primary factors affecting biodiversity in the absence of manmade disturbance. However, major changes in the functioning of systems occur whenever an induced perturbation or damage takes place. This necessitates a clear understanding of the ecological systems which constitutes a critical basis for sound biodiversity assessment.

Biodiversity conservation is important because it helps to manage change as it provides alternatives to fall back on when other resources are absent. Knowledge of the biodiversity of an area enables the resources to be proactively adapted to better suit new conditions. The ecological assemblage of any habitat is defined by the aggregates of fauna and flora species within the community. These aggregates in their natural settings and abundances maintain the ecological balance of the habitat and promote biodiversity resilience over time. As development pressures grow, areas containing unique characteristics have become more vulnerable to pressures from commercial interests and local inhabitants.

The general important biodiversity data in ecological impact studies often include:

- **Species Inventories** of particular species important to the indigenous or local community as food, medicine, fuel, fodder, construction, artifacts production, clothing, and for religious and ceremonial purposes etc.
- **Identification of endangered species or species at risk:** possible referenced to the World Conservation Union (IUCN) Red Data Book, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and national inventories
- **Identification of particular significant habitat** as breeding/spawning grounds, remnant native vegetation, wildlife refuge areas including buffer zones and corridors, habitats and routes for migratory species and crucial breeding seasons for endangered and critical species.
- **Identification of particular significant physical features and other natural factors which provide for biodiversity and ecosystem** e.g., water course, lake, etc.
- **Identification of areas of particular economic significance** e.g., hunting areas and trapping sites, fishing grounds, gathering areas, grazing lands, timber harvesting sites and other harvesting areas.
- **Identification of sites of religious, spiritual, ceremonial and sacred** significance such as sacred groves and totemic site.

1.2 Indicators of Ecological Health

Ecological habitats are important in the provision of ecosystem goods and services to humans. The integrity of the ecosystem is measured by its structure and function. The concept of ecosystem health presupposes defining a normative state of natural systems and identifying limits of human intervention (e.g., Costanza *et al*., 1992). A healthy ecosystem prevents any shift toward a new mode of functioning, by reducing environmental stochasticity that could push the system away from its optimal state and cause undesirable economic or ecological effects. Also, a healthy ecosystem or community might be indicated by ranges of values considered to be normal, and by attributes that are regarded as stable and sustainable. Ostensibly, disruption/destruction of the ecosystem's health (e.g., value, stability and resilience) due to environmental stressors (mainly anthropogenic) affects the overall functioning of the system. Ecological indicators are used as a tool to assess the effectiveness of measures to conserve and sustainably use biodiversity. They play an important role in regard to ecological status

assessment of critical habitats. The ecological indicators have been shown to detect anthropogenic perturbations on biological communities in critical ecosystems.

An indicator is a measurable parameter whose numeric value reflects a range of conditions or some aspect of ecosystem structure and function that is of interest to scientists and resource managers. The best indicators of ecosystem health are measurable features of animal and plant communities and their habitats, including their interactions with human environment. Ecological indicators can be used to assess the condition of the environment, to provide an early warning signal of changes in the environment, or to diagnose the cause of an environmental problem. Ideally the suite of indicators should represent key information about structure, function, and composition of the ecological system.

Ecological indicators should meet the following criteria: i) be easily measured, ii) be sensitive to stresses on the system, iii) respond to stress in a predictable manner, iv) be anticipatory, v) predict changes that can be averted by management actions, vi) be integrative, vii) have a known response to disturbances, anthropogenic stresses, and viii) changes over time, and have low variability in response. Ideally the suite of indicators should represent key information about structure, function, and composition.

1.3 Terms of Reference

The terms of reference for the ecological survey were as captured in the specification for ecological consultant document (3513188A) prepared by Parsons Brinckerhoff:

- Establish the survey area for biodiversity, this will include the redline boundary of all project infrastructure and buffer where access allows including but not be limited to: all access roads, pipelines terrestrial and marine, transmission lines, storage areas and buildings.
- An ecological desk based study of the project area
- A summary of relevant wildlife legislation including international and Ghanaian Law in the baseline;
- Baseline biodiversity surveys to include reporting and mapping of habitats, flora and fauna within the survey area.
- Impact assessment to include valuation of ecological receptors, characterization of impacts and details of mitigation/ compensation and residual effects

1.4 Scope of Study

Thus, in accordance with the terms of reference and also as a legal requirements for propositions of major development projects (the Environmental Assessment Regulations of 1999 [LI 1652] Section 11-13 and Appendix 10 of Ghana's Environmental Impact Assessment Procedures, 1995), IUCN-PAM Category VI policy guideline and IFC/World Bank requirement, make Amandi Energy's proposed 190MW Thermal Power facility at Abaadze in the western region of Ghana mandatory for an ecological impact assessment. (EcIA) The primary focus of the EcIA was:

- Carrying out ecological survey and describe the ecological entities that may potentially be affected directly or indirectly by the proposed development facility;
- Mapping out ecological habitats in the project area
- Evaluate ecological impacts of the proposed undertaking;
- Proposition of measures to prevent or mitigate future adverse ecological impacts,

The following pertinent questions were considered for formulating appropriate mitigation strategies.

- If the proposed facility will impact the flora and associated fauna in the site/locality and land use pattern of the area. Are the plant community and associated fauna in the area the same as adjacent areas? If not, how different are they?
- Would excessive clearance of species for proposed facility today compromise the ecological status tomorrow or would it be associated with degraded ecological quality.

1.5 Limitations to the Study

- For adequate and comprehensive data that will ensure sound ecological impact evaluation, data/information on seasonality of ecological entities (i.e., flora & fauna) and temporal trends are critical for a better understanding of the biotic dynamics. However, due to project time constraints, such seasonal and long term temporal data collection was not feasible;
- Owing to time constraints trends and scenarios analyses could not be adequately projected with or without the proposed project because of the 'snapshot' data collection.
- Integration of aquatic vegetation/flora hampered accurate and clear delineation of the terrestrial flora;

- Climate scenarios based on climate model results could be considered in the impact assessment as the baseline biodiversity is a moving baseline since the proposed Amandi's power project would only become fully operational after many years and biodiversity in the area may have changed subject to different climatic conditions (e.g. storms, increased flooding, etc.).
- Due to the inaccessibility of the study area as a result of the marshy wetland some line transects were truncated and that hampered floral species identification.
- Due to time constraints a maximum of three survey days were utilized for the each component of the ecological survey.
- The exact location of the proposed power plant was not known at the time of the surveys to help relate various facility components to evaluate actual ecological impacts.
- That is bird species recorded were those encountered by sound or sight and on the basis of the technical competence of the bird specialist that carried out the field assessment it was assumed that any species recorded was properly identified.
- Cryptic, silent and nocturnal species (e.g. birds, mammals & herpetofauna) in the area could miss detection for enumeration and could lead to underrepresentation as only captured species were identified and counted.

1.6 Structure of the Report

The report is made up of six sections. A non-technical executive summary provides a synopsis of the assessment written in a non-technical language. Following the summary is Section 1 providing general background information of the study, the terms of reference as well as the limitations of the study. Section 2 presents the legal and regulatory basis for the assessment and international agreements on biodiversity. The study approach and methodology employed for the study are contained in Section 3. Description of results and discussions is presented in Section 4. Section 5 looks at the ecological impact and sensitivity evaluation. Section 6 draws conclusions from the study and makes appropriate recommendations.

SECTION TWO: Legal & Regulatory Agreements on Biodiversity

2.0 Introduction

The Rio declaration on Environment and Development has resulted in many 'biodiversity-related convention or Multilateral Environmental Agreements (MEAs).

2.1 Convention on Biological Diversity- CBD (Rio de Janeiro, 1992)

The Convention establishes three main goals:

- the conservation of biological diversity,
- the sustainable use of its components, and
- the fair and equitable sharing of the benefits from the use of genetic resources.

In its text, it calls for impact assessment measures to ensure that biodiversity is addressed in projects, plans and policy decisions.

Article 14.1 states that "Each Contracting Party, as far as possible and appropriate shall:

- Introduce appropriate procedures requiring environmental impact assessment of its proposed project that are likely to has significant adverse effects on biological diversity with a view to avoiding or minimizing such effects and, where appropriate, allow for public participation in such procedures
- Introduce appropriate arrangements to ensure that the environmental consequences of its programme and policies are likely to have significant adverse impacts on biological diversity are taken into account".

2.2 Convention on Wetlands of International Importance especially as Waterfowls Habitats- Ramsar Convention (Ramsar, 1971)

The primary goal of the Convention on Wetlands, signed in Ramsar, Iran, in 1971, "is the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world" (Ramsar COP8, 2002).

Under Objective 2 of the Strategic Plan – developing Ramsar Wise Use Guidelines impact assessment tools were viewed as a core component of modern land-use planning and resource management toolkit. This is made clear in the Operational Objective 2.5 of the Strategic Plan which calls for Parties to "carry out EIA particularly of proposed

developments or changes in land/water use which have potential to affect [wetlands] whose ecological character is likely to change as the result of technological development, pollution or other human influence".

Action 2.5.1 of the Strategic Plan calls for additional guidance on wise use by preparing the results of a review of environmental appraisal guidelines and examples of current best practice in EIA. Action 2.5.4 calls for Parties to take account of Integrated Environmental Management and Strategic Environmental Assessment when assessing impacts of development proposals or changes in land or water use.

2.3 Convention on the Conservation of Migratory Species of Wild Animals – CMS (Bonn, 1979)

This convention (the Bonn Convention), is an intergovernmental treaty, concluded under the guidance of the United Nations Environment Programme (UNEP). It is concerned with the conservation of wildlife and their habitats on a global scale and aims to conserve terrestrial, marine and avian migratory species throughout their range.

Resolution 7.2 (Impact Assessment and Migratory Species), which was adopted by the Conference of the Parties at its seventh meeting "emphasises the importance of good quality environmental impact assessment (EIA) and strategic environmental assessment (SEA) as tools for implementing Article II (2) of the Convention on avoiding endangered migratory species and Article III (4) of the Convention on protection of Appendix I species. Urges Parties to include in EIA and SEA, where relevant, as complete a consideration as possible of effects involving impediments to migration, furtherance of Article III (4) (b) of the Convention, of transboundary effects on migratory ranges. Further urges Parties to make use, as appropriate, of the "Guideline for Incorporating Biodiversity-related Issues into Environmental Impact Assessment Legislation and/or Processes and in Strategic Environmental Assessment endorsed by Decision VI/7 of CBD COP 6.

Other biodiversity-related conventions may have no articles pertaining directly to impact assessment issues in their original convention texts, perhaps because of the relative youth of the impact assessment concept at the time of their drafting. On the other hand, some may have few articles which might indirectly mention issues on impact assessment. However, the conventions have addressed varying aspects of impact assessment in their more recent decisions and COPs. These conventions and their relative articles include:

- United Nations Framework Convention to Combat Desertification-UNCCD (Paris, 1994): No mention of impact assessment.
- Convention on International Trade in Endangered Species of Wild Flora and Fauna Convention-CITES (1973): No mention of impact assessment.
- Convention Concerning the Protection of World Cultural and Natural Heritage (1972): No mention of impact assessment.

2.4 International Union for Conservation of Nature (IUCN)

The IUCN focuses on valuing and conserving nature, ensuring effective and equitable governance of its use, and deploying nature-based solutions to global challenges in climate, food and development. The IUCN Protected Area Management (PAM) Category VI provides guidelines for ensuring long-term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet the needs of affected communities (IUCN, 1994; Dudley, 2008).

2.5 African Convention on the Conservation of Nature and Natural Resources

The African Convention on the Conservation of Nature and Natural Resources is a continent-wide agreement signed in 1968. It supersedes the Convention Relative to the Preservation of Fauna and Flora in their Natural State of 1933 and has been superseded by the African Convention on Conservation of Nature and Natural Resources (revised) signed in Maputo in 2003.

The main goals of the convention were to draw up a document that enhanced the environmental protection, fostered the conservation and sustainable use of natural resources and brought together and coordinated policies in these fields.

Article II of the Convention mandates contracting States to undertake to adopt measures necessary to ensure conservation, utilization and development of soil, water, flora and faunal resources in accordance with scientific principles and with due regard to the best interests of the people.

2.6 World Bank Safeguard Policies (OP 4.04, September 1995)

The World Bank by this policy does not support projects that involve the significant conversion of critical natural habitats. It also indicates that if natural habitats would be

significantly converted, acceptable mitigation measures are included in design: minimizing habitat loss and establishing and maintaining ecologically-similar protected area

2.7 Status of Ghana in the Multinational Environmental Agreements (MEAs)

Many countries including Ghana now incorporate environmental considerations into development projects (Appiah-Opoku, 2001) and has thus enacted local laws and also signatory to MEAs. These local laws and MEAs seeks to maintain the functional integrity of environmental systems Ghana's Environmental Protection Agency Act (EPA Act 490, 1994 Section 12 [1]) legally requires that proponents of major development projects conduct and submit EIA studies for consideration (EPA, 1994).

SECTION THREE: **Assessment Methodology**

3.0 APPROACH AND METHODS

3.1 Description of Site

The proposed project area with an estimated area of 0.27km^2 consists of a mosaic of coastal marshes, creeks and dryland, sandwiched between the Takoradi International Company (TICO) Thermal Power Plant to the east, the Asipon Sports Stadium on the west and the sea to the south. The area falls within the coastal savannah plain ecological zone (Hall and Swaine, 1981), with its characteristic wooded savannah and coastal scrub thicket vegetation which at its current state appeared quite modified by various human activities. About half of the area of the proposed project site consists of creeks and brackish water marshes with the black mangrove (*Avicennia germinans*) as the dominant woody plant species. The western end of the site appeared to be an abandoned salt pan that was overgrown with black mangrove trees and sedge grass.

The other half of the site on a slightly elevated area was predominantly a cultivated area dominated by naturally regenerated oil palm (*Elaeis guineensis***)** and several woody plant species and *Imperata cylindricum.* Several portions of the sites were cultivated with mainly cassava at the time of the field survey. As with most coastal areas in Ghana, coconut tree (*Cocos nucifera*) was a prominent feature at the site, both at the beach and the inland area of the site. The Acacia tree (*Sena siame*) and Portia tree (*Thespesia populnea*) and other woody plants were also present at the site but in relatively lower density.

The coastline of the project area lies in the Central coast according to Ly (1980) comprising of sandy beaches interspersed with rocky headlands and sand bars enclosing lagoons. The ecological habitat of the beach is essentially sandy with rocky outcrops at the mid to western section beyond the mouth of the Anakwari stream. The splash zone and the upper (eulittoral) are entirely sand stretching to approximately 50m along the beach slope. The rocky out crops cover the midlittoral to sub littoral sections of the beach.

Figure 3.1 shows the map of the locating indicating the project area.

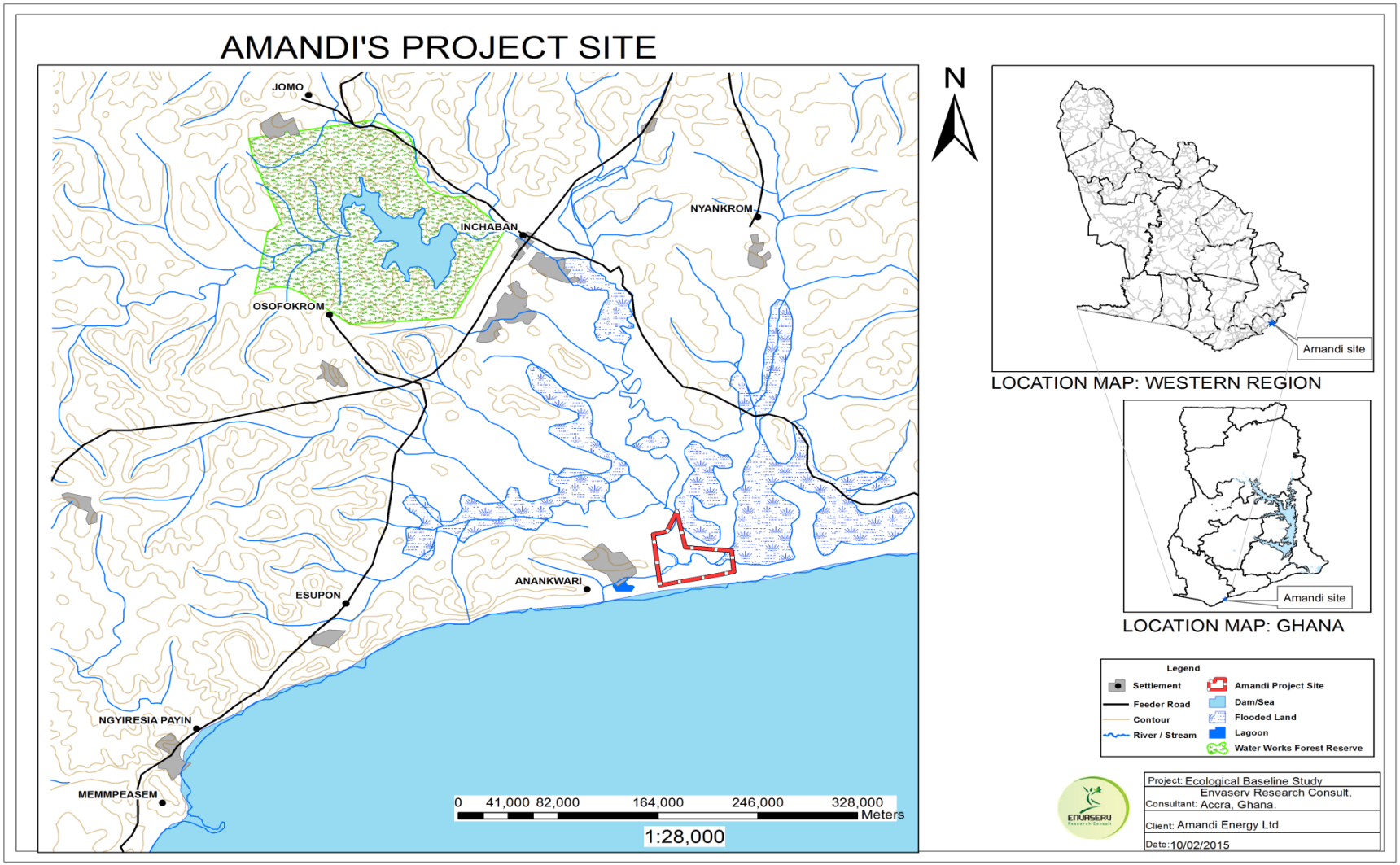

Fig. 3.1: Locality map indicating Amandi Project site

3.2 Terrestrial Habitat Survey

A rapid but thorough survey was carried out to assess and document the assemblage of flora in accordance with standard ecological study methods (Hawthorne and Swaine, 1981; Hawthorne and Musah, 1993*)*.The purpose of a terrestrial habitat survey was to identify the different types of floristic habitats found within the area and to delineate their coverage and the fauna type they support.

3.2.1 Vegetation and Plant Species

The vegetation types and plant species in the study area were inventoried with the purpose of providing information on plant species diversity and their conservation importance. Quantitative data (e.g. percentage cover) was obtained with a 10 x10m quadrat along demarcated transects lines as described in the section 3.2.1.1 below.

3.2.1.1 Transects

Three line/belt transects were laid along east-west axis with Transect 1 closer to the shoreline, whilst Transect 3 is farthest (Fig. 3.2). Plant species along the transect lines were identified and recorded. Series of 10 x 10m frame quadrats were laid along each transect for detailed plant species enumeration and abundance cover estimation. Plant species inside the quadrats were identified and the species percentage covers estimated. The transect and quadrat locations were geo-referenced (Appendix 1).

Plate 1: Line transect walk for vegetation survey

Plate 2: Establishment of quadrat and plant cover estimation.

3.2.2 GIS Analysis

LandSat image of the site was obtained from the Advanced Land Observation Satellite (ALOS) and the Astrium sateliite services. The images were geo-referenced to the coordinate system of Ghana to allow overlay of other geographic features. The plant data within the transects and quadrants were superimposed on the satellite image to provide the vegetation profile of the area in order to track future changes in the vegetation structure when the power plant facility become fully operational. All images were pre-processed by the performance of atmospheric corrections and orthographic rectification to eliminate possible image errors. This pre-processing was done using IDRISI Selva and ENVI 5.0. Prior to image classification using ArcGIS 10.0 a class

probability and principal component assessment were done to ascertain the possible classes and the accuracy of the digital numbers of the satellite images. The filed data was consolidated into habitat map with various legends showing the locations of different types of habitats on the map.

All GIS process and map composition were performed using ArcGIS 10.0 from Environmental System Research Institute (ESRI). A local interpolation model was used to predict the shoreline topography from recorded beach profile depths. The local polynomial interpolation was used to fit a second order polynomial using points only within the defined neighborhood of the shoreline.

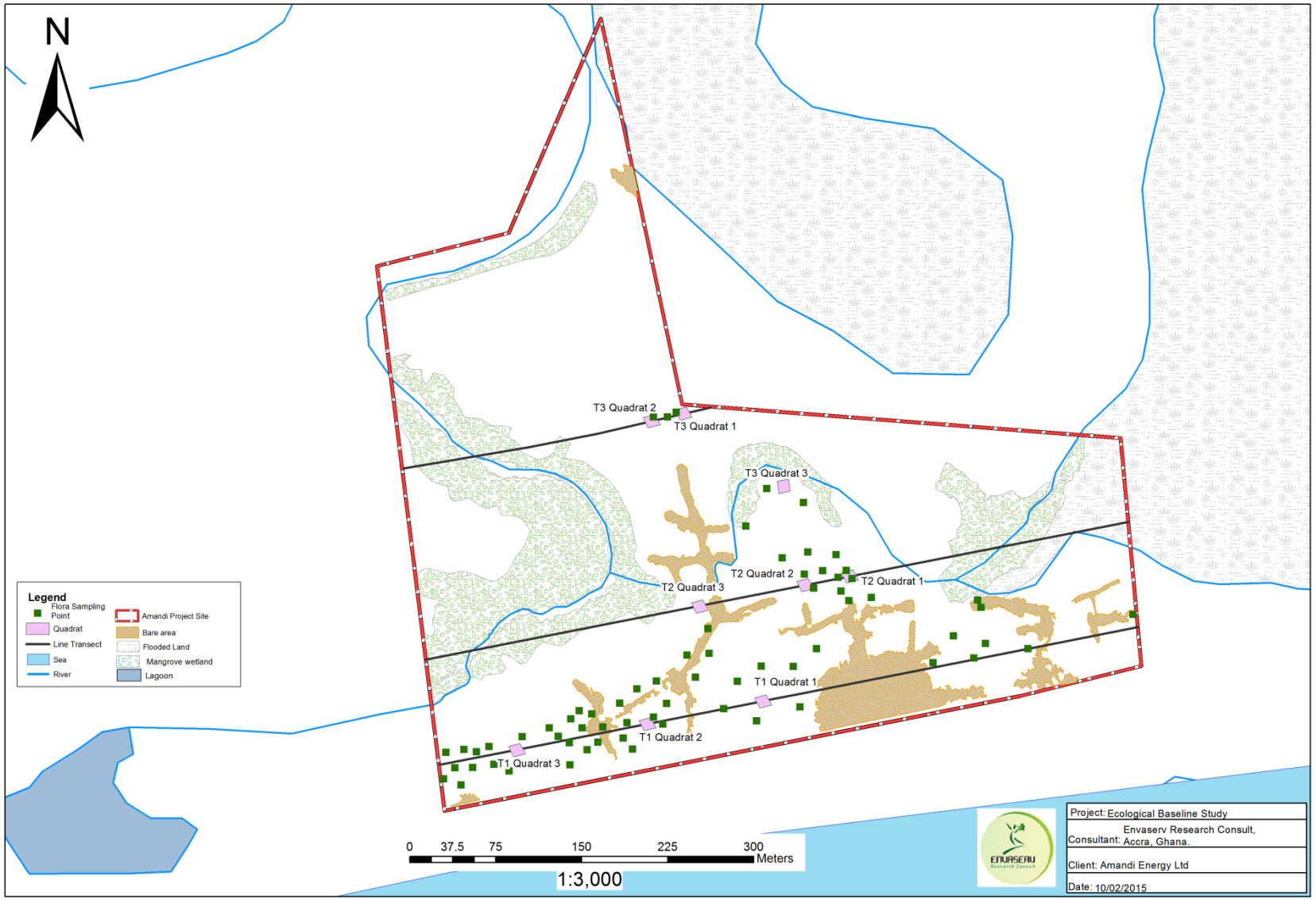

Fig. 3.2: Map showing transects and quadrats for vegetation study.

3.2.3 Mammal and Herpetofauna Survey

Mammals and herpetofauna identification and counted were done in parallel with the vegetation survey. Four pitfall traps were set along a 40m drift fence along each of the three transect lines. The pitfall traps (Plate 1) consisted of large plastic buckets spaced at 10m interval. Each pitfall trap was buried to its rim and the space around it filled and smoothened with the dugout soil. Traps were inspected for catches in the mornings for two consecutive days.

Small mammals were trapped using Sherman collapsible live-traps (23cm x 9cm x 7.5cm), which were set in 10 x 10m quadrats. Three quadrats were established on each transect except for Transect 3, which had two quadrats due inaccessibility. A Sherman trap (Plate 3) baited with a mixture of groundnut paste and corn meal was placed in each of the corners of the quadrats. A total of 20 traps were set along the transects (see Fig. 3.3). The traps were set during the day and inspected early the following morning and re-baited. This was done for two consecutive days. All the trap locations were geo-referenced (Appendix 1).

Plate 3: A set up of Pitfall trap with drift fence (left) and Sherman collapsible live-traps (right)

Data Analysis

The *relative abundance* of each captured species (number of captures per 100 trap-nights) was calculated as follows:

$$\textit{Relative abundance} = \frac{\textit{Number of individuals captured x 100}}{\textit{Number of trap-nights}}$$

(where one trap-night = one trap set for one night)

Conservation significance at the national and global levels was assessed using the International Union for the Conservation of Nature - (IUCN), Red List of Threatened species (IUCN, 2014) and the Ghana Wildlife Conservation Regulation 1971 (LI 685). Assessment of the conservation status focused on the various IUCN threat categories whereas protection status focused on **Schedule I** of the Wildlife Conservation Regulation. All animal species listed under **Schedule I** of the Wildlife Conservation Regulation 1971, LI 685, are Wholly Protected in Ghana from any form of hunting and capture.

3.2.4 Bird Survey

The bird survey was carried out using spot count at interval of 200m along transects at the site. At each spot, birds encountered by sight or sound within 50m radius, were identified and recorded. Due to the relatively small size of the site, the transects covered the entirety of the site, with observation points dotted throughout the site. Observations of birds at distant were aided with a pair of binoculars (x10 magnification). The field survey was carried out in the morning between 6:30 am and 9:30am and also in the evening between 3:30 and 5:30pm and each species encountered was identified to the species level. Borrow and Demey, (2010), was used to confirm the identity of species encountered. Global Positioning system (GPS) reference for each observation point is presented in Appendix 1.

Data Analysis

Bird species recorded in the study were grouped according to their family using Borrow and Demey (2010). Conservation significance at the national and global levels was assessed using the International Union for the Conservation of Nature - (IUCN), Red List of Threatened species (IUCN, 2014) and the Ghana Wildlife Conservation Regulation 1971 (LI 685). Assessment of the conservation status focused on the various IUCN threat categories whereas protection status focused on **Schedule I** of the Wildlife Conservation Regulation. All animal species listed under **Schedule I** of the Wildlife Conservation Regulation 1971, LI 685, are Wholly Protected in Ghana from any form of hunting and capture.

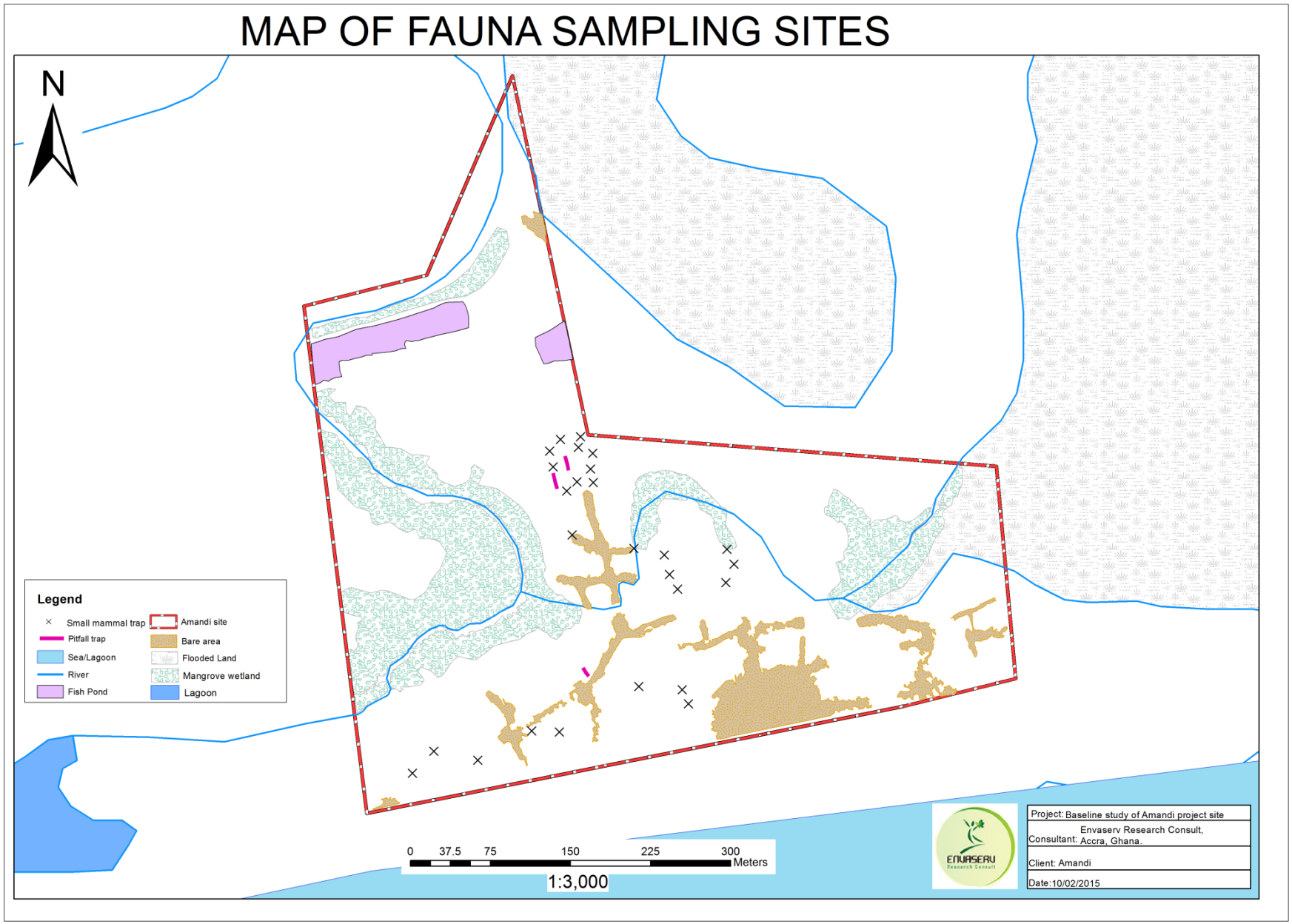

Fig. 3.3: Map of site showing fauna trap points

3.3 Coastal Marine Ecology

Three spatial locations were established for the intertidal sampling. Station 1 (Eastern section) is characterized by artificially created groyne/headlands of rocky boulders, which was constructed to serve as breakwaters as part of the West African Gas Pipeline (WAGP). The sheltered conditions as a result of the gryones seem to provide suitable/favorable substrate for colonization of rocky shore organisms.

Station 2 is the mid-section and lies within Amandi's project site. The site is characterized by a small extent of exposed rocky seabed/outcrops which are covered during high tides. The site is represented by a gradient of exposure to the prevailing tidal currents and wave. Along the beach slope beyond the 30m sandy beach present a uniformly distinct green algal belt of *Chaetomorpha linum* with patches of *Ulva flexuosa*.

Station 3 is located at western section beyond the Anakwari lagoon and it's composed of high rising rocky outcrops which provides sheltered condition and microhabitat for some organism notably sea urchins, *Echinometra lacunter (*Plate 4).

Plate 4: *Echinometra lacunter* dominated microhabitats on the sheltered rocky shore

3.3.1 Rocky Shore

Sampling on the rocky shore was designed to accommodate small scale heterogeneity along the shore slope. As a result, single belt transects of three were laid at each site from the back shore to the low water mark. Each transect extends to the sublittoral within safety limits imposed by the natural features, channels and conditions present at the seaward end.
A continuous $1m^2$ quadrat was placed along each transect to identify and estimate species percentage cover (macroalgae) and count epibenthic animals (Plate 5). In cases of high numerical abundance of encrusting organisms (e.g., barnacles), actual 5% of the coverage in

the quadrats was counted and the total percentage cover of the species extrapolated with the 5% count.

3.3.2 Sandy Shore

The sandy shore survey comprised of macro invertebrates and crab ecology (Plate 5).

3.3.2.1 Macro-invertebrate

In all, three stations were located on east to west transect. An open ended box corer of surface area 0.1m^2 (0.3 x 0.3m) was placed randomly at each location within the sub-tidal area. Sediment samples were collected from the upper 30cm into a 0.5mm mesh size sieve. The sediment samples were carefully washed in the sieve with seawater to get rid-off fine grain materials (Plate 5). The retained sediments were transferred into labeled plastic containers and fixed with 10% pre-buffered formaldehyde/Rose bengal solution for later taxonomic identification in the laboratory. In the laboratory, all the samples were washed to remove the formaldehyde solution and further get rid-off fine sediments. The washed sampled were sorted, identified and counted under a stereoscopic microscope.

3.3.2.2 Crab Ecology

Semi–terrestrial crabs especially of the genus Ocypode are characteristic members of the tropical sandy shore population. These crabs are ecologically and economically important as they provide practical estimates for assessing the level of anthropogenic impact on beaches due to their occurrence and abundance. Two horizontal line transects measuring about 20m each were laid on an east to west axis to cover the mid-section of the sandy shore. A 1m^2 quadrat was laid randomly along each transect. The number of crab burrows per quadrat were counted and recorded as well as crab the hole density. Further, the diameters of the holes were measured to serve as a surrogate of the age structure of the ocypode population. Crabs were also trapped and identified.

Plate 5: Rocky shore survey (top) and Sandy shore survey (bottom)

3.4 Aquatic Ecology

3.4.1 Mangrove and Lagoon Macro-invertebrate

Four sampling stations were located in an east to west transect within the mangrove wetland and the Anakwari lagoon. At each station, three PVC corer samples (with area equivalent to 0.063 m^2) constituting one replicate was collected from the 0.20m surface layer where the macro-invertebrates predominantly dwell. Two replicate samples were collected at each location. The sediment samples were washed through a sieved of a mesh size of 0.5 mm to remove fine-grained sediment (Plate 6). The retained sediment material in the sieve was put into HDPE containers and treated (fixed) with 10% formaldehyde. Rose Bengal solution was added to the samples to facilitate sorting (picking of organism) in the laboratory. The formaldehyde will fix the internal organs and prevent deterioration of the organisms.

3.4.2 Aquatic Flora

Aquatic flora assessment and sampling was carried out at representative sections of the sites. The assessment method adopted was mainly opportunistic qualitative counts to

document the species richness (i.e., number of species). Local inhabitants also provided information on the composition of the dominant species to supplement primary data collected.

Plate 6: Macroinvertebrate sampling of wetland and Anakwari lagoon

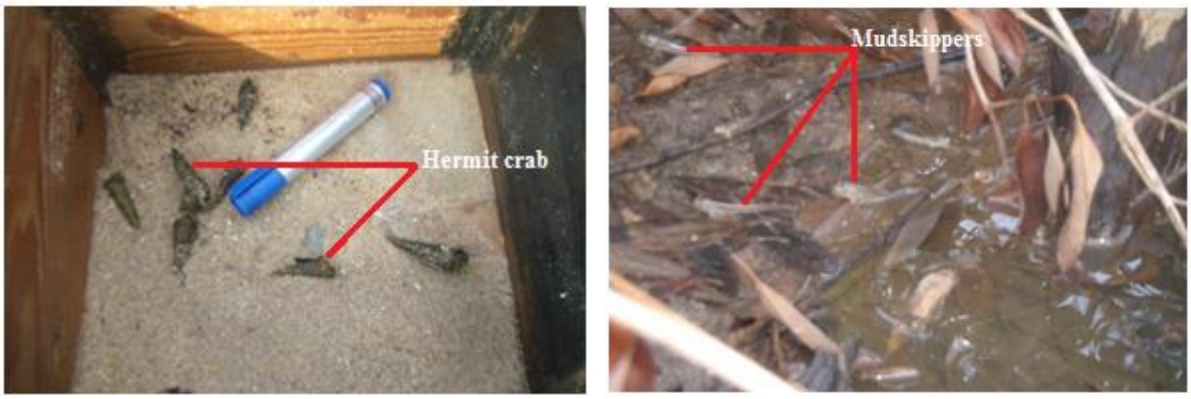

Plate 7: Fauna of the wetland

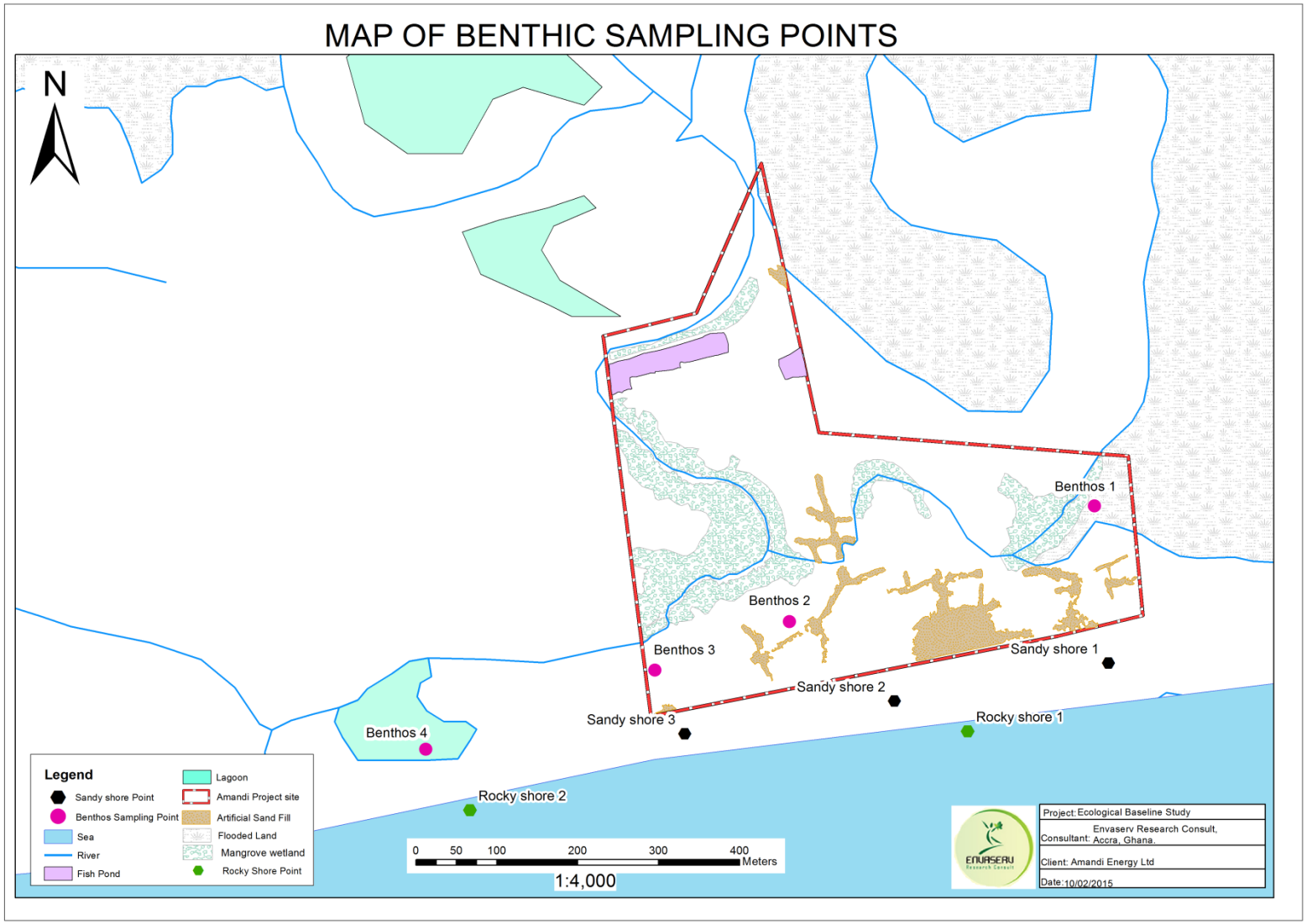

Fig. 3.4: Study area showing benthic sampling sites

SECTION FOUR: Results of the Assessments

4.0 RESULTS

4.1 TERRESTRIAL ECOLOGY

4.1.1 Vegetation and Plant Species

The purpose of a terrestrial habitat survey is to identify different types of habitats found within the study area and to delineate their coverage and supporting fauna. Three major vegetation types are found in Ghana namely coastal savanna (south), forest (central interior) and savanna in the north (Hopkins, 1965). These major zones can be classified into six ecological zones namely the Rain forests, Deciduous Forest, Forest Savanna transition, Coastal Savanna and Northern Savanna (Dickson and Benneh, 1988). The natural vegetation in the Western region is primarily rain forest, however secondary forest comprising pioneer species dominates as a result of anthropogenic activities including logging and poor agricultural practices.

The vegetation of the study area fall within the dry semi-deciduous and it includes extensive mangrove forest. In general, the vegetation of the area is made up of mixtures of herbs (41.4%), shrubs (25%), trees (18.7%), grass (9.3%), and vine (5.3%). The floristic composition indicates a moderate diverse community consisting of herbaceous species and grasses. In all, a total of 76 plant species from 37 families were recorded along the three transects. The families with the highest occurrence were Fabaceae, Asteraceae, Malvaceae and Poaceae, whilst Apocynaceae, Euphoribiaceae, Rutuceae showed the lowest occurrence. Plants species belonging to the family Rutuceae (*Zanthoxyloides zanthoxylem*), Avicenniaceae (*Avicennia germinans*), Poaceae (*Paspaluum vaginatum*), Arecaceae (*Phoenix reclinata*) and Rhizophoroceae (*Rhizophora racemosa*) were particularly common in the study area. The Plant species with the highest occurrence (F>50%) were *Azadirachta indica*, *Phoenix reclinata*, *Zanthoxyloides zanthoxylem*, *Paspallum vaginatum* and *Cocos nucifera*. The grass *Paspallum vaginatum* accounted for a greater proportion of grass species that showed increased abundance coverage northwards. Of the herbal plant species, *Passiflora foetida, Crotalaria retusa* were common. The dominant trees species were the coconut (*Cocos nucifera)*, Neem tree (*Azadirachta indica)* and the wild date palm (*Phoenix reclinata*). Along east-west gradient, the *Zanthoxyloides*

zanthoxylem accounted for more than 40% of the vegetation within Transect I, with coverage increasing westward of the concession.

Three important wetland mangrove species encountered were the *Avicennia germinans*, *Rhizophora racemosa and Laguncularia racemosa,* which formed more than 60% coverage of the total land area (see Fig. 4.1). It is worth noting that the study area is one of the few wetlands in Ghana where all the three mangrove species are present. Thus the study area is critical in terms of the mangrove diversity and the potential biodiversity it supports. Mangroves are salt tolerant trees and shrubs that grow within the sheltered marine intertidal zones of the tropics and subtropics (Long and Giri, 2011). Mangrove forests are known to support significant aquatic biodiversity, serving as breeding ground for some marine and estuarine species, buffer against coastal storm, purification of water pollutants, carbon sequestration (thus important climate change mitigator) as well as numerous ecosystem good and services to coastal populations such as firewood, charcoal, medicines, thatching used for construction etc. making mangrove forest a highly sensitive receptor.

4.1.1.1 Plant Species Conservation Status

Two methods are used to assess the flora of Ghana namely the IUCN (International Union for the Conservation of Nature and natural Resources) Red List and the color coded star rating developed by Hawthorne and Abu-Juam (1995). The latter is mainly used in forest setting and may not be applicable in the study area.

The IUCN Red List of threatened species is widely recognized as a comprehensive world-wide approach used to evaluate the conservation status of plant and animal species (IUCN, 2014). These threatened species or species of conservation concern include species which are classified (by the IUCN) as critically endangered, endangered, vulnerable, rare, indeterminate, out of danger, near threatened or data deficient. Almost all the plant species recorded were either yet to be assessed or were of Least Concern per the IUCN Red List.

4.1.1.2 Plants of Economic Importance

A checklist of the common economic plants within the concession is presented in Appendix II. Nearly all of the encountered plants were economic plants with more than 80% of the total number of economic plants per 100m^2 of land area being luxuriant

stretch of mangrove forest. Also, numerous plant species encountered in the area were of medicinal value. In fact, nearly all of the terrestrial plant species are used for medicine, food, craft, dyes, oil, fuel and games. Medicinal plants play a major role in the health system of rural communities with more than 73 species used in Ghana. Important medicinal plants recorded included *Azadirachta indica, Chromolaena odorata, Secamone afzelli, Passiflora foetida, Indigofera arrecta, Eclipta alba, Jatropha gosypiifolia* and *Ocicum canum*. The study area thus usurps diverse of important economic plants but not certain if the abutting communities make absolute use of them.

4.1.1.3 Agricultural Plant

About 6 crop plants belonging to 4 families are cultivated in a farm north of the concession. The crops include cassava (Euphorbiaceae), maize (Poaceae), okro (Malvaceae), garden eggs (eggplant), tomato and pepper (Solanaceae). The crop plants density was moderately high compared to the small farm size. The farm was weedy and the crop plants appeared dry and withering.

4.1.1.4 Spatial Land Cover

Figures 4.2 and 4.3 depict temporal land cover patterns in 2000 and 2011 respectively indicating the coverage of vegetation. A visual comparison of the maps indicates considerable changes over the period. The most significant change is the increase in coverage of mangrove forest across the project site. In 2011, the mangrove forest was restricted to the northern fringes of the project site but this has increased in from 0.02 km^2 to 0.044 km^2. The observation showed the potential growth of the mangrove forest in the area possibly due to increase in wetland size as a result of flooding.

The mangrove forest is one of the biologically rich habitats in the project area. Another obvious change is the increase in bare land or artificially sand filled areas, which may have been created by recent activities on the land (e.g., scientific study). Artificially sand filled areas and clearing of vegetation have increased particularly in the southern and central areas attributed to pre-construction activities (access to borehole drilling sites). The eastern sections have remained waterlogged with moderately dense shrubs and grasses.

Chromolaena odorata

Passiflora foetida

Paspallum vaginatum

Imperata Cylindricum

Plate 8: Dominant plant species recorded

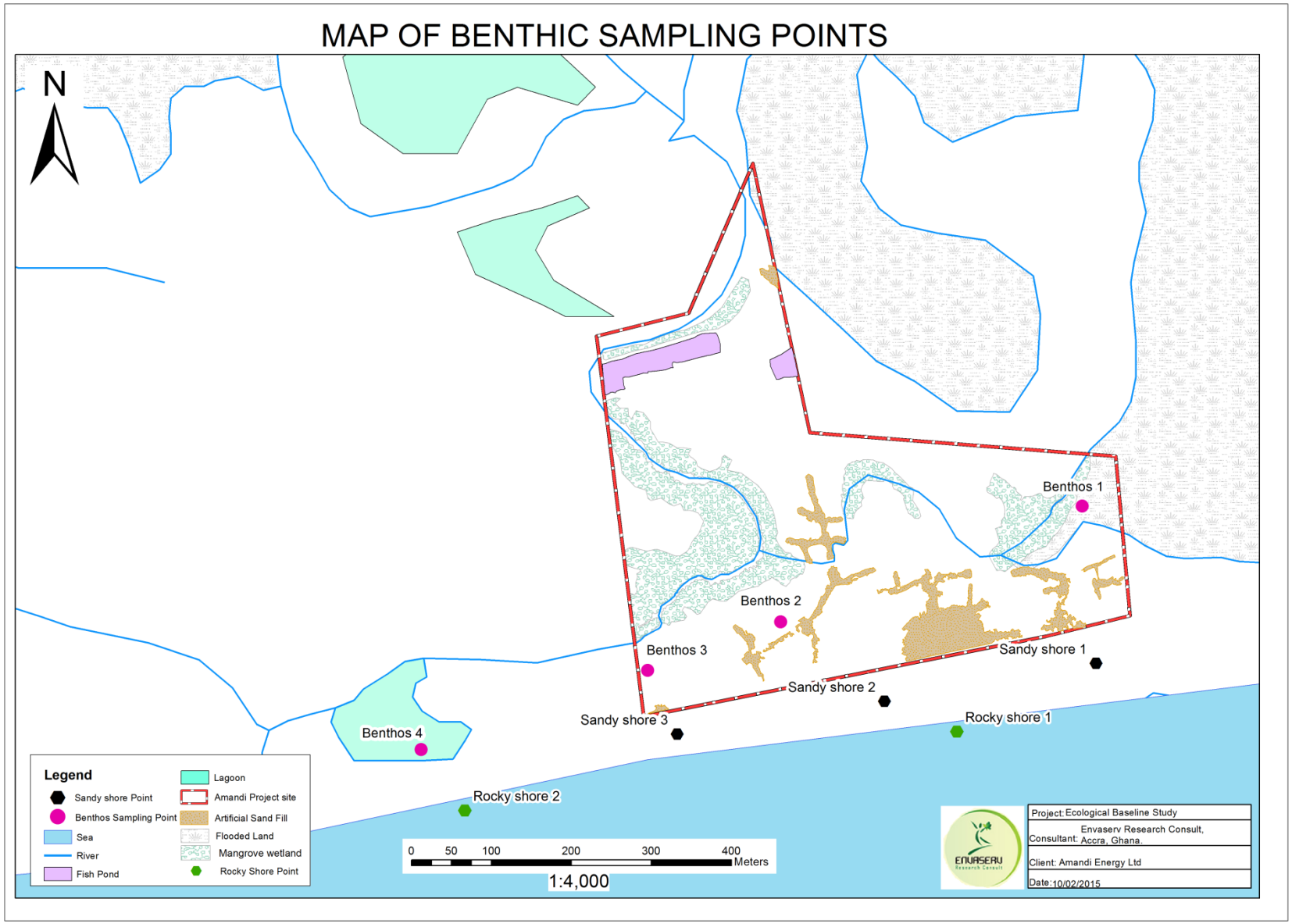

Fig. 4.1: Map showing the extent of mangrove coverage of Amandi's Project site. Artificial sand filling was done to create access to convey equipment for borehole drilling.

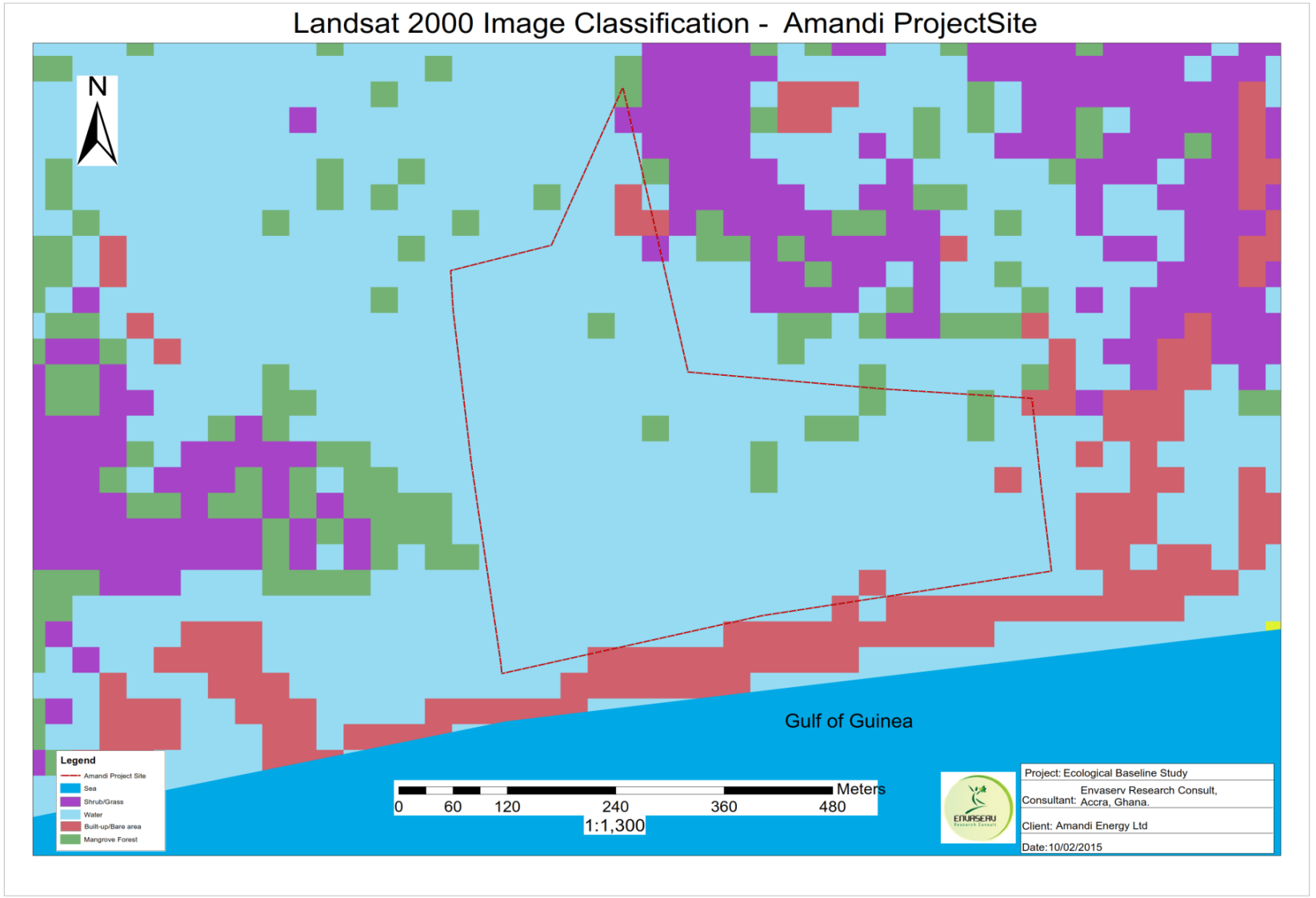

Fig 4.2: Land cover of map of the Amandi's Project site in 2000

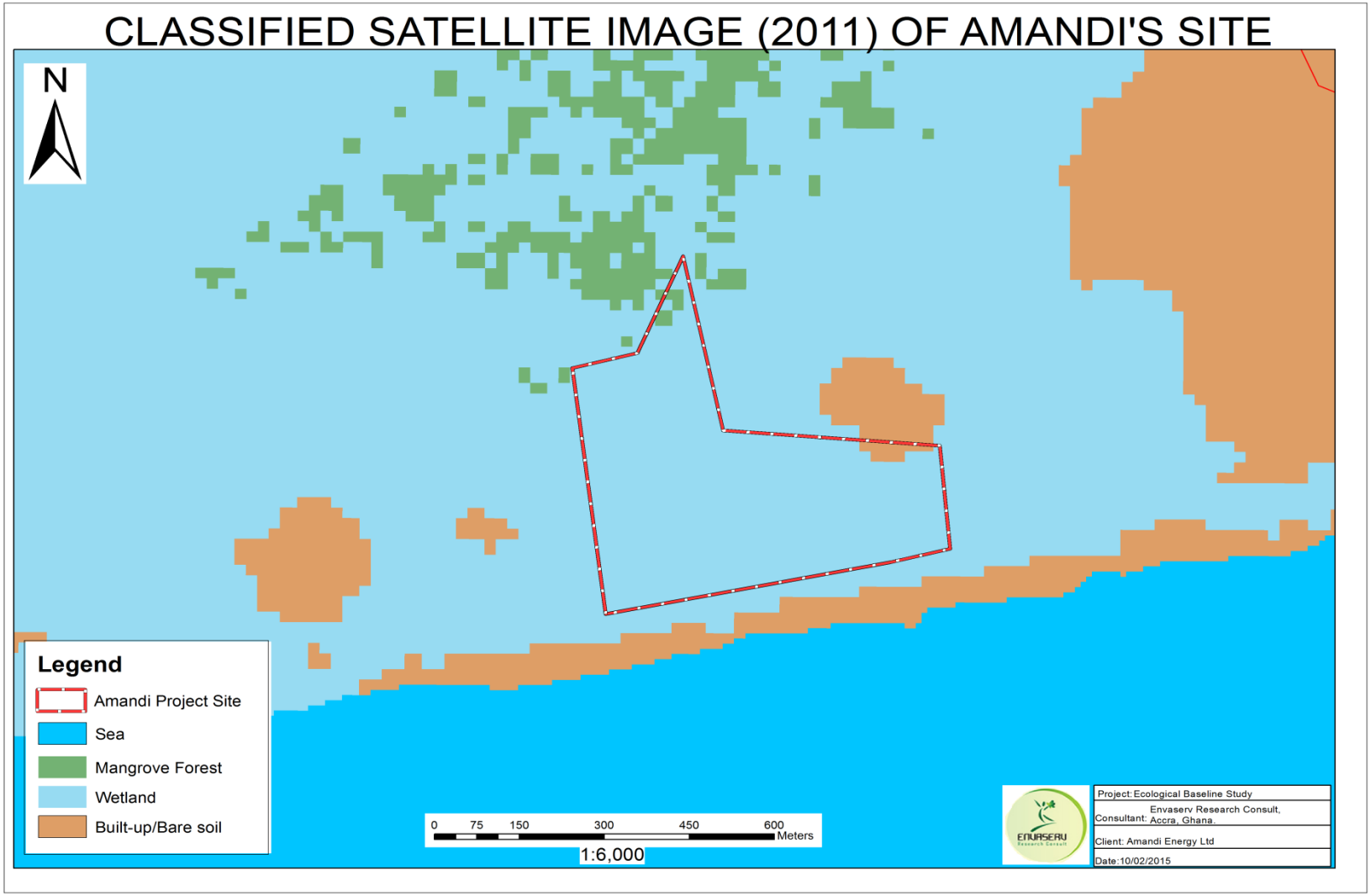

Fig. 4.3: Land cover of map of the Amandi Project site in 2011

4.1.2 Distribution of Small Mammals and Herpetofauna

Approximately 230 species of mammals are found in Ghana. Further there are around 160 reptile and 80 amphibian species in Ghana. The diversity of small mammals, reptiles and amphibians in the studied habitat was generally low with a record of five species, which was made up of two species of small mammals and three species of reptiles (Table 4.1). None of these recorded species is listed by IUCN as endangered, vulnerable or threatened. The Agama lizard and orange flanked skink (Plate 9) recorded have not been ranked by the IUCN.

Plate 9 *Trachylepis sp* (left) observed during refuge search and captured *Mastomys natalensisin (right)* in a Sherman trap

Small mammals, amphibians and reptiles provide insight to environmental health and faunal diversity because they have high energy conversion efficiency and reproductive rates and therefore serve as food sources for many other organisms. As a result, their presence as well as changes in their diversity and populations is seen as ecological indicator to deduce trends in other faunal communities.

A total number of twelve small mammals were captured in the area of which 92% were Multimammate mice (*Mastomys natalensis*) (Plate 9) and 8% being Soft-furred mouse (*Praomys tulbergii*). The eleven small mammals (92%) were captured by the Sherman trap whilst 1 (8%) was captured by the pitfall trap. Strikingly, of the 92%, 73% were found in transect one (near the shoreline). This percentage composition of the small mammals decreased through 18% on Transect two to 9% on Transect three (Table 4.2).

Table 4.1 List of herpetofauna and mammals recorded in the study area.

Class	Common name	Species name	Number recorded	Method of recording			IUCN ranking	National
				Sherman Trapping	Pitfall trapping	Opportunistic observation and refuge search		
Reptilia	Agama lizard	*Agama agama*	1			✔	-	Not Listed
	Orange flanked skink	*Trachylepis sp*	1			✔	-	Not Listed
	African beauty snake	*Psammophis sibilans*	2			✔	LC	Not Listed
Mammalia	Natal multimammate mouse	*Mastomys natalensis*	11	✔	✔		LC	Not Listed
	Tullberg's soft-furred mouse	*Praomys tulbergi*	1	✔			LC	Not Listed

LEGEND

IUCN: The International Union for the Conservation of Nature and Natural Resources (IUCN) periodically publishes a Red List of Threatened Species List which categorises globally-threatened animals as follows:

X Extinct: No reasonable doubt that the last individual has died

EW Extinct in the wild: Known only to survive in captivity or as naturalized populations well outside its previous range

CR Critically Endangered: The species is in imminent risk of extinction in the wild

EN Endangered: The species is facing an extremely high risk of extinction in the wild

VU Vulnerable: The species is facing a high risk of extinction in the wild.

NT Near Threatened: The species does not meet any of the criteria that would categorise it as risking extinction but it is likely to do so in the future

LC Least Concern: There are no current identifiable risks to the species

DD Data Deficient: There is inadequate information to make an assessment of the risks to this species.

.**Table 4.2:** Small mammal abundance data based on catches from Sherman traps

Grid identity	Number of small mammals		
	Transect 1	Transect 2	Transect 3
1	0	0	0
2	3	1	1
3	5	1	-
Total	8	2	1
Percentage composition (%)	**73%**	**18**	**9**
Relative abundance	**33%**	**8.3%**	**5.5**

Table 4.3 shows historic species known to inhabit habitats similar to the study area. These species may be encountered should survey carried out across different seasons for a long period.

Table 4.3: A list of herpetofauna and mammals likely to be regular users of studied habitat

Class	**Species**	**Common Name**	**IUCN ranking**	**National**
Reptilia	*Pelomedusa subrufa*	Marsh Terrapin	LC	II
	Lygodactylus conraui	Gecko	LC	Not Listed
	Varanus. niloticus	Nile Monitor	LC	I
	Bitis arietans	Puff Adder	LC	II
	Causus maculates	Night Adder	LC	Not Listed
	Python regius	Royal Python	LC	II
	Python sebae	African Python	LC	II
	Chelonia mydas	Green Turtle	EN	I
Mammalia	*Crocidura oliveri*	White-toothed Shrew	LC	Not Listed
	Mus minutoides	African pygmy mouse	DD	Not Listed
	Arvicanthis niloticus	Rufous Nile rat	LC	Not Listed
	Rattus rattus	Common Rat	LC	Not Listed
	Cricetomys gambianus	Gambian Giant Pouched Rat	LC	II

	Thryonomys swinderianus	Grasscutter	LC	Not Listed
	Lophuromys flavipunctatus	Brush-furred Mouse	LC	Not Listed
	Protoxerus aubinii	Slender-tailed squirrel	*LC*	II

Legend

Schedule I – species are completely protected under Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971, and Ghana Wildlife Conservation (Amendment) Regulations, 1988; 1995 (i.e., their hunting, capture or destruction is prohibited at all times)

Schedule II – species are partially protected under Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971, and Ghana Wildlife Conservation (Amendment) Regulations, 1988; 1995 (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).

4.1.2.1 Conservation Status

The assessment did not reveal any endangered, vulnerable or threatened species. Three of the vertebrates species recorded were listed by IUCN as Least Concern. Further, the species encountered occur in many other similar habitats and thus the proposed project may not present any adverse impact to the conservation of herpetofauna and small mammals in the area. This statement is made per the available data for this short-term survey since long-term seasonal data was not available to enable sound evaluation of the ecological impacts. However, per the list of species associated with identified habitats of the area, there is inadequate information to make an assessment of the risks to African pygmy mouse (*Mus minutoides).*

One species of snake *Psammophis sibilans* was found in the area is diurnal and prey on lizards and rodents. *Psammophis sibilans* has very large venom glands and produce significant amounts of venom but the venom is mild and not dangerous to humans (Bates *et al*., 2014).

4.1.2.2 Discussion

The total number of small mammals, and reptiles recorded were low and generally confirm that the habitat may not support high diversity of mammals and herpetofauna. The reason could be due in great part to the marshy nature (wetland) of the area. Although marshy wetlands are generally known for their high diversity and richness in amphibians, the noticeable absence of amphibians on the wetland could be due to the salty nature as a result of proximity to the shore. Amphibians generally are intolerant to salt water because they have no salt glands and get dehydrated in salt water (Pough *et al.,* 2003).

Although the small mammal diversity of the habitat is generally low, the highest abundance was noted along the edge habitat close to the shoreline (Transect one), and this decreased landwards through Transects two to three. This result is consistent with the observation that transects two and three, which were located landward had significant portions flooded with brackish water rendering those habitats possibly unstable and inhabitable to the small mammal species. The edge habitat (Transect one) presented a more stable habitat, not easily flooded and therefore supported relatively higher species.

4.1.3 Avifauna Species Composition

Ghana is home to approximately 725 bird species, of which about 300 are associated with the savanna-forest transition zone. A total of 91 species of birds from 33 avian families and 70 genera were recorded at the site (Appendix III). The composition of the avifauna reflected the general mosaic nature of the habitat condition at the site. Although the site can be described as a wetland, only 19 species (21%) of the species recorded are typically associated with water. This may be attributed to the absence of an open lagoon of considerable size at the site to serve as feeding grounds. The creeks and the marshes were rather much wooded and generally lacked the open and bare areas usually found in some coastal wetlands.

None of the 91 bird species recorded in the study is of any global conservation significance. However 17 of the species are listed on Schedule I of the Wildlife Conservation Regulation and thus are protected from hunting. These included species from the family Ardeidae, Accipitridae, Falconidae and Tytonidae. None of the 19 species of waterbirds recorded at the site was recorded in globally significant numbers. The profile of the species recorded suggests that the avifauna of the site may be remnant of a climax community that previously existed in the area. The fallow area of which the site formed part is surrounded by industrial activities and human settlement, hence it is obvious that the birds recorded are remnant of the species that are able to withstand the prevailing environmental pressures, emanating from the persistent habitat degrading human activities.

Since the study was carried out during the over-wintering period, the low numbers of migrant water birds recorded reflected the low potential of the site as roosting grounds. It was obvious that the site may not be important as wetland due to the relatively small number of waterbirds that were recorded at the site and therefore not designated as one of the Important Bird Areas of Ghana (Ntiamoa-Baidu *et al.*, 2001). The site may however be ecologically important as a wetland in flood control. The site and its immediate surrounding areas appear to be the flood plain of a number of streams flowing down south but without access into the sea.

Plate 10: Little Bee-eater (left) and Common fiscal (right)

4.2 AQUATIC ECOLOGY

4.2.1 Aquatic Plants Species

A total of eleven (11) species representing aquatic flora in the study area were found. The most conspicuous aquatic plant species were *Avicennia germinans, Laguncularia racemosa* and *Rhizophora racemosa* as well as the dense multiple trunk shrub *Conocarpus erectus.* These species were observed to be associated with the Anakwari lagoon and the extensive wetland within the project site (Plate 11). The edges of the wetland and lagoon were fringed with aquatic macrophytes such as *Paspallum vaginatum*, *Sporobolus pyramidalis*, *Philozerus vermicularis*, *Sesuvium portulacastrum*, *Canavalia rosea*, *Ipomoea perscape*, *Remeria maritima* and *Thespesia populnea*. Generally true aquatic plants were conspicuously absent from the study area which is attributable to the brackish nature of the wetland.

Plate 11: Aquatic plants within the Anakwari lagoon

4.2.2 Macrobenthic Invertebrates

The macro-invertebrate constitute an important component of the natural wetland ecosystem. Ecologically, the macrobenthos population plays an important role in the transfer of food, energy and nutrient cycling of the wetland. They form an important link in the estuarine and marine food chain as fishes, birds and marine mammals depend on them directly or indirectly for their food supply (Barnes and Huges, 1988). The macro-invertebrates are also especially suitable for cost effective long-term comparative investigations since many of the constituent species are sedentary or sessile, relatively long lived and integrate effects of environmental changes over time.

The occurrence of the various macrobenthic fauna encountered within the wetlands of the study is presented in Table 4.4. A total of 62 individuals made up of 7 species , which belong to 4 major taxonomic groups namely Polychaeta, Crustacea, Insecta, Mollsuca were recorded within the mangrove wetland. Of this number, polychaetes constituted 65%, crustacean (32%) whilst the remaining 3% is made up of insects and bivalves. *Capitella capitata* numerically dominated the invertebrate community accounting for more than 60% of the total abundance giving indication of habitats perturbation and ecologically stressed system possibly due to organically-rich mangrove sediment. *Capitella capitata* is an opportunistic polychaete that has been considered an important universal indicator of organic pollution in marine sediments (Mendez et al, 2000). The presence of populations of *C. capitata* in the wetland represents an index to evaluate disturbance impact. The Sesarmid crab dominated the crustacean community. Species of Mollusca and Insecta were poorly represented in the wetland with one species each recorded. The insect encountered belong to the order Diptera (Family Chironomidae and genus Chironomus) and was only recorded west of the concession. A noticeable observation is the increasing trend in species richness and abundance from east to west. Although, mudskippers (*Periophthalamus barbarus*) were not recorded as part of the grab samples, they formed a significant number of the fauna of the wetland observed during the field study. Among the wetland fauna, only the mudskippers are ranked as "Least Concern", the conservation status of the other recorded fauna is yet to be assessed. Many of the recorded species are common in other mangrove forests along the Ghanaian coast.

Highest macro-invertebrate abundance occurred at western (Point 3) of the concession whereas the east (Point 1) showed low numerical abundance. Shannon-Wiener diversity index was generally low across the wetland, but the highest was noted west of the wetland

and also downstream location of the Anakwari lagoon. Margalef's species richness index ranged from 0 (East) to 2.11 (West). The spatial patterns of the diversity indices are consistent for the Margalef's richness and Shannon-Wiener's diversity (Fig. 4.4).

Table 4.4. Inventory of Wetland macro-invertebrates within the study area

Species	Class	Family	Benthos 1	Benthos 2	Benthos 3	Benthos 4
Chironomus sp	Insecta	Chrironomidae			√	
Capitella Capitata	Polychaeta	Capitellidae			√	√
Heteromastus sp	Polychaeta	Capitellidae			√	√
Sersamid crab	Malacostraca	Sesarmidae		√	√	√
Hermit crab	Malacostraca				√	√
Crab indet	Malacostraca		√			√
Modiolus modiolus	Bivalvia	Mytilidae		√		

Table 4.5. Abundance, species richness and density of macrobenthic faunal groups in the study area

Taxa	**No. of Species**	**Abundance (No. of ind.)**	**Percent Abundance**	**Density (ind./m²)**
Polychaeta	2	40	65	635
Crustacea	3	20	32	317
Mollusca	1	1	1.6	16
Insecta	1	1	1.6	16
Total	**7**	**62**	**100**	**984**

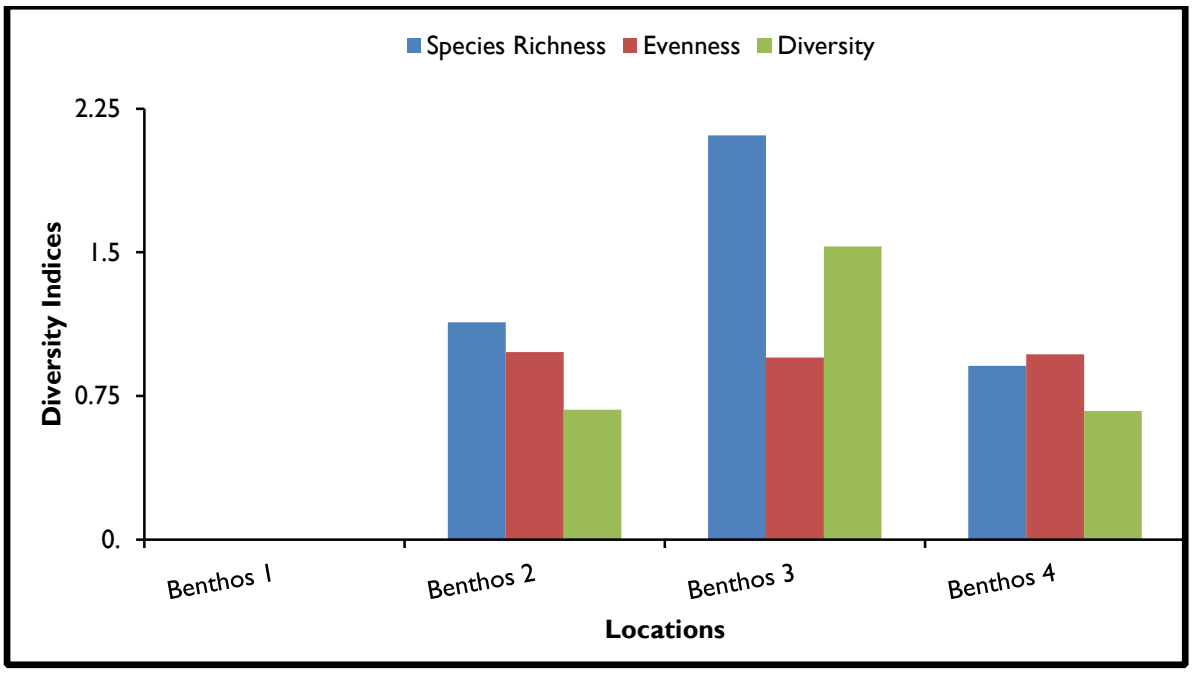

Fig. 4.4 Distribution of diversity indices across sampling stations of the study area

4.3 COASTAL MARINE ECOLOGY

4.3.1 Rocky Shore

A total of 18 species from 12 families in 4 phyla of marine invertebrates were identified (Appendix IV). The fauna recorded comprised 10 species of gastropods, 3 species crustaceans, 3 species cnidarians, 1 taxa each of bivalve and echinoderm. The number of species for the gastropods was higher but the highest numerical abundance was noted for the crustacean (mainly *Chthalamus dentata*). The gastropods and the barnacle (crustacean) collectively contributed about 98% of the total abundance recorded (n=4295) along the 60m stretch transect. The gastropods were numerically dominated by the limpet *Patella safiana*, followed by *Echinolittorina punctata, Siphonaria pectinata* and *Nerita atrata*. The gastropod *Siphonaria pectinata* was widely distributed occurring between the eulittoral to sub-littoral. The most frequently occurring fauna in that order were *Siphonaria pectinata*, *Patella safiana*, *Echinolittorina punctata*, *Nerita atrata* and *Chthalamus dentata*.

Other species of interest that were not recorded in quadrats but observed along the transect included *Echinolittorina granosa, Ostrea* sp*, Grapsus grapsus,* and colonies of *Palythoa* sp. (yellowish brown) and *Zoanthus* sp. (blue-green). The dominance and high diversity of gastropods seems to be due to the existence of sheltered rocks onto which the gastropods easily attach. Comparatively the rocky outcrops westward recorded the highest abundance

and diversity and appeared to be more sheltered from the influences of tides and waves. All species recorded in this study were compared to marine invertebrate species previously reported from Aboadze. The results showed that nearly all species recorded in this study are known to exist on the rocky shore of Aboadze (see EIA for Takoradi Thermal Power Plant Expansion Project (T3), 2009).

Zonation on the rocky shores for the fauna appeared weakly conspicuous, however, the littorind *Echinolittorina punctata* was patchily abundant over a very narrow vertical band of the littorinid zone that also had a high proportion of *Siphonaria pectinata*. Within the broad midlittoral zone were the barnacle *Chthalamus dentata*, *Patella safiana*, *Nerita atrata*, *Siphonaria pectinata*, *Thais haemastoma* and the littorinid *Enchinolittorina punctata*. *Patella safiana* had the highest vertical range of these species reaching into sub-littoral areas. The barnacles were fairly dense in the mid-littoral. Of the other species, *Nerita atrata* was patchily abundant in crevices cuddling together possibly to conserve moisture. The lower intertidal areas had dense coverage of macroalgae with the smaller key-hole limpet *Fissurella nebecula* occurring underneath the algae.

The flora composition comprised 24 macroalgae species belonging to 17 families. Of the total species 29% (7) were Chlorophytes (green algae), 17% (4) Phaeophytes (brown algae) and 54% (13) Rhodophytes (red algae). A checklist of macroalgae species identified in the study area and their IUCN status is presented as Appendix V. The alagal cover relative to the shore is shown in Plate 14). The green alga *Chaetomorha linum* laced with *Centroceras clavulatum* formed an extensive conspicuous green band on the rocks of the Eulittoral (upper intertidal). The encrusting *Lithothamnia* sp. was also common in small patches in the Eulittoral. The mid-littoral composed of a multi-species algal bed dominated by red algae *Centroceras clavulatum*. Generally the mid-littoral represented a transitional zone with high diversity of macroalage species. Typical algae species encountered include *Ulva Flexuosa, Ulva faciata, Centroceras clavulatum, Padina antillarum, Padina durvillaei* and *Ralfsia expansa, Gelidium corneum Hildenbranchia rubra, Hydropuntia dentata, Bryocladia thyrsigera, Chondracanthus acicularis and Polysiphonia ferulacea.* Patches of brown alage were common on the seaward sections to the sub-tidal areas. The seaward sections had some *Sargassum vulgare, Hydropuntia dentata* but the algae grew sparse with decreasing distance toward the sublittoral. The tidal/rock pools were considerably dominated by *Sargassum vulgare, Hydropuntia dentate, Hypnea cervicornis, Ulva fasciata* and *Delidiopsis variabilis.*

An interesting feature was the high population of sea urchins (*Echinometra lacunter*) within

tidal pools of rocky outcrops beyond the Anakwari lagoon. The high population of sea urchin has had significant effect on the diversity and number of macroalgae, leading to the absence of soft algae, rather encrusting *Lithotamnia* sp. dominates. In addition, the rocky shores at Aboadze are known to be the type locality for the *Griffithsia schousboei*, however the species was not observed during this study. Once again, it is worth noting that the macroalgae community of Aboadze is similar to macroalgae communities along the coastline of Ghana, as such the project is not expected to have any significant deleterious effect on the distribution, occurrence and composition of macroalgae.

Plate 12: Exposed rocky outcrops of Aboadze

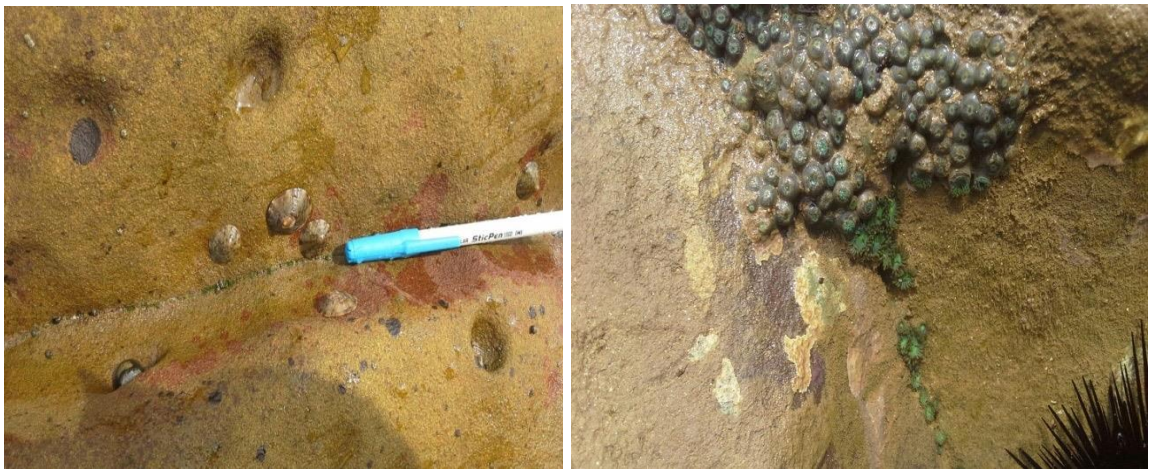

Plate 13: *Patella Safiana* (Left) and colonial *Zoanthus* sp. (Right) encountered.

Plate 14: Mats of *Ulva flexuosa* with *Chaetomorpha linum* (L) and *Centroceras clavulatum (R*)

4.3.2 Sandy Shore

4.3.2.1 Macrobenthic Invertebrates

The species diversity and abundance on the sandy shore was generally low compared to the rocky shore. This reflects the physically harsh and highly dynamic environment associated with exposed sandy beaches including the Aboadze beach.

A total of 14 individuals were identified and recorded in the three samples. The macrofaunal community of the sandy shore comprised of 5 species belonging to two major taxa. Appendix VI summarizes the taxa recorded from the sandy intertidal with their distribution and abundance.

Crustacea were numerically dominant accounting for about 64% of the total macrofauna. The crustacean was represented by *Ocypode cursor, Excirolana* sp., and tanaids. The species composition showed that the macrobenthic community was largely represented by a single species (*Ocypode cursor*) which contributed to greater than 40% of the total abundance and spanned the whole area. Polychaetes were poorly represented at the various sampling points and were represented by *Goniada* sp. and *Nephtys* sp. The most dominant polychaete species was noted for *Goniada* sp. (3 ind/m^2) at Sandy shore Point 3. The macrobenthic fauna showed considerable variation in composition and abundance along the same stretch of beach, although they had similar characteristics. The abundance ranged from 2-8 individuals (mean=5±3.05). Sandy shore point 3 (west) recorded the highest abundance and lowest were at Sandy shore 1 (east). Overall species diversity and richness increased westward, similar to trends observed for the wetland macrobenthos and the rocky shore studies.

4.3.2.2 Crab Ecology

A total of 150 individuals belonging to *Ocypode cursor* were recorded along the beach. The burrow size ranged between 0.03 -10 cm and 0.01-6 cm for Transect 1 and Transect 2 respectively. The maximum diameter recorded was 10 cm and the smallest burrow size was 0.01cm.

Sizeable burrows dominated the sandy beach an indication that the beach is less frequently disturbed by natural and anthropogenic factors resulting in the dominance of adult crabs. The number of burrows per quadrat ranged between 8-121 ind./m^2. The highest number of crab burrows and density were observed for transect 1 westward of the beach. The average burrow density (63 ind./m^2) for this study was significantly higher than reported values (7 ind./m^2, EIA Eni Offshore Cape Three Points Oil & Gas Project 2014) for disturbed shore in

the Ellembelle district of the Western region where human use of the beach was considerably high resulting in adverse impact on the numbers of the ghost crab community.

Barros (2001) found evidence suggesting significantly higher burrow density of ghost crabs with lower anthropogenic impact. Ghost crabs are ecologically important and are reported to play a vital role in the preservation of intertidal environments through the aeration of the bottom substrate as they sift through the sands. They offer practical advantage for estimating beach ecological status because of their occurrence and abundance on many beaches. Berry (1976) reported that because of their burrowing and scavenging habits, ghost crabs may be adversely affected by increased oil traffic and its resultant increase in the amount of oil spills on the beaches. Contact with oil is believed to reduce ghost crab breeding rate and increase mortality at molting. Nonetheless, globally there is no immediate adverse impact on the numbers and distribution of ghost crabs. In developing countries, including Ghana the biggest threat to the ghost crab is alterations to the upper intertidal zone caused by residential and commercial development of coastal areas. Consequently the crabs are either displaced to unfavorable environment or exterminated. Given the high abundance of ghost crabs at the project site, and along the coastline of Ghana the project is less likely to significantly impact on the populations of the species in the area.

4.3.3 Shoreline Morphology

The topography of a beach determines the effect of wave energy on that beach. Extensive and flatter shores tend to have irregular profiles and more gentle conditions, however with increasing steepness, water movement tends to be more violent. The profile of a beach extends from upper limit of wave action to the low water mark of spring tides including the seaward zone over which sediments may be moved by waves.

An important feature of beach profiles is their overall gradient, i.e. the average slope between seaward and landward limits. The gradients vary between two extremes: profiles are either steep or shallow (Pethick, 1984). The unique topography and slope of any beach area is the outcome of several interactions between abiotic and biotic factors. Textural properties of beach sediments and the size of waves have been documented to significantly influence beach slope variation (King, 1959). The shores of Ghana have been reported to exhibit variable beach morphology. Furthermore, coastal erosion, flooding, and shoreline retreat are serious problems along the coast (Boateng, 2009).

The profile of the beach for the east, west and midpoints of the Amandi's site are provided in Figures 4.5 and 4.6 below. The beach gradient (Height:Distance) measured for all the sites show gentle sloping beach with intermittent sharp scarps. The mean beach width recorded was 44.48 m ranging between 37.54m and 51.0 m. The longest stretch was recorded at the east and the shortest midpoint of the concession. About 10m of the beach reaching the backshore is relatively flat with turf *of Sersuvium portulacastrum*. Although a greater part of the beach within the project area appeared firm, portions appeared eroded possibly as a result of significant wave action.

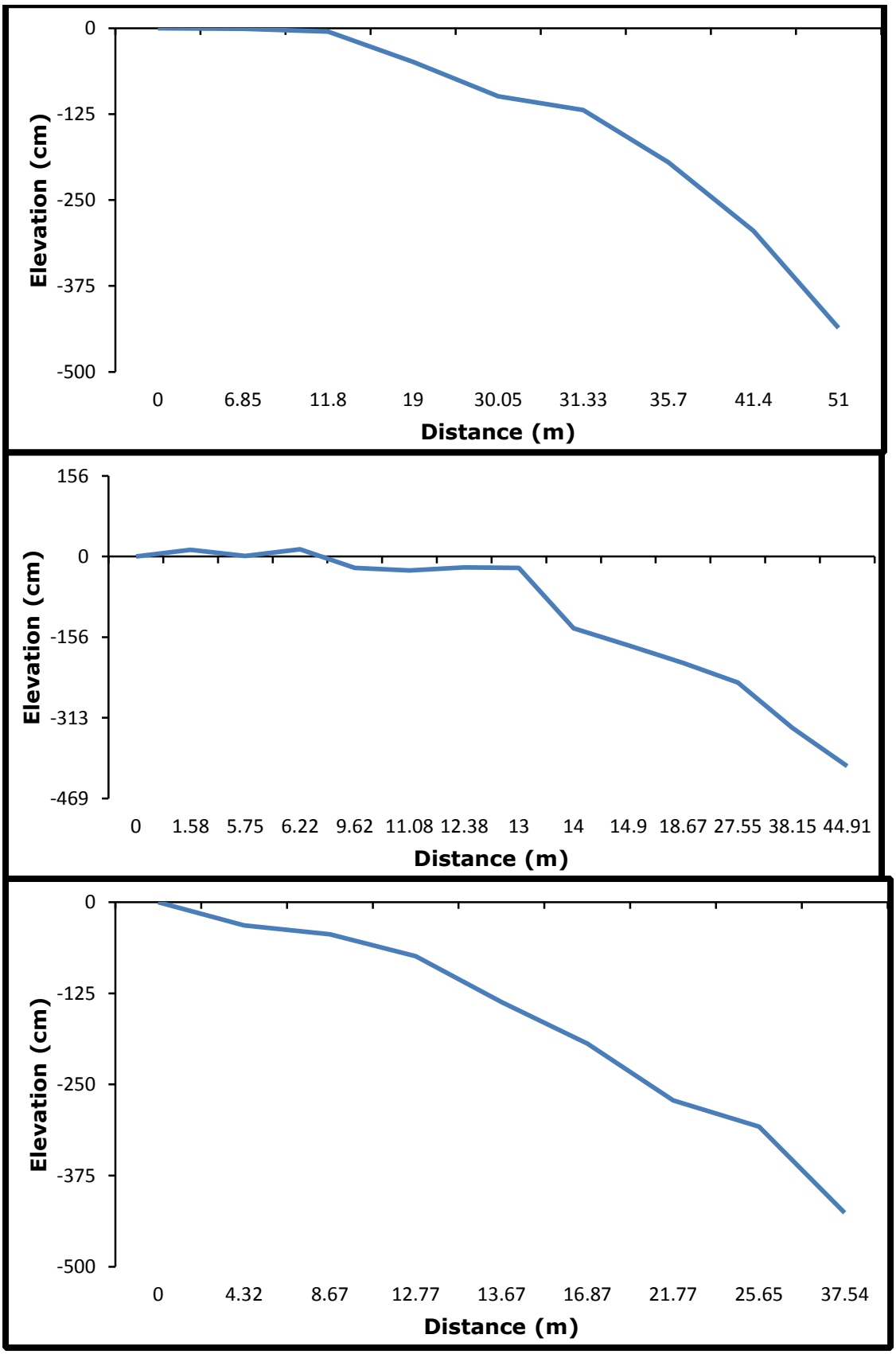

Fig 4.5: Beach profile of the east point (top), midpoint (middle) and west point (bottom).

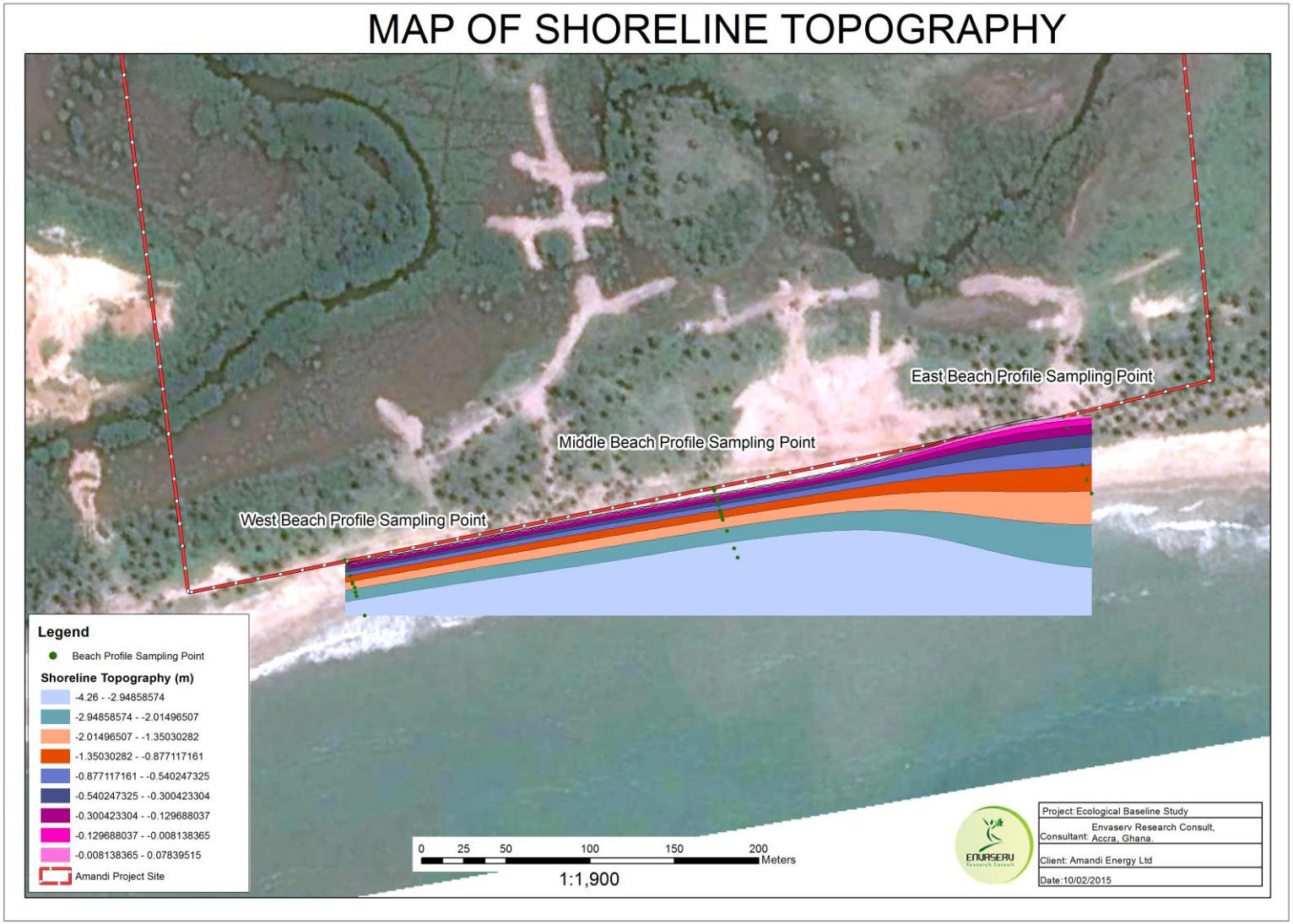

Fig. 4.6: Shoreline morphology and profile of Amandi's Project site

SECTION FIVE: Ecological Sensitivity

5.0 Impact Assessment Criteria

The key primary ecological concern of the proposed project may stem from:

- changes in the provision of ecosystem services as a result of loss of species and/or critical habitats;
- habitat loss and degradation, (e.g., earthworks, vegetation clearing, pollution, air emissions). For example, possible pollution of the Anakwari stream may affect valued aquatic species or cause irreversible destruction of mangroves forest that support biodiversity;
- habitat fragmentation — ecosystems and their species need a certain amount of interconnectivity for processes to continue; breaking a natural area into smaller pieces, means that eventually species disappear and certain functions are lost; e.g., adverse impact on the water quality and flow regimes of the Anakwari stream will potentially impact adversely on mangrove species and associated fauna, also avifauna fauna species would be deprived of valuable food items, habitats and breeding grounds.
- loss of species, e.g. the plants and animals endemic to a particular habitat will not be able to survive if that habitat is destroyed or altered by the development;
- changes in natural environmental processes, such as reduced river flow, discharge of brine into nearshore/coastal environment, coastal sediment transport, which can have long-term impact on habitats and species.

5.1 Assessment Methodology

Identifying impacts on ecological entities necessitate certain criteria elements in methodologies which include ecosystems and habitats containing high diversity, large numbers of endemic or threatened species, threatened habitats that are required by migratory species, those that are of social, economic, cultural, or scientific importance, and those that are representative of unique biological processes. The evaluation of ecological impacts was primarily focused on conservation importance of the species and/or the habitats.

Conservation Importance:

The conservation importance of the site gives an indication of the necessity to conserve areas based on factors such as the importance of the site on a national and/or regional scale and on the ecological state of the area (degraded or pristine). This is determined by the presence of a high diversity, rare or endemic species and areas that are protected by legislation. The criteria used are defined as follows:

High – Ecosystems with high species diversity and usually provide suitable habitat for a number of threatened species. These areas should be protected.

Medium – Ecosystems with intermediate levels of species diversity without any threatened species.

Low – Areas with little or no conservation potential and usually species poor (most species are usually exotic).

Areas of high sensitivity: Remnant forest patches, riparian areas as well as buffers around these areas are classified as highly sensitive and no development should occur within these areas.

Areas of medium sensitivity: Degraded woodland and corridors linking areas of high sensitivity.

Areas of medium to low sensitivity: Degraded area and historically cultivated areas. These areas are of low ecological sensitivity and can be used for agricultural activities.

Buffer zones around sensitive areas: There are two purposes of an ecological buffer around sensitive areas:

1. to restrict human disturbance to the sensitive areas and preserve key ecosystems and species; and
2. to reduce negative impacts to humans or infrastructure resulting from the protected areas (Correll, 2005). The buffers described here are applicable to fauna and flora.

Impact Assessment and Mitigation

Any activity or development in a natural area will impact on the surrounding environment in either a positive or negative way. The purpose of this study was to determine and assess

the major impacts associated with proposed power plant facility development on the ecological environment.

Assessment Criteria

The environmental impacts are assessed with mitigation measures (WMM) and without mitigation measures (WOMM) and the results presented in impact tables which summaries the assessment.

The criteria against which these activities were assessed are discussed below.

Nature of the Impact

This is an appraisal of the type of effect the project would have on the environment. This description includes what would be affected and how and whether the impact is expected to be positive or negative.

Extent of the Impact

A description of whether the impact will be local (extending only as far as the servitude), limited to the study area and its immediate surroundings, regional, or on a national scale.

Duration of the Impact

This provides an indication of whether the lifespan of the impact would be short term (0-5 years), medium term (6-10 years), long term (>10 years) or permanent.

Intensity

This indicates the degree to which the impact would change the conditions or quality of the ecological environment. This was qualified as low, medium or high.

Probability of Occurrence

This describes the probability of the impact actually occurring. This is rated as improbable (low likelihood), probable (distinct possibility), highly probable (most likely) or definite (impact will occur regardless of any prevention measures).

Degree of Confidence

This describes the degree of confidence for the predicted impact based on the available information and level of knowledge and expertise. It has been divided into low, medium or high.

5.2 Evaluation of Impact Significance

Possible significant impacts associated with the proposed activity and their sources are provided in Tables 5.1. Based on the current information, the most pertinent and significant impacts (negative) associated with the power plant facility on indigenous fauna and flora would span from medium to low.

Table 5.1 Summary of impact significance

Possible Negative Impact	**Source of Impact**	**Impact Significance (WOMM)**	**Impact Significance (WMM)**
Destruction of indigenous flora as well as habitat fragmentation	Clearing of vegetation & civil works	Medium	Low
Recurring disturbance to fauna utilizing the area	Constructional disturbance Operational noise from turbines, machinery etc.	Medium	Low
Possible diversion of Anakwari Stream	Constructional disturbance Operational noise from turbines, machinery etc.	Medium	Low
Habitat fragmentation & loss	Pipeline construction for desalination plant may cause fragmentation of habitats or loss of critical habitats	Low	Negligible

5.3 Impact and Mitigation Measures

In determining the applicability of measures to be undertaken to limit impacts on the ecological habitats and associated wetlands (natural critical habitat), it is recommended that the environmental impact hierarchy to be adhered to should follow:

- Avoidance of impact – the design and planning must first take into consideration the environmental sensitivities of the site and undertake to avoid impacts wherever possible. This should include timing of the project construction not to coincide with periods that will impact on biodiversity (e.g., avifauna) and wetland (e.g., change in hydrology). As much as possible construction activities should be restricted to the dry

period of the season to minimise runoff. Creation of buffer zones from sensitive receptors (e.g., wetland & rivers/stream) is also recommended. Well-designed buffers protect and maintain wetland functions by removing sediments and associated pollutants from surface water runoff, removing, detaining, or detoxifying nutrients and contaminants from upland sources, influencing the temperature and microclimate of a water body, and providing organic matter to the wetland. Buffers also maintain habitat for aquatic, semi- aquatic, and terrestrial wildlife, and can serve as corridors among local habitat patches, facilitating movement of wildlife through the landscape (Environmental Law Institute, 2008).Protection of vegetated buffers may reduce the severity of water fluctuations and flooding (Environmental Law Institute, 2008). Appropriate buffering of wetlands and hydrological processes will help reduce negative sedimentation processes which could potentially affect essential resources such as fish. No standard buffer zones are recommended for wetlands in Ghana. However, four criteria were identified for determining adequate buffer sizes for aquatic resources (Castelle *et al.,* 1994 cited in Grundling 2008):

  - Resource functional value;
  - Intensity of adjacent land use;
  - Buffer characteristics; and
  - Specific buffer functions required

- Minimisation of impact – where impacts to the wetland are unavoidable (e.g., mangrove clearing), the project design/layout should be fashioned to minimise the impacts associated with their activities. For example re-designing of facility layout to ensure that project active areas are away from mangrove coverage area .

- Mitigation of impact – once all possible impacts have been avoided and minimised as far as possible, the remaining significant impacts must be mitigated on site. This can be undertaken through effective control measures through rehabilitation measures to ensure no net mangrove loss but net positive compensation (e.g. relocating the exact or higher quantities of mangrove to adjacent land corridor.

Generally, mitigation measures are developed to avoid, reduce, remedy or compensate for any negative impacts identified, and to create or enhance positive impacts such as

environmental and social benefits. Specifically, it is estimated that about 0.05km^2 of mangrove within the project footprint will be directly removed. It is envisaged that it will not be possible to avoid all direct impacts on mangroves, hence practical mitigation measures will be taken to minimize and compensate for the impacts on the mangrove forest.

Potential Impact on Vegetation

The main impact of the project of the vegetation and plant species will potentially happen during the construction phase of the project. Clearing of vegetation and earthworks will lead to loss of certain plants. The loss of vegetation would be permanent within the project footprint. However, the total project area coverage would be small and there are no plant species of conservation significance, thus adverse impact is expected to be low. Since there are similar plant species in the adjacent areas, food resources may be not be completely destroyed making the overall adverse impact low.

Potential Negative Impact	**Source of Impact**	**Impact Significance (WOMM)**	**Impact Significance (WMM)**
Loss of vegetation cover	Clearing of vegetation and civil works	Low	Low
Destruction of food sources	Clearing of vegetation and land preparation activities	Low	Low

- To the extent possible vegetation clearance will be limited to the areas required for the Thermal Power Plant development;

Potential impact on the Mangrove forest

The site for the power plant is largely covered by mangrove forest wetland making the area a natural critical habitat. Mangrove wetlands provide vital ecological services such as filtering and assimilating pollutants from upland run-off, serving as a habitat for various fisheries species and bird populations, carbon sequestration and protection of the coastline from

erosion and storm. Clearing these mangrove forests to make way for the project would therefore impact the ecosystem due to loss of natural critical habitats and associated loss of key ecological services.

Potential Negative Impact	**Source of Impact**	**Impact Significance (WOMM)**	**Impact Significance (WMM)**
Loss of natural critical habitats	Clearing of vegetation	Medium	Low
Loss of carbon sink	Clearing of vegetation and civil works	Medium	Medium
Loss of vital ecological services		Medium	Low

The mitigation measures here will include replanting to compensate for the exact quantities of mangroves that would be affected by the project. It was estimated that of the 0.044 km^2 (18.33%) mangrove coverage on the proposed site, 0.017 km^2 (6.92%) would be cleared for the project development (Fig. 5.1) lay out cleared in an adjacent land so that there is no net loss of mangrove although replanting will take time before establishment for the full ecosystem benefits to be realized.

However, of the 18.33% (0.044 km^2) mangrove coverage on the site boundary, 6.92% (0.017 km^2) that would be affected by the project development should be compensated at the non-mangrove areas (0.021 km^2) at northern portions of the site.

It means there will be temporarily loss of ecosystem services which would be restored after the mangroves established. Further, the project layout will be engineered that more active areas are away from mangrove forest. Regular monitoring and evaluation of the replanted mangrove would be carried out to ensure early growth and establishment, and also not tampered by the community folks. Annual assessments and monitoring of the mangroves should be conducted so as to identify and remove any alien vegetation that has established among them.

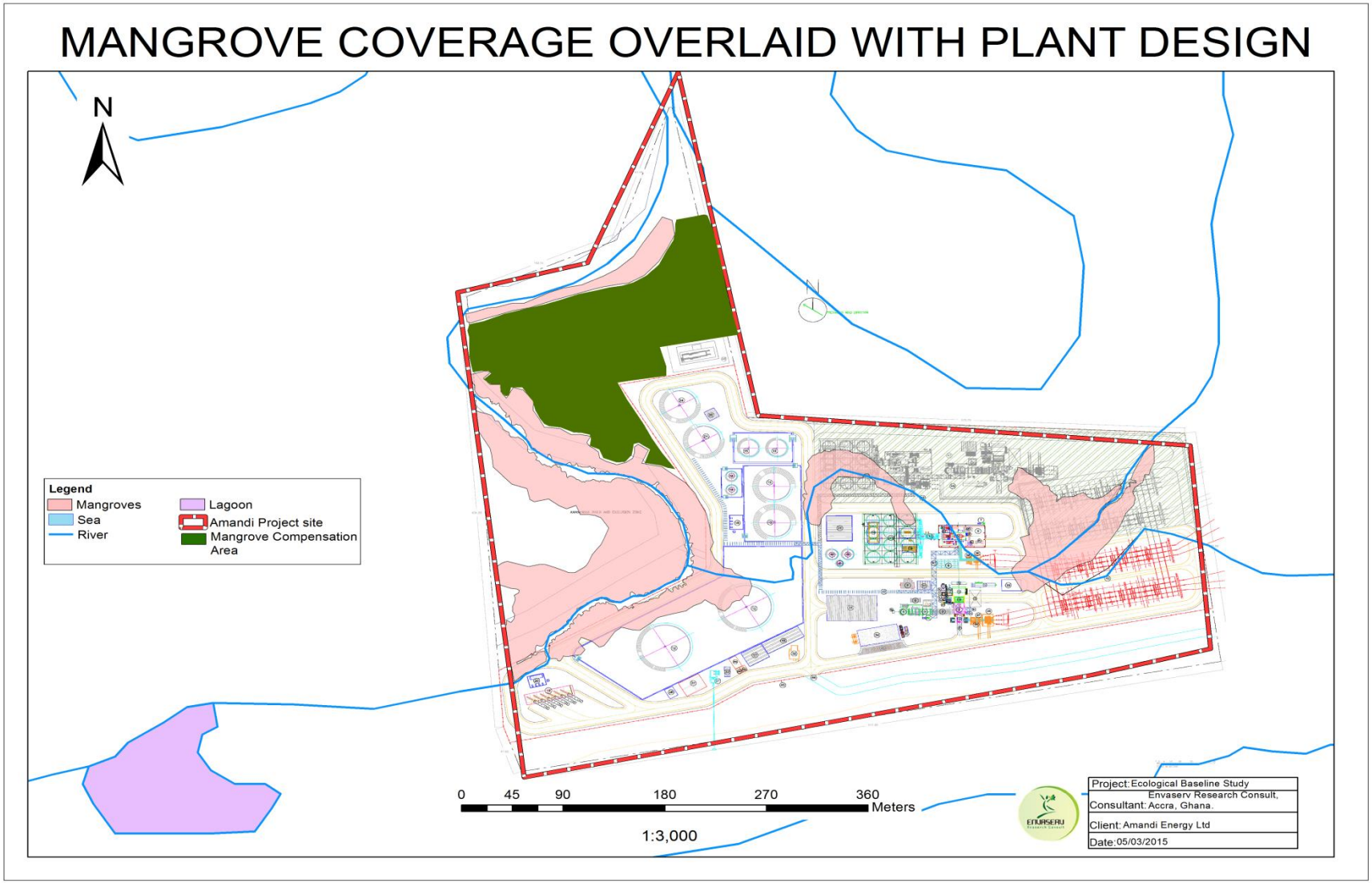

Figure 5.1 Superimposition of proposed project lay out on the mangrove forest to identify quantities affected for compensation.

Expected Impact on Avifauna

The main expected impact of the proposed project would be the loss of the existing natural critical habitat. Fauna species are primarily dependent on their habitat for their survival, hence habitat loss is the main factor that threatens their survival. However, all the species recorded at the site are common widespread birds with no global conservation significance. The global importance of a wetland is reckoned in terms of the numbers of a particular species that roost at the wetland at a particular period. However, none of the 17 water birds recorded at the site was in globally significant numbers, hence the implementation of the project is not likely to result in the destruction of a site that will affect any avifauna of global significance. This means the species are resident and could utilise nearby similar habitats due to their mobility.

Due to the strategic position of Ghana as the boundary of two flyways, many coastal wetlands in Ghana are important for many migratory bird species, however the proposed project site is not listed as one of the important roosting sites for resident and migratory water birds. The site is also not in close proximity to any of the existing coastal Ramsar Sites in Ghana. Although water birds were not present in significant numbers at the site, the physical disturbances that may be associated with the implementation of the project may result in the outright loss of the habitat.

Potential Negative Impact	**Source of Impact**	**Impact Significance (WOMM)**	**Impact Significance (WMM)**
Loss of natural habitat	Clearing of vegetation and civil works	Medium	Low
Destruction of food sources	Clearing of vegetation and land preparation activities	Low	Low
Recurring disturbance	Construction and operational phase	Medium	Medium

As a mitigation measure, construction should not coincide with overwintering period of the birds. Replanting of mangroves will ensure creation of habitats for the birds. Turbines and noise generating sources will be positioned away from the natural habitats for the birds taking into consideration the direction of the wind. Noise suppressing devices should be used to avoid recurring noise disturbance.

Potential Impact to Mammals and Herpetofauna

The mangrove and other wetlands are known to serve as breeding grounds and habitats for many amphibians and reptiles, thus contributing to sustaining the populations of these amphibians and reptiles and their ecological roles. The clearing of the mangrove forest to for the project will in effect lead to the loss of these habitats for the amphibians and reptiles that are adapted to breeding in wetlands. The noise that will be generated from the construction works could disturb and drive out the amphibians and reptiles within the project area.

Potential Negative Impact	**Source of Impact**	**Impact Significance (WOMM)**	**Impact Significance (WMM)**
Destruction of breeding grounds and natural habitats	Vegetation clearing	Low	Low
Noise impact	Construction works and operation of the power plant	Low	Low

However, the impact from these activities on the mammals and herpetofauna are expected to be low due in great part to low species diversity of these taxa in the area. The few identified species which are not of any conservation significance could utilise similar habitats nearby. Nonetheless, the project will ensure that no mammal and herpetofauna are killed and weaker species would be escorted to abutting habitats. In this respective the project management unit (PMU) will educate all site workers on the importance of the biodiversity and the do's and don'ts when an animal is spotted. In addition, the PMU will take measures to minimize light, noise and vibration to reduce disturbance to fauna during construction.

Potential impact on the rocky intertidal biodiversity

The development of the site is could cause the dislodgement of various species of invertebrates especially during pipeline construction that is expected to traverse the intertidal zone. Morphological damage may also be sustained by algae which may affect their physiological or reproductive process. Overturning or crushing of rocks during construction could result in the crushing of flora and fauna near and beneath the rocks. The removal of the rocky intertidal biodiversity as a result of the construction activities could also disrupt the ecological balance of competitors, predators and food supply.

Potential Negative Impact	**Source of Impact**	**Impact Significance (WOMM)**	**Impact Significance (WMM)**
Removal of invertebrates	Construction activities	Low	Low
Damaging and crushing of flora and fauna	Construction activities	Low	Low
Disruption of ecological balance	Construction activities	Medium	Low

The footprint of the pipe laying is small and the activities would be temporary, thus the negative impact is expected to be low. Nonetheless, smothering will occur and decimate many epifauna organisms thereby disrupting the ecological balance of the habitats, which may create a cascading effect. The impact on the disruption of ecological balance will be medium but expected to be reduced to low if the pipe traverses areas with low diversity as possible since the footprint is small.

5.4 Analysis of Project Compliance with IFC Policy

Paragraphs 9 and 10 of Performance Standard 6 (PS6) of IFC (2006) provide the most relevant guidance regarding Critical Natural Habitats. In addition, IFC (2010) and IFC (2012) provide additional guidance in a draft confidential Project Guidance Note.

According to Paragraph 10 of PS 6:

"In areas of critical habitat, the client will not implement any project activities unless the following requirements are met:

- *There are no measurable adverse impacts on the ability of the critical habitat to support the established population of species described in paragraph 9 or the functions of the critical habitat described in paragraph 9*
- *There is no reduction in the population of any recognized critically endangered or endangered species*
- *Any lesser impacts are mitigated in accordance with paragraph 8"*

According to Paragraph 8 of IFC (2010):

"Critical habitats are areas of high biodiversity value that include at least one of the seven criteria specified in paragraph 9 of PS6. These are as follows and should form the basis of any critical habitat assessment:

- Critically Endangered and Endangered Species (IUCN
- Endemic and Restricted-range Species
- Migratory and Congregatory Species
- Unique Assemblages of Species
- Key Evolutionary Processes
- Key Ecosystem Services
- Biodiversity of Significant Social, Economic or Cultural Importance to Local Communities"

The Inter-America Bank (IDB, 2006) IDB (2006) defines Critical Natural Habitats (CNH) as including existing or officially proposed protected areas, and unprotected areas of known high conservation value. Existing protected areas may include reserves that meet the criteria of the IUCN Protected Area Management Categories I through VI; World Heritage Sites; areas protected under the RAMSAR Convention on Wetlands; core areas of World Biosphere Reserves; and areas in the UN List of National Parks and Protected Areas. Areas of known high conservation value are sites that, in the Bank's opinion, may be: (i) highly suitable for biodiversity conservation; (ii)

crucial for critically endangered, endangered, vulnerable or near threatened species listed as such in the IUCN Red List of Endangered Species; or (iii) critical for the viability of migratory routes of migratory species.

IDB Policy Directive B.9 defines natural habitats as "biophysical environments where: (i) the ecosystems' biological communities are formed largely by native plant and animal species; and (ii) human activity has not essentially modified the area's primary ecological functions. Natural habitats may be sites that (i) provide critical ecological services required for sustainable human development (e.g., aquifer recharge areas, areas that sustain fisheries, mangrove or other ecosystems that help to prevent or mitigate natural hazards); (ii) are vital to ensure the functional integrity of ecosystems (e.g., biological corridors, natural springs); and (iii) have high levels of endemism (IDB 2006).

Table 5.2 Analysis of project compliance with IFC policy

Criteria	**Determination**	**Description of Conclusion**
Criterion 1: CR and EN species	Project meets criterion	There are no CR species and no EN mammals, herpetofauna, avifauna or invertebrates listed by IUCN and none were observed during the field assessment. An evaluation of the habitat requirements, habitat availability, geographic ranges and geographic extent and nature of impacts in the project area indicates that the Project will not result in significant loss or degradation of CNH for the identified species.
Criterion 2: Endemic & restricted-range species	Project meets the criterion	No single-site endemic species were found in the proposed project site during the field campaign. Virtually, all the species encountered occur elsewhere in similar habitats
Criterion 3: Migratory & congregatory species		There were 4 species from 4 families recorded from the site which are pelearctic migrants. However, these species have broad distribution in Ghana and clearing of their putative habitats, the project might not impact on them significantly as they can find similar habitats. The replanting of the mangrove vegetation in close proximity will ensure that their putative habitats are reestablished.
Criterion 4. Unique Assemblages of species	Project meets criteriion	There were habitats specialist species present on the site but these habitats are not unique to the project area. For instance, although all the 3 mangrove species are present on the site, there are other few areas along the coast of Ghana (e.g., Butre, Akwadea) where the 3 mangrove species occur.

		However, seasonally assessment would fully determine unique species assemblages since season structure community assemblages.
Criterion 5: Key evolutionary processes	Project meets criterion	The project will not interfere with any evolutionary process within the site. The project footprint is small and most key evolutionary processes that lead to increased biodiversity often occur on broader scale and very pristine habitats.
Criterion 6: Key ecosystem services	Project likely meets criterion	There are a number of potential key ecosystem services especially provided by the mangrove wetland, whose destruction might impact adversely on these services. However, the project meets this criterion because the quantities of mangroves to be cleared shall be compensated for in close proximity so that metapopulation that they support will still be maintained.

Criteria	**Determination**	**Description of Conclusion**
Criterion 7: Biodiversity of significant social, economic or cultural importance to local communities.	Project possibly meets criterion	No significant social, economic or cultural important uses of biodiversity by the local communities were observed, although significant percentage of the plant species identified possess social, economic and cultural significance. However, this observation can be confirmed by dedicated local community engagements.

SECTION SIX: Conclusion and Recommendations

6.1 Conclusion

The ecological assessment was aimed at documenting plant and animal species of critical habitats of terrestrial, aquatic and coastal with the Amandi's proposed project site and sphere of influence. The results of the assessment indicated low species richness and diversity with recorded species being either of Least Concern according IUCN Redlist or yet to be assessed. Nonetheless, many of the plant species possess medicinal and economic values but there is no evidence of the abutting communities exploiting these values. Of ecological importance and impact concern was the coverage (approx. 18.33%) of mangrove forest of the site and with the unique presence of all three mangrove species (e.g., *Rhizophora racemosa, Avicennia germinans & Laguncularia racemosa).* The results however suggest that these mangrove forest support low biodiversity with none of the fauna of any international significance. Nevertheless, mangrove forests have huge ecological significance and are therefore regarded as critical natural habitats.

In sum, the ecological assessment indicated that adverse impact of the proposed CCGT facility will moderate to low impacts on the ecological entities with the project site and immediate sphere of influence. Overall ecological impact significance is expected to be low with the implementation of the right mitigation measures especially of the mangrove forest. It is envisaged that it will not be possible to avoid all direct impacts on mangroves, hence mitigation measures to be adopted will include replanting the exact quantities of mangroves cleared in an adjacent land so that there is no net loss of mangrove. Regular monitoring and evaluation of the replanted mangrove would be carried out to ensure early growth and establishment. Also the project layout will be engineered that more active areas are away from mangrove forest.

6.2 Recommendation

To the extent possible trees and patches of vegetation especially mangrove, that are not in the active area of the proposed active should be left standing so as to provide habitat for

mammals, birds and other fauna that may persist in the area. Clearing of vegetation should be phased so as afford fauna species the opportunity to escape from the site.

Although the site may not be considered as one of the important wetlands in Ghana, it would be most advisable that site clearing for the commencement of the proposed project be carried out during the off-migration period when not many migrant birds would be present at the site.

There is the need to carry out ecological monitoring during various phases of the project to obtain adequate data that would assist in sound impact evaluation. We recommend the following ecological indicators for the monitoring exercise.

Proposed indicators for monitoring the Ecosystem health of the Critical habitats

- **Mangroves**
    - Percentage of mangrove left untouched
    - Number of species in mangrove forest
    - Spatial extent of mangrove coverage
    - Height of mangrove plants
    - Thickness of mangrove forest
    - Number of endangered/threatened species within mangrove forest
    - Alternative means of firewood in community
    - Number of mangroves forests converted into aquaculture
    - Number of educational seminars of mangrove benefits
- **Terrestrial Fauna**
    - Integrity of habitats for terrestrial fauna
    - Composition & diversity of fauna species
    - Spatial extent of fauna
    - Number of endangered/threatened faunal species
    - Diversity of native fauna
    - Species richness (number, number per unit area, number per habitat area)
    - Change in presence, location, area, numbers of invasive animal species
- **Macrobenthos**
    - Species richness (number, number per unit area, number per habitat area)
    - Integrity of habitats for terrestrial fauna

- Species diversity and abundance
- Functional diversity of macrobenthos
- Geographical range of species
- Biomass
- Change in number and/or distribution of keystone or indicator species
- Percentage of intertidal area under intensive collection

- **Terrestrial Vegetation**
  - Percentage of cover of vegetation or canopy cover
  - Number of species in mangrove forest
  - Number of exotic or alien plant species
  - Spatial extent of dominant species
  - Height of plants species
  - Thickness of plants
  - Number of extinct, endangered, threatened, vulnerable and endemic forest dependent species by group (e.g. birds, mammals, vertebrates, invertebrates)
  - Percentage of planted plant species
  - Percentage primary and secondary trees
  - Change in presence, location, area, numbers of invasive plant species

- **Avifauna**
  - Composition & diversity of avifauna
  - Number of endangered/threatened avifaunal species
  - Change in presence, location, area, numbers of resident species

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APPENDICES

APPENDIX I GPS coordinates of transects and quadrats and sampling points

APPENDIX II Checklist of Plant Species with economic importance as well as their IUCN Red list Status

APPENDIX III Checklist of Bird species recorded in the study area and their national protection status

APPENDIX IV Checklist of rocky shore fauna recorded in the study area

APPENDIX V Checklist of rocky shore macroalgae as well as their IUCN Red list status

APPENDIX VI Checklist of sandy shore and Wetland fauna and their IUCN Red List status

Appendix I: GPS of transects, Quadrats and Sampling points

1. Transect locations for Vegetation study

Transect Identity		Latitude	Longitude
Transect 1	East Point	4° 58' 5.95" N	1° 39' 52.87" W
	West Point	4° 58' 2.06" N	1° 40' 12.56" W
Transect 1	East Point	4° 58' 8.91" N	1° 39' 53.12" W
	West Point	4° 58' 5.02" N	1° 40' 12.95" W
Transect 1	East Point	4° 58' 12.15" N	1° 40' 4.93" W
	West Point	4° 58' 10.43" N	1° 40' 13.60" W

1.1. Quadrat locations for Vegetation study

Quadrat identity	Latitude	Longitude
T1 Quadrat 1.1	4° 58' 3.741" N	1° 40' 3.195" W
T1 Quadrat 1.2	4° 58' 3.649" N	1° 40' 3.526" W
T1 Quadrat 1.3	4° 58' 4.026" N	1° 40' 3.35" W
T1 Quadrat 1.4	4° 58' 3.667" N	1° 40' 3.943" W
T1 Quadrat 2.1	4° 58' 3.096" N	1° 40' 6.459" W
T1 Quadrat 2.2	4° 58' 3.01" N	1° 40' 6.793" W
T1 Quadrat 2.3	4° 58' 3.378" N	1° 40' 6.626" W
T1 Quadrat 2.4	4° 58' 3.301" N	1° 40' 6.928" W
T1 Quadrat 3.1	4° 58' 2.362" N	1° 40' 10.161" W
T1 Quadrat 3.2	4° 58' 2.276" N	1° 40' 10.483" W
T1 Quadrat 3.3	4° 58' 2.65" N	1° 40' 10.305" W
T1 Quadrat 3.4	4° 58' 2.567" N	1° 39' 10.618" W
T2 Quadrat 1.1	4° 58' 7.281" N	1° 40' 0.743" W
T2 Quadrat 1.2	4° 58' 7.184" N	1° 40' 1.077" W
T2 Quadrat 1.3	4° 58' 7.559" N	1° 40' 0.895" W
T2 Quadrat 1.4	4° 58' 7.478" N	1° 40' 1.211" W
T2 Quadrat 2.1	4° 58' 7.027" N	1° 40' 2.004" W
T2 Quadrat 2.2	4° 58' 6.939" N	1° 40' 2.338" W
T2 Quadrat 2.3	4° 58' 7.314" N	1° 40' 2.154" W
T2 Quadrat 2.4	4° 58' 7.235" N	1° 40' 2.479" W
T2 Quadrat 3.1	4° 58' 6.417" N	1° 40' 4.985" W
T2 Quadrat 3.2	4° 58' 6.33" N	1° 40' 5.317" W
T2 Quadrat 3.3	4° 58' 6.703" N	1° 40' 5.139" W
T2 Quadrat 3.4	4° 58' 6.62" N	1° 40' 5.449" W
T3 Quadrat 1.1	4° 58' 11.873" N	1° 40' 5.449" W
T3 Quadrat 1.2	4° 58' 11.782" N	1° 40' 5.777" W
T3 Quadrat 1.3	4° 58' 12.159" N	1° 40' 5.607" W
T3 Quadrat 1.4	4° 58' 12.065" N	1° 40' 5.917" W

T3 Quadrat 2.1	4° 58' 11.658" N	1° 40' 6.343" W
T3 Quadrat 2.2	4° 58' 11.575" N	1° 40' 6.683" W
T3 Quadrat 2.3	4° 58' 11.952" N	1° 40' 6.494" W
T3 Quadrat 2.4	4° 58' 11.861" N	1° 40' 6.822" W
T3 Quadrat 3.1	4° 58' 9.794" N	1° 40' 2.672" W
T3 Quadrat 3.2	4° 58' 9.715" N	1° 40' 2.985" W
T3 Quadrat 3.3	4° 58' 10.111" N	1° 40' 2.713" W
T3 Quadrat 3.4	4° 58' 10.058" N	1° 40' 3.023" W

2. Quadrat locations along three transect chosen for mammal trapping

Quadrat identity	**Geographical Co-ordinates of grid**		
	Transect 1	Transect 2	Transect 3
1	4°58'5.75"N, 1°39'53.17"W	4°58'10.47"N, 1°40'6.40"W	4°58'11.95"N, 1°40'10.52"W
2	4°58'3.33"N, 1°40'6.10"W	4°58'8.86"N, 1°40'2.56"W	4°58'12.30"N, 1°40'6.84" W
3	4°58'0.55"N, 1°40'16.98"W	4°58'9.37"N, 1°39'54.79"W	-

0.

3. Locations for Benthic studies

Location Identity	Latitude	Longitude
Benthos 1	4° 58' 9.8" N	1° 39' 54.7" W
Benthos 2	4° 58' 4.6" N	1° 40' 06.9" W
Benthos 3	4° 58' 2.3" N	1° 40' 12.9" W
Benthos 4	4° 57' 3.1" N	1° 40' 21.4" W
Sandy Shore 1	4° 58' 2.8" N	1° 39' 54.4" W
Sandy Shore 2	4° 58' 1.0" N	1° 40' 04.7" W
Sandy shore 3	4° 58' 0.1" N	1° 40' 10.9" W
Rocky shore 1	4° 58' 0.147" N	1° 39' 59.77" W
Rocky shore 2	4° 57' 57.0" N	1° 40' 19.7" W

4. GPS reference of 50 metre radius observation point

Observation Point #	Northern	Eastern
1	04°58′07.3″N	001°39′53.5″W
2	04°58′13.8″N	001°39′54.7″W
3	04°58′15.7″N	001°39′58.9″W
4	04°58′17.2″N	001°40′06.2″W
5	04°58′20.6″N	001°40′07.0″W
6	04°58′19.2″N	001°40′01.3″W
7	04°58′23.4″N	001°40′01.7″W
8	04°58′21.2″N	001°39′56.9″W
9	04°58′16.6″N	001°39′56.6″W
10	04°58′09.2″N	001°39′58.8″W
11	04°58′06.5″N	001°39′59.4″W
12	04°58′09.7″N	001°40′02.9″W
13	04°58′02.0″N	001°40′06.3″W
14	04°58′12.0″N	001°40′14.0″W
15	04°58′04.4″N	001°40′08.8″W

Appendix II: Checklist of Plant species recorded in the study area with their economic importance as well as the IUCN Red list Status

SPECIES	FAMILY	CONSERVATION STATUS	ECONOMIC USE
Abelmoschus esculentus	Malvaceae	Not Assessed	Construction and medicinal
Abrus precatorius	Fabaceae	Not Assessed	Medicinal purposes
Abutilon sp	Malvaceae	Not Assessed	Medicinal purposes
Agave Sp	Asparagaceae	Not Assessed	Weaving
Allophylus africanus	Sapindaceae	Not Assessed	Medicinal purposes
Asystasia sp	Acanthaceae	Not Assessed	Food and medicinal purposes
Avicennia nitida syn. Avicennia germinans	Avicenniaceae	Least Concern	Construction and fuel wood
Azadirachta indica	Maliaceae	Not Assessed	Medicinal purposes and Construction
Baphia nitida	Fabaceae	Least Concern	Construction and Medicinal purposes
Baphia pubescens	Fabaceae	Not Assessed	Medicinal purposes
Blumea sp	Asteraceae	Not Assessed	Medicinal purposes

Boerhavia diffusa	Nyctaginaceae	Not Assessed	Medicinal purposes
Cactus sp	Cactaceae	Not Assessed	Medicinal purposes
Caesalpinia bonduc	Caesalpiniaceae	Not Assessed	Medicinal purposes, seeds for games
Canavalia rosea	Fabaceae	Not Assessed	Medicinal purposes
Capparis tomentosa	Capparaceae	Not Assessed	Medicinal purposes
Carisa edulis	Apocynaceae	Not Assessed	Medicinal purposes
Cassytha sp	Lauraceae	Not Assessed	Medicinal purposes
Catharanthus roseus	Apocynaceae	Not Assessed	Medicinal purposes
Chromolaena odorata	Asteraceae	Not Assessed	Medicinal purposes
Cocos nucifera	Arecaceae	Not Assessed	Construction and consumption
Commelina erecta	Commelinaceae	Least Concern	Fodder and medicinal purposes
Conocarpus erectus	Combretaceae	Least Concern	Ornamental, fodder, firewood
Crotalaria retusa	Fabaceae	Not Assessed	Fodder and medicinal purposes
Croton lobatus	Euphoribiaceae	Not Assessed	Medicinal purposes

SPECIES	FAMILY	CONSERVATION STATUS	ECONOMIC USE
Cyperus sp	Cyperaceae	Not Assessed	Weaving, food and ornamental purposes
Deinbollia pinnata	Sapindaceae	Not Assessed	Medicinal purposes
Digitaria insularis	Poaceae	Not Assessed	Weaving and medicinal purposes
Diospyros mobitensis	Ebeneceae	Not Assessed	Medicinal purposes, Craft
Diospyros tricolor	Ebeneceae	Not Assessed	Medicinal purposes, Fruits edible
Drepanocarpus lunatus	Fabaceae	Not Assessed	Medicinal purposes
Drypetes floribunda	Putranjivaceae	Not Assessed	Carving
Eclipta alba	Asteraceae	Not Assessed	Medicinal purposes
Euphorbia hirta	Euphoribiaceae	Not Assessed	Medicinal purposes
Flacourtia flavascens	Flacourtiaceae	Not Assessed	Medicinal purposes
Flagellaria sp	Flagellariaceae	Not Assessed	Medicinal purposes
Grewia carpillifolia	Malvaceae	Not Assessed	Craft
Jasminum sp	Oleaceae	Not Assessed	Food and ornamental purposes

Jatropha gossypiifolia	Euphoribiaceae	Not Assessed	Medicinal purposes
Laguncularia racemosa	Combretaceae	Not Assessed	Construction and fuel wood
Lanthana camara	Verbenaceae	Not Assessed	Medicinal purposes
Leucaena grabra	Fabaceae	Not Assessed	Fodder
Imperata cylindrical	Poaceae	Not Assessed	Construction
Indigofera arrecta	Fabaceae	Not Assessed	Medicinal purposes
Lonchocarpus sericeus	Fabaceae	Not Assessed	Medicinal purposes
Ipomoea Mauritania	Convolvulaceae	Not Assessed	Medicinal purposes
Mimosa pudica	Fabaceae	Not Assessed	Medicinal purposes
Momordica charantia	Cucurbitaceae	Not Assessed	Medicinal purposes
Ocimum canum	Lamiaceae	Not Assessed	Medicinal purposes
Panicum maxima	Poaceae	Not Assessed	Fodder
Paspalum vaginatum	Poaceae	Not Assessed	Fodder
Passiflora foetida	Passifloraceae	Not Assessed	Medicinal purposes
Phoenix reclinata	Arecaceae	Not Assessed	Food, weaving and dye
Phyllanthus amarus	Phyllanthaceae	Not Assessed	Medicinal purposes

Phyllanthus niruri	Phyllanthaceae	Not Assessed	Medicinal purposes
Physalis angulate	Solanaceae	Not Assessed	Medicinal purposes
SPECIES	**FAMILY**	**CONSERVATION STATUS**	**ECONOMIC USE**
Pupalia lappacea	Amaranthaceae	Not Assessed	Medicinal purposes
Rauvolfia vormitoria	Apocynaceae	Not Assessed	Construction and medicinal purposes
Rhizophora racemosa	Rhizophoraceae	Not Assessed	Construction
Riccia sp	Ricciaceae	Not Assessed	Used in aquarium
Sanseviera sp	Asparagaceae	Not Assessed	Weaving
Sesbania sudanica ssp occidentalis	Fabaceae	Not Assessed	Medicinal purposes
Secamone afzelii	Apocynaceae	Not Assessed	Medicinal purposes and weaving
Securinega virosa	Euphoribiaceae	Not Assessed	Medicinal purposes
Sesuvium sp	Aizoceae	Not Assessed	Food, medicinal and ornamental purposes
Sida cordifolia	Malvaceae	Not Assessed	Medicinal purposes
Solanum nigrum	Solanaceae	Not Assessed	Medicinal purposes

Sporobolus pyramidalis	Poaceae	Not Assessed	Fodder
Stachytapherta indica	Verbenaceae	Not Assessed	Medicinal purposes
Talinum triangulare	Talinaceae	Not Assessed	Vegetable
Thespesia populnea	Malvaceae	Not Assessed	Food, carving, dye and medicinal purposes
Triclisia patens	Menispermaceae	Not Assessed	Weaving and medicinal purposes
Tridax procumbens	Asteraceae	Not Assessed	Fodder
Vernonia cinerea (Cyanthillium cinereum)	Asteraceae	Not Assessed	Medicinal purposes
Zanthoxylum zanthoxyloides	Rutaceae	Not Assessed	Construction and Medicine

Appendix III: Checklist of Bird species in the study area and their national protected status

Legend: E/S – open habitat, Co – cosmopolitan, SA- Savannah, C – common, PM – Palearctic migrant, U – uncommon, R – rare, BR – Biome Restricted, WP – Wholly protected

Species					
Family/ Scientific Name	**Common Name**	**Prefered Habitat**	**Rarity**	**Conservation Status**	**Number of Individuals**
PHALACROCORACIDAE					
Phalacrocorax africanus	Long-tailed Cormorant				15
ARDEIDAE					
Butorides striatus	Green-backed Heron			WP	3
Egretta gularis	Western Reef Egret			WP	21
Egretta garzetta	Little Egret			WP	15
Egretta alba	Great White Egret			WP	7
Egretta intermedia	Intermediate Egret			WP	3
Ardea purpurea	Purple Heron			WP	11
Ardea cinerea	Grey Heron			WP	8
BURHINIDAE					
Burhinus senegalensis	Senegal Thick-knee				7
CHARADRIIDAE					
Charadrius marginatus	White-fronted Plover				17
Pluvialis squatarola	Grey Plover				19
Vanellus spinosus	Spur-winged Lapwing				13
SCOLOPACIDAE					
Actitis hypoleucos	Common Sandpiper				39
Calidris alba	Sanderling				38
Numenius arquata	Eurasian Curlew				17
Numenius phaeopus	Whimbrel				11
Tringa glareola	Wood Sandpiper				12

Species		Prefered Habitat	Rarity	Conservation Status	Number of Individuals
Family/ Scientific Name	**Common Name**				
Tringa nebularia	Common Greenshank				23
Tringa ochropus	Green Sandpiper				5
ACCIPITRIDAE					
Butastur rufipennis	Grasshopper Buzzard	E/S	C	WP	2
Elanus caeruleus	Black-shouldered Kite	SA	C	WP	1
Milvus migrans	Black Kite	Co	C	WP	14
Micronisus gabar	Gabar Goshawk	SA	C	WP	2
Circus aeruginosus	Eurasian Marsh Harrier	PM	C	WP	1
FALCONIDAE					
Falco ardosiaceus	Grey Kestrel	E/S	C	WP	3
Falco peregrinus	Peregrine Falcon	PM	C	WP	1
PHASIANIDAE					
Francolinus bicalcaratus	Double-spurred Francolin	SA	C		3
RALLIDAE					
Amaurornis flavirostris	Black Crake	SA	C		1
COLUMBIDAE					
Streptopelia semitorquata	Red-eyed Dove	SA	C		3
Streptopelia senegalensis	Laughing Dove	SA	C		7
Turtur afer	Blue-spotted Wood Dove	E/S	C		5
MUSOPHAGIDAE					
Crinifer piscator	Western Grey Plantain-eater	SA	C		4
CUCULIDAE					
Centropus senegalensis	Senegal Coucal	E/S	C		7
Chrysococcyx caprius	Didric Cuckoo	SA	C		2
Clamator glandarius	Great spotted Cuckoo	SA	U		2
TYTONIDAE					
Bubo cinerascens	Greyish Eagle owl	SA	C	WP	1

Species					
Family/ Scientific Name	**Common Name**	**Prefered Habitat**	**Rarity**	**Conservation Status**	**Number of Individuals**
Otus icterorhynchus	Sandy Scops Owl	E/S	U	WP	1
Tyto alba	Barn Owl	E/S	U	WP	2
CAPRIMULGIDAE					4
Caprimulgus binotatus	Brown Nightjar	E/S	R	BR	6
Caprimulgus inornatus	Plain Nightjar	E/S	C		4
APODIDAE					
Cypsiurus parvus	African Palm Swift				12
ALCEDINIDAE					
Alcedo cristata	Malachite Kingfisher	SA	C		4
Ceryle rudis	Pied Kingfisher	SA	C		8
Halcyon senegalensis	Woodland Kingfisher	SA	C		2
Megaceryle maxima	Giant Kingfisher	SA	U		1
MEROPIDAE					
Merops albicollis	White-throated Bee-eater	SA	C		12
Merops pusillus	Little Bee-eater	SA	C		8
BUCEROTIDAE					
Tockus fasciatus	African Pied Hornbill	E/S	C		4
Tockus nasutus	African Grey Hornbill	SA	C		1
CAPITONIDAE					
Pogoniulus chrysoconus	Yellow-fronted Tinkerbird	SA	C		1
Lybius vieilloti	Vieillot's Barbet	SA	C		2
HIRUNDINIDAE					
Hirundo rustica	Barn Swallow	Co	C		22
MOTACILLIDAE					
Motacilla flava	Yellow Wagtail	PM	C		4
Anthus leucophrys	Plain-backed Pipit	SA	C		3
Macronyx croceus	Yellow-throated Longclaw	SA	C		2
Motacilla aguimp	African Pied Wagtail	SA	C		3

Species		Prefered Habitat	Rarity	Conservation Status	Number of Individuals
Family/ Scientific Name	**Common Name**				
PYCNONOTIDAE					
Pycnonotus barbatus	Common Bulbul	SA	C		7
Chlorocicla simplex	Simple Leaf Love	E/S	C		3
Andropadus virens	Little Greenbul	E/S			2
TURDIDAE					
Cossypha niveicapilla	Snowy-crowned Robin Chat	E/S	U		2
Turdus pelios	African Thrush	SA	C		1
SYLVIIDAE					
Camaroptera brachyura	Grey-backed Cameroptera	E/S	C		3
Cisticola cantans	Singing Cisticola	SA	C		2
Cisticola galactotes	Winding Cisticola	SA	C		5
Cisticola brachypterus	Short-winged Cisticola	SA	C		12
Hippolais polyglotta	Melodious Warbler	PM	C		3
Prinia subflava	Tawny-flanked Prinia	E/S	C		3
PLATYSTEIRIDAE					
Platysteira cyanea	Common Wattle-eye	SA	C		2
NECTARINIIDAE					
Anabathmis reichenbachii	Reichenbach's Sunbird	SA	R		2
Anthreptes gabonicus	Brown Sunbird	SA	U		4
Chalcomitra fuliginosa	Carmalite Sunbird	SA	R		2
Cinnyris coccinigaster	Splendid Sunbird	SA	C	GS	3
Cinnyris cupreus	Copper Sunbird	SA	C		5
Cyanomitra verticalis	Green-headed Sunbird	SA	C		3
LANIIDAE					
Lanius collaris	Common Fiscal	f	C		5
MALACONOTIDAE					
Antichromus minutus	Marsh Tchagra	E/S	U		1

Species		Prefered Habitat	Rarity	Conservation Status	Number of Individuals
Family/ Scientific Name	**Common Name**				
Laniarius aethiopicus	Tropical Boubou				1
Laniarius barbarus	Yellow-crowned Gonolek				3
Tchagra senegala	Black-crowned Tchagra	SA	C		2
CORVIDAE					
Corvus albus	Pied Crow	Co	C		43
STURNIDAE					
Lamprotornis splendidus	Splendid Glossy Starling	SA	C	GS	5
PASSERIDAE					
Passer griseus	Northern Grey-headed Sparrow	SA	C		4
PLOCEIDAE					
Euplectes afer	Yellow-crowned Bishop	SA	C		19
Euplectes hordeaceus	Black-winged Red Bishop	E/S	C		20
Ploceus cucullatus	Village Weaver	SA	C		13
Ploceus aurantius	Orange Weaver	SA	U	BR	8
Ploceus nigricollis	Black-necked Weaver	E/S	C		7
ESTRILDIDAE					
Estrilda melpoda	Orange-cheeked Waxbill	SA	C		12
Lagonosticta rufopicta	Bar-breasted Firefinch	SA	C		20
Lonchura cucullata	Bronze Mannikin	SA	C		16
	Total Number of species				**91**

Appendix IV: Checklist of Rocky shore fauna recorded in the study area and their IUCN Red list conservation status

Species List	Class	IUCN Status	Transect 1	Transect 2	Transect 3
Chthalamus dentata	Maxillopoda	Not Assessed		√	√
Cypraea sp **	Gastropoda	Not Assessed			
Echinolittorina granosa **	Gastropoda	Not Assessed			
Echinolittorina punctata	Gastropoda	Not Assessed	√	√	√
Echinometra lacunter	Echinoidea	Not Assessed		√	√
Fissurella nebucula	Gastropoda	Not Assessed	√	√	√
Grapsus grapsus **	Malacostraca	Not Assessed			
Hermit crab	Malacostraca	Not Assessed			√
Nerita atrata	Gastropoda	Not Assessed		√	√
Patella safiana	Gastropoda	Not Assessed	√	√	√
Sea anemone		Not Assessed		√	
Siphonaria pectinata	Gastropoda	Not Assessed	√	√	√
Thais haemastoma	Gastropoda	Not Assessed	√	√	
Thais nodosa	Gastropoda	Not Assessed	√	√	
Littorina cingulifera syn. Littoraria cingulifera	Gastropoda	Not Assessed		√	
Ostrea sp **	Bivalvia	Not Assessed			
Zoanthus sp (blue-green) **	Anthozoan	Not Assessed			
Palythoa sp (yellowish brown) **	Anthozoan	Not Assessed			

** Species not observed within quadrats but were part of the rocky shore community

Appendix V: Checklist of Rocky shore macroalgae and their IUCN Red List Conservation status

SPECIES	***FAMILY***	***Transect 1***	***Transect 2***	***Transect 3***	***IUCN Status***
CHLOROPHYTA (Green Algae)					
Bryopsis pennata Lamouroux	*Derbesiceae*	√			*Not Assessed*
Caulerpra taxifolia (Vahl) C. Agardh	*Caulerpaceae*	√			*Not Assessed*
Chaetomorpha antennina (Bory) Kützing	*Cladophoraceae*	√	√		*Not Assessed*
Chaetomorpha linum (O.F. Muller) Kützing	*Cladophoraceae*		√		*Not Assessed*
Cladophora prolifera (Roth) Kützing	*Cladophoraceae*	√			*Not Assessed*
Ulva fasciata Delile	*Ulvaceae*	√	√		*Not Assessed*

Ulva flexuosa	*Ulvaceae*		√		*Not Assessed*
PHAEOPHYTA (Brown Algae)					
Bachelotia antillarum (Grunow) Gerloff	*Ectocarpaceae*	√			*Not Assessed*
Padina antillarum (Kützing) Piccone *Synonym: Padina tetrastromatica Hauck*	*Dictyotaceae*	√	√	√	*Not Assessed*
Padina durvillaei Bory	*Dictyotaceae*	√	√	√	*Not Assessed*
Ralfsia expansa (J. Agardh) J. Agardh	*Ralfsiaceae*	√	√	√	*Not Assessed*
RHODOPHYTA (Red Algae)					
Acrochaetium sp.	*Acrochaetiaceae*		√	√	*Not Assessed*
Bostrychia radicans (Montagne) Montagne	*Rhodomelaceae*		√	√	*Not Assessed*
Bryocladia thyrsigera (J. Agardh) Schmitz	*Rhodomelaceae*	√	√	√	*Not Assessed*
Centroceras davulatum (C. Agardh) Montagne	*Ceramiaceae*		√	√	*Not Assessed*
Chondracanthus acicularis (Roth) Fredericq *Synonym:Gigartina acicularis (Roth) Lamourux*	*Gigartinaceae*	√	√	√	*Not Assessed*
Cryptonemia seminervis (C. Agardh) J. Agardh	*Halymeniaceae*	√	-		*Not Assessed*
Gelidium corneum sensu Borgesen	*Gelidiaceae*	√	√	√	*Not Assessed*

SPECIES	FAMILY	Transect 1	Transect 2	Transect 3	IUCN Status
RHODOPHYTA (Red Algae)					
Gracilaria gracilis (stockhouse)Steentoft, L. Irvine & Farnham *Synonym: Gracilaria verrucosa (Hudson)*	*Gracilariaceae*		√	√	*Not Assessed*
Hildenbrandia rubra (Sommerfelt), Menegheni	*Hildenbrandiaceae*	√	√	√	*Not Assessed*
Hydropuntia dentata (J. Agardh) Wynne *Synonym: Polycavernosa dentata (J. Agardh) G.W. Lawson & D. M. John*	*Gracilariaceae*	√	√	√	*Not Assessed*
Hypnea cervicornis J. Agardh	*Hypneaceae*	√			*Not Assessed*
Polysiphonia ferulacea Suhr	*Rhodomelaceae*	√			*Not Assessed*
Lithothamnia sp.	*Corallinaceae*	√	√	√	*Not Assessed*

Appendix VI: Checklist of Sandy shore and wetland Fauna

Species List	Class	Wetland	Sandy shore	IUCN Status
Hermit crab	Malacostraca	√		Not Assessed
Chironomid	Insecta	√		Not Assessed
Capitella capitata	Polychaeta	√		Not Assessed
Sersamid crab	Malacostraca	√		Not Assessed
Crab indet 2	Malacostraca	√		Not Assessed
Periophthalmus barbus	Actinopterygii	√		Not Assessed
Ocypode cursor	Malacostraca		√	Not Assessed
Goniada sp	Polychaeta		√	Not Assessed
Nephtys sp	Polychaeta		√	Not Assessed
Modiolus modiolus	Bivalvia	√		Not Assessed

Excirolana sp	Malacostraca		√	Not Assessed
Tanaids	Malacostraca		√	Not Assessed

APPENDIX 9A

COMPENSATION REPORT

Compensation report contains confidential information. Redacted version of report to be inserted.

APPENDIX 10

PHASE 2 CONTAMINATION INVESTIGATION REPORT

Phase 2 Contamination Investigation Report

Amandi CCTG Site

Aboadze, Ghana

Revision 2

Requested By

Amandi Energy Limited

5, Osu Badu Street, Dzorwulu, Accra

Ghana

Prepared By

RIMOG COMPANY LTD

Accra, Ghana

DECEMBER, 2014

Table of Contents

Page

1.0 Introduction..... 1
1.1 Scope of Works..... 1
1.2 Pupose and Objectives..... 2
1.3 Methodology..... 2

2.0 Phase 1 Desk Study Results
2.1 Enviromental Setting..... 3
2.2 Conceptual Site Model..... 3
2.3 Consultations..... 6
2.4 Findings and Recommendatins..... 6

3.0 Intrusive Investigation
3.1 Sampling Rationale..... 7
3.2 Sampling Procedures..... 7
3.3 Field Observations - Soils..... 8
3.4 Field Observations - Groundwater..... 8
3.5 Field Measurement (VOCs) 9

4.0 Laboratory Analysis 10

5.0 Preliminary Risk Assessment
5.1 Screening Criteria..... 12
5.2 Contaminants of Concern (COC) 14
5.3 Extent of Contamination..... 15
5.4 Sources and Contaminant Pathways..... 15
5.5 Conceptual Site Model..... 16
5.6 Assessment of Risks..... 17

6.0 Closure..... 19

1.0 INTRODUCTION

This Phase 2 Intrusive Investigation-Limited Sampling and Testing was undertaken subsequent to a Phase 1 Preliminary Contamination Assessment-Desk Study carried out by RIMOG for the proposed 240MW Combined Cycle Thermal plant in the Takoradi Thermal Power Enclave (TTPE) at Aboadze, Ghana.

1.1 Current Scope of Works

This Phase 2 Contamination Investigation builds on the information and recommendations included in the Phase 1 - Desk Study report and it is designed to quantitatively investigate the status of the soil and groundwater beneath the site for potential ground contamination. The scope included:

— Review of RIMOG's Phase 1 Preliminary Contamination Assessment report and relevant information from the Client.

— Construction of 5 window sampler environmental test bores up to a maximum depth of 3m into surficial deposits and excavation of 2 trial trenches at locations not readily accessible with the window sampling equipment. Sampling of groundwater and soil samples at regular intervals and at changes in the strata.

— Conduct laboratory analysis on 4 selected soil samples and 1 groundwater sample at CSIR-WRI analytical laboratory for various combinations of the following potential contaminants:

- Total petroleum hydrocarbons (TPH);
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX);
- Heavy metals (As, Cd, Cr, Cu, Pb, Hg, Zn);
- Polycyclic aromatic hydrocarbons (PAH);
- Polychlorinated biphenyls (PCB);
- Organochlorine pesticides (OCP); and
- Phenols

— Prepared this report to include the results of the fieldworks, laboratory analysis, findings and recommendations.

1.2 Objectives and Purpose

The main objective of this Phase 2 Contamination Investigation-Limited Sampling and Testing is to engage in a process of soil and groundwater sampling within the boundaries of the reference site and to follow up with laboratory chemical analysis. The aim of this process is to provide factual information on what contaminants of concern (if any) are actually present on the site, where they are and what impacts they could have on the proposed development. The process sought to confirm plausible source-pathway-receptor linkages at the site to allow refinement of the preliminary site conceptual model.

By fulfilling these objectives, this limited sampling and testing provides the information needed for mapping of any pollutant, its occurrence or distribution across the site. The information would further aid initial risk assessment, which will enable clear definition of the risk of harm from contamination to the identified receptors.

1.3 Methodology

This Phase 2 Site Contamination Assessment-Limited Sampling and Testing was performed in general accordance with BS 10175:2011 *Investigation of Potentially Contaminated Sites – Code of Practice* with due regard to R&D Technical Report P5-066/TR – UK Environment Agency (2001) *Secondary Model Procedures for the Development of Appropriate Soil Sampling Strategies.* The soil and groundwater samples collected were analyzed at an accredited laboratory for a range of contaminants.

Based on the analytical results, contaminants of concern (COCs) were identified by broadly comparing the laboratory results against Generic Assessment Criteria (GAC). In the absence of standards from the Environmental Protection Agency of Ghana, the GAC used in this assessment were contaminant threshold values published by regulatory organizations from the Netherlands, United Kingdom, United States, and the World Health Organization. Although these criteria were not necessarily derived through the same approach, they provide, in combination, a reasonable indication of the significance of the contamination according to international standards.

2.0 PHASE 1 DESK STUDY RESULTS

The Phase 1 Desk Study report (September 2014) outlined some historical background for the reference site obtained from several Local and National Regulatory Agencies and Authorities. Historical maps of the area were obtained, scrutinized and the site history was ascertained. In summary, large portions of the site have remained essentially undeveloped with no peculiar industrial use identified. Menial farming activities were identified as the main potential contaminant source on site. Surrounding land use to the north, south and west is of the nature that could not significantly impact the reference site from contamination viewpoint. The significant surrounding land use with the potential to impact the site area is the construction and expansion of thermal power generation facilities: TTP1, TTP2, WAGP, and TTP3 to the east of the site.

2.1 Environmental Setting

2.1.1 Site Location and Description

The Amandi CCTG site is situated in the Takoradi Thermal Power Enclave (TTPE), at Aboadze, near Takoradi in the Western region of Ghana. The TTPE is an agglomeration of existing and proposed thermal power plants in a dedicated area west of the Aboadze community in Ghana. The Amandi CCTG site is situating south-west to the existing VRA thermal plants, in the low-lying area of the thermal enclave.

Surface features include sand dunes, alluvial sands and mud flats, marshy and inundated at key areas with surface water. Although there are recognized and protected wetlands in Ghana, our investigation shows that the reference site has not been designated as such. A drainage gully enters the site from the north east corner which discharges run-off from VRA Township, Takoradi Thermal Power Station (TTP1, TTP2, TTP3) and part of the Aboadze Townships. The reference site is at average elevation 1m (National Height Datum).

2.1.2 Geology

The solid geology of the site consists of seaward dipping strata of the Carboniferous Sandstone Elmina Formation, comprising cyclic sequences of sandstones, siltstones, mudstones with a total thickness up to 370m. The Elmina formation unconformably overlies and is faulted against a basement complex of granite, gneiss and schists. Precious minerals occurrence in the rocks are very rare. Hence, mining activities in the vicinity of the thermal power enclave are very rare. They are no records of any shafts or mine entries within 500m of the site boundary. According to the Phase I desk study mining and mine drainage are not considered potential contamination source.

Superficial geology comprises recent alluvial sediments of sands, sandy clays and sandy silts, medium to coarse grained and residual soil from weathering of the top column of the sandstone bedrock. The thickness of the alluvial deposits varies across the site up to 2.5m. The thickness of the residual soil was reportedly up to 4.5m. Due to the medium to coarse nature of the surficial deposits, there is the potential to transmit a wide range of pollutants due to rapid drainage and low attenuation potential. Peat accumulation with the potential to generate ground gas is considered low. Available information shows that excavated spoil from the construction of TTP1, TTP2 and TTP3 were not dumped at the reference site and the site was not previously used as 'contractor's compound'. Local information also indicated that the grounds of the have not been raised by any fill before the TTPS developments.
Recent made ground deposits are known to be present over portions of the site, comprising imported fill of weathered sandstone.

2.1.3 Hydrogeology

According to the Phase 1 Preliminary Contamination Assessment-Desk Study report, the site is underlain by unconfined aquifer consisting of a top layer of highly permeable, medium to coarse grained sands, clayey sands and sandy silts. The lower half of the aquifer consists of the Elmina Formation of massive sandstone, scarcely fractured, low permeability, low hydraulic conductivity and transmissivity. Static water levels at three wells indicate a near 'horizontal' water table at elevation 1.4mNLD under direct influence of the nearby Anankwari river. Observations over a period of twelve (12) months show that groundwater level on the site coincides with the water level in the nearby river and ponded water level on parts of the site area. Monitoring data suggests a moderate connection between seawater and site aquifer on the fact that the Elmina Sandstone outcrops on the sea bed directly south of the site. This indicates high hydraulic conductivity in the surficial deposit and unrestricted hydraulic connection with the Elmina Formation.

It is difficult to accurately determine the direction of groundwater movement and hydraulic gradient, but a review of the literature suggests that the groundwater in the Elmina aquifer is expected to flow southwest towards the sea under low tides and reverse to inland under high tides. A check with the Ghana Environmental Protection Agency (EPA) and the Ghana Geologic Services Department (GSD) reveals that there is no groundwater vulnerability map for the area. The closest groundwater abstraction well is approximately 6km from the site. Data from the Ghana Water Company Limited shows that there are no public water supply mains near the site.

2.1.4 Surface Water

According the Phase 1 Preliminary Contamination Assessment – Desk Study report, the nearest surface water is river Anankwari, which inundates portion of the reference site when flow increases. Anankwari behaves as a closed lagoon separated from the sea by sand bar. Occasionally, when river flow increases, the overflow breaches the sand bar allowing river water and salty sea water to mix. Due to its interface location, between land and sea, and low depth, it is strongly subjected 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 surface flow regime is most likely to be to the west, conforming to the general topographic slope.

Anankwari is dammed at Ntweaban to provide water supply to Sekondi, Ntweaban and Aboadze. Sometimes during the rainy season, water is spilled if the maximum operating levels of the reservoir is reached. Much of the flow downstream of the dam is due to surface drainage from Ntweaban and VRA townships, TTPS and part of Aboadze townships via a system of dykes and ditches through the reference site into river Anankwari. A number of other un-named ephemeral streams originate in the slopes of the highlands, descends onto the flatter areas to the north and west of the project area where they become less well defined drainage paths.

Sprawled developments in the Ntweaban townships have resulted in encroachment of the river banks. Domestic and industrial liquid wastes which may contain a broad spectrum of contaminants could have been discharged directly to the river. Run-off water over lawns, backyard gardens, sidewalks, streets, open markets, mechanical workshops, fuel depots, scrap yards etc could take contaminants into open sewers and discharged into the river. Contamination of river water by pesticides, petrol and diesel stored in underground tanks at fuel depots, motor oil, and heavy metals could have occurred.

2.2 Phase 1 Conceptual Site Model

A conceptual site model (CSM) of the site conditions has been constructed from information obtained from available EIA reports of the TTPE, information obtained from the Local Authority and the National Regulatory Agencies, knowledge of previous studies of the site areas by RIMOG and supplemented by interviews with persons familiar with the TTPE and walkover observations. The model took into consideration current land use, which is predominantly undeveloped, and surrounding land uses and structures, mostly thermal power plants.

Possible intact pollutant linkages have been identified between a number of potential contaminant sources, human heath, property, surface and groundwater targets. The principal contaminant sources are off site, including petroleum storage structures, liquid waste impoundment structures, medical

waste disposals, construction activities, metal and automobile workshops, and fuel depots. Potential on site sources include fertilizer and herbicides associated with subsistence farming, additional potential contaminants that may be brought to site during construction and operational phase of the proposed development. Potential contaminants include toxic metals, various hydrocarbon species, polychlorinated biphenyls, organochlorine pesticides, and phenols.

2.3 Findings and Recommendations

The Phase 1 Desk Study (September 2014) concluded that overall, the environmental risks to the identified receptors are generally classified as low. Potential for significant contamination being present is considered low, risk of harm to human health during construction is classified as low, risk of harm to human during operation is classified as low, risks to building materials from potential sulphate soils is classified as moderate, risk to pollution of groundwater is classified as low, risks to pollution of surface water is classified as low.

Specific recommendations made include a preliminary intrusive investigation at the site, including the sampling of soil and groundwater and subsequent laboratory analysis. Screening of the samples for known industrial contaminants; heavy metals, cyanide, total petroleum hydrocarbon (TPH), volatile organic compounds (VOC), BTEX, PAHs, PCBs.

3.0 INTRUSIVE INVESTIGATION

3.1 Sampling Rationale

The sampling density was 7 boreholes (including 2 trial trenches) for a site area of 52 acres. Available information shows that potential contaminants could be site wide. Therefore, sampling locations were intercalated to create a systematic pattern over the whole site area with a view to providing appropriate site coverage. Considering the size of the site the 7 sampling points represent a small statistical sampling but, given the low risk of contamination on the site (based on the *Phase 1 Desk Study*) the sampling density was considered to be sufficient for the preliminary assessment of the contamination potential. Figure 1 in Appendix A shows the approximate sampling locations on site.

3.2 Sampling Procedures

A total of 5 sampling boreholes and 2 trial pits were carried out on the site on the 30th September 2014 in the presence of a qualified and experienced hydrogeologist who maintained a log of sampling activities, general stratigraphic descriptions, depth of soil sampling, sample notation and level of groundwater. Sampling was undertaken in accordance BS 10175:2011 *Investigation of Potentially Contaminated Sites – Code of Practice* with due regard to R&D Technical Report P5-066/TR – UK Environment Agency (2001) *Secondary Model Procedures for the Development of Appropriate Soil Sampling Strategies.*

An Archway Stand-Alone Dart Rig was used for the borehole sampling. Sampling was done by percussive drive mechanism; a chain-driven drop weight repeatedly strikes an anvil, pushing the sampler tube into the ground. The hole is cased to prevent caving and cross-contamination between successive samples. Trial pits were dug at locations not readily accessible with the sampling rig. Equipment in contact with the ground (including digging tools and soil/groundwater samplers) were cleaned thoroughly between each borehole and trial trenching. Strata logging for the boreholes and trial pits was undertaken by a qualified and experienced hydrogeologist. The logs show the general stratigraphic sequences and descriptions, depth of soil samples and groundwater level at the time of the fieldworks. The boring logs are attached in Appendix A.

The sample containers used were laboratory cleaned, water-tight with Teflon-lined lids. Samples were placed in the sample containers in the size that would fill the entire volume without any headspace in the container. Groundwater samples were collected using Teflon bailer before decanted into the glass containers. No free product (floating oily layer) was encountered at all the sampling locations during the site investigation works. As such, no free product was collected and sent to the laboratory for identification analysis. Sample containers were placed in a cooled, insulated and sealed container for transport to the laboratory. Samples were delivered to the laboratory within 24 hours of collection.

3.3 Field Observations - Soils

Natural soils were encountered in all the test bores. Bores encountered fine to medium grained sands, sandy clays, clays and sandy silts up to 2.5m in thicknesses. The borehole logs provided in Appendix A of this report should be referenced for the subsurface profile at each test location. Recently placed fills of weathered sandstone was noted at key areas of the site.

Underlying bedrock (not encountered in the field investigation due to shallow depth of the test bores) is expected to be massive sandstone, weathered and friable. According to the Phase 1 Geotechnical Investigation by RIMOG, sandstone bedrock was intercepted at depths of 2.5m to 7.5m below ground level at the time of investigation.

3.4 Field Observations - Groundwater

Shallow groundwater was encountered in all the test boreholes just below ground level and up to 0.8m below ground level. The groundwater levels appear to coincide with the level of surface water on the site. No free product, separate phase liquids or odours were detected in any of the test bores prior to sampling.

Table 1-1 Sampling Locations and PID Readings

Borehole ID	Coordinates (GNC)		Sample Label	Sample Depth (m)	PID (ppm)	Observations
	EAST	NORTH				
BH1	200588.332	33238.423	SS1	0.5	3.8	No odours noted
			SS2	1.5	0.9	No odours noted
			SS3	2.5	2.8	No odours noted
BH2	200499.606	33050.087	SS1	0.5	6.7	No odours noted
			SS2	1.5	3.1	No odours noted
TP3	200311.284	33176.112	SS1	0.5	5.8	No odours noted
			SS2	1.0	0.6	No odours noted
TP4	200032.982	33301.087	SS1	0.5	2.1	No odours noted
			SS2	1.0	3.3	No odours noted
BH5	200136.216	33452.703	SS1	0.5	5.1	No odours noted
			SS2	1.0	1.8	No odours noted
			SS3	2.0	0.7	No odours noted
			SS4	3.0	0.7	No odours noted
BH6	200274.674	33060.814	SS1	0.5	2.2	No odours noted
			SS2	1.0	3.4	No odours noted
			SS3	1.5	0.7	No odours noted
BH7	200020.336	33010.181	WS1	0.75	-	No odours noted
			SS1	0.5	0.2	No odours noted
			SS2	1.5	0.8	No odours noted
			SS3	2.5	0.8	No odours noted

3.3 Field Measurements (VOCs)

The soil samples taken at each sampling depth were subjected to on-site measurement of VOCs using a PID meter. For the PID measurement, a handful of the soil sample was placed in a ziplock bag. After few minutes, the probe of the calibrated PID was then inserted into the bag to take the measurement. Prior to site investigation, the PID was calibrated to isobutylene standard reference gas at 100ppm. Zero-span checks were also conducted to assure the accuracy of the PID readings. The PID used on site was equipped with lamp having energy of 10.6eV with measurement range of 0.0 to 99.9 ppm. Readings were corrected with background concentration. Measurements are averaged readings over a period of 10 seconds.

4.0 LABORATORY TESTS

The groundwater and soil samples retrieved during the intrusive investigation were presented to the Center for Scientific and Industrial Research (CSIR), Water Research Institute (WRI) Environmental Chemistry Laboratory based in Accra. The laboratory is a governmental institute of the Ministry of Water Resources, Works and Housing. Available information shows that this laboratory has done most of the chemical testing for the majority of the environmental projects in Ghana which were funded by the international lending and donor agencies. See additional information in Appendix B.

4.1 Analytical Results

Based on our experience from soil investigation in the Takoradi Thermal Power Enclave, the range of potentially hazardous contaminants are wide and varied. For this assessment the chemical components for analysis were selected to encompass both commonly suspected contaminants and those which according to the Phase 1 Desk Study were likely to be present. Analytical results by CSIR-WRI Environmental Chemistry Laboratory for 4 soil samples and 1 groundwater sample are shown in Appendix B of this report. The following comments are provided in relation to the laboratory test results.

4.2 Volatile Organic Compounds

Volatile organic compounds (VOC) concentrations were measured on-site during the fieldwork for all the samples retrieved. The VOC vapour concentrations detected by the PID were low which indicates apparently low volatile organic contents in the soil samples. The results of PID readings are provided in Table 1-1.

4.2 Total Petroleum Hydrocarbons (TPH)

Three (3) samples were analysed for long chain hydrocarbon (TPH fraction C10-C36). TPH were below the laboratory limits of detection.

4.3 BTEX

Three (3) soil samples and one (1) groundwater samples were analysed for Benzene, Toluene, Ethyl benzene and Xylene (BTEX) as part of this investigation. BTEX compounds were detected below the laboratory reporting limits in the samples analyzed.

4.4 Heavy Metals

Four (4) soil samples and one (1) groundwater samples were analyzed for selected heavy metals. Analysis showed Arsenic, Tin, Zinc, Copper, Chromium, Mercury and Vanadium above laboratory detection limits. Silver, Lead and Cadmium were below laboratory detection limit. Cyanide was below detection limit.

4.5 Phenols

Three (3) soil and one (1) groundwater samples were analyzed for Phenols. Phenols were detected above laboratory reporting limits.

4.6 Polynuclear Aromatic Hydrocarbons (PAHs)

Three (3) soil and one (1) groundwater samples were analyzed for Polynuclear Aromatic Hydrocarbons (PAHs). PAHs were found below the detection limit.

4.7 PCBs

Three (3) soil and one (1) groundwater samples were analyzed for Polychlorinated biphenyls (PCBs). PCBs were found below the detection limit.

4.8 Organochlorine Pesticides

Three (3) soil and one (1) groundwater samples were analyzed for Organochlorine Pesticides, DDE, DDD, DDT. Organochlorine pesticides were found below the detection limit.

4.9 Laboratory Limits of Detection

The laboratory limits of detection for the potential contaminants were sufficiently below the adopted GAC Intervention Values for soil and groundwater. The laboratory detection limit of Total Petroleum Hydrocarbon (TPH) however exceeded the adopted GAC Intervention Value for groundwater. Table 1-2 identifies the laboratory detection limits exceeding the 'Intervention Values'.

Table 1-2 Limits of Detection Exceeding GAC Intervention Values

Laboratory Analyte	LOD	Intervention Values		Intervention Value Exceedance
		Soil	Groundwater	
TPH	50mg/l	5000mg/l	600ug/l	YES
Arsenic; Cadmium; Chromium; Copper, Lead; Mercury; Nickel; Zinc, Cyanide-total; Polyaromatic Hydrocarbons (PAH); Polychlorinated biphenyls (PCBs; Phenol-total; Organochlorine pesticides	NO EXCEEDANCE The laboratory limits of detection for the potential contaminants were sufficiently below the adopted GAC Intervention Values for soil and groundwater			

LOD = Limits of Detection

5.0 PRELIMINARY RISK ASSESSMENT

5.1 Screening Criteria

The significance of the ground contamination for the reference site was assessed by broadly comparing the laboratory analytical results against *Generic Assessment Criteria* (GAC) which are environmental pollutant reference values (i.e., concentrations in environmental medium) used in environmental remediation, investigation and clean up. In the absence of standards from the Environmental Protection Agency of Ghana, a number of GACs (contaminant threshold values) published by regulatory organizations from the Netherlands, United Kingdom, United States, and the World Health Organization were considered. Although these criteria were not necessarily derived through the same approach, they provide, in combination, a reasonable indication of the significance of the contamination according to international standards.

Based on site-specific features and limitations of each GAC approach, the Netherlands guidance values published in the Soil Remediation Circular of 2009 was used. The guidance values consists of groundwater 'target values', soil remediation 'intervention values' and 'indicative levels for serious contamination'. These are environmental pollutant reference values underpinned by environmental risk analysis used for investigation, environmental remediation and cleanup. A simplified interpretation of the values is as follows:

1. Target Value – is the baseline concentration value below which compounds and/or elements are known or assumed not to affect the natural properties of the soil.

2. Intervention Values – is the maximum tolerable concentration above which remediation is required. This occurs if one or more substances in concentration equal to or exceeds the intervention values measured in a soil volume of at least 25 m^3 in the case of soil contamination, or in a pore-saturated soil volume of at least 100 m^3 in the case of groundwater contamination.

3. Indicative Levels – the indicative levels for serious contamination is the intervention values derived for substances for which have no standardized measurements are available or where ecotoxicological underpinning of the intervention values does not exist or is minimal.

The GAC does not by itself represent the threshold at which there is a *significant possibility of significant harm* to the identified receptors. Nor does it automatically represent an unacceptable intake of a contaminant. A list of the GAC used in this assessment is provided in Table 1-3.

Table 1-3 Target and Intervention Values for Groundwater and Soil (Soil Remediation Circular, 2009)

Substance	Target Value	Intervention Values	
	Groundwater (ug/l)	Soil (mg/kg)	Groundwater (ug/l)
TOTAL PETROLEUM HYDROCARBON			
TPH (C10-C36)	50	5000	600
AROMATIC COMPOUNDS (BTEX)			
Benzene	0.2	1.1	30
Toluene	7	32	1000
Ethylbenzene	4	110	150
Xylene	0.2	17	70
Phenols	0.2	14	2000
Styrene	6	86	300
HEAVY METALS			
Arsenic	10	76	60
Cadmium	0.4	13	6
Chromium	1	-	30
Copper	15	190	75
Lead	15	530	75
Mercury	0.05	-	0.3
Zinc	65	720	800
Tin	2.2	900	50
OTHER INORGANICS			
Cyanide (total)	10	50	1500
POLYAROMATIC HYDROCARBONS (PAH)			
Napthalene	0.01	50	70
Phenanthrene	0.003	-	5
Anthracene	0.0007	-	5
Fluoranthene	0.003	-	1
Benzo(a)pyrene	0.0005	-	0.05
POLYCHLORINATED BIPHENYLS (PCBs)			
Polychlorinated biphenyl (sum 7)	0.01	1	0.01
ORGANOCHLORINE PESTICIDES			
DDT, DDE, DDD (sum)	0.004ng/l	-	-
OTHER SUBSTANCES			
Mineral Oil	50	5000	600

5.2 Contaminants of Concern (COC)

The results of chemical analysis on 4 soil samples showed that the concentrations of the potential contaminants, TPH, PAHs, PCBs, OCPs, BTEX, Phenol, Cyanide and Heavy metals: Zinc, Lead, Copper, Tin, Chromium, Cadmium, Vanadium and Mercury were below the threshold of the adopted assessment criteria which implies the soil is uncontaminated by these potential pollutants. However, all the soil samples analyzed showed elevated concentration of arsenic, detected in soil samples from BH-1 at 0.5m, BH-2 at 1.5m, TP-3 at 1.0m and BH-5 at 2.0m. The concentration of arsenic in the soil samples exceeded the 'Intervention Value' of the adopted substance contamination criteria which implies the soil is polluted by arsenic.

The results of chemical analysis of one groundwater sample showed that the concentrations of the potential contaminants, PAHs, PCBs, OCPs, BTEX, Cyanide and Heavy metals: Arsenic, Zinc, Lead, Copper, Tin, Chromium, Cadmium, Vanadium and Mercury were below the threshold of the adopted assessment criteria which implies the shallow groundwater is uncontaminated by these potential pollutants. The concentration of phenols detected in the groundwater sample at BH 7 at 0.5m exceeded the groundwater 'Target Value' of the adopted criteria.

Based on the results of this limited preliminary sampling and testing, **Arsenic** is considered the contaminant of concern in soil and **Phenol** in shallow groundwater at the reference site. The laboratory detection limit for TPH of 50mg/l exceeded the groundwater 'Intervention Value' of 0.6mg/l and the contamination of the groundwater by TPH could not be ascertained.

Table 1-4 Summary of Soil Samples Exceeding Intervention Value

Sampling Location	Depth (m, bgl)	Contaminant	Concentration (mg/kg)	Intervention Values (mg/kg)	Dutch Level Exceeded
BH1	0.5	Arsenic	99.6	76	Intervention Level
BH2	1.5	Arsenic	124	76	Intervention Level
TP3	1.0	Arsenic	88.9	76	Intervention Level
BH5	2.0	Arsenic	85.4	76	Intervention Level

Table 1-5 Groundwater Sample Exceeding Target Value

Sampling Location	Depth (m, bgl)	Contaminant	Concentration (ug/l)	Target Values (ug/l)	Dutch Level Exceeded
BH7	0.50	Phenols	300	0.200	Target Value

5.3 Extent of Contamination

The extent of contamination was estimated based on the results of the limited preliminary sampling and testing. In general, the contaminants of concern are considered to be site wide. The vertical distribution of the contaminants of concern is up to 2m below ground level which is the maximum sampling depth for this study. Limitation to this assessment exists due to the low sampling density and unknown contamination levels between wide sampling locations.

5.4 Source and Contaminant Pathways

Sources

Based on the assessment of the industrial activities in the surrounding land areas, review of the site history and the geologic setting of the site, the arsenic detected are to a large extent likely to represent elevated naturally occurring concentrations. Limitations to this assessment exist as there is no established national or local background level for arsenic and the concentrations detected are limited to the confines of the reference site.

Potential Exposure Pathways

During construction, workers involved in the disturbed soil and groundwater management operations could be exposed to the contaminants of concern, phenols and arsenic. Excavations and disposal of unsuitable foundation soil has the potential to generate significant amount of contaminated dust and atmospheric water vapor with exposure pathways to the human receptors as follows:

- Construction workers are exposed by direct contact with the skin through improper handling of the soil and groundwater without the appropriate personal protection gear. People in the surrounding land areas could be exposed by dermal contact through contaminated ‘fugitive’ dust;

- Construction workers and people in the surrounding land areas could be exposed by inhalation of contaminated dust generated from soil or inhalation of aerosol from contaminated groundwater spray;

- Ingestion of soil and groundwater through poor hygiene practices; for instance, eating or drinking during earthwork activities, not washing hands properly before eating etc;

- Possible secondary exposure pathways from contaminated equipment or protection clothing through pathways such as those identified above.

5.5 Conceptual Site Model

Based on the review of available information, consultations with informed persons, local inhabitants, site reconnaissance and findings from the limited intrusive ground investigation, the following potential risk sources, pathways and receptors were identified and re-affirmed.

Table 1-6 Conceptual Site Model

Water Environment Anankwari river/lagoon to west of the site. Occasional seawater intrusion resulting in rapid changes in chemical constituents. In hydraulic connection with shallow groundwater at site. Shallow groundwater, unrestricted hydraulic connection with river Anankwari. **Geology/Surficial Soils** ➧ Alluvia Deposits - Soft, loose, medium dense alluvial sands, sandy silts and sandy clay, up to 2.5m in thickness. Potential for local peat accumulations ➧ Residual Soil - Derived from decomposing and weathered sandstone bedrock, permeable sands, clay, silt, sandy clay mixtures up to 4.5m in thickness. Superficial soils are moderate to high in permeability with the potential to transmit a wide range of pollutants due to rapid drainage and low attenuation potential. — Resting on Elmina Formation. Massive sandstone, moderately to distinctly weathered, friable, weak to moderately strong, becoming fresh with increased depth.	***SOURCES*** Based on the review of available information, the Phase 1 Desk Study report, site reconnaissance and findings from the intrusive ground investigation, the following potential risk sources are identified	**Locally Impacted Soil** Potential acid sulphate soil on site or imported acid sulphate soil for construction. Disturbed acid sulphate soils through a process of oxidation can produce sulfuric acid. As the acid moves through the soil profile it may 'mobilise' or cause the release of metals and other toxins from the soil
		Farming Organochlorine pesticides (DDT, DDD, DDE) and polychlorinated biphenyls (PCBs). Naphthalene, xylene, heavy metals, chlorinated hydrocarbons
		Chemical/Petroleum Storage Facilities Potential mobile contaminants include metals and hydrocarbons
		Landfills Household and community refuse dumps near surface waters and in permeable soils with shallow water table. Potential contaminants include PAHs, PCBs, OCPs, BTEX, Phenols and Heavy metals.
		Workshops (Metal and Automobile) Possible contaminants could be associated with these activities: petroleum products, PAHs, solvents like trichloroethylene (TCE), used engine oil may contain chromium, lead, molybdenum, nickel from engine wear, lead or mercury form used batteries
		Medical/Health Posts Potential source of toxic and hazardous spills, most of which entail health risk due to their toxic, carcinogenic, mutagenic, irritants, corrosive, and flammable nature.
		Construction Phase Potential contaminants include used oil, hydraulic fluid, diesel fuel, waste paints, concrete additives, adhesives, acids, lubricants, varnish, thinners, solvents, resins,
		Operation Phase Potential contaminants include used oil, hydraulic fluid, diesel fuel, waste paints.
	PATHWAYS Environmental pathways and exposure routes by which potentially contaminating substances could reach environmental and human health receptors.	**Direct Pathways**
		Dermal contact with the soil and groundwater
		Inhalation of airborne dust and vapors
		Direct/indirect ingestion of groundwater or soil particles
		Indirect Pathways
		Vertical and lateral transport of contaminants through permeable surficial soil
		Lateral contaminated transport through the groundwater underlying the site
	RECEPTORS The environmental and human health receptors that were identified as a result of the proposed end use and ground conditions recorded on site.	Construction phase - site users
		Surrounding land users during construction
		Operation phase site users – workers, visitors
		Shallow groundwater underlying the site
		Anankwari river

5.6 Assessment of Potential Risks

5.6.1 Risk Rating Criteria

The degree of risk that a receptor may actually be exposed to land contamination depends on the toxicology and concentration of chemicals present, the vulnerability and sensitivity of the receptor and the exposure pathway between the source and receptor. Based on the recognized plausible pollutant linkages and the identification of the contaminants of concern on site, the environmental risks and risks to human health have been rated using the risk rating criteria shown in **Table 1-7**. Considering the nature of the proposed development (thermal power generation) and site-specific factors, the end-use is assumed to be 'sensitive', for the purposes of the risk rating.

Table 1-7 Risk Rating Criteria

Description	Risk Rating
Concentrations of contaminants of concern are up to the Generic Assessment Criteria (Dutch Target Value). Pollutant linkages are complete and direct exposure pathways predominate, indicating a measurable but generally low risk of significant environmental and/or health impacts. Further investigation required to serve as closure, remedial actions not warranted.	Low Risk
Concentrations of contaminants of concern are above the Generic Assessment Criteria (Dutch Intervention Value). Pollutant linkages are complete with direct and indirect exposure pathways, indicating a moderate risk of significant environmental and/or health impacts. Further assessment and/or remedial action warranted.	Moderate Risk
Concentrations of contaminants of concern are significantly above the Generic Assessment Criteria (Dutch Intervention Value). Direct exposure pathways predominate, indicating a reasonable likelihood of significant environmental and/or health impacts. Further assessment and/or remedial action warranted.	High Risk

5.6.2 Risks to Water Environment

Due to the saline nature of the surface and groundwater, it is not currently used for drinking or irrigation. Considering site-specific factors and the contaminant of concern, phenols, the risk posed to the ground and surface water is assessed to be low. This assessment is augmented on the fact that the concentration of phenols detected in the groundwater sample was significantly below the adopted GAC 'Intervention Value' and the concentration of phenols in the soil samples were significantly below the 'Target' value. Therefore, there is no unacceptable risk posed to the water environment.

5.6.3 Risks of Harm to Human Health

Exposure to the contaminants of concern, **Arsenic** and **Phenol,** identified on the site poses health risks to the site users; largely people at the construction phase and to a limited extent, personnel during operation phase. Summary of the risks and health effects of the contaminants of concern identified on site is provided as follows:

Arsenic

For the contaminant of concern, arsenic, the risks posed to workers and surrounding land users during construction is assessed as moderate and the risk to site users at operation phase is assessed as low (without remediation). Management or remediation of arsenic is beyond the scope of this study.

Arsenic is a metalloid element, having properties of both metals and non metals. It is a potent human carcinogen and toxicant. Arsenic in soil results from human activities including pesticide use, mining, ore processing operations, and waste disposal, telecommunication systems and solar cells. Both trivalent and pentavalent inorganic arsenic are readily absorbed in the gastrointestinal tract. Arsenic is also absorbed in the lugs following inhalation. Arsenic has been implicated to cause cancers of skin, lungs, urinary bladder, kidney and liver (WHO, 1987)

Phenols

Phenols were detected in soil and groundwater at concentrations significantly below the adopted GAC 'Target Value' and the 'Intervention Value' respectively. Therefore, the risks posed to workers, surrounding land users at construction phase and users at the operation phase is assessed as low (without remediation) and there is no unacceptable risk posed to the human receptors overall. It is assessed that phenol contamination at the reference site is able to be managed by ensuring that measures are put in place to minimize the requirement to over excavate contaminated material; ensure that contractors and workers are made aware of the potential for phenol contaminated groundwater to be encountered and preparation of health and safety plans to minimize potential exposure to phenols.

Phenol forms naturally during the decomposition of organic materials but its presence in the environment is primarily the consequence of anthropogenic activities. Phenol can be found in soil, air and water after release from use, and disposal of products containing phenol. Phenol has been shown to cause liver, heart, lungs and kidney damage and neurotoxic effects. Exposure occurs through breathing by contaminated air and dermal by skin contact.

6. CONCLUSIONS

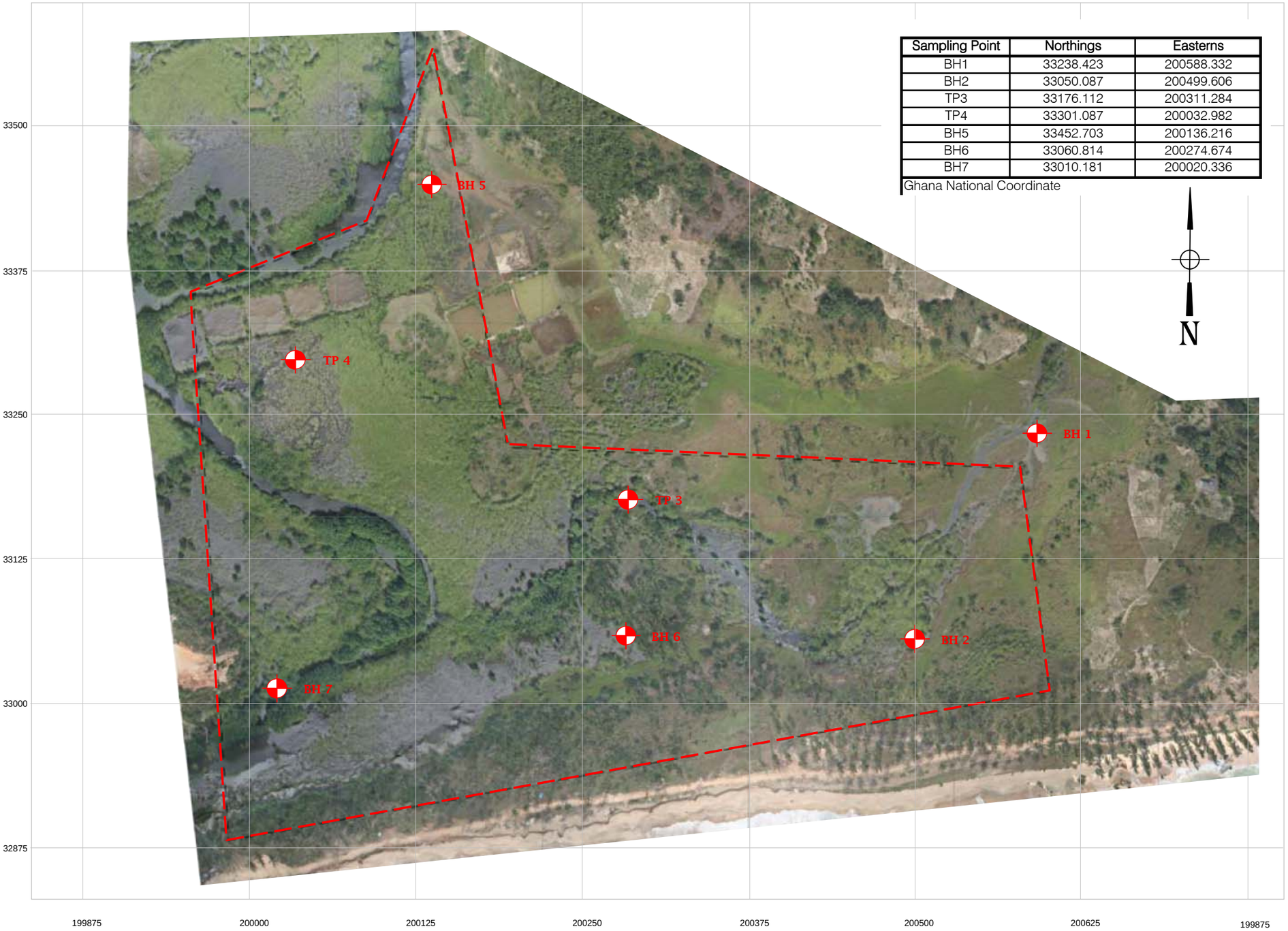
– A limited Phase 2 site investigation has been carried out at Amandi CCTG Site at Aboadze, Ghana to ascertain on preliminary basis the nature and extent of contamination within the site boundary. The investigation has identified **Arsenic** and **Phenol** as the contaminants of concern in soil and groundwater.

– Based on the identification of the contaminants of concern (Arsenic and Phenol) and potential pathways, the risk to construction workers who may come into contact with contaminated soil and groundwater are assessed as low to moderate. The risk to surrounding land users who may be impacted by off-site spoil disposal is assessed as low to moderate. The risk to the water environment is assessed as low.

– It is assessed that the extent of phenol contamination at the reference site is able to be managed. The extent of arsenic contamination requires management and remediation. It is therefore considered that the subject site is suitable for the proposed thermal power plant construction. Remediation of the contaminant, arsenic, is beyond the scope of the present study.

– The above assessments were made and conclusions drawn based on limited sampling at the subject site. Limitations to these assessments exist due to the low sampling density and unknown contamination levels between wide sampling locations.

APPENDIX A



Sampling Point	Northings	Easterns
BH1	33238.423	200588.332
BH2	33050.087	200499.606
TP3	33176.112	200311.284
TP4	33301.087	200032.982
BH5	33452.703	200136.216
BH6	33060.814	200274.674
BH7	33010.181	200020.336

Ghana National Coordinate

LEGEND

Borehole

Site Boundary

This drawing is prepared for the sole reliance of Amandi Energy Limited

FIGURE 1

BY	CK	NO	ENGINEERING RECORD	DATE
			DRAWN BY: D.A.	22/10/2014
			DESIGNED BY:	-
			DESIGN CHECKED	-
			APPROVED BY:	-

Drilling and in-situ test findings and statements of professional opinion do not constitute a guarantee or warranty, expressed or implied..

TITLE OF DRAWING:

INVESTIGATION PLAN - PHASE 2 CONTAMINATION ASSESSMENT AMANDI CCTG SITE - ABOADZE, GHANA

DRAWING NUMBER	REV NO	SHEET
C-AMANDI-TTPE-01	-	1 OF 1

BH 1 - Drillhole Record

Project Number	Exploration Number
-	_

Project	Proposed Amandi 240MW CCTG	G'Elevation (m)	N/A
Location	Takoradi Thermal Enclave - Aboadze	Logged By	A. OSEI
Client	Amandi Energy Limited	Date	30-Sep-14

DEPTH (m)	SAMPLES	GRAPHIC LOG	DESCRIPTION	LABORATORY TESTS NMC %	CLC %	OGC %
0.1 – 0.4			*VEGETABLE TOPSOIL*			
0.5 – 1.0	SS 1		*SAND, Silty, Odourless, Light Yellowish Grey*	13.8	1.8	2.8
1.1 – 2.0	SS 2					
2.1 – 2.5	SS 3		*SAND, Silty, Clayey, Odourless, Light Bluish Grey*			
2.6 – 3.0			END			

NMC Moisture Content
CLC Clay Content
OGC Organic Content

BH 2 - Drillhole Record

Project Number	Exploration Number
-	_

Project	Proposed Amandi 240MW CCTG	G'Elevation (m)	N/A
Location	Takoradi Thermal Enclave - Aboadze	Logged By	A. OSEI
Client	Amandi Energy Limited	Date	30-Sep-14

DEPTH (m)	SAMPLES	GRAPHIC LOG	DESCRIPTION	LABORATORY TESTS NMC %	CLC %	OGC %
0.1 – 3.0	SS 1		*SAND, Clayey, Silty, Odourless, Light Brown Grey*			
	SS 2			18.5	15.7	2.9
			END			

NMC Moisture Content
CLC Clay Content
OGC Organic Content

TP 3 - Trial Pit Record

Project Number	Exploration Number
-	_

Project	Proposed Amandi 240MW CCTG	G'Elevation (m)	N/A
Location	Takoradi Thermal Enclave - Aboadze	Logged By	A. OSEI
Client	Amandi Energy Limited	Date	30-Sep-14

DEPTH (m)	SAMPLES	GRAPHIC LOG	DESCRIPTION	LABORATORY TESTS MC %	CL %	OGC %
0.1 – 1.2	SS 1 SS 1		*SAND, Silty, Clayey, Odourless, Light Greenish Grey*	9.8	11.1	3.1
1.3 – 3.0			END			

MC Moisture Content
CL Clay Content
OGC Organic Content

TP 4 - Trial Pit Record

Project Number	Exploration Number
-	_

Project	Proposed Amandi 240MW CCTG	G'Elevation (m)	N/A
Location	Takoradi Thermal Enclave - Aboadze	Logged By	A. OSEI
Client	Amandi Energy Limited	Date	30-Sep-14

DEPTH (m)	SAMPLES	GRAPHIC LOG	DESCRIPTION	LABORATORY TESTS MC %	CL %	OGC %
0.1 – 1.2	SS 1, SS 2		*SAND, Silty, Clayey, Light Brownish and Greenish Grey*			
1.3 – 3.0			END			

MC Moisture Content
CL Clay Content
OGC Organic Content

BH 5 - Drillhole Record

Project Number	Exploration Number
-	_

Project	Proposed Amandi 240MW CCTG	G'Elevation (m)	N/A
Location	Takoradi Thermal Enclave - Aboadze	Logged By	A. OSEI
Client	Amandi Energy Limited	Date	30-Sep-14

DEPTH (m)	SAMPLES	GRAPHIC LOG	DESCRIPTION	LABORATORY TESTS MC %	CL %	OGC %
0.1–1.9	SS 1, SS 2		*CLAY, Silty, Sandy, Odourless, Dark Grey and Brownish Grey*			
2.0	SS 3			13.9	79.6	2.1
2.1–3.0	SS 4		*CLAY, Sandy, Odourless, Bluish Grey, Brownish Green*			
			END			

MC Moisture Content
LC Clay Content
OGC Organic Content

BH 6 - Drillhole Record

Project Number	Exploration Number
-	_

Project	Proposed Amandi 240MW CCTG	G'Elevation (m)	N/A
Location	Takoradi Thermal Enclave - Aboadze	Logged By	A. OSEI
Client	Amandi Energy Limited	Date	30-Sep-14

DEPTH (m)	SAMPLES	GRAPHIC LOG	DESCRIPTION	LABORATORY TESTS MC %	CL %	OGC %
0.1 – 1.0	SS 1, SS 2, SS 3		*CLAY, Silty, Sandy, Odourless, Dark Grey and Brownish Grey*			
1.0 – 3.0			END			

MC Moisture Content
LC Clay Content
OGC Organic Content

BH 7 - Drillhole Record

Project Number	Exploration Number
-	_

Project	Proposed Amandi 240MW CCTG	G'Elevation (m)	N/A
Location	Takoradi Thermal Enclave - Aboadze	Logged By	A. OSEI
Client	Amandi Energy Limited	Date	30-Sep-14

DEPTH (m)	SAMPLES	GRAPHIC LOG	DESCRIPTION	LABORATORY TESTS MC %	CL %	OGC %
0.1–3.0	SS 1 SS 3 SS 3		*CLAY, Silty, Odourless, Dark Grey and Dark Brown*			
			END			

MC Moisture Content
LC Clay Content
OGC Organic Content

APPENDIX B

Name of Laboratory Testing laboratory for the determination of main and trace elements/ selected soil and groundwater pollutants	Center for Scientific and Industrial (**CSIR**) Research Water Research Institute (**WRI**) Environmental Chemistry Lab

Address	CSIR Premises, Airport Residential Area P.O. 32 M32 Accra, Ghana

Project	Funded By
Northern Region Water Sanitation Project (NORWASP)	Canadian International Development Agency (CIDA)
Accra Sewerage Improvement Project (ASIP)	Africa Development Bank
Community Water and Sanitation Program (CWSP)	World Bank
Small Towns Water Supply and Sanitation Project	German Development Agency (GTZ)
Urban Water Project	World Bank
Water Resources Information Services (WRIS) Project	DANIDA
National Environmental and Sanitation Assessment Programme	Water-Aid Ghana

Total Petroleum Hydrocarbons Analysis Results

Water Research Institute, Environmental Chemistry Division
CSIR Premises, Airport Res. Area
P.O. Box M 32
Accra, Ghana
Phone: (+233-302) 775351/52 Fax: (+233-203) 777170 E-mail: wri@ghana.com

Order ID: *Company Name: Amandi Energy Limited*
Contact Name:
Address: *Phone No.* *City:*

Lab Code: *Project Name: PCA-Amandi CCTG at TTPE* Aboadzi, Ghana

Sample ID:

Analysis start date: 31/10/2014 *Analysis stop date: 04/11/2014*

Sample	Method No.	Unit	Value
Water BH7-WS1	34	mg/l	<50.0

Sample	Method No.	Unit	Value
BH1-SS1	34	mg/kg	<50.0
BH2-SS2	34	mg/kg	<50.0

Remarks:

Approved by:

Dr. Osmund D. Ansa-Asare (Head, ECD)

CSIR WATER RESEARCH INSTITUTE
P. O. BOX M 32, ACCRA
OR CO BOX 38 ACHIMOTA

Polyaromatic Hydrocarbons Analysis Results

Water Research Institute, Environmental Chemistry Division
CSIR Premises, Airport Res. Area
P.O. Box M 32
Accra, Ghana
Phone: (+233-302) 775351/52 Fax: (+233-203) 777170 E-mail: info@csir-water.com

Company Name: Amandi Energy Ltd ***Contact Name:***

Address: ***City*: Accra** ***Phone No.:***

Sample ID: **Soil** **Project Name: PCA-Amandi CCTG at TTPE Aboadze, Ghana**

Analysis start date: 03/10/14 ***Analysis stop date: 20/10/14***

Parameter	Units	BH1-SS1	BH5-SS3	TP3-SS2
Naphthalene	µg/kg	<0.001	<0.001	<0.001
Acenaphthylene	µg/kg	<0.001	<0.001	<0.001
Acenaphthene	µg/kg	<0.001	<0.001	<0.001
Fluorene	µg/kg	<0.001	<0.001	<0.001
Phenanthrene	µg/kg	<0.001	<0.001	<0.001
Anthracene	µg/kg	<0.001	<0.001	<0.001
Fluoranthene	µg/kg	<0.001	<0.001	<0.001
Pyrene	µg/kg	<0.001	<0.001	<0.001
Benz(a)anthracene	µg/kg	<0.001	<0.001	<0.001
Chrysene	µg/kg	<0.001	<0.001	<0.001
Benzo(b)fluoranthene	µg/kg	<0.001	<0.001	<0.001
Benzo(k)fluoranthene	µg/kg	<0.001	<0.001	<0.001
Benzo(a)pyrene	µg/kg	<0.001	<0.001	<0.001
Indeno(123-cd)pyrene	µg/kg	<0.001	<0.001	<0.001
Dibenz(a,h)anthracene	µg/kg	<0.001	<0.001	<0.001
Benzo(g,h,i)perylene	µg/kg	<0.001	<0.001	<0.001

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P. O. BOX M 32, ACCRA
P. O. BOX 38 ACHIMOTA

Polyaromatic Hydrocarbons Analysis Results

Water Research Institute, Environmental Chemistry Division
CSIR Premises, Airport Res. Area
P.O. Box M 32
Accra, Ghana
Phone: (+233-302) 775351/52 Fax: (+233-203) 777170 E-mail: info@csir-water.com

Company Name: Amandi Energy Ltd *Contact Name:*
Address: *Phone No.*
City:

Lab Code: *Project Name: PCA-Amandi CCTG at TTPE Aboadze, Ghana*

Sample ID: BH7-WS1(Water)

Analysis start date: 03/10/14 *Analysis stop date: 20/10/14*

Parameter	Method No.	Unit	Value
Naphthalene	34	µg/l	<0.001
Acenaphthalene	34	µg/l	<0.001
Acenaphthene	34	µg/l	<0.001
Fluorene	34	µg/l	<0.001
Phenanthrene	34	µg/l	<0.001
Anthracene	34	µg/l	<0.001
Fluoranthene	34	µg/l	<0.001
Pyrene	34	µg/l	<0.001
Benz(a)anthracene	34	µg/l	<0.001
Chrysene	34	µg/l	<0.001
Benzo(b)fluoranthene	34	µg/l	<0.001
Benzo(j,k)fluoranthene	34	µg/l	<0.001
Benzo(a)pyrene	34	µg/l	<0.001
Indeno(123-cd)pyrene	34	µg/l	<0.001
Dibenz(a,h)anthracene	34	µg/l	<0.001
Benzo(g,h,i)perylene	34	µg/l	<0.001

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PCBs Analysis Results

Water Research Institute, Environmental Chemistry Division
CSIR Premises, Airport Res. Area
P.O. Box M 32
Accra, Ghana
Phone: (+233-302) 775351/52 Fax: (+233-203) 777170 E-mail: info@csir-water.com

Company Name: Amandi Energy Ltd *Contact Name:*

Address: *City:* *Phone No.:*

Lab Code *Project Name: PCA-Amandi CCTG at TTPE Aboadze, Ghana*

Sample ID: BH7-WS1(Water)

Analysis start date: 03/10/14 *Analysis stop date: 20/10/14*

Parameter	Method No.	Unit	Value
PCB -52 (2,2',5,5'-Tetrachlorobiphenyl)	34	µg/L	<0.001
PCB -138 (2,2',3,4,4',5'-Hexachlorobiphenyl)	34	µg/L	<0.001
PCB-101 (2,2',4,5,5'Pentachlorobiphenyl),	34	µg/L	<0.001
PCB -180 (2,2',3,4,4',5,5'-Heptachlorobiphenyl)	34	µg/L	<0.001
PCB -153 (2,2',4,4',5,5'-Hexachlorobiphenyl),	34	µg/L	<0.001
PCB -118 (2,3',4,4',5-Pentachlorobiphenyl),	34	µg/L	<0.001
28 PCB -28 (2,4,4'-Trichlorobiphenyl),	34	µg/L	<0.001

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P. O. BOX 38 ACHIMOTA

PCBs Analysis Results

Water Research Institute, Environmental Chemistry Division
CSIR Premises, Airport Res. Area
P.O. Box M 32
Accra, Ghana
Phone: (+233-302) 775351/52 Fax: (+233-203) 777170 E-mail: info@csir-water.com

Company Name: Amandi Energy Ltd *Contact Name:*

Address: *City:* *Phone No.:*

Lab Code *Project Name: PCA-Amandi CCTG at TTPE Aboadze, Ghana*

Sample ID: Soil

Analysis start date: 03/10/14 *Analysis stop date: 20/10/14*

Parameter	Method No.	Unit	BH1-SS1	BH5-SS3	TP3-SS2
PCB -52 (2,2',5,5'-Tetrachlorobiphenyl)	34	µg/kg	<0.001	<0.001	<0.001
PCB -138 (2,2',3,4,4',5'-Hexachlorobiphenyl)	34	µg/kg	<0.001	<0.001	<0.001
PCB-101 (2,2',4,5,5'Pentachlorobiphenyl),	34	µg/kg	<0.001	<0.001	<0.001
PCB -180 (2,2',3,4,4',5,5'-Heptachlorobiphenyl)	34	µg/kg	<0.001	<0.001	<0.001
PCB -153 (2,2',4,4',5,5'-Hexachlorobiphenyl),	34	µg/kg	<0.001	<0.001	<0.001
PCB -118 (2,3',4,4',5-Pentachlorobiphenyl),	34	µg/kg	<0.001	<0.001	<0.001
28 PCB -28 (2,4,4'-Trichlorobiphenyl),	34	µg/kg	<0.001	<0.001	<0.001

CSIR WATER RESEARCH INSTITUTE
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P. O. BOX 38 ACHIMOTA

BTEX Analysis Results

Water Research Institute, Environmental Chemistry Division
CSIR Premises, Airport Res. Area
P.O. Box M 32
Accra, Ghana
Phone: (+233-302) 775351/52 Fax: (+233-203) 777170 E-mail: info@csir-water.com

Order ID: *Company Name: Amandi Energy Limited*
Contact Name:
Address: *Phone No.*
City:

Lab Code: *Project Name: PCA-Amandi CCTG at TTPE Aboadze, Ghana*

Sample ID: BH7-WS1 (Water)

Analysis start date: 03/10/2014 *Analysis stop date: 20/06/2014*

Sample	Method No.	Unit	Value
Benzene	34	µg/l	<20.0
Toluene	34	µg/l	<20.0
Ethylbenzene	34	µg/l	<20.0
Xylene	34	µg/l	<20.0

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Accra, Ghana
Phone: (+233-302) 775351/52 Fax: (+233-203) 777170 E-mail: info@csir-water.com

Order ID: *Company Name: Amandi Energy Limited*
Contact Name:
Address: *Phone No.*
City:

Lab Code: *Project Name: PCA-Amandi CCTG at TTPE Aboadze, Ghana*

Sample ID: Soil

Analysis start date: 03/10/2014 *Analysis stop date: 20/06/2014*

Sample	Method No.	Unit	BH1-SS1	BH5-SS3	TP3-SS2
Benzene	34	µg/kg	<20.0	<20.0	<20.0
Toluene	34	µg/kg	<20.0	<20.0	<20.0
Ethylbenzene	34	µg/kg	<20.0	<20.0	<20.0
Xylene	34	µg/kg	<20.0	<20.0	<20.0

Remarks: Results are satisfactory.

Approved by:

Dr. Osmund D. Ansa-Asare (Head, ECD)

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Analysis Results

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Phone: (+233-21) 775351/52 Fax: (+233-21) 777170 E-mail: info@csir-water.com

Project: PCA-AMANDI CCTG AT TTPE ABOADZE, GHANA **Company Name: AMANDI ENERGY LIMITED**

Contact First Name: **Contact Last Name:**

Analysis start date: 03/10/14 **Analysis stop date: 21/10/14**

Sample ID Soil	PHENOL	Oil/Grease	Arsenic (As)	Tin (Sn)	Silver(Ag)	Zinc (Zn)	Lead (Pb)	Copper (Cu)	Chromium (Cr)	Cadmium (Cd)	Mercury (Hg)	Vanadium (V)	Free Cyanide	Complex Cyanide
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
BH1-SS1	3.10	1.25	99.6	81.5	<0.025	14.7	<0.025	11.9	27.7	<0.025	2.36	83.3	<0.001	<0.001
BH2-SS2	2.70	<1.00	124	5.08	<0.025	39.0	<0.025	13.1	29.2	<0.025	1.48	9.03	<0.001	<0.001
TP3-SS2	2.00	<1.00	88.9	44.7	<0.025	0.990	<0.025	5.27	18.8	<0.025	1.33	3.35	<0.001	<0.001
BH5-SS3	5.40	<1.00	85.4	207	<0.025	99.2	<0.025	10.1	30.4	<0.025	<0.025	97.3	<0.001	<0.001

Approved by:

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Dr. Osmund D. Ansa-Asare (Head, ECD)

Analysis Results

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Project: PCA-AMANDI CCTG AT TTPE ABOADZE, GHANA **Company Name: AMANDI ENERGY LIMITED**

Contact First Name: **Contact Last Name:**

Analysis start date: 03/10/14 **Analysis stop date: 21/10/14**

Sample ID Water	Phenol	Oil/Grease	Arsenic (As)	Tin (Sn)	Silver(Ag)	Zinc (Zn)	Lead (Pb)	Copper (Cu)	Chromium (Cr)	Cadmium(Cd)	Mercury (Hg)	Vanadium (V)	Free Cyanide	Complex Cyanide
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
BH7-WS1	0.300	<1.00	0.013	0.066	<0.001	<0.005	0.011	0.016	<0.010	<0.002	<0.001	0.078	<0.001	<0.001

Approved by:

Dr. Osmund D. Ansa-Asare (Head, ECD)

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APPENDIX X

ENVIRONMENTAL & SOCIAL MANAGEMENT PLAN (ESMP)

AMANDI ENERGY LIMITED

ENVIRONMENTAL & SOCIAL MANAGEMENT PLAN

190 MW COMBINED CYCLE POWER PLANT AT ABOADZE, GHANA

PARSONS BRINCKERHOFF

CONTENTS

		Page
Acronyms		**5**
1	**Introduction**	**8**
2	**Regulatory and Other Requirements**	**10**
3	**Project Description and Schedule**	**20**
4	**Organisation**	**30**
5	**Environmental Specifications**	**37**
6	**Overview of Project Phases**	**43**
7	**Management Plans**	**45**
8	**Environmental and Social Action Plan**	**59**
Appendices		**78**

Owner's Environmental, Social, Health and Safety Requirements – DRAFT SUBJECT TO REVIEW

ACRONYMS

%	Per cent
°C	Degrees Celsius
ACC	Air Cooled Condenser
AEL	Amandi Energy Limited
AfDB	African Development Bank
AIDS	Acquired Immune Deficiency Syndrome
ANLG	Ambient Noise Level Guidelines
BCMP	Biodiversity and Conservation Management Plan
BOD	Biological Oxygen Demand
BS	British Standards
CCGT	Combined Cycle Gas Turbine
CESMP	Contractor Environmental and Social Management Plan
CITES	Convention on International Trade in Endangered Species
CO	Carbon Monoxide
dB	Decibels
dB(A)	A-weighted decibels
DFO	Distillate Fuel Oil
EBRD	European Bank for Reconstruction and Development
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EPA	Environmental Protection Agency
EPC	Engineering, procurement and construction
EPFI	Equator Principle Financial Institution
ESAP	Environmental and Social Action Plan
ESC	Environmental Solutions Centre
ESHS	Environmental, Social, Health and Safety
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan

ESMS	Environmental and Social Management System
GRIDCo	Ghana Grid Company Limited
HIV	Human immunodeficiency virus
HRSG	Heat Recovery Steam Generator
HV	High Voltage
IFC	International Finance Corporation
IFC PS	International Finance Corporation Performance Standards
ILO	International Labour Organisation
IPP	Independent Power Producer
ISO	International Organisation for Standardisation
IUCN	International Union for the Conservation of Nature
km	Kilometres
kV	Kilo volts
$LA_{eq,T}$	A-weighted equivalent sound pressure level measured over time
LCO	Light Crude Oil
LI	Legislative Instrument
m	Metres
MW	Megawatts
µg / m^3	Microgram per cubic metre
mg/l	Milligram per Litre
N/A	Not Applicable
NGO	Non-governmental organization
NLCD	National Liberation Council Decree
NOSCP	National Oil Spill Contingency Plan
NOx	Nitrous Oxides
NTU	Nephelometric Turbidity Unit
O_2	Oxygen
OH&S	Occupational Health and Safety
O&M	Operations and Maintenance

OPIC	Overseas Private Investment Corporation
OSRMP	Oil Spill Response and Management Plan
PAP	Project Affected Person
PM_{10}	Particulate matter with less than 10 microns diameter
PNDCL	Provisional National Defence Council Law
PPE	Personal Protective Equipment
PPM	Parts Per Million
PURC	Public Utilities Regulatory Commission
SEP	Stakeholder Engagement Plan
SPM	Single point mooring
S	Sulphur
SO_2	Sulphur Dioxide
STI	Sexually Transmitted Infection
TBC	To be confirmed
TCU	True colour unit
VRA	Volta River Authority
WHO	World Health Organisation

1 INTRODUCTION

1.1.1 An Environmental and Social Management System (ESMS) is required as part of all Category A and B Projects[1]. An ESMS sets out the environmental and social mitigation programmes for the Project in a comprehensive, systematic, planned and documented manner. It includes the organisational structure, planning and resources of developing, implementing and maintaining policy for environmental and social protection.

1.1.2 This Environmental and Social Management Plan (ESMP) has been prepared as part of the ESMS for the Amandi Energy Ltd (AEL) Project. An explanation of the requirements for an ESMP is provided in the following section.

1.1.3 As part of an ESMS, a Contractor Environmental and Social Management Plan (CESMP[2]) is also required. Requirements for the CESMP have been referenced in this report and discussed in the following sections.

1.2 Environmental and Social Management Plan

1.2.1 This ESMP for the AEL 190MW Combined Cycle Gas Turbine (CCGT) Project (the Project) near Aboadze, Western Ghana, has been developed to address and manage the potential negative and positive effects associated with the Project throughout the pre-construction, construction, operational and eventual decommissioning phases.

1.2.2 The Environmental and Social Impact Assessment (ESIA), consolidated and updated in 2015, identified a number of environmental and social effects and set out the principles for mitigating negative effects and enhancing positive effects. As such, the objectives of this ESMP are to:

- Identify the required mitigation measures that are needed in order to reduce negative impacts and enhance positive ones;
- Define specific actions to be taken, roles and responsibilities for these actions, timetables for implementation; and
- Outline the resource, consultative and training and capacity building requirements.

1.2.3 The ESMP will also identify where monitoring is required in relation to positive and negative effects, environmental performance, and compliance with statutory environmental, social, health and safety (ESHS) regulations. Monitoring will provide the information for periodic review and subsequent alteration of the ESMP as necessary. This will ensure that undesirable effects are detected early and remedied effectively. It will also demonstrate compliance with regulatory requirements.

1.2.4 AEL will aim to ensure that all appropriate Ghanaian and international standards will be met during construction, operation and decommissioning. The ESMP has been developed to meet these requirements.

1.2.5 Provisions of this ESMP apply to the following phases of work:

1 Equator Principles 2013 – Principle 4 Environmental and Social Management System and Equator Principles Action Plan

2 The CESMP is to be produced by the applicable contractor and details the specific plans that the contractor will undertake for implementing the various mitigation measures identified in AEL's ESMP.

- *Design phase & preconstruction* – applies to all work prior to starting construction.
- *Construction phase* - will apply from the beginning of site works to the practical completion of works.
- *Operational phase* - will apply from commissioning to decommissioning of the Project.
- *Decommissioning phase.*

1.2.6 The ESMP sets the framework for these phases of the Project and can be updated during detailed design, construction and operation of the Project. As discussed, the contractor(s) will be required to provide a detailed CESMP to cover their component specific ESHS procedures.

1.2.7 This document is divided into the following sections:

- Section 2 – Policy, legal and administrative requirements – lists the legislation and standards which need to be applied to the Project.
- Section 3 – Project description and schedule.
- Section 4 – Organisation structure, including budget.
- Section 5 – Environmental specifications.
- Section 6 – Overview of the project phases.
- Section 7 - Sets out the various management plans – both for AEL and the contractor(s) - which will be required to set a framework for mitigation and monitoring.
- Section 8 – Environmental and Social Action Plan – sets out the actions, responsibilities and periods for mitigation and monitoring.

2 REGULATORY AND OTHER REQUIREMENTS

2.1 Introduction

2.1.1 There are a number of relevant national and international policies and regulations that provide safeguards for development projects. The national and international standards which will generally apply to the Project are:

a The National Laws of Ghana;

b World Bank Group Environmental, Health and Safety (EHS) Guidelines, including the International Finance Corporation Performance Standards (IFC PS);

c Equator Principles; and

d All relevant international conventions etc. and any further standards adopted by the international lending community.

2.1.2 Furthermore, Parsons Brinckerhoff has reviewed certain prospective Lenders' EHS requirements (including those of OPIC, EIB and AfDB). With respect to this Project, the standards were found to be broadly in line with those of the World Bank Group/IFC and any differences have been considered and incorporated into this ESMP.

2.1.3 This section sets out the administrative, legal and policy framework relevant to the Project at international, national, regional and local levels.

2.2 National Laws of Ghana

2.2.1 Some of the legislation, guidelines, and policies which are considered to be of relevance to the Project include among others:

The Environmental Protection Agency Act (1994) Act 490

2.2.2 The Environmental Protection Agency (EPA) Act 1994 (Act 490) was promulgated by the Government of Ghana to replace the erstwhile Environmental Protection Council Decree (NRCD 239). The Act provided the Agency with the compliance and enforcement powers necessary for the achievement of the environmental policy objectives.

2.2.3 Act 490 established the authority, functions, structure and funding of the EPA and gave mandate to the Agency to ensure compliance of all investments and undertakings with the provisions of the Environmental Assessment procedures in the planning and execution of development projects, including compliance in respect of existing ones.

2.2.4 The Act empowers the EPA Board to appoint officers to be designated as "Environmental Protection Inspectors" and have such other officers and employees as may be necessary for the proper and effective performance of its functions under this Act. The Board may create such departments or divisions in the Agency as the Board may consider necessary for the efficient discharge of the functions of the Agency.

Environmental Assessment Regulations (1999) LI 1652

2.2.5 In order to give effect to provisions of Act 490, the Environmental Assessment Regulations 1999 (LI 1652) was enacted in February 1999, in accordance with Section 28 of the Act 490. The LI sets out the requirements for environmental

permitting, environmental impact assessment (EIA), the production of preliminary environmental reports and subsequent environmental impact statements, environmental certificates and environmental management plans.

2.2.6 The EIA procedure is not only a regulatory tool to be enforced pursuant to Section 24 of LI 1652, but also a compliance promotion tool to ensure effective prevention, minimisation and mitigation of potential impact of industrial developments existing prior to and after the coming into force of LI 1652.

2.2.7 The legislative functions conferred on EPA by the Act, included the authority to request from categories of undertakings, enterprises, construction or development an environmental impact assessment to assess the impacts associated with projects and environmental management plan for the evaluation of compliance with set guidelines and standards to ensure environmental integrity of operations.

2.2.8 The Agency may by notice in writing require any person responsible for any undertaking which in the opinion of the Agency has or is likely to have adverse effect on the environment to submit to the Agency in respect of the undertaking an environmental impact assessment containing such information within such period as shall be specified in the notice.

2.2.9 Where it appears to the Agency that the activities of any undertaking poses a serious threat to the environment or to public health, the Agency may serve on the person responsible for the undertaking, an enforcement notice requiring him to take such steps as the Agency thinks necessary to prevent or stop the activities.

2.2.10 Where a person to whom a notice has been served under subsection (1) of section 13 fails to comply with the directives contained in the notice within the stipulated time or such further period as the Agency may grant, the Minister, may without prejudice to a prosecution under subsection (4) of section 13, take such steps as he considers appropriate to ensure compliance with the notice.

2.2.11 Under Schedule 1 Regulation 3, 13 (a-e) for Power Generation and Transmission Projects, construction and operation of thermal power plants is one of the undertakings for which an EIA is mandatory.

Environmental Agency Fees and Charges (Amendment) Instrument LI 2206, 2013

2.2.12 In exercise of the powers conferred on the Minister responsible for the Environment, under section 28 of the EPA Act, 1994 (Act 490) and on the advice of the EPA Board this Legislative Instrument was promulgated to serve as legal backing to the Environmental Processing and Permit fees charged under the principal act.

2.2.13 The LI 2206, 2013 stipulates the "fees and charges for environmental permits and certificates" and is accompanied by Schedules indicating the respective fees for processing, permit and environmental certificates for different categories of undertakings (large scale and others). The fees are graded according to the scale of impact entailed by the project activities, and in the case of hotels, the occupancy or number of rooms. Some of the industrial groups covered under the LI 2206 of 2013 include the Mining, Energy, and Tourism, Manufacturing, Agricultural and General Construction Sectors among others.

Pesticides Control and Management Act (1996) Act 528

2.2.14 The Act which is now part of the EPA Act 490, was enacted to ensure the control, management and regulation of chemicals and pesticides and related matters in Ghana. It provides the EPA the powers to register and classify chemicals, to determine "Restricted" and "Suspended" chemicals, license and approve chemical dealers, and to ensure enforcement and penalties. The Act states that no person shall import, export, manufacture, distribute, advertise, sell or use any chemical in Ghana unless the chemical has been registered by the EPA in accordance with this Act.

2.2.15 Any person seeking to register any pesticide shall submit to the Agency an application for registration which shall be in such form and be accompanied with such fee, information, samples and such other material as the Agency may determine.

Energy Commission Act (1997), Act 541

2.2.16 Act 541 established the Energy Commission with functions including the regulation, management, development and utilization of energy resources in Ghana in addition to granting of licenses for the transmission, wholesale supply, distribution and sale of electricity and natural gas; refining, storage, bulk distribution, marketing and sale of petroleum products and to provide for related matters.

2.2.17 The provisions of the Energy Commission's Public Notice EC N.003 requires developers to register the proposed project with the Commission and to obtain a permit prior to the commencement of construction of the proposed project. This permit is subject to the granting of an Environmental Permit by the EPA.

2.2.18 A Manual for Service Providers in the Electricity Supply Industry was developed and issued by the Commission in 1996 to formally establish the framework for licensing electricity production, supply, and distribution and sale services in the power sector of Ghana as stipulated by the Energy Commission Act (Act 541), 1997.

Public Utilities Regulatory Commission (PURC) 1997, Act 538

2.2.19 The PURC 1997, Act 538 requires the PURC to set up guidelines for pricing of power generated by utility companies taking into consideration assurance of financial viability of power produced, investor interests and best use of natural resources. PURC is also responsible for the determination of actual tariffs for both production and service providing utilities including electricity hence will be responsible for pricing of the electric power to be generated from the Project.

Ghana Investment Code, Provisional National Defence Council Law (PNDCL) 116, 1985

2.2.20 The 1985 Investment Code, PNDCL 116, requires that the Ghana Investment Promotion Centre, which is the government agency for the promotion and coordination of private investment in the Ghanaian economy must in its appraisal of enterprise, have regards to any effect the enterprise is likely to have on the environment and the measure proposed for the prevention and control of any harmful events to the environment before giving approval for its establishment.

Factories, Offices and Shops Act (1970) Act 328

2.2.21 Act 328 promotes and ensures the health, welfare and safety of persons employed in the country as well as the responsibilities of the employer. Under the Act, employers are required to ensure that a safe and healthy workplace is provided for the safety, health and welfare of all employees.

Labour Act No (2003) Act 651

2.2.22 Part XV, Section 118 (1) and (2 a-h) of the Act enjoins employers to ensure that every worker employed by him or her works under satisfactory, safe and healthy conditions, and is further obliged to provide necessary information, instructions, training and supervision to ensure the health and safety at work of those other workers engaged in a particular work.

National Museums Decree (1969) National Liberation Council Decree (NLCD) 387

2.2.23 NLCD 387 provides for the care of any archaeological finds. This is the law governing the activities and operations of the National Museums and Monuments Board. Procedures to be followed on the discovery of any such artefacts are outlined in NLCD 387. Any archaeological finds during the construction activities shall be reported accordingly.

Ghana National Fire Service Act of 1997 (Act 537)

2.2.24 The Ghana National Fire Service Act of 1997 (Act 537) states that a Fire Certificate shall be required for premises used as a public place or place of work. The owner or occupier of the premises shall apply to the Chief Fire Officer for a Fire Certificate, valid for 12 months from the date of issue and subject to renewal.

Electricity Regulations, L.I. 1937: 2008

2.2.25 The purpose of these Regulations is to provide for:

a The planning, expansion, safety criteria, reliability and cost effectiveness of the national interconnected transmission system;

b The regulation of a wholesale electricity market;

c The market operations of the electricity transmission utility;

d The technical operations of the electricity transmission utility;

e Minimum standards and procedures for the construction and maintenance of facilities and installations;

f The protection of the mains and electrical installations and services;

g The protection of life and property and the general safety of the public in respect of electricity services;

h Minimum reserve margins to satisfy demand; and

i The development and implementation of programmes for the conservation of electricity.

Fire Precaution (Premises) Regulations, 2003, LI 1724

2.2.26 LI 1724 among other requirements requires that adequate measures are taken to eradicate potential sources of fire outbreaks and that a fire certificate be acquired for any project or facility.

Lands Commission Act, (1994), Act 483

2.2.27 Act 483 provides for the management of public and vested lands and the certification of stool lands transactions. Indeed, the 1992 Constitution requires that there shall be no disposition or development of any stool land unless the Lands Commission of the region in which the land is situated has certified that the disposition or development is consistent with the development plan drawn up or approved by the planning authority for the area concerned.

Lands Statutory Way leaves Act, (1963) Act 186

2.2.28 Act 186 provides for entry on any land for the purpose of the construction, installation and maintenance of works of public utility, and for the creation of rights of way for such works. The owner / occupier of the land must be formally notified at least a week in advance of the intent to enter, and be given at least 24 hours‘ notice before actual entry. An authorized person may enter at any time for the purpose of inspecting, maintaining, replacing or removing any specified works (Section 5). Any damage due to entry must be compensated in accordance with the established procedure, unless the land is restored or replaced. In the case of roads, not more than one-fifth of a plot may be taken and the remainder must be viable, or the entire plot must be taken; Section 6-3(b).

The Lands (Statutory Way leaves) Regulations, 1964 (LI334)

2.2.29 LI 1334 law restates the principles of the Lands (Statutory Way leaves) Act of 1963, and establishes provisions for Way leave Selection Committees to determine the

optimal routing and to ensure that the selected way leaves are consistent with town and country planning.

Water Resources Commission Act, 1996

2.2.30 Act 1996 established a Water Resources Commission, with mandate for the regulation and management of water resources in Ghana as well as the co-ordination of any policy in relation to these functions. The Commission is also mandated to propose comprehensive plans for the utilization, conservation, development and improvement of water resources; initiate, control and co-ordinate activities connected with the development and utilization of water resources; grant water rights; collect, collate, store and disseminate data or information on water resources; require water user agencies to undertake scientific investigations, experiments or research into water resources in addition to monitoring and evaluating programmes for the use and management of water resources.

National Energy Policy

2.2.31 The National Energy Policy outlines the Government of Ghana's policy direction regarding the current challenges facing the energy sector. The document provides a concise outline of the Government's policy direction in order to contribute to a better understanding of Ghana's Energy Policy framework. It is hoped that the document will facilitate the effective management and development of the energy sector as well as provide the public with information about the Government's policy goals. The energy sector vision is to develop an Energy Economy to secure a reliable supply of high quality energy services for all sectors of the Ghanaian economy and also to become a major exporter of oil and power by 2012 and 2015 respectively.

National HIV/AIDS Sexually Transmitted Infection (STI) Policy (2004)

2.2.32 The National HIV/AIDS STI Policy has been developed to address the very serious health and developmental challenges posed by HIV/AIDS. The policy provides the framework for Ghana's strategy to reduce the spread of HIV infection. It provides the necessary statement of commitment around which a legislative framework will be built for an Expanded Multi-sectorial Response to reduce further spread of the epidemic, and for the protection and support of people infected with HIV/AIDS in Ghana. Subsequently, a National HIV/AIDS Strategic Framework for Ghana has been formulated in recognition of the developmental relevance of the disease. Ghana, by this document has joined the global community in a united effort to combat the epidemic. The Strategic Framework document is updated periodically and it provides for a Workplace HIV Policy. Ghana has now developed a National HIV/AIDS Strategic Plan 2011-15.

National Oil Spill Contingency Plan (NOSCP) 1986 (revised in 2009)

2.2.33 The NOSCP of Ghana aims to bring together the combined resources of the national government organisations and the oil industry (including shipping and extraction), to provide a level of preparedness to the potential threats posed by oil and chemical spills.

2.2.34 The NOSCP highlights that the focus of any oil spill plan should be firstly on protecting human health and safety, secondly minimising environmental impacts and thirdly restoring the environment to pre-spill conditions. In the process of preparing oil spill response plans, the Environmental Sensitivity Atlas and associated reports will

be considered in order to understand the risk index rating that has been applied to the coastal area of the project.

Guidelines

2.2.35 The EIA Guidelines for the Energy Sector, Volume 1 & 2, of September 2011, has been prepared to guide the development of energy projects as well as ensure the sustainable use of energy resources and also contribute towards sound environmental management in the energy sector.

2.2.36 Environmental Assessment in Ghana, A Guide (1996) produced by the EPA provides detailed guidance on the procedures to be adhered to when undertaking an EIA.

2.2.37 EPA's Environmental Quality Guidelines for Ambient Air provide advice on maximum permissible levels for various air pollutants.

2.2.38 EPA's Environmental Quality Guidelines for Ambient Noise provide the maximum permissible noise levels at various facilities including educational and health institutions, places of worship, commercial areas as well as light and heavy industrial areas.

Implementation of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)

2.2.39 CITES published lists in the form of Appendices (CITES Appendices, 1975) which limit global trade of certain categories of animal species:

a Appendix I species are threatened species which cannot be traded in; and

b Appendix II species are species for which levels of trade are limited.

2.2.40 The 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:

a Schedule I species are completely protected (i.e. their hunting, capture or destruction is prohibited at all times); and

b Schedule II species are partially protected (i.e. their hunting capture or destruction is absolutely prohibited between 1 August and 1 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).

2.3 International Standards

World Bank Group EHS Standards

2.3.1 The EHS Guidelines produced by the World Bank Group are technical reference documents on cross-cutting environmental, health, and safety issues applicable to all industry sectors. They cover general and industry-specific examples of Good International Industry Practice, as defined in IFC's Performance Standard 3 on Pollution Prevention and Abatement.

2.3.2 The General EHS Guidelines (April 2007) contain the performance levels and measures that are normally acceptable to the IFC and are generally considered to be achievable in new facilities at reasonable costs by existing technology.

2.3.3 When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

2.3.4 Specific industry EHS Sector guidelines relevant to the Project are:

- Thermal Power Plants (December 2008);
- Electric Power Transmission and Distribution (April 2007); and
- Construction Materials Extraction (April, 2007).

Performance Standards

2.3.5 To manage the social and environmental risks and impacts of IFC projects, the IFC has developed a number of environmental and social Performance Standards. The IFC PS, updated in 2012, and the accompanying Guidance Notes have been adopted by AEL for this Project.

2.3.6 IFC PS indicate that the party responsible for implementing and operating the project must comply with the applicable national laws, including those laws implementing host country obligations under international law. The project operator is also required to meet the requirements of the standards throughout the life of an investment by IFC or other relevant financial institution. These are as follows:

Performance Standard 1	Assessment and Management of Environmental and Social Risks and Impacts
Performance Standard 2	Labour and Working Conditions
Performance Standard 3	Resource Efficiency and Pollution Prevention
Performance Standard 4	Community Health, Safety, and Security
Performance Standard 5	Land Acquisition and Involuntary Resettlement
Performance Standard 6	Biodiversity Conservation and Sustainable Management of Living Natural Resources
Performance Standard 7	Indigenous Peoples
Performance Standard 8	Cultural Heritage

2.3.7 All the above Performance Standards are applicable to this Project except PS 7 Indigenous Peoples. As determined in the socio-economic baseline of the ESIA, persons or group that could be reported or defined (based on accepted criteria) as “indigenous”.

2.3.8 These Performance Standards have been used as the basis for the assessment of the Project in the ESIA.

Equator Principles

2.3.9 The Equator Principles revised in June 2013 are a set of voluntary principles for financial institutions to ensure that the projects financed are developed in an environmentally and socially responsible manner. The financial institutions that have signed up the Equator Principles are called Equator Principle Financial Institutions (EPFIs). The principles (see Table 2.1) are intended to serve as a common baseline and framework for the implementation by each EPFI.

2.3.10 The Principles apply to all new EPFI project financings globally with total project capital costs of US$10 million or more, and across all industry sectors.

Table 2.1: Summary of Equator Principles

Principle	Description
Principle 1: Review and Categorisation	Relates to the categorisation of projects based on the magnitude of its potential impacts and risks in accordance with the environmental and social screening criteria of the IFC.
Principle 2: Social and Environmental Assessment	Requires a Social and Environmental Assessment. The Assessment should propose mitigation and management measures relevant and appropriate to the nature and scale of the Project.
Principle 3: Applicable Social and Environmental Standards	Establishes the IFC PS and EHS Guidelines to complement the host country legislation as the basis for social and environmental performance.
Principle 4: Action Plan and Management System	Requires preparation of an Action Plan which should describe and prioritise the actions needed to implement mitigation measures, corrective actions and monitoring measures.
Principle 5: Consultation and Disclosure	Requires consultation with project affected communities in a structured and culturally appropriate manner, ensuring free, prior and informed consultation and facilitate informed participation.
Principle 6: Grievance Mechanism	Requires the establishment of a grievance mechanism as part of the management system which addresses concerns promptly and transparently, in a culturally appropriate manner, and is readily accessible to all segments of the affected communities.
Principle 7: Independent Review	Requires an independent social or environmental review of the Assessment.
Principle 8: Covenants	Requires compliance with all relevant host country social and environmental laws, regulations and permits, Action Plan implementation commitments, periodic reviews of reports, and facility decommissioning in accordance with an agreed decommissioning plan.
Principle 9: Independent Monitoring and Reporting	Requires ongoing monitoring and reporting over the life of the loan through the appointment of an independent environmental and / or social expert.
Principle 10: EPFI Reporting	Commits the EPFIs to report publicly at least annually about its Equator Principles implementation processes and experience, taking into account appropriate confidentiality considerations.

2.3.11 The Equator Principles are based on the IFC PS on social and environmental sustainability and on the World Bank Group EHS Guidelines. These principles are relevant for the purposes of this Project as they represent industry best practice.

Other Standards

2.3.12 Parsons Brinckerhoff has reviewed certain prospective Lenders' EHS requirements (including those of OPIC, EIB and AfDB). With respect to this Project, the standards were found to be broadly in line with those of the World Bank Group/IFC and any differences have been considered and incorporated into this ESMP.

2.3.13 Also to be considered are:

- Voluntary Principles on Security and Human Rights
- UK & US Bribery Acts

3 PROJECT DESCRIPTION AND SCHEDULE

3.1 Project Overview

3.1.1 Analysis of the current Ghanaian Power generation / supply revealed an energy supply deficit (as demand for power is constantly over growing the supply). This is evidenced by the current energy crisis and the general challenges facing the sector and the economy as a whole. The government of Ghana has planned to increase total production of power to 5,000 MW by 2015.

3.1.2 The advent of power sector reform in Ghana that commenced in 1994 opened up the sector to allow investment by the Private Sector in the development and operation of power plants for the supply of electricity for socio-economic and industrial development. The reform programme aimed at creating a conducive environment in the energy sector to attract private capital and also provide a reliable energy supply system to support socio-economic development of the country.

3.1.3 This situation has been very greatly helped by the discovery of oil off the shore of Ghana. The country has also put in place institutions and is developing infrastructure to harness the associated natural gas for power generation and other industrial use. Currently a number of Independent Power Producers (IPPs) have shown great interest and made investments to construct and operate power plants.

Amandi Energy Ltd

3.1.4 AEL is a power company established by Radewood Energy Ltd and incorporated in Ghana under Companies Registration Code 1963, Act 179, to engage in the business of producing electrical energy for sale to prospective customers. In June 2014 Radewood signed a Joint Development Agreement with Aldwych International Ltd. Together, Radewood and Aldwych will work in partnership to complete the development of the AEL Project, to jointly manage the construction and operation phases of the Project and to be co-investors in the Project.

3.1.5 The Project will produce electricity for sale to the Electricity Company of Ghana as the main off taker. AEL therefore enters the Ghanaian power market as a Wholesale Supplier licensed by the Energy Commission, the entity mandated to license electricity producers.

Environmental and Social Impact Assessment

3.1.6 ESC has prepared an ESIA of the AEL Project. The ESIA fulfils the requirements of the Ghanaian EPA Act (1994) Act 490 and associated Acts relevant to protection of the environment, social wellbeing and electricity regulations.

3.1.7 The ESIA was preceded in 2013 by an ESIA Scoping and Terms of Reference stage, in accordance with EIA Regulations. The EPA issued the Permit for the Project, to AEL, in July 2014.

3.1.8 The ESIA was then updated and consolidated by Parsons Brinckerhoff in order to develop the assessment in accordance with the international standards that may apply to the Project, as outlined in Chapter 2. An addendum to the EPA approved ESIA, containing the updated information, will be submitted to EPA in due course. The team from Parsons Brinckerhoff comprised specialists in air quality, noise, water, ecology and general ESIA. They were also supported by Envaserv for ecology, a Ghanaian consultancy with particular expertise in aquatic ecology.

3.1.9 The Updated ESIA consolidates all the environmental and social information and studies on the Project to date (as of March 2015).

3.1.10 This ESMP document has been prepared by Parsons Brinckerhoff. It is a 'live' document and provides details of the further works required. This ESMP will be updated as these works are completed, as required.

3.2 Amandi Combined Cycle Power Project

3.2.1 The Project comprises the development of a CCGT with a generating capacity of approximately 190 MW. The plant will consist of one gas turbine coupled with a generator, one heat recovery steam generator and one steam turbine.

3.2.2 It will operate on light crude oil (LCO) as the primary fuel for the first few years of its operation. It is envisaged that natural gas may then be used from Ghana's Jubilee Oil fields, which are currently under development. However the natural gas option is not considered within the scope of this ESMP.

3.2.3 The site proposed for the Project consists of land of approximately 62.55 acres in an area designated for industrial development. The Volta River Authority (VRA) current operate the existing Takoradi T1, T2 and T3 Power Plants (VRA Takoradi Power Plants) with a combined generating capacity of approximately 800 MW, to the east of the site, and there are currently plans to develop additional generating capacity 190 MW (T4). A number of IPPs have also been allocated land nearby for new development: 360 MW Jacobsen project, 400MW Globeleq project, and 1000MW One Energy project (also referred to as the GE Ghana 1000 project). A description of these prospective projects can be found in the ESIA.

3.2.4 The land proposed for the site presently consists mainly of undeveloped farmland with scattered vegetation and gradually increasing site elevation in a northward direction. This land is (or is bordered by) marshy, wet ground conditions across a wide area with small streams feeding towards the Anankwari River, to the west of the site. The wet ground conditions in the general area are expected to be in part due to the silted mouth of the Anankwari River which prevents downstream flow to the sea during wet seasonal periods.

3.2.5 The site is located approximately 2 km west of the town of Aboadze, in western Ghana. The site location is shown in Figure 3.1 and 3.2.

Figure 3.1 - Project Site Location (outlined in red)

Figure 3.2 - Site Location

3.3 Project Infrastructure

3.3.1 The 62.55 acre plot allocated for the Project will include the power plant, pressure reducing and metering station, switchyard, and roads; however it is expected that the plant will occupy only part of the land available, as portions of the site will be reserved for the potential future expansion of the Project (i.e. through the addition of another CCGT unit of a similar capacity) and dedicated mangrove development.

3.3.2 The site is arranged such that there are logical boundaries between the key elements of the proposed plant:

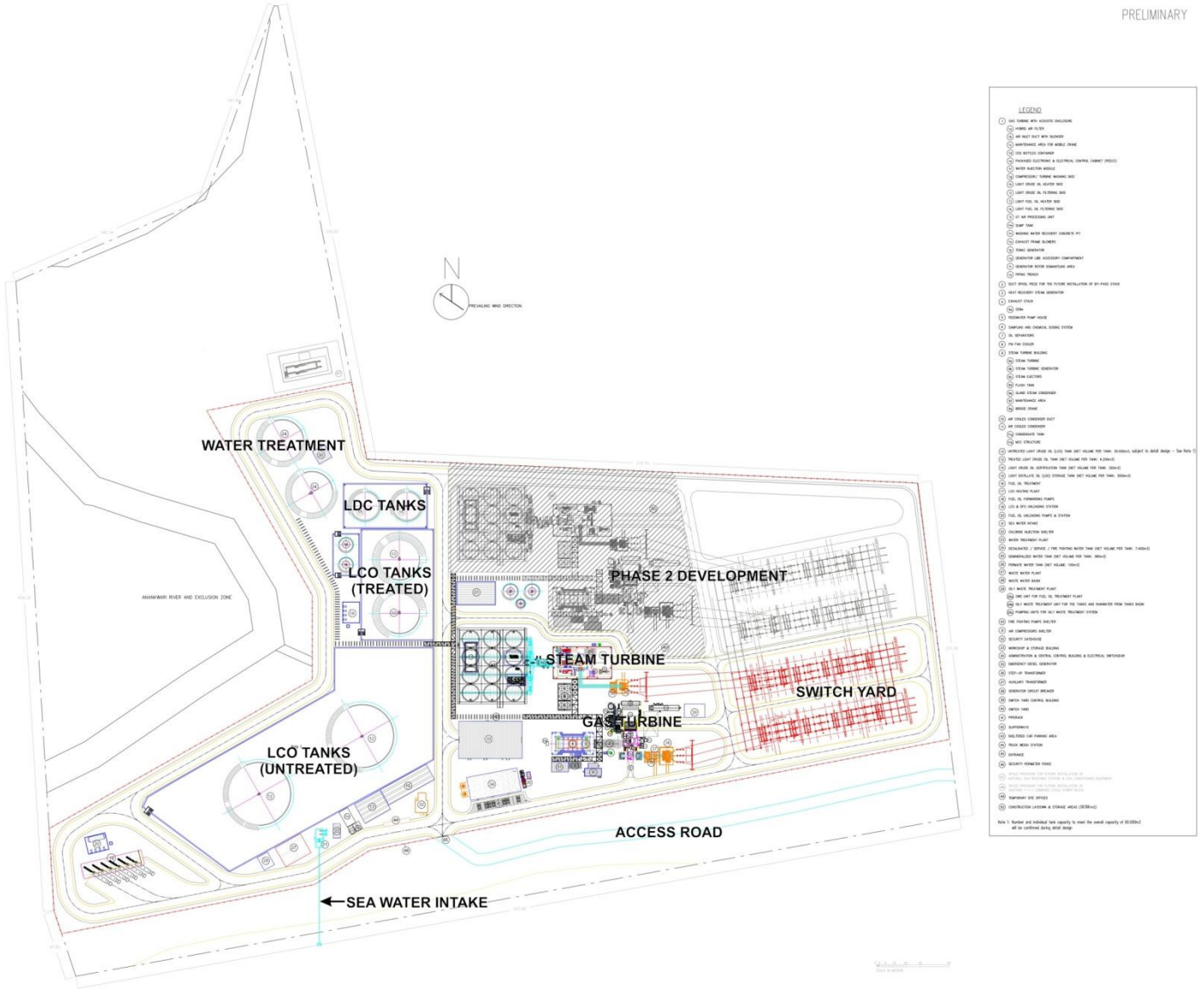
a Storage / treatment of fuel;

b Power generation; and

c Export of electricity.

3.3.3 The location of these elements reflects the existing landscape and topography with regards to the connection to the existing substation. The indicative arrangement shown in Figure 3.3 has been selected in order to minimise the required high voltage (HV) cable route distance to the existing Ghana Grid Company Limited (GRIDCo) 330 kV substation.

Figure 3.3 - Amandi Energy Indicative CCGT Layout



3.3.4 A security fence will be constructed around the site and the site will be fitted with closed circuit television. A new access road will provide access to the site via the southern boundary.

3.3.5 The site layout has considered existing physical and topographical constraints. As required by the Ghanaian EPA, the site layout will not include development within 20 m of the Anankwari River. In addition, the existing drainage system will be diverted to enable development of the Project without adversely affecting the existing drainage provisions of the VRA Takoradi Power Plants.

3.3.6 The Project site is situated in a wetland area which has the potential to become flooded. However to mitigate this, the plant has been designed to raise the ground level of the site by approximately 4m to ensure that all plant items are above the high tide level.

3.3.7 During construction, prior to the level of the land being raised sufficiently to be above the flood level, there will be a period of time when construction staff will be required to work within this area which is potentially liable to flooding. In order to address this risk, flood mitigation should be considered as part of the emergency procedures of the CESMP. It should cover identifying a process for forecasting the potential risk of flooding and allocation appropriate evacuation routes / procedures etc.

3.3.8 Given that the nature of flooding in the area is likely to be a result of tidal inundation, the raising of the ground level will not result in displacement of water to other potentially sensitive areas.

Ancillary Development

3.3.9 The Project will see the construction of four key elements which extend outside of the main site boundary and are considered as development ancillary but necessary to its successful implementation:

a LCO supply pipeline;

b Raw water intake / effluent discharge pipework;

c Site access road; and

d High voltage overhead connection to the existing VRA Takoradi substation.

3.3.10 The LCO pipeline, intake/effluent discharge pipeline and access road will be developed by AEL and are considered part of the Project. The overhead transmission line will be built, owned and operated by GRIDCo.

LCO Supply

3.3.11 LCO is currently delivered by ship tanker to the existing VRA Takoradi Power Plants via a single point mooring (SPM) located approximately 4.5 km offshore. The SPM is owned by VRA.

3.3.12 AEL has agreed with VRA that LCO deliveries for the Project will be unloaded at the SPM and forwarded to the site via a new dedicated LCO pipeline. The pipeline will be approximately 1.7 km in length. The pipeline will be routed along the southern border of the existing VRA Takoradi Power Plants and then continue alongside the access road to the site.

3.3.13 AEL has obtained the necessary permits and rights of way to run the pipeline through the land between the site and the SPM.

Water Abstraction / Discharge Infrastructure

3.3.14 All water required for the Project will be obtained from the Atlantic Ocean via a buried / submerged pipeline (of approximately 500 mm diameter) that will extend to a distance of approximately 1.2 km offshore. A sea water pumphouse (with appropriately sized pumps) on the shore will be constructed to transfer water from the submerged intake to the site. Screens will be installed to prevent the ingress of fish and other aquatic biota.

3.3.15 Discharge will take place in the Atlantic Ocean; the discharge pipeline is anticipated to be of a similar construction to the intake pipeline and will extend approximately 600 m offshore. The discharge infrastructure may include diffusers to accelerate the mixing of the combined Project effluent with the receiving sea water.

Site Access Road

3.3.16 An access road currently exists from the highway to the VRA Takoradi Power Plants, which will be extended by 2 km to provide access to the south of the Project site. The road will be utilised for permanent access as well as for the movement of vehicles during construction and will be constructed of material suitable for the intended use of the movement of large construction vehicles.

3.3.17 The access road route will run to the north of the beach to the south of the site.

Overhead Transmission Line

3.3.18 Export of electricity from the power plant will be via two sets of new overhead lines, totalling approximately 1.3 km in length. This will be achieved by diversion of the existing 330 kV lines coming from Tema in the East via the new AEL switchyard, requiring a 600 m set of new lines and then connecting into the existing 330 kV VRA Takoradi substation to the north east of the proposed HV switchyard, requiring a 700 m set of new lines. The line will be constructed and owned by GRIDCo.

3.4 Landowners and Land Use

3.4.1 The site has been leased, by AEL, from the Royal Family of Aboadze. An arrangement was settled once AEL had presented the Project to the landowners and all other relevant stakeholders; the directly Project Affected People (PAPs) include the owners of crops at the site and owners of unused infrastructure found within the site (as shown in Figure 3.4). During this engagement the stakeholders had the opportunity to ask questions and also clarify what the implications of the land lease would be.

3.4.2 As part of the lease AEL engaged the Land Valuation Division of the Ghana Lands Commission (Sekondi Office) in order to determine the compensation to be paid for the crops and the identified infrastructure within the site, including a salt pan and an abandoned building foundation. The PAPs are members of the Royal Family and as such are legally entitled to benefit from the lease of the land for the Project. A *"Valuation of Crops & Others for Compensation Payment"* report has been prepared by the same Land Valuation Division and AEL, to ensure that the PAPs were compensated properly.

3.4.3 Consultations held with these PAPs determined that they did not rely on these crops as their main source of livelihood, but were used as additional sources of income – as such any economic displacement has been avoided. The valuations determined that the crop patches were past their optimal conditions and had been extended to beyond their optimum productive lifetime. Further to this, the crop patches were not being tended to or managed on a regular basis and much of the production of the crops occurred in wild conditions.

3.4.4 The land lease was agreed on a voluntary basis as have the compensation values calculated and discussed in the "*Valuation of Crops & Others for Compensation Payment*" by the PAPs. Values were calculated at market value, with the view of ensuring that the PAPs could replace lost assets with assets of similar value and be better off overall.

3.4.5 In regards to access of the local population to the sea, the Project will not bear any impacts in regards to access. Nonetheless, consideration should be given to the fact that the beach front stretch is a restricted area by the Ghanaian Navy as a security measure to protect the West Africa Gas Pipeline and the VRA Takoradi Power Plants. As such there is very limited movements and activity from the public in this stretch of beach, even though occasionally, some members of the public have been spotted in the beach.

Resettlement

3.4.6 There are no settlements within the proposed Project site therefore it is anticipated that there will be no physical displacement as a result of the Project. It should be noted that neighbouring proposed projects are undertaking resettlement to IFC standards as part of project development. Further information in regards to this resettlement has been provided in Section 9 of the ESIA.

Figure 3.4 - Location of Assets belonging to Compensation Beneficiaries

3.5 Construction Schedule

3.5.1 Table 3.1 below provides a high-level outline of the construction schedule for the, construction of the Project. This programme will be refined throughout the detailed Project design and dependant on the selected EPC contractor.

Table 3.1 – Construction Schedule

Mechanical and electrical plant	**Steam turbine manufacture**	**July 2015 – December 2016**
	HRSG manufacture	October 2015 - October 2016
	Gas turbine manufacture	October 2015 – January 2017
	Steam turbine installation	February 2016 – August 2016
	HRSG installation	October 2016 - May 2017
	Gas turbine plant installation	March 2017 – August 2017
	Steam turbine commissioning	August 2017 – December 2017
	HRSG commissioning	August 2017 – December 2017
	Gas turbine plant commissioning	August 2017 – December 2017
	Power plant commercial operation	January 2018
Ancillary Development	LOC Pipeline	January 2016 – July 2017
	Intake Water Pipeline	December 2015 – February 2017
	Discharge Water Pipeline	December 2015 – February 2017
	Access Road	February 2016
	Overhead Transmission Line	**To be constructed by GRIDCo**

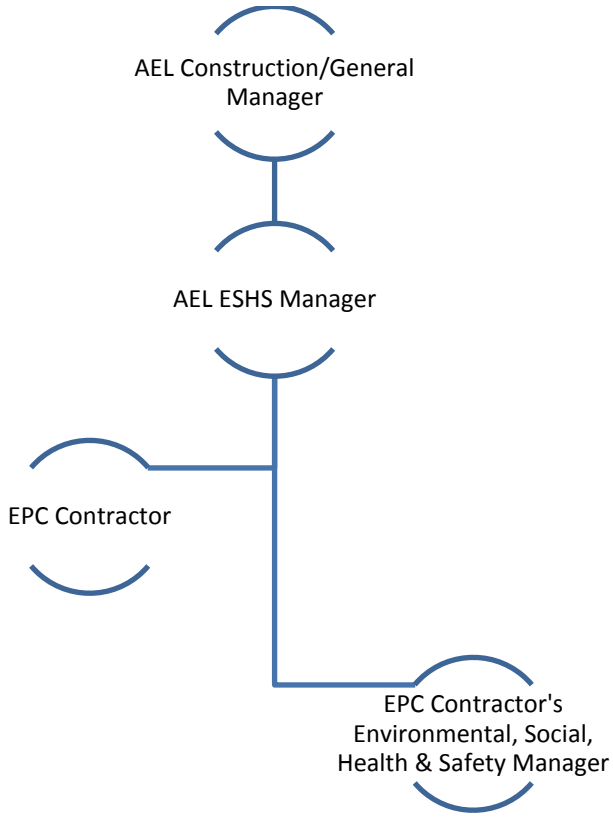
4 ORGANISATION

4.1.1 This section identifies the proposed arrangements for the organisational management of all ESHS impacts associated with the design, construction and operation phases of the Project.

4.2 Construction Phase Responsibilities

ESHS Management Structure

4.2.2 An Organisational Chart of the proposed AEL Project team, with respect to ESHS management has been provided below:



4.2.3 *Roles and Responsibilities*

4.2.4 **AEL Construction/General Manager** – will have overall responsibility for all ESHS matters. He/she will have overall responsibility for definition and implementation of the company's environmental policy and ensuring availability of trained and capable staff to manage, perform and verify work affecting the environment.

4.2.5 **AEL ESHS Manager** - shall be constituted to have oversight of the implementation of this ESMP and day-to-day running of the ESMS. He/she will oversee site construction activities as well as monitor specific ESHS criteria, and compliance of the EPC contractor with requirements for the construction phase. The AEL ESHS Manager will also be required to focus on environmental and social aspects not only during construction phase, but throughout the lifetime of the project.

4.2.6 The AEL ESHS Manager will be responsible for the preparation of all ESHS reporting requirements of the Project, including those of the Project Lenders and Environmental Permit granted by the EPA.

4.2.7 Specific responsibilities shall include:

- Monitor the EPC contractor's compliance with Health and Safety Rules, and Guidelines provided in the Factories, Offices and Shops Act, 1970 (Act 328) during construction phases of the Project.
- Monitor the environmental performance of the EPC contractor with regard to implementation of environmental mitigation measures during the construction and commissioning phases of the Project.
- Monitor the EPC contractor's compliance with conditions of the Environmental Permit, granted by EPA, as well as ensuring compliance with any other statutory environmental regulatory requirements during the construction phase.
- Review and recommendation of all Project ESHS reports including EPC Contractor's monthly progress reports and their CESMPs during construction.
- Analyse combustion turbine emissions data for SO_2, NO_x, CO and particulates (PM_{10}) during commissioning phase to ensure that emissions guarantees are met during performance testing.
- Liaise with the designated laboratory to ensure the analysis of LCO samples for gas turbine operations.
- Make budgetary provision for Project environmental and social programmes.
- Increase Project staff awareness of environmental and social issues through training programmes.
- Organise activities to motivate and maintain the interest of Project staff in environmental and social issues.
- Arrange for ESHS audits in accordance with Project monitoring guidelines.
- Serve as liaison between EPC contractor, AEL and relevant regulatory agencies to ensure full compliance with all legal and regulatory requirements.
- Oversee the community grievance mechanism.
- Prepare Project ESHS reports.
- Develop a work plan for the implementation of the ESMP.
- Develop the ESMS whilst in construction and for operations.

4.2.8 **Contractor's Project Manager** – Will agree and follow the indications set out in this ESMP and develop their own CESMP. He/she will follow requirements set by the AEL ESHS Manager and the AEL Construction/General Manager. The contractor's Project Manager will ensure that everyone within his team are familiarised with the requirements set out in this ESMP, and hence their CESMP, and are adequately trained in health and safety, as well as environment and social awareness as required.

4.2.9 **Contractor's EHSH Manager** – will work closely with the contractor's Project Manager, advising on the performance of the contractor's compliance with the requirements set in this ESMP. The contractor's EHSH Manager will be there to ensure that all of the contractor's working on the development adhere to the

requirements set as agreed with the AEL ESHS Manager and AEL Construction/General Manager.

4.2.10 **External ESHS consultants** – links have been made with various reputable ESHS consultants who can be called upon to support the AEL ESHS Manager as required. ESC and Envaserv are the local environmental consultants for the Project. They have undertaken a number of environmental and social baseline studies in the area, as well as also having participated in stakeholder engagement and consultation. They may be called upon to assist the AEL EHSH Manager with defined tasks, as required.

4.3 Operations Phase Responsibilities

4.3.1 Identification of the parties responsible for ESHS management and monitoring during the operational phase of the Project will be confirmed during the construction phase, with those responsible identified in advance of the operational phase. At this stage it is envisaged that the number of ESHS personnel will be scaled back. For example the EPC contractor would have completed their works and hence there will a reduction in overall workforce and construction impacts.

4.3.2 Whilst it is recognised that the operation phase should pose a reduced risk in terms of the scope and severity of ESHS issues, it remains important that these are effectively managed and the impact minimised during operation. A detailed operational phase ESMP will be developed prior to the transition to operation.

4.4 Budget and Resources

4.4.1 An estimate of capital costs needed to implement the proposed Environmental and Social Action Plan (ESAP), in Section 8, are .summarised below. Costs for some of these resources are to be determined as the Project progresses further. AEL is working to obtain them, once obtained the ESAP will be updated accordingly.

Table 4.1 - Approximate Costs for Implementation of the ESAP

	Recommended action(s) to address impacts[3]	Responsible	Capital cost
	Develop a ESHS Monitoring Plan	AEL	TBC
Air Quality	Ensure measures taken to control atmospheric dust emissions	EPC Contractor.	USD 4,500 (period of EPC contract)
	Provide all sand and burrow materials being transported to site with sheeting cover		USD 3,500 (period of EPC contract)
	Cover all stockpiles of top soil to prevent wind blow up		USD 3,000 (period of EPC contract)
	Spraying of access road with water		TBC
	Provide speed mitigating procedures e.g. construct speed ramps to control dust emission		USD 500 (period of EPC contract)

[3] Note, these are suggested action items as AEL endeavours to not prescribe to the contractor exactly the actions they need to take. The contractor or actioning party will take the responsibility for addressing the impact, and AEL will leave some room for flexibility in a way they can mitigate the impact.

	Control smoke and other pollution from vehicle exhausts by undertaking compulsory periodic maintenance of all Project vehicles		USD 1,000 (period of EPC contract)
	Design construction phase monitoring program		TBC
	Set up monitoring sites for ambient monitoring, Project site boundary, off site monitoring and meteorological data collection for parameters: PM10, NOx and SO2.		TBC
	Purchase and install ambient air ground level concentrations monitoring equipment and undertake staff training of how to be used.		USD 100,000. Training costs: TBD
Noise	Apply noise limits specified in this ESMP (IFC EHS Guidelines and Ghanaian EPA standards).	EPC Contractor	USD 500 (period of contract)
	Provide PPE to deal with increase in noise levels during construction.		TBC
	Ensure construction activities are carried out during the designated working hours and days		N/A
	Enhance noise monitoring procedures and actions in the event of a non-compliance		USD 5,000 (period of contract).
	Carryout training to staff in regards to noise monitoring and impacts. Undertake monitoring at specified locations as shown in the ESIA.		USD 7,000 – USD 14,000 per visit
	Construct an acoustic screening wall on the site to run south from the southernmost edge of the Air Cooled Condensers (ACC) for a length of 35m. The acoustic screen would need to be a minimum height of 6m and be continuous with no gaps or breaks. It should be formed from either; close boarded timber fencing with a minimum surface mass of or concrete block construction..		TBC TBC
Water Resources and quality	Implementation of best practice construction methods stipulated in this ESMP and those to be implemented in CESMP. Including storm water management.	EPC Contractor	USD 800 (period of contract)
	Provide storm drains which connect to the Anankwari River and eventually to the sea. Ensure these are kept free of obstructions.		Storm drains part of inherent design.
	In case of oil or chemical spillage, all water from storm drains shall be treated to meet the local Ghanaian EPA standards and those set by the IFC EHS		TBC
	Monitoring of wastewater quality. Establish monitoring regime (define sampling locations, monitoring parameters and frequency of measurements). Procure waste water sampling and measurement instrumentation		TBC

Socio-economics	Develop a Stakeholder Engagement Plan (SEP) and community grievance mechanism.	AEL	TBC
	Develop a Code of Conduct	AEL	TBC
	An Employment and Human Resource Management Plan, in compliance with this ESMP and specifies favouring local communities will be developed.	EPC Contractor	TBC
	Retrenchment plan for employee job loses (if applicable)		TBC
	Adequate compensation provided.	A compensation valuation report has been carried out and agreed with the PAPs. They have now been paid.	Part of best practice - Compensation was calculated at market value to a total of 39,932 GHC (11,360 USD).
	Monitor local traffic accidents and health statistics for change in traffic related accidents.	EPC Contractor	USD 30,000 (period of contract).
	Ensure that vehicles transporting construction materials are not overloaded.		N/A
	Display appropriate speed limits visible in the site and implement other speed retardation procedures.		TBC
	Proper maintenance of the vehicles.		USD 15,000 (period of contract)
	Ensure local populations access routes are not blocked		N/A
	Construction programme to be designed to allow appropriate religious rituals to be undertaken.	AEL	TBC
	Provision of worker accommodation on site if deemed necessary and implementation of a worker grievance mechanism	EPC Contractor	TBC
	Induction training, including cultural awareness training		TBC
	Health education and awareness programmes		TBC
Soil and Geology	PPE	EPC Contractor	USD 15,000 and USD 1,000 recurrent costs/year
	Best practice construction methods		N/A
Waste	Testing, separation and remediation or disposal of contaminated waste at suitable sites according to Ghanaian EPA specifications and IFC EHS.	EPC Contractor	USD 10,000
	Seek opportunities to provide local communities with any waste materials which may have other uses.		TBC

	Contractor to develop Waste Management Plan.		
	Waste taken to suitable disposal site in sealed tankers if necessary.		TBC
	Fuelling of construction vehicles shall be done in designated areas with impermeable surfaces located away from drains or watercourses.		N/A
	Drip trays and spill kits shall be immediately available.		TBC
	Fuel hoses, valves and coupling points / joints shall be regularly checked for leakages and wear and tear.		TBC
Ecology	Standard best practice guidelines to reduce dust movements	EPC Contractor	N/A
	Working hours restrictions to minimise disturbance.		N/A
	Provision of sanitation and welfare facilities for workforce to minimise localised pollution		TBC
	Avoid culverting which would minimise biodiversity of the stream, increase fragmentation and create maintenance issues.		TBC
	Create an open channel and involve geomorphologists in design to minimise maintenance requirements and increase biodiversity and ecosystem service value.		TBC
	Minimise working area and avoid/ create buffer around sensitive areas.		TBC
	The extent will be limited to the construction footprint with other areas		N/A
	Vegetation will be cleared in a phased manner towards retained vegetation.		TBC
	Establish on site compensation habitat to produce net gain in habitat (formalise in a Biodiversity and Conservation Management Plan). There will be a lag of ~ 5years to establishment resulting in a temporary loss of mangrove and ecosystem services. International Biodiversity Offsetting principals will be applied to take account and offset the time lag.	AEL	TBC
	Form buffers around key sensitive areas such as the Anankwari Stream. Ecological supervision will ensure species are not killed or injured during construction and species where necessary will be moved to safety.	AEL & EPC Contractor	TBC

	All staff will be given a Tool Box Talks on the importance of biodiversity and given advice on finding species.	AEL	TBC
	Through best practice minimise light spill/ noise and vibrations off site.	EPC Contractor	TBC
	Construction should avoid overwintering periods and be carried out in the off migration periods. Restoration of habitats will ensure habitat on the long term for birds.	EPC Contractor	TBC

5 ENVIRONMENTAL SPECIFICATIONS

5.1.1 The Ghanaian and international standards outlined in Chapter 2 will be applied.

5.1.2 During the construction, the EPC contractor will be responsible for meeting the requirements set out by these standards, as well as complying with mitigation and monitoring requirements established in the ESIA and expanded upon in this ESMP.

5.1.3 When host country regulations differ from the levels and measures presented in the World Bank/ IFC EHS Guidelines, projects are expected to achieve whichever is more stringent. As such, the most stringent have been applied for this development.

5.2 Air Quality Specification

5.2.1 The Standards set by the Ghanaian EPA are generally in agreement with IFC EHS guidelines – these have been listed below. The plant will operate on LCO and diesel fuel oil (DFO). Table 5.1 below summarises the requirements of the IFC with regards to stack emissions for combustion of these fuels.

Table 5.1 - Emission Guidelines (in mg/Nm3) or as indicated for Combustion Turbines

Combustion Technology/Fuel	Particulate Matter (PM)		Sulphur Dioxide (SO_2)		Nitrogen Oxides (NOx)	Dry Gas, Excess O_2 Content (%)
Fuels other than Natural Gas (Unit >50MW)	50	30	Use of 1% or less S fuel	Use of 0.5% or less S fuel	152 (74 ppm)	15%

5.2.2 Table 5.2, Table 5.3, Table 5.4 and Table 5.5 provide an overview of the ambient air quality standards/limits for various pollutants considered in the air dispersion modelling study. The World Health Organization (WHO) guidelines are referenced by the IFC EHS guidelines.

Table 5.2 - Assessment Criteria for NO_2

Averaging period (all values in µg/m^3)	Ghanaian EPA Residential areas (industrial areas)	WHO
19th highest hourly maximum	-	-
Maximum one hour	200 (400)	200
Maximum 24-hour	60 (150)	-
Annual average	-	40

Table 5.3 - Assessment Criteria for SO_2

Averaging period (all values in µg/m^3)	Ghanaian EPA Residential areas (industrial areas)	WHO
Maximum 10 minute	-	500
25th highest hourly maximum	-	-

Maximum one hour	700 (900)	-
4th highest 24-hour	-	-
Maximum 24-hour	150 (100)	125
Annual average	50 (80)	50

Table 5.4 - Assessment Criteria for CO

Averaging period (all values in µg/m^3)	Ghanaian EPA Residential areas (industrial areas)	WHO
15 min	100,000	100,000
30 min	60,000	60,000
One hour	30,000	30,000
Running 8-hour average	10,000	10,000

Table 5.5 - Assessment Criteria for PM_{10}

Averaging period (all values in µg/m^3)	Ghanaian EPA Residential areas (industrial areas)	WHO
24-hour	70	50
24 hours (7th Highest)	-	-
Annual limit	-	20

5.3 Aqueous Emissions Specification

5.3.1 The AEL plant will use Air Cooled Condensers (ACC) as a cooling mechanism. As such there will not be a major outfall of aqueous emissions to surface waters or the sea. Additionally, an advantage of ACCs is that no evaporation of water takes place, thereby significantly reducing water consumption requirements. This will avoid seawater being used for cooling purposes and as such avoid large effluents being discharged back to the sea.

5.3.2 Nevertheless, even with ACCs, there will still be aqueous emissions from the plant which will consist of the following:

- Boiler blowdown;
- Water treatment plant effluent; and
- Miscellaneous minor process effluents.

5.3.3 The aqueous emissions shall be discharged to a sewer connection/waste water outfall and treated.

5.3.4 It is expected that there will be surface water run-off from the site that will need to be channelled to oil separators/interceptors, in some cases prior to disposal to an onsite sewer connection/waste water outfall.

5.3.5 The Ghanaian EPA and the IFC EHS guidelines (1.3 Wastewater and Ambient Water Quality) for effluent discharge limits have been provided below in Table 5.6:

Table 5.6 - Ghanaian and IFC EHS values for aqueous emissions

Parameter	Ghanaian EPA Limits	IFC EHS Limits
pH	6 – 9	6 – 9
BOD5 (mg/l)	50	50
Total nitrogen		10
Oil & Grease (mg/l)	5	10
Total Suspended Solids (mg/l)	50	50
Total Phosphorous (mg/l)	2.0	2
Temperature increase by thermal discharge from cooling system	< 3^{o}C above ambient temperatures at the edge of the mixing zone	Site specific requirements to be established by the ESIA. Elevated temperature areas due to discharge of once-through cooling water (e.g., 1^{o}C above, 2^{o}C above, 3^{o}C above ambient water temperature) should be minimised by adjusting intake and outfall design through the project specific ESIA depending on the sensitive aquatic ecosystems around the discharge point.
Colour (TCU)	200	-
COD (mg/l)	250	125
Sulphide (mg/l)	1.5	-
Turbity (NTU)	75	-
Lead (mg/l)	0.1	0.5
Arsenic (mg/l)	-	0.5
Cadmium (mg/l)	-	0.1
Nitrate (mg/l)	50	-
Total residual chlorine (mg/l)		0.2
Chromium (total) (mg/l)	-	0.5
Copper (mg/l)	-	0.5
Iron (mg/l)	-	1.0
Zinc (mg/l)	-	1.0
Mercury (mg/l)	-	0.005

5.4 Discharges to Land and Ground Contamination Specification

5.4.1 Solid wastes generated on site will include domestic and commercial waste (paper, etc.), miscellaneous waste produced during maintenance (including air filters), sludge removed from oil separators and any deposits removed from the heat recovery steam generator (HRSG) during maintenance. In addition, operation of the demineralisation plant will generate a waste stream of used ion exchange resin (or reverse osmosis membrane, depending on the technology used), typically every 5 to 10 years.

5.4.2 Where possible, any waste soils at the site generated during the installation of the plant equipment would likely be re-used on site. Where this is not possible (e.g. because of contamination or because they are geotechnically unsuitable) they would be disposed of by an appropriate contractor, approved by the Ghanaian EPA.

5.4.3 All non-hazardous solid wastes will be disposed of appropriately at the Shama District Assembly's designated landfill.

5.5 Noise Specification

5.5.1 ISO 1996-2:2007 '*Description and Measurement of Environmental Noise*' defines and prescribes best practice during recording and reporting of environmental noise. This standard should be applied in all instances when undertaking environmental noise measurements. These have been applied as part of the noise assessments undertaken as part of the ESIA.

5.5.2 The Ghanaian Environmental Protection Agency - Ambient Noise Level Guidelines (ANLG) set out noise limits based on the sensitivity of the receptor and its location, such as residential, educational, healthcare, light industrial areas and heavy industrial areas. However, the ANLG does not specifically set out noise limits relating to construction activities. As such, the assessment carried out in the ESIA uses the guidance of British Standard (BS) 5228:2009 '*Noise and vibration control on construction and open sites*' to assess noise from the construction phase.

5.5.3 BS 5228:2009 gives recommendations for basic methods of noise and vibration control relating to construction sites and other open sites where construction activities are carried out. It offers a methodology to predict noise levels from construction sites, and methods for assessing its impact on those exposed to it. BS 5228 is an industry approved code of practice.

5.5.4 A noise modelling study involving monitoring background noise at nearby sensitive receptors and the plant boundary to establish the baseline noise conditions in the area has been carried out using the mentioned standards.

5.5.5 Table 5.7 sets out the construction noise significance threshold taken from the method in BS 5228 for day, night, and evening and weekend periods for the construction phase of the project.

Table 5.7 - Construction Noise Significance Threshold (dB)

Period	BS 5228 Threshold Level ($LA_{eq,T}$) *
Night-time	45
Evening & Weekends	55
Daytime	65

** Averaging periods, T: Night-time 23:00 – 07:00; Daytime (07.00−19.00) and Saturdays (07.00−13.00); and Evenings & Weekends 19.00 – 23.00 weekdays*

5.5.6 Ghanaian and IFC EHS ambient noise level standards are shown in Table 5.8. The Ghanaian EPA has specified that the Project complies with the heavy industrial areas limit of 70 dB(A) during daytime and night-time for the operational phase of the project.

Table 5.8 - Permissible Noise level in dB (A)

	Ghanaian Noise level guidelines		IFC EHS Noise level guidelines	
Description of Area of Noise Reception	Daytime (06:00 – 22:00)	Nighttime (22:00 – 06:00)	Daytime (07:00 – 22:00)	Nighttime (22:00 – 07:00)
Residential areas with negligible or infrequent transportation	55	48	55	45
Educational (school) and health (hospital) facilities	55	50		
Area with some commercial or light industry	60	55	70	70
Area with some light industry, place of entertainment or public assembly and place of worship such as churches and mosques	65	60		
Predominately commercial areas	75	65		
Light industrial areas	70	60		
Predominately heavy industrial areas	70	70		

5.6 Ecology Specification

5.6.1 The importance of habitats is evaluated on the basis of their size, recognised status (e.g. International Union for the Conservation of Nature - (IUCN) Red List of Threatened species (IUCN, 2014) and legal protection status (e.g. the Ghana Wildlife Conservation Regulation 1971 (LI 685)). Their ecosystem service value has also been taken into consideration in the ecological assessment carried out as part of the ESIA.

5.6.2 The importance of species populations is based on their size, recognised status (IUCN Red List) and legal protection status. Assessment of the conservation status focused on the various IUCN threat categories whereas protection status focused on Schedule I of the Wildlife Conservation Regulation. All animal species listed under Schedule I of the Wildlife Conservation Regulation 1971, LI 685, are Wholly Protected in Ghana from any form of hunting and capture. Bird populations, for example, exceeding 1% of published bio geographic populations are considered to be of international importance; those exceeding 1% of published national populations are considered to be of national importance, and so forth. In some instances it is the species assemblage that is of importance.

5.6.3 IFC PS 6, OPIC and EIB standards have also been referenced to inform the ESIA and this ESMP.

5.7 Cultural Heritage Specification

5.7.1 Cultural Heritage has been considered during the development of social impacts chapter of the ESIA, in line with IFC Performance Standard 8: Cultural Heritage.

5.8 Socio-Economics Specification

5.8.1 Socio-economic impacts have been studied as part of the ESIA and free prior informed consultations have been carried out. A SEP has also been developed following IFC PS requirements. This SEP will be continually updated throughout the

development of the Project and enhanced. IFC PS1: Assessment and Management of Environmental and Social Risks and Impacts; PS 5: Land Acquisition and Involuntary Resettlement; as well as PS 7: Indigenous Peoples informed the socioeconomic assessments carried out as part of the ESIA. These will continue to inform any monitoring carried out in relation to socioeconomics as the Project progresses.

5.9 Traffic Specification

5.9.1 Details of the routes to be used for the construction and operational phase, as well as the impacts expected due to traffic have been presented in the ESIA, within the socio-economics section. IFC PS1: Assessment and Management of Environmental and Social Risks and Impacts; along with PS 4: Community Health, Safety, and Security have been used to inform this section of the ESIA.

6 OVERVIEW OF PROJECT PHASES

6.1 Planning and Design Phase

6.1.1 The planning and design phases of the Project are not expected to have any direct negative impacts on the environment and consequently no management control measures are required and/or proposed.

6.1.2 AEL has considered various layout options and designs in order to maximise the Projects efficiency and technical viability, whilst aiming to minimise negative environmental impacts.

6.1.3 AEL will approve the CESMP ahead of construction in line with the Owner's ESHS Requirements, as per final version in the respective contract (draft version appended to this ESMP).

6.2 Construction Phase

6.2.1 The construction phase has the potential to generate negative impacts.

6.2.2 Construction related activities associated with the Project include:

- Surveying;
- Clearance of vegetation from the portion of site required for construction;
- Topsoil removal and appropriate storage;
- Setting up of laydown areas;
- Storage of construction materials and equipment in laydown areas;
- Excavations for foundations;
- Excavation of trenches for pipelines,
- Sourcing, temporary storage of fill materials and rehabilitation of borrow pits;
- Identification of sites for spoil material disposal and associated landscaping or screening;
- Cement mixing and pouring (for foundations);
- Site levelling, grading and erection of security fencing;
- Construction of buildings and other facilities;
- Grading of internal roads and construction of new access roads;
- Installation of electrical infrastructure;
- Erection of generators;
- Operation of construction plant and equipment;
- Drainage and water supply works;
- Post-construction rehabilitation;
- Wildlife habitat mitigation offsetting.

Contractor Mobilisation/De-mobilisation Compliance Auditing

6.2.3 Parsons Brinckerhoff is working with AEL to identify the most effective methods to ensure contractors are fully aware of site sensitivities and any rehabilitation process and standards as required.

Incidents

6.2.4 The contractor will identify and define the most suitable emergency preparedness and response plan; AEL will then need to approve on this as part of their approval of the CESMP. This plan will describe how incidents will be recorded and investigated as well as reported in order to reduce future probability of the incidents occurring again.

6.3 Operation and Maintenance Phase

6.3.1 Once the plant becomes operational, the nature and significance of the environmental and social risks and impacts changes so that different mitigation, remedy and monitoring activities are anticipated for:

- Air quality;
- Noise;
- Water quality;
- Waste management/monitoring;
- Ecological monitoring;
- Public consultations/updates (on a regular basis);
- Grievances (under the grievance mechanism put in place for all stakeholders, including plant workers); and
- Socio-economics (including traffic monitoring).

6.3.2 Information in regards to environmental and social impacts and monitoring during this phase of the development have been discussed in the ESIA and in the ESAP (Section 8 of this ESMP).

6.4 Closure and Decommissioning Phase

6.4.1 The plant is anticipated to have an operational life span of in excess of 20 years. No detailed specific closure/decommissioning phase actions or monitoring are currently proposed. It is however recommended that AEL will develop a preliminary closure and rehabilitation plan after approximately 15 years of operation (to ensure adequate financial planning for dismantling the facility), then prepare a definitive plan at least 18 months prior to the anticipated cessation of activities.

7 MANAGEMENT PLANS

7.1 Introduction

7.1.1 The section provides a summary of the management plans identified for the mitigation of Project impacts. AEL has drafted this ESMP for the Project. AEL will hire an EPC contractor to undertake the construction works, consequently it will be the responsibility of that contractor to manage ESHS aspects on the ground (with oversight from AEL). This ESMP sets the framework for how the works are to be undertaken and the EPC contractor must ensure that its CESMP complies fully with this document (as per the Owner's ESHS Requirements, see Appendix A of this ESMP).

7.1.2 As discussed previously, the EPC contractor will be responsible for all ESHS matters during construction however it is acknowledged that there are particular aspects which would be more appropriately lead by AEL. These aspects include stakeholder engagement and environmental conservation. Consequently AEL will draft specific management plans to address these two components:

7.2 Contractor's Environmental and Social Management Plan

7.2.1 A contractor's ESMP, also known as a CESMP, for the management of construction related impacts will be prepared and made a contractual requirement for all relevant construction contractors prior to construction and implemented for the period of the construction phase.

7.2.2 The CESMP will be based on the management measures/specifications mentioned and set out in Section 5 and cover the following aspects[4] (as relevant to the contractor's scope of work):

1. Accommodation for any temporary construction camps;
2. Access management;
3. Vegetation clearing;
4. Erosion and sediment control;
5. Quarries and borrow pits management;
6. Oil Spill management;
7. Spoil management;
8. Waste management;
9. Chemical management and storage;
10. Fuel management;
11. Water management;
12. Wildlife and biodiversity management;
13. Noise mitigation/management;
14. Emission and dust control;
15. Fire prevention;

[4] Abbreviated extract from Owner's ESHS Requirements of the EPC Contract (see Appendix A).

16. Traffic management;
17. Equipment and materials lay-down;
18. Site restoration, landscaping and re-vegetation;
19. Occupational health and safety;
20. Employment and human resource management;
21. Emergency preparedness and response;
22. Physical cultural resources;
23. Training for employees;
24. Community interaction;
25. Fencing & Security.

7.3 Components of the CESMP

7.3.1 The components to be considered in the CESMP are discussed in further detail:

1) Accommodation for any temporary construction camps or facilities

7.3.2 There are currently no plans to construct temporary housing for workers on the Project site for the duration of the contraction period. The workers will be sourced from the local area or workers moving to the area will find accommodation locally and commute to the site. If however any temporary accommodation is required, then they shall be designed, installed and operated to an internationally recognised standard[5]. This includes offices, ventilation, potable water, eating, toilets, laundry, waste and general storage receptacles and washing facilities.

7.3.3 Currently it is anticipated that some migrant workers will stay throughout the construction period in local accommodation in the nearby town of Takoradi. AEL is also inquiring with the owner of a number of nearby townhouses west of the site, to assess the suitability of the accommodation for senior AEL staff.

7.3.4 If temporary camps are created they will be designed and operated by the contractor in accordance with the requirements set by IFC PS2 and the relevant guidelines within the guidance document *Workers' Accommodation: Processes and Standards: A Guidance Note by IFC.* These principles include:

- Fundamental human rights of the workers and freedom of association in particular the need for respect. Accommodation for the workers should not restrict their rights and freedoms.
- Minimum space per worker with need to be considered, to ensure appropriate space is provided for each. A safe water supply for the workers dwellings, along with sewage facilities and garbage disposal systems will be needed. Appropriate protection from the elements, against heat, cold, dampness, noise, fire, diseases, animals and in particular, insects.
- Adequate ventilation will be required given the high temperatures in the area, such as air conditioning. Both natural and artificial lighting must be provided and maintained in living facilities.

[5] i.e. IFC/EBRD: Workers' accommodation: processes and standards.

- Separate beds should be made available for all workers, with the minimum space between them being of at least 1m. Double deck bunks are not advisable for fire safety.
- Canteen facilities, cooking and laundry facilities should be made available and kept clean. These facilities should be made separate from the sleeping quarters.
- Management plans, such as health and safety, security plans should be put into place for the accommodation facilities.
- A security plan should be implemented to avoid any thefts, attacks, etc. Security staff must be checked to ensure that they have not been implicated in previous crimes and/or abuses.
- Process and grievance mechanisms for workers' to articulate their grievances mush be in accordance with PS2.
- Community representatives must be provided with an easy means to express their opinions and to lodge complaints to the management. There must be a transparent and efficient process for dealing with community grievances in accordance with PS1.
- In order to avoid any potential impacts in relation to workers camps, AEL and the contractors will ensure that:
- A grievance mechanism is developed and implemented to provide a transparent and easily accessible way of raising issues.
- If relevant, an audit design and implementation of worker's camps against the checklist in the IFC guidance document would be carried out: (i) Prior to construction of accommodation; (ii) Prior to its opening; and (iii) On a monthly basis.

2) Access management

7.3.5 Information in regards to a perimeter embankment around the site which will be created to control access will have to be incorporated in the CESMP.

7.3.6 The contractor is to erect temporary barriers to constrain plant and visitors to prescribed corridors in order to reduce impacts on persons and visitors not associated with construction. Further details of this shall be provided.

3) Vegetation clearing

7.3.7 The CESMP shall cover information in regards to the site clearing, collecting, and disposing of all standing vegetation or organic debris that is present on the undeveloped Facility Site, and fencing, contractor's offices, workshops and laydown areas, construction access roads, temporary drainage provisions etc. Topsoil will be removed and stockpiled for finished grading and site restoration.

7.3.8 The contractor shall perform all site grading. This shall include excavating, backfilling, filling, and compacting of soils as required. Soils unsuitable for subgrades shall be removed and replaced with suitable backfill material. The removed soils may be used for general site fill, if appropriate.

4) Erosion and sediment control

7.3.9 The contractor shall ensure that all exposed surfaces of earthworks whether temporary or permanent are fully protected from erosion and deterioration due to climatic conditions.

7.3.10 Exposed surfaces of earthworks shall not be allowed to cause a dust nuisance. During construction, surfaces shall be watered to prevent nuisance from dust.

7.3.11 Within the main site, exposed areas of earthworks shall be sealed at the close of each day of construction.

7.3.12 The contractor's site layout shall indicate how the various areas of the plant site shall be protected and finished. This will include areas to receive hard paving, granular site surfacing and soft and hard landscaping. The contractor's site layout for site surface finishes shall be submitted to AEL for review and approval prior to commencing construction on site.

7.3.13 All materials and workmanship shall be in accordance with the highest appropriate standards and procedures.

7.3.14 All areas of roads or hardstanding that could be subjected to a fuel, oil or chemical spillage shall be constructed in concrete.

7.3.15 All the areas within the limit of the plant road system that are not covered by asphalt, concrete, grass or structures shall be covered by 150 mm (6 inch) of aggregate surfacing.

7.3.16 All paving areas shall be asphalt unless noted otherwise.

7.3.17 On completion of the works, all site areas, including laydown and construction areas shall be cleared of all debris, graded and laid to an approved level and left in a completely tidy condition to meet the approval of AEL.

5) Quarries and borrow pits management

7.3.18 Information in regards to the management of borrow areas/pits shall be presented in the CESMP.

7.3.19 Borrow pits shall be graded and re-vegetated to prevent long-term erosion. Top soil shall be spread out and seeded as required.

6) Oil spill management

7.3.20 An oil spill response and management plan (OSRMP) will be developed in accordance with the EPA National Oil Spill Contingency Plan (NOSCP) guidance documents and published information.

7.3.21 The OSRMP will take into consideration the oil spill response plans of the adjacent VRA Takoradi power generation units/plants and other prospective development (as and when relevant) in order to account for any additional volumes of oil that will be stored and transported through the pipeline and identify any new/increased risks associated with the changes.

7.3.22 Training for the response and management of oil spills will be delivered to relevant staff members at the site. Suitable equipment will be provided to effectively respond and manage oil spills of varying scales.

7.3.23 OSRMP should include:

- The names and responsibilities of the spill response coordinator and team members;
- The procedures for notifying the oil spill coordinator and relevant team members;
- The procedures for notifying off-site agencies and organisation of spills and coordinating the response of these groups with onsite personnel;
- An inventory and site map of all spill response equipment and materials;
- The general procedures to be followed for responding to oil spills of various sizes in different locations under different scenarios;
- Record keeping and reporting requirements;
- Decontamination procedures of personnel and equipment;
- Method to identify the quantity, area coverage, direction of travel and state of the oil spill, with reference to potential for combustion; and
- Reporting procedure to National Reporting Centre (where the national oil spill reporting centre is situated).

7.3.24 Depending on the nature and scale of the oil spill, the National Oil Spill Reporting centre may then allocate further resources to assist in the further containment/management/clean-up of the oil spill.

7.3.25 These resources could include but are not limited to the following organisations:

- Fire brigade and Police services
- Navy/ Army
- Non-governmental organisations (NGOs)
- Game and wildlife service
- Maritime safety authorities
- Specialist regional/international organisations.

7.3.26 Every effort has been made to mitigate the potential impact from oil spill events through the design process.

7) Spoil management

7.3.27 The CESMP will ensure spoil wastes generated during construction of the Project are effectively managed in accordance with a waste management.

7.3.28 All staff are to be trained in effective waste handling and management procedures outlined in the ESIA and this ESMP.

7.3.29 The contractor will ensure compliance with the waste requirements of the Shama District Assembly. A company with the capacity to spoil waste will need to be contracted for this work.

8) Waste management

7.3.30 The contractor will ensure solid and liquid wastes generated during construction of the project are effectively managed in accordance with a waste management plan.

7.3.31 All staff are to be trained in effective waste handling and management procedures.

7.3.32 Contractor to ensure compliance with the waste water management requirements of the Shama District Assembly. The contractor will have to identify and contract a company with the capacity to handle hazardous waste.

7.3.33 All oily wastes generated on site from equipment and machinery shall be collected in appropriate containment, stored under a shed in a bunded area (if required). Contractor will be responsible in ensuring that waste oil stored is sold to EPA certified waste oil dealers.

7.3.34 During operation, the contractor will ensure cleaner production operations during test runs and operational phase by improving programmes aimed at possible reuse, recycling and preventative measures to reduce waste and pollution.

7.3.35 Details of this will have to be added to the CESMP.

9) Chemical management and storage

7.3.36 The CESMP shall discuss the facility design which shall take into account any special requirements concerning the nature, handling and storage of all fuels, oils, gases and chemicals. Plant, equipment, buildings, structures and other services shall be provided to ensure the safety and security of all plant and personnel. Hazardous areas shall be classified to the IEC or NEC criteria and the necessary certified equipment provided. In particular, the NFPA 850 recommendations shall be implemented to ensure fire safety.

7.3.37 A uniform system of locks and keys shall be provided. All relevant equipment shall have locking capability. For the purpose of safe operation and maintenance, all valves and electrical switchgear shall be provided with suitable and adequate locking devices.

7.3.38 The contractor shall provide material safety data sheets (MSDSs) and other documented details of items of materials, including consumables that could be potentially hazardous, along with all necessary provision for containing and reducing the hazard during an emergency.

10) Fuel management

7.3.39 The contractor shall provide all gasoline, diesel, or other fuels required for its plant and equipment for the work. On-site storage of large quantities of fuel shall be in an area remote from permanent or temporary structures. Storage, dispensing, and spill containment methods shall meet all applicable legal requirements.

11) Water management

7.3.40 The contractor shall make reference to furnishing and maintaining all equipment, connections, piping and devices needed for its water supply system.

7.3.41 The contractor shall obtain construction water in reasonable quantities to meet construction requirements. The contractor shall provide its own pumping and supply equipment.

7.3.42 The contractor shall provide its own water stations (coolers) and shall furnish ice for drinking water as required.

7.3.43 Fresh water for hydrostatic tests, flushing, and start-up activities shall be provided by the Contractor and be acceptable to AEL.

12) Wildlife and biodiversity management

7.3.44 The contractor shall make reference to the protective measures to be implemented to avoid impacting the wildlife and biodiversity within the site. The CESMP will have to commit to the requirements made in the ESIA and this ESMP and refer to training to be given to staff in regards to wildlife and biodiversity management.

13) Noise management

7.3.45 The contractor shall make reference to compliance with EPA permissible noise levels for industrial areas. Ensuring that noise levels do not exceed 70dB (A) during the day i.e. 06:000hrs-22:00hrs and at night between 22:00hrs-06:00hrs. Low noise piling techniques are to be used during construction.

7.3.46 Maintain transportation vehicles and machinery in good working order in order to minimize noise emissions.

7.3.47 The contractor will ensure that the CESMP complies with existing Shama District Assembly's by-laws on noise.

14) Emission and dust control

7.3.48 The contractor shall ensure effective control and management of construction air emissions (dust, exhaust emission) in accordance with the national air quality guidelines are included in the CESMP.

7.3.49 Reference to dust suppression measures carried out by dousing should be included along with the need to maintain transportation vehicles and machinery in good working order in order to minimize gaseous emissions.

15) Fire prevention

7.3.50 The contractor shall be responsible for the development of a fire prevention and protection programme for all work at the site, including construction camp/laydown facilities (as relevant), training of personnel in fire safety and firefighting and providing adequate firefighting equipment. Training shall be provided for all contractor's personnel.

7.3.51 The programme shall comply with the applicable provisions for safety and protection set forth in applicable parts of the National Fire Protection Association Bulletin No. 241, Building Construction Operations.

7.3.52 The contractor shall take precautionary measures to prevent fires, especially from welding operations, and shall provide adequate approved blankets to prevent welding sparks from starting fires or damaging equipment.

7.3.53 The contractor shall carefully supervise its operations and housekeeping to prevent fires.

7.3.54 Storage of flammable materials such as paint, solvents, chemicals, cleaning fluids, etc, shall be in a separate building dedicated for this purpose. The building shall be equipped with proper fire extinguishers and arranged / located in accordance with the applicable code.

7.3.55 When construction fires occur, all fire fighting equipment provided shall be used effectively to control and extinguish the fire regardless of the cause and all personnel at the Facility Site shall be directed to assist in fighting the fires.

7.3.56 Permanent fire water yard hydrants shall be installed early for use during the construction period in fighting fires. It should be noted that no fuel supply or back energisation of the plant will be allowed until after the complete fire system is fully commissioned and tested. The contractor shall provide temporary fire hose, hose connections, nozzles, appurtenances and any other equipment required for fire fighting. Sufficient hose shall be supplied for obtaining fire water at any area of contractor's work, and shall be in a state of readiness at all times. The contractor shall allow AEL's personnel full access to the construction area in case of fire and for routine fire safety inspections.

7.3.57 Dry, chemical type fire extinguishers shall be provided throughout the station and in contractor's buildings. The number, location, installation, inspection and maintenance of this equipment shall be in compliance with applicable legal requirements, safety and fire protection codes and requirements, and shall be acceptable to AEL.

16) Traffic management

7.3.58 In regards to traffic management, the CESMP shall refer to the following:

- Contractor's will try to avoid congestion and will avoid parking on access roads in the project area.

- Contractor's trucks and vehicles carrying equipment and materials during the construction phase should display appropriate safety signs.

- Contractor's will provide legible and adequate directional and wining signage to regulate truck movements.

- Contractor's will ensure only the appropriate entries and exits are used by their vehicles in order to avoid risking public safety.

- Delivery of materials to the Project site will be carried out in such a manner that the arrival of trucks and other delivery vehicles do not cause traffic conflicts in the area.

- Contractors shall obey any traffic wardens/security hired by AEL to operate in the site. Further to this, speed limits will be respected by contractor's.

17) Equipment and materials lay-down

7.3.59 Reference to the need of having an appropriate equipment and materials lay-down area will be made. This location will have to be clearly marked and all staff working on

site will be aware of its location and use it accordingly. Safety considerations when working in this area will be set and followed by all staff.

18) Site restoration, landscaping and re-vegetation

7.3.60 Site's disturbed by the construction works will be restored and remediated as necessary. Re-vegetation will take place topsoil removed from the site for construction works and non-invasive species will be planted. Details of these works will be presented in the CESMP.

7.3.61 The contractor shall prepare in conjunction with AEL, a landscaping plan for the facility and surrounding areas.

19) Occupational health and safety

7.3.62 The CESMP shall include the following in regards to occupational health and safety:

7.3.63 The contractor will provide health and safety training to all employees:

- Health and safety training on the use of chemical and hazardous materials (including oil);
- Provision of the appropriate Personal Protective Equipment (PPE);
- Traffic management plan and driver training;
- Accident prevention monitoring;
- Training in the use of all equipment;
- Safeguards of environmental pollution of water resources;
- Safeguards in hazardous materials handling and transportation;
- First Aid access and communications; and
- Emergency Response Procedures.

7.3.64 In addition, health education with regard to communicable diseases will be undertaken as part of the induction training for workforce members. This will include health education on STIs as well as diseases such as malaria.

7.3.65 The level of influx is anticipated to be high, and an increase in the wealth in the area may also lead to an increase in STIs through prostitution. As such, provision will be made for education awareness of communicable diseases within the wider community. If possible, this will be undertaken in collaboration with NGOs relevant to health and care, and the District Council.

20) Employment and human resource management

7.3.66 The Contactor will ensure policy and procedural consistency with international standards related to workers' rights. This includes the following key principles:

- Observing statutory requirements relating to minimum age for employment of children (13 and 15) and meeting international standards of not employing any persons under the age of 16 for general work and no persons under the age of 18 for work involving hazardous activity.

- Ensuring acceptable conditions of work including by observing national statutory requirements related to minimum wages and hours of work.
- Meeting international standards related to paying all wages, including bonuses and premium pay for overtime work, to all employees in a timely fashion and in a manner consistent with *International Labour Organisation (ILO) Convention 95: Protection of Wages – Access to Archives*.
- There should be clearly benchmarked payment schedules in the contractors' contracts.
- Having contractors commit that they will not take any action to prevent employees from exercising their right of association and their right to organise and bargain collectively.
- Ensuring no workers are charged fees to gain employment on the Project.
- Ensuring rigorous standards for occupational health and safety are in place.
- Having contractors base employment decisions on principles of non-discrimination and equal opportunity, in particular fair and equal pay, especially for women carrying out the same work as men.
- Having contractors establish a labour grievance mechanism and documenting its use for complaints about unfair treatment or unsafe living or working conditions without reprisal. Access to labour grievance mechanisms needs to stress its relevance for both genders.

7.3.67 The contractor should take special note of the AEL's zero tolerance for: child, forced or trafficked labour; discrimination; and any action that may detrimentally affect the freedom of association or the right to organise of the personnel of the Contractor/subcontractor.

7.3.68 As emphasised above, these commitments will be passed on to Contractors and Sub-contractors via main and subcontract clauses, and requirements to address them in management systems and work procedures.

7.3.69 The contractor will prepare an employment and human resource management plan, aimed at maximising employment opportunities for local communities and to manage expectations and the potential for influx into the area during the construction. The plan will take into account vulnerable groups such as women and Project PAPs.

7.3.70 The Plan will include for job training and capacity building prior to and during the construction and operation activities. The Plan will also include procedural guidelines and a code of conduct concerning employment and workforce in order to encourage appropriate work ethics and behaviour; this will be particularly important should employment opportunities be realised by individuals outside of the Project area.

7.3.71 Finally, this Plan will include an on-going communication strategy to clearly and consistently disclose information regarding employment opportunities and contracting procedures, with the idea of managing expectations of job opportunities, and therefore influx of workers. Key messages may include the number of positions available, the timeframe for employment availability, and an explanation of the contracting process.

21) Emergency preparedness and response

7.3.72 An emergency preparedness and response plan shall be put in place and described in the CESMP, this shall cover all types of operations on the site and provide

indications on what to do in case of an emergency. Training and workshops will be given to all staff by the EHSH manager in charge. Such operating instructions shall cover local / remote and manual modes of operation and shall also include action on receipt of alarms.

7.3.73 Details of infrastructure and means to egress in case of an emergency will also be discussed, as will the emergency response in the event of, flooding.

22) Physical cultural resources

7.3.74 Contractors are to include chance find management within their method statements, with provisions for notifying AEL of any discoveries.

23) Training for employees

7.3.75 Contractors shall provide induction training for personnel, covering aspects such as health, safety and environmental and cultural awareness.

7.3.76 A basic environmental and social training programme, recommended for Project management staff and key personnel of the contractor assigned to the Project, will cover the following:

- Basic environmental and social terminology and definitions;
- Environmental and social laws, regulations and compliance;
- Ghana EIA procedures (including familiarisation with provisions of Environmental Assessment Regulations, 1999 (LI 1652)); and
- Environmental and social clauses in construction contracts (including Lenders' expectations).

24) Community interaction

7.3.77 The contractor shall participate in the AEL's community grievance mechanism, which will allow the affected communities to express concerns about the conduct of personnel and other ESHS issues. Participation of the contractor in relation to consultations with the local community will also be referenced in the CESMP.

7.3.78 Road safety training and education should be offered in local schools and community centres.

7.3.79 Requirements for community engagement will be made in the CESMP in accordance with the standards set in this ESMP and ESAP.

25) Fencing & Security

7.3.80 Storage and construction areas used for the project shall be enclosed by a security fence provided by the contractor. The existence and maintenance of this fence places no liability on the Owner for protection of the contractor's tools, materials, equipment and property under control of the contractor.

7.3.81 As construction progresses, additional fences and gates shall be erected to separate complete units from those still under construction as necessary.

7.3.82 Controlled access gates shall be provided to control movement of delivery, construction, and personnel vehicles in and out of the Site.

7.3.83 The contractor shall prepare and submit to the AEL, for review and acceptance, a detailed site security plan, as part of the CESMP. The plan shall address the contractor's overall responsibilities for security services. It shall cover the requirements for all work areas, including, but not limited to, storage areas and facilities throughout the construction, operation and maintenance period.

7.3.84 The contractor shall provide security services as stipulated herein to enforce the restrictions imposed by AEL for vehicular and personnel passage through controlled gates.

7.3.85 All personnel employed at the Project shall undergo security orientation and be notified of the security requirements.

7.3.86 The Site Security Plan shall include, but not be limited to, the following:

a Details of the security organisation.

b Procedure and report forms, including visitor's log.

c Distribution and enforcement plan for use of numbered, tamperproof identification cards issued by both AEL/ designated contractor. These cards shall be in each person's possession at all times on the site.

d Vehicular parking and personnel access to the work areas.

e Equipment and materials delivery and storage.

f Description of disciplinary action.

7.3.87 Security notices, signs and announcements shall be posted in highly visible areas throughout the site.

7.3.88 The site security plan shall ensure compliance with all Ghanaian legal requirements and international standards including IFC PS 4 and the Voluntary Principles on Security and Human Rights.

7.4 AEL's Management Plans

7.4.1 As discussed previously, in addition to this ESMP, AEL is developing a SEP and Biodiversity and Conservation Management Plan (BCMP) in order to support the contractor's efforts with respect to these social and environmental aspects respectively. Further to these, a Project Code of Conduct will also be prepared for the Project's labour force. These three are discussed briefly in this section.

Project Code of Conduct

7.4.2 A Code of Conduct for the labour force will be implemented for all phases of the Project. This will recognise the provision of resources by the employer and will share responsibilities among the workers for the use of equipment, procedures and training. It aims to contribute to a harmonious relationship with local communities, to reduce behaviours that could lead to social conflict, and to prevent further environmental degradation.

7.4.3 Typical issues to be addressed would include:

- Proper use of PPE and other work equipment that has been provided;
- Personal health that takes into consideration messages about sexual health HIV/AIDs STI;
- Restrictions related to consumption of alcohol and drugs;
- Respect for the local community and its cultural norms in which labourers are working; and
- Professional behaviour and integrity when dealing with the public.

Stakeholder Engagement Plan

7.4.4 In order to effectively manage community expectations and disseminate information, a Project SEP is being developed; this will be implemented and revised regularly. The SEP addresses the whole Project and not just the requirements of the ESIA to ensure that a coordinated approach to communication and engagement is undertaken.

7.4.5 Principles that have been taken into account in the SEP include:

- Provision of clear and accurate information regarding the Project in culturally appropriate formats, to facilitate an accurate and realistic understanding of potential impacts and benefits generated by the Project.
- Involvement of community representatives and residents in ongoing consultation and engagement in order to communicate Project information in a timely and transparent manner.
- Inclusion of vulnerable people and their representatives in community development and stakeholder engagement initiatives to ensure equal representation of affected people. Sensitive approach to engagement so as not to offend local cultural structures.
- Showing equal respect to traditional community authorities and local government representatives in all stakeholder engagement activities, negotiations and community development initiatives.

7.4.6 A culturally appropriate and accessible Grievance Mechanism for the Project is set out in the SEP, with the aim of ensuring that PAPs and the local community are able to present their requests, concerns and observations directly to the Project without fear of recourse and free of any cost.

Biodiversity and Conservation Management Plan

7.4.7 A BCMP will be carried out in order to ensure that the off-site compensation habitat for the affected mangrove habitats is done appropriately. This BCMP will also consider species affected by the Project. There is expected to be a lag of approximately five years for the habitat to be established. International biodiversity offsetting principles have been applied to take account and offset the time lag.

7.5 Mitigation & Monitoring Framework

Monitoring and Reporting

7.5.2 As part of this ESMP, monitoring requirements and reporting processes need to be implemented. This will be carried out throughout the construction and operation phase

of the Project. The frequency and format of this reporting (monthly report, etc.) that will be carried out have been described in this section.

7.5.3 The following statutory environmental reports shall be prepared and submitted to the Ghana EPA at times indicated in the Environmental Permit:

i Annual Environmental Report

ii Environmental Management Plan

iii Environmental Certificate

iv Decommissioning and Site Closure Plan.

7.5.4 The ESIA identified a number of positive and negative impacts; it assumed that measures would be put in place to mitigate negative effects and enhance positive effects. The ESAP in Chapter 8 sets out a log of the actions required to ensure that these measures are undertaken. It links each action with an objective, based on the topics in the ESIA, so each impact can be traced between the two documents. The ESAP sets out the actions required throughout the different phases of the project and assigns responsibility for each action.

7.5.5 The management plans in the previous sections, and actions mentioned below, will also require measures to monitor their achievements and the requirement for periodic performance reviews of their effectiveness.

7.5.6 Monitoring will normally include recording information to track performance and comparing this against established benchmarks or requirements contained within the various plans or actions. It is proposed that the indicators to measure the overall success of the Project will be developed in agreement with stakeholders as appropriate.

7.5.7 Stakeholders will be able to an extent, be actively involved in the monitoring and be able to provide “early warning” flags to the management team, and to encourage involvement in the Project. Any issues identified will be documented, and the necessary corrective and preventive actions identified. Measures will also be put in place to ensure that these corrective and preventive actions have been implemented. It is also recommended that the commercial farm should keep appropriate records which should be available to the relevant stakeholders.

7.5.8 An outline Monitoring Plan will be further developed by AEL in parallel to the development of the various other plans.

8 PROJECT ENVIRONMENTAL AND SOCIAL ACTION PLAN

8.1.1 Proposed ESHS actions for the design, construction and operation of the Project are set out in Tables 8.1 - 8.3.

8.1.2 As stated earlier, these are suggested action items as AEL endeavours to not prescribe to the contractor exactly the actions they need to take. The contractor or actioning party will take the responsibility for addressing the impact, and some flexibility will remain in how they mitigate the impact, subject to AEL's final approval.

Table 8.8.1 - Design Phase ESAP

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Time frame/due date	Applicable PS	Comments/further action and monitoring
Pre-construction general environmental management	Would represent a non-compliance. Project would not be approved for development.	Consult local authorities and meet requirements	AEL and Environmental Consultants	Project Planning/ESIA stage/throughout project development	IFC PS 1	Has been carried out and is on-going throughout project development. Financed with a front end pre engineering budget.
	Would represent a non-compliance/risk project opposition from local communities/potential impacts would remain unknown	Consultations with communities	AEL and Environmental Consultants	Project Planning/ESIA stage/throughout project development	IFC PS1, PS5 and PS7	Has been carried out and is on-going throughout project development. Financed with a front end pre engineering budget.
	Would represent a non-compliance. Project impacts would remain unknown.	Prepare an ESIA in compliance with international standards	AEL and Environmental Consultants	Project Planning/ESIA stage	IFC PS 1 -8	Has been prepared. Financed with a front end pre engineering budget.
	Would represent a non-compliance	Prepare ESMP	AEL and Environmental Consultants	Project Planning/ESIA stage	IFC PS 1	Has been prepared. Financed with a front end pre engineering budget.
	Would represent a non-compliance	Define qualification, experience and functions of prospective AEL ESHS Manager	AEL and Environmental Consultants	Project Planning/ESIA stage	IFC PS 1	To be completed following financial close

Table 8.2 - Construction Phase ESAP

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Time frame/due date	Applicable PS	Comments/further action and monitoring
Air Quality	Detriment of air quality Public health	Ensure measures taken to control atmospheric dust emissions Provide all sand and burrow materials being transported to site with sheeting cover Cover all stockpiles of top soil to prevent wind blow up Spraying of access road with water Implement speed retardation methods e.g. construct speed ramps to control dust emission Control smoke and other pollution from vehicle exhausts by undertaking compulsory periodic maintenance of all project vehicles	EPC Contractor	Start of construction activities and during operation	PS1, PS2, PS3	To be financed by EPC Contractor
	Detriment of air quality Public health	Design construction phase monitoring program. Set up monitoring sites for ambient monitoring, Project site boundary, off site monitoring and meteorological data collection for parameters: PM_{10}, NO_x and SO_2.	EPC Contractor	Prior to start of construction activities and during operation; to be approved by AEL	PS1, PS2, PS3	To be financed by EPC Contactor
	Detriment of air quality	Purchase and install ambient air ground	EPC Contractor	Prior to start of construction activities	PS1, PS2, PS3	To be financed by EPC Contractor

	Public health	level concentrations monitoring equipment and undertake staff training of how to be used.		and during operation		
Noise	Increase in ambient noise resulting in public and fauna's health impacts	Apply noise limits specified in this ESMP (IFC EHS Guidelines and Ghanaian EPA standards). Provide PPE to deal with increase in noise levels during construction. Ensure construction activities are carried out during the designated working hours and days. Enhance noise monitoring procedures and actions in the event of a non-compliance. Carry out training to staff in regards to noise monitoring and impacts. Undertake monitoring at specified locations as shown in the ESIA.	EPC Contractor	Prior to start of construction activities and implementation during construction.	PS1, PS2, PS3, PS4 and PS6	To be financed by EPC Contractor
	Impact of increase in noise levels at NSR 10[6] receptor identified in ESIA.	Construct an acoustic screening wall on the site. The acoustic screen would need to be a minimum height of 6m and be continuous with no gaps or breaks. Acoustic screens should be formed from either; close boarded	EPC Contractor	During construction	PS1, PS3, PS4	To be financed by EPC Contractor

[6] NSR 10 is a small development of residential town houses to the west of River Anankwari

		timber fencing with a minimum surface mass of or concrete block construction. The acoustic screen will run south from the southernmost edge of the ACC's for a length of 35m.				
Water Resources and quality	Pollution of watercourse Interference with water supply to riparian communities	Implementation of best practice construction methods stipulated in this ESMP and those to be implemented in CESMP. Including storm water management. Provide storm drains which connect to the Anankwari River and eventually to the sea. Ensure these are kept free of obstructions. In case an oil or chemical spillage, all water from storm drains shall be treated to meet the local Ghanaian EPA standards and those set by the IFC EHS. Monitoring of wastewater quality. Establish monitoring regime (define sampling locations, monitoring parameters and frequency of measurements). Procure waste water sampling and measurement instrumentation	EPC Contractor	Plans to be carried out prior to construction and applied during	PS1, PS3 and PS4	To be financed by EPC Contractor

Socio-economics	Increase in employment during the construction period	An Employment and Human Resource Management Plan, in compliance with this ESMP and specifies favouring local communities will be developed.	EPC Contractor	Plans to be carried out prior to construction and applied during	PS2	-
	Decrease in employment following reduction in workers ahead of operations	Retrenchment plan for employee job loses (if applicable)	EPC Contractor	Plans to be carried out prior to ahead of commissioning	PS2	-
	Economic displacement due to loss of land where site will be located and where ancillary infrastructure will be built during the construction period	Adequate compensation provided.	AEL and local consultants	Prior to start of construction.	PS1 and PS5	A compensation valuation report has been carried out. Compensation was calculated at market value to a total of 39,932 GHC (11,360 USD), agreed with the PAPs and paid.
	Traffic related health impacts	Monitor local traffic accidents and health statistics for change in traffic related accidents. Ensure that vehicles transporting construction materials are not overloaded. Displays of appropriate speed limits will be made visible in the site. Speed ramps will also be built. Proper maintenance of the vehicles will be required.	EPC Contractor	Prior to start of construction. Implementation during the construction phase.	PS2 and PS4	To be financed by EPC Contractor
	Growth of local economy due to influx of migrant workers during the construction period	N/A	AEL	During construction	N/A	-
	Access to land and sea during the	Ensure local populations access	AEL and EPC Contractor	During construction	PS1 and PS4	-

	construction period	routes are not blocked				
	Effects on tourism during the construction period	N/A	-	During construction	N/A	-
	Effects on cultural heritage during the construction period	Construction programme to be designed to allow appropriate religious rituals to be undertaken[7].	AEL	To be developed prior to the construction period and implemented prior to construction commencing.	PS2	To be supported by AEL
	Competition for food supplies leading to an increase in prices during the construction period	-	-	N/A	N/A	-
	Disruption of local communities with an increase in crime and anti-social behaviour during the construction period	Induction training, including cultural awareness training	EPC Contractor (overseen by AEL)	To be developed prior to the construction period and implemented during.	PS2 and PS4	To be financed by EPC Contractor
	Increase in prostitution leading to higher risk of sexually transmitted diseases during the construction period	Health education and awareness programmes	EPC Contractor	To be developed prior to the construction period and implemented during.	PS2 and PS4	To be financed by EPC Contractor
Soil and Geology	Impacts to health arising from oral, inhalation or dermal contact with potential pollutants within the ground	PPE / Best practice construction methods	EPC Contractor	To be implemented during construction phase	PS2 and PS4	To be financed by EPC Contractor
	Loss of geology /soils	N/A	EPC Contractor	N/A	PS1	
	Pollution of groundwater	Best practice construction methods	EPC Contractor	To be developed prior to the construction period and implemented during.	PS1 and PS3	To be financed by EPC Contractor
	Soil compaction / surface flooding / run off of contaminated water	Best practice construction methods	EPC Contractor	To be implemented during construction phase	PS1 and PS3	To be financed by EPC Contractor
Waste	Mobilisation of contamination, particularly hydrocarbons	Testing, separation and remediation or disposal of contaminated waste at suitable sites	EPC Contractor	To be implemented during construction phase	PS3	To be financed by EPC Contractor

[7] Relevant only to the rerouting of the river.

		according to Ghanaian EPA specifications and IFC EHS.				
	Inert waste taken to landfill	Seek opportunities to provide local communities with any waste materials which may have other uses. Contractor to develop Waste Management Plan.	EPC Contractor	To be implemented during construction phase	PS3	To be financed by EPC Contractor
	Risk of hazardous waste entering environment if not properly disposed of.	Waste taken to suitable disposal site in sealed tankers if necessary. Contractor to develop Waste Management Plan.	EPC Contractor	To be implemented during construction phase	PS3	To be financed by EPC Contractor
	Spills of hazardous materials	Fuelling of construction vehicles shall be done in designated areas with impermeable surfaces located away from drains or watercourses. Drip trays and spill kits shall be immediately available. Fuel hoses, valves and coupling points / joints shall be regularly checked for leakages and wear and tear.	EPC Contractor	To be implemented during construction phase	PS3	To be financed by EPC Contractor
Ecology	Clearance works for construction causing loss/ disturbance Potential disturbance during construction from noise, dust vehicle movements and from an increased population (500 people).	Standard best practice guidelines to reduce dust movements. Working hours restrictions to minimise disturbance. Provision of sanitation and welfare facilities for workforce to minimise localised pollution	EPC Contractor	To be implemented during construction phase	PS 1, PS6	To be financed by EPC Contractor
	Potential loss of the mangrove forest (critical natural habitat)	Establish on site compensation habitat to produce net gain in	AEL and EPC Contractor	To be designed ahead of construction phase	PS 6	TBC

	on site resulting in fragmentation. Associated loss of ecosystem services (carbon sink/ flood control/ fish nursery/ fuel supply/ building materials).	habitat. There will be a lag of ~ 5years to establishment resulting in a temporary loss of mangrove and ecosystem services. International Biodiversity Offsetting principals will be applied to take account and offset the time lag.				
	Potential diversion of Anakwari stream	Avoid culverting which would minimise biodiversity of the stream, increase fragmentation and create maintenance issues. Create an open channel and involve geomorphologists in design to minimise maintenance requirements and increase biodiversity and ecosystem service value.	EPC Contractor	To be implemented during construction phase	PS3 and PS6	To be financed by EPC Contractor
	Clearance works for pipeline will cause loss of marine habitats and potentially fragmentation	Minimise working area and avoid/ create buffer around sensitive areas.	EPC Contractor	To be implemented during construction phase	PS1, PS3 and PS6	To be financed by EPC Contractor
	Vegetation clearance for civils works Loss of vegetation as food source (crops)	The extent will be limited to the construction footprint with other areas	EPC Contractor	To be implemented during construction phase	PS3 and PS6	To be financed by EPC Contractor
	Potential killing or injury of small mammals and herpetafauna and displacement from working area due to noise/vibration/dust during construction	Vegetation will be cleared in a phased manner towards retained vegetation. Establish off site compensation area as soon as possible. Form buffers around key sensitive areas such as the Anakwari	AEL & EPC Contractor. Advised by Environmental Consultant	To be implemented during construction phase	PS1, PS6	TBC

		Stream. Ecological supervision will ensure species are not killed or injured during construction and species where necessary will be moved to safety. All staff will be given a Tool Box Talks on the importance of biodiversity and given advice on finding species. Through best practice minimise light spill/ noise and vibrations off site.				
	Temporary loss of natural habitat and food sources for avifauna due to vegetation clearance. Reoccurring disturbance due to noise/vehicle movements and dust	Construction should avoid overwintering periods and be carried out in the off migration periods. Restoration of habitats will ensure habitat on the long term for birds.	EPC Contractor	To be implemented during construction phase	PS3 and PS6	To be financed by EPC Contractor
	Loss of flora and fauna with killing and injury	Minimise footprint of pipeline.	Environmental Consultancy/Ecologists and EPC Contractor	To be implemented during construction phase	PS3 and PS6	TBC

Table 8.3 - Operation Phase ESAP

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Timeframe/due date	Applicable PS	Comments/further action and monitoring
Air Quality	Detriment of air quality Public health	Atmospheric pollution from emissions. Continuous emissions monitoring system for monitoring stack emissions to ensure compliance with World Bank Group EHS and Ghana EPA Guidelines.	O&M Contractor (Installed by EPC Contractor)	To be implemented during operation.	PS3	O&M Budget.
		NOx emissions control. Combustors to be fitted with low NOx control technology to minimise NOx emissions.	EPC Contractor	To be implemented during operation.	PS3	O&M Budget.
		Employ appropriate emissions control practices to ensure ambient air quality can be achieved.	O&M Contractor	To be implemented during operation.	PS3	O&M Budget
		Model cumulative impact of stack emissions. Carry out modelling of atmospheric emissions to establish additional levels of existing emissions to air shed pollution levels.	Environmental Consultant	Carried out during project planning/ESIA phase. Updates will be required during the operation phase.	PS1 and PS3	Front end pre-engineering budget.
		Design operations phase air quality monitoring program in accordance with recommendations from this ESMP.	Environmental Consultant	Prior to operations	PS3	O&M Budget
		Set up monitoring sites for ambient monitoring at the point of maximum plant outfall	Environmental Consultant	To be implemented during operation.	PS3	O&M Budget

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Timeframe/due date	Applicable PS	Comments/further action and monitoring
		as predicted in the Updated ESIA (2015) report for meteorological data collection, PM_{10}, NO_x and SO_2.				
		Purchase and install ambient air ground level concentrations monitoring equipment for PM_{10}, NO_x and SO_2.	Environmental Consultant	To be implemented during operation.	PS3	O&M Budget
		Undertake staff training for air quality monitoring	Environmental Consultant	To be implemented during operation.	PS3	O&M Budget
Noise	Public health	Single-tone sources or equipment to be operated at noise levels 5 dB less than ambient conditions	O&M Contractor	To be implemented during operation.	PS2 and PS3	O&M Budget
		Monitor noise levels indicated areas by ESIA and Ghanaian EPA permit and World Bank EHS Guidelines.	Environmental Consultant			O&M Budget
		All noisy maintenance activity to be carried out only during the daytime shift	PEC/Environmental Consultant	During operation	PS2 and PS3	O&M Budget
		Noise mitigation measures required at the One Energy, Globeleq and Jacobsen sites to ensure existing ambient noise levels at sensitive receptor locations are maintained.	Other IPP's	During construction and/or operation	PS1, PS2, PS3. PS4	-
Water Resources and Quality	Pollution of watercourses Interference with water supply to riparian communities	Operation phase water supply. Ensure operation phase potable water supply does not interfere with supply to	O&M Contractor	During operation	PS3 and PS4	O&M Budget

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Timeframe/due date	Applicable PS	Comments/further action and monitoring
		riparian communities, source water supply from dedicated wells dug during construction phase at the Project site.				
		Storm water management. Provide storm drains of such capacity at site to carry away all rainfall runoff. Connect all storm drains to a site boundary drainage channel which empties into Anankwari Lagoon and eventually to sea. Keep all drainage maintained and cleared of silt and other obstructions as appropriate. In the event of oil or chemical spillage, all water from storm drains shall be treated to meet compliance standards of Ghana EPA and/or IFC standards before discharge into sea.	O&M Contractor	During operation	PS3 and PS4	O&M Budget
		Prevention of water pollution. Ensure measures taken to prevent discharge of plant effluent without prior treatment. Provide containment	O&M Contractor	During operation	PS3 and PS4	O&M Budget

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Timeframe/due date	Applicable PS	Comments/further action and monitoring
		bunds for all untreated plant effluent to prevent contact with environment Supervise all effluent treatment processes to ensure compliance with EPA guidelines and/or IFC standards prior to discharge. Construction of appropriate drains to capture rainfall runoff Direct all site runoff into Anankwari lagoon and sea.				
		Monitoring of plant effluent (waste water) quality. Establish monitoring regime (define sampling locations, monitoring parameters and frequency of measurements). Procure waste water sampling and measurement instrumentation Undertake waste water quality monitoring at regular intervals prior to discharge. Carry out compliance assessment with Ghana EPA guidelines and/or IFC standards.	O&M Contractor and Environmental consultants	During operation	PS3 and PS4	O&M Budget
Socio-economics	Traffic related health impacts	Control of vehicle speed.	O&M Contractor	During operation	P2 and P4	O&M Budget

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Timeframe/due date	Applicable PS	Comments/further action and monitoring
		Display appropriate speed limits along road leading to plant site. Construct speed ramps to check over speeding of plant vehicles.				
		Proper maintenance of site vehicles. Ensure that maintenance is carried out on all plant vehicles according to the maintenance schedule.	O&M Contractor	During operation	P2 and P4	
		Reduction of road traffic. Liaise with Police and Ghanaian relevant authorities to provide regular education to staff on traffic offences and accident prevention.	O&M Contractor	During operation	P2 and P4	O&M Budget
	Employment during the operational period	To include a local recruitment provisions within operational ESMP favouring local communities	O&M Contractor	During construction and operation	P2	O&M Budget
	Growth of local economy due to employment during the operational period	Economic growth for region	AEL	During construction and operation	P2	-
Soils and Geology	Impacts to health arising from oral, inhalation or dermal contact with potential pollutants within the ground	PPE /Best practice construction methods	O&M Contractor	During operation	P2 and P4	O&M Budget
Waste	Chemical/fuel spills	Store hazardous materials in an orderly manner and in safe	O&M Contractor	During operation	P3	O&M Budget

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Timeframe/due date	Applicable PS	Comments/further action and monitoring
		stacks, tiers or piles. Materials shall be stored so as not to obstruct passageways. Where necessary warning signals, lights and barricades shall be provided. Store all oils, cement, cleaning materials, and paint with potential pollution hazards on an impervious base within a bund wall to contain any spillages.				
		Remove leaking or empty oil / chemical drums from the plant site and safely dispose.	O&M Contractor	During operation	P3	O&M Budget
		Contents of all tanks / drums containing chemicals shall be clearly marked.	O&M Contractor	During operation	P3	O&M Budget
		All contents of tanks/drums to be disposed shall be emptied and perforated by competent personnel before final safe disposal.	O&M Contractor	During operation	P3	O&M Budget
		Fuelling of operational vehicles shall be done in designated areas with impermeable surfaces located away	O&M Contractor	During operation	P3	O&M Budget

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Timeframe/due date	Applicable PS	Comments/further action and monitoring
		from drains or watercourses. Drip trays and spill kits shall be immediately available. Fuel hoses, valves and coupling points / joints shall be regularly checked for leakages and wear and tear. Regular oil pipeline and related infrastructure maintenance				
		Discharging of fuels by bulk road vehicles or fuel tankers shall be done in designated areas with impermeable surfaces located away from drains or watercourses.	O&M Contractor	During operation	P3	O&M Budget
		Develop Oil Spill Response and Management Plan and clearly post around the Project site. Provide a suitable range of materials and containment equipment such as sawdust and sand for containing spillages at designated locations on site. Provide regular oil spill response and management training to staff on site.	O&M Contractor	During operation	P3	O&M Budget

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Timeframe/due date	Applicable PS	Comments/further action and monitoring
		All oil spill incidents to be documented in the Oil Spill Reporting Form	O&M Contractor	During operation	P3	O&M Budget
Ecology	Potential degradation of habitats and reduction in species biodiversity due to poor air and water quality from the power station.	Implement best practice guidelines maintaining good water quality standards and minimising air pollution (Specifications chapter of ESMP).	O&M Contractor		PS3 and PS6	
	Reoccurring disturbance of species in the wider area from operational noise and vibration from turbines and maintenance activities.	Turbines will be located away from natural habitats. Noise/vibration supressing devices will be implemented in accordance with best practice guidelines.	O&M Contractor		PS3 and PS6	O&M Budget
	Potential for pollution incident affecting fauna	All hazardous chemicals will be stored in accordance with best practice guidelines. Undertake regular monitoring of the oil pipeline condition to ensure no leaks or vandalism. An incident response plan will be set out in the eventuality of a spill to contain it.	O&M Contractor		PS3 and PS6	O&M Budget
	Potential for marine species/ fish kills by operation of sea water pump inlet	Fit pumps with filters and ensure flow is no more than 2m/s to minimise drawing into the pumps. Undertake regular maintenance of the pump inlets (bi -	O&M Contractor		PS3 and PS6	O&M Budget

ESIA Objective	Potential Impact	Action(s) to address impacts	Responsibility for activity	Timeframe/due date	Applicable PS	Comments/further action and monitoring
		annually) to ensure filters are not damaged.				
	Discharges out to sea from plant affecting marine flora and fauna	Monitor the effluents to ensure that the discharges are within safe parameters.	O&M Contractor		PS3	O&M Budget

APPENDICES

Appendix A

Note these draft requirements are currently under review; once finalised this draft will be replaced.

Owner's Environmental, Social, Health and Safety Requirements – DRAFT SUBJECT TO REVIEW

1. Preamble

This Schedule sets out the Owner's Environmental, Social, Health and Safety (ESHS) Requirements for the Works. Defined terms used in this Schedule shall have the meanings given to them in the Contract. It shall be the responsibility of the Contractor to identify any such conflicts between this Schedule and any other requirements of the Contract and report them to the Owner. The Contractor shall carry out all necessary work, whether of design, construction, safety and environmental management aspects, necessary to mitigate any such conflict.

2. Introduction

The Owner has prepared a Project specific policy statement (Section 3 below) which sets out the guiding principles and standards for ESHS requirements of the Project, these Owner's ESHS Requirements. The Contractor shall carry out the Works such that the performance of the Works and the Works fully satisfy and comply with the Owner's ESHS Requirements. Without prejudice to the foregoing, the Contractor and its subcontractors shall comply with the requirements of these Owner's ESHS Requirements.

3. Owner's Project ESHS Policy Statement

Any construction or other work on the Site, or associated with the Site or construction of the Project must be to international practice, in accordance with the Project's European / US Environmental, Social, Health, and Safety (ESHS) standards listed below. The Owner has adopted the Equator Principles as the general guiding ESHS principles for the Project along with these specific Owner's ESHS Requirements. These Project standards and guiding principles are enshrined in the referenced documents below to ensure that the Project is developed in a manner that is socially responsible and reflects sound environmental management practices. The Contractor shall ensure that its employees and the employees of any subcontractor implement all or any part/component associated with the Project in accordance with the Owner's 2015 Updated Environmental and Social Impact Assessment (the **ESIA**) and the version of the Environmental and Social Management Plan (the **ESMP**) as valid at the signing of the Contract and as related to the EPC scope of works and the guiding principles detailed in the documents listed below.

(a) Equator Principles (June 2013);

(b) International Finance Corporation's (IFC) Policy and Performance Standards on Social and Environmental Sustainability (January 2012);

(c) Overseas Private Investment Corporation's (OPIC) Environmental and Social Policy Statement (October 2010);

(d) IFC's Environmental, Health and Safety Guidelines for Thermal Power Plants (December 2008);

(e) World Bank Group's Environmental Health & Safety General Guidelines (April 2007);

(f) the Conventions and Recommendations of the International Labour Organization in force at the moment the contract is signed;

(g) the findings, recommendations and requirements of the Owner's ESIA and associated ESMP as valid at the signing of the Contract; and

(h) the Contractor's Environmental and Social Management Plan (the **CESMP**), as defined in this Schedule, to be developed by the Contractor (see Clause 5 below for details).

With respect to subcontractors, Contractor shall monitor the policies and procedures (and their implementation), employment files and payroll records of subcontractors on a periodic basis to assure compliance with the requirements specified here.

The Contractor shall comply with and implement the following Project adopted policies, Prudent Utility Practices, as well as the applicable legislative and regulatory requirements of the Government of Ghana and its agencies (including all relevant conditions of the Environmental Permit for the Project, dated 23 July 2014).

Further detailed assessments of Noise, Air Quality, and Ecology impacts have been undertaken since the Environmental Permit was issued by the EPA. This additional date will be submitted to the EPA as an addendum to the ESIA. As a result, further conditions may be added to those already attached to the permit.

Procedures for monitoring and ensuring compliance with ESHS standards shall be employed by the Contractor. If any individual (Contractor or subcontractor) does not comply with such standards, work will be stopped, and if non-compliance persists, that Contractor/subcontractor will not be allowed on the Site.

4. General Health and Safety Requirements

Contractor shall:

(a) comply with the Owner's ESHS Requirements, the ESIA and ESMP, its CESMP and all applicable Laws in force at the moment the contract is signed relating to health, safety, environmental and social responsibility, provided that to the extent there is a conflict between the standards set out in the Owner's ESHS Requirements, the ESIA and ESMP, its CESMP and/or the applicable Laws, the Contractor shall comply with the most stringent of these;

(b) take care for the safety of all persons on the Site, along access roads and that part of the Site upon which the Contractor is performing the Works, and/or upon which the Contractor's Equipment is being stored (including any part of the Site where the same are being stored on a temporary basis only) (the **Areas of Contractor Activity**). For the avoidance of doubt, the Contractor shall be responsible for the safety of persons about the Site and temporary areas connected to the execution of the Works;

(c) in accordance with Prudent Utility Practices, use all efforts to keep the Site and access roads clear of unnecessary obstruction and clutter so as to avoid danger to persons, including disposing of materials or equipment in designated disposal locations, dedicated lay-down area, any material, chemical or fuel storage areas and to limit the time during which any

equipment is located on Site before its construction, erection, commission or operation implementation scheduled to a reasonable mobilisation period only; and

(d) provide first-line, free and qualified medical services for all Contractor and subcontractor employees. First aid equipment and trained first aid attendants shall be made available at the construction site. In order to facilitate placement decisions and early detection of occupational diseases, pre-placement and periodic medical screening of all workers is required. Contractor shall keep health records of all personnel.

5. Contractor's Environmental and Social Management Plan

5.1 The Contractor shall prepare a Project-specific ESHS management plan (the **Contractor's Environmental and Social Management Plan** or **CESMP**) to safeguard environmental, social, health and safety of the Contractor's Personnel, Owner's Personnel, personnel of Other Contractors and the general public in the immediate vicinity of the Area of Contractor Activity as well as the environment of the Area of Contractor Activity.

5.2 The CESMP should indicate how and when the Contractor expects to put the relevant mitigation and remedial measures listed in the ESIA and ESMP into practice, as well as how to monitor and report compliance in accordance with the requirements established under Clause 6.

5.3 **CESMP Approval**

The Contractor shall submit a draft of the CESMP to the Owner for approval **not later than sixty (60) days prior to the Contractor commencing the Works on Site**. The Owner may within thirty (30) days of receipt request reasonable additional information and/or reasonable changes to the draft CESMP, which the Contractor must supply within seven (7) days. Upon approval by the Owner, the draft CESMP shall become the CESMP for the Works.

5.4 The CESMP shall include the following specific procedures and monitoring for the following (as applicable and as per the Owner's ESMP):

(a) Accommodation for any temporary construction camps or facilities required including offices, ventilation, potable water, eating, toilets, laundry, waste and general storage receptacles and washing facilities, and designed, installed and operated to an internationally recognised standard[8];

(b) Access management;

(c) Vegetation clearing;

(d) Erosion and sediment control;

(e) Quarries and borrow pits management;

(f) Oil Spill management;

(g) Spoil management;

[8] i.e. IFC/EBRD: Workers' accommodation: processes and standards.

(h) Waste management (general, household, wastewater, hazardous, accidental spills);

(i) Chemical management and storage;

(j) Fuel management;

(k) Water management;

(l) Wildlife and biodiversity management;

(m) Noise mitigation/management;

(n) Emission and dust control;

(o) Fire prevention;

(p) Traffic management;

(q) Equipment and materials lay-down;

(r) Site restoration, landscaping and re-vegetation;

(s) Occupational health and safety;

(t) Employment and human resource management. The Contractor should take special note of the Owner's zero tolerance for: child, forced or trafficked labour; discrimination; and any action that may detrimentally affect the freedom of association or the right to organise of the personnel of the Contractor/subcontractor;

(u) Emergency preparedness and response;

(v) Physical cultural resources, including chance find management with provisions for notifying the Owner of any discoveries;

(w) Training for employees;

(x) Security.

5.5 In addition, the CESMP shall contain procedures for risk assessments (e.g. Job Hazard/Safety Analysis and Toolbox Talks), ESHS induction and training of all personnel (casual, temporary or permanent), incident reporting and investigations, ESHS monitoring and inspection, and a format for monthly ESHS reporting to the Owner.

5.6 The CESMP details the specific plans that the Contractor will undertake for implementing the various mitigation measures identified in the Owner’s ESIA and ESMP. The CESMP shall provide the name/person or the organisation/body responsible for undertaking the action and the period for which the action should be taken (who, what, where, when and how) and the need for short, medium or long term monitoring or additional mitigation. The CESMP is an organic document that will be amended and updated as the Project is implemented in accordance with change management principles provided by the Owner that may include: monitoring and review of hazards; identification of changes in risks from identified hazards; determining the adequacy of current control measures; and, as appropriate, determining suitable changes to, or new, control measures.

5.7 The following principles should be used in the preparation of the CESMP:

(a) Compliance with relevant legislation, standards, codes, permits, licensing requirements and Prudent Utility Practices in the application of occupational health and safety as well as safe technologies. In some cases the Contractor may need to submit applications to and obtain licenses, permits and or consents from the relevant authorities in accordance with the Contract and its relevant appendices;

(b) Focus on environment risk prevention. Certain tasks that are being undertaken for the first time or have the potential to cause harm to environment, people, equipment and property (e.g. works affecting surface waters, swamps, community access to land, working at heights, working within pits, enclosed areas, unloading or lifting of heavy loads etc.) may require a risk assessment detailing the control measures to be undertaken by the Contractor or subcontractor to mitigate the risk to people, plant and the environment. Method Statements should be prepared in advance to commencement of these high risk activities. Risk Assessment and Method Statement templates will be agreed between the Contractor and the Owner, however, no work should commence until the Owner issues a 'Sensitive Area/ Work Permit' to proceed and the Contractor has confirmed its capacity to comply with any specific instructions therein;

(c) Focus on occupational and public health, safety and security. Where the Contractor utilises its own security personnel they must be from a recognised/certified company, adhere to international standards, trained to perform the service and suitably attired;

(d) Minimisation of impacts on the environment and animals in full accordance with the relevant policies, principles, and legislative and regulatory requirements identified in Clause 3;

(e) Minimisation of impacts on human beings in full accordance with the relevant policies, principles, and legislative and regulatory requirements identified in Clause 3;

(f) Performance of all activities in a safe and effective manner and maintenance of all tools and equipment in good operating condition for the protection of the health and safety of all persons and to conserve the environment and property;

(g) Tool-box talks; and

(h) Undertaking of all necessary precautions to control, remove, or otherwise correct any leaks and/or spills of hazardous materials, or other occupational health and safety hazards.

5.8 A CESMP must:

(a) describe the actions necessary to implement the various sets of mitigation measures or corrective actions to be undertaken (who, what, when and where);

(b) prioritise these actions;

(c) include the timeline for their implementation;

(d) describe the schedules and mechanisms for auditing all activities within the Areas of Contractor Activity for their compliance (or otherwise) with the CESMP;

(e) describe the schedule and mechanism for external reporting; and

(f) be disclosed to the affected communities.

5.9 Contractor's Dedicated ESHS Manager

The Contractor shall appoint a full time dedicated accident prevention Manager at the Site (the **Contractor's ESHS Manager**), responsible for day to day monitoring and maintaining safety at the Site, providing oversight management for accident prevention, overseeing the CESMP, undertaking daily Site walk-downs and liaising with the Owner (or Owner's designate) on behalf of the Contractor.

The Contractor's ESHS Manager shall be qualified for this responsibility and have extensive experience in overseeing ESHS in a similar construction project, and shall have the authority to issue instructions and take protective measures to prevent accidents and/ or stoppage of unsafe activities. Throughout the execution of the Works, the Contractor shall provide whatever is required by this person to exercise this responsibility and authority.

The Contractor's ESHS Manager will be responsible for putting in place ESHS awareness training induction programme for all of the Contractor's Personnel. The programme shall be submitted as part of the CESMP for the Owner to comment and approve. All Contractor Personnel with direct responsibility for activities relevant to the Project ESHS performance or carrying out activities on Site must attend the ESHS induction course. After being briefed, all attendees shall sign an induction training register as proof of undertaking and understanding the ESHS requirements.

The Contractor's ESHS Manager shall ensure that all of the Contractor's Personnel are adequately trained for the roles to be performed, wearing correct personal protective equipment (PPE), as defined below, and have undertaken the CESMP introduction training course. All of the Contractor's senior and supervisory staff members shall familiarise themselves with these Owner's ESHS Requirements and the CESMP. They shall understand and know how to implement control measures in the CESMP and shall be able to assist other personnel in matters relating to the CESMP.

As part of the Contractor audit of the CESMP, the Contractor's ESHS Manager will be responsible for the identification of emerging/further training needs of, or an increased need to raise awareness amongst, the Contractor's Personnel (where appropriate) and to take actions to deliver (or arrange for the delivery of) suitable training. The Contractor's ESHS Manager will be responsible for the evaluation of all training undertaken implemented as part of the CESMP.

5.10 Personal Protective Equipment

The Contractor shall provide and ensure the appropriate sizes, standards and use of PPE and equipment for the nature of the work being undertaken from time to time by the Contractor's Personnel in accordance with the Owner's ESHS Requirements, the CESMP, applicable Laws and Prudent Utility Practices (and those other documents identified in Clause 3).

The entire Site will be designated a "Hard Hat" facility and the appropriate PPE for the activity being undertaken shall be worn. The Contractor will be responsible for undertaking Risk Assessments (in accordance with agreed templates provided by the Owner) in order to determine the appropriate level of PPE for each of the works within the Areas of Contractor Activity. The Owner will review these Risk

Assessments and no such works will be permitted to commence until the Owner has indicated, in writing, its acceptance of the specific definition of PPE for each particular work.

Personal identification may be needed for workers entering certain restricted areas such as sensitive areas, activities involving permits to work, certain offices, fuel, chemical and other stores. In accordance with Best Industry Practices, Contractors are advised that their employees should have visible name tags and company logos for identification purposes.

5.11 Social Dialogue and Labour Aspects

Where possible, both the skilled and non-skilled labour force (including female workers) should be recruited from the local area. Conditions of employment and working hours shall adhere as a minimum to Ghanaian OH&S regulations, standards and Prudent Utility Practice. There will be no recruitment allowed or conducted within the Site perimeter boundary.

The Contractor will be required to prepare a code of conduct for the employees covering the main rules of interaction with local communities and the rules of conduct in case of conflict situations. Contractor/subcontractors should also meet the Owner's workforce policy requirements, taking account of its zero tolerance for any form of: child, forced or trafficked labour; discrimination; and any action or that may detrimentally affect the freedom of association or the right to organise of the personnel of the Contractor/subcontractor. Contractor/subcontractors will also implement minimum salary requirements in accordance with the Owner's workforce policy requirements.

In addition, the excessive use of manual labour (e.g. breaking rock with sledgehammers, carrying heavy parts or equipment long distances, manually mixing large batches of concrete etc.) is prohibited. The Contractor shall provide HIV and other STD awareness programmes throughout construction, which can be audited by the Owner, for its workforce (including subcontractors). The Contractor shall also take special precautions at his own expense to keep the incidence of malaria as low as possible, including elimination or spraying of mosquito breeding places in an approved manner and provision of mosquito nets and prophylactic treatment of workers.

6. ESHS Reporting Requirements and Decision Making

Reporting the results of ESHS monitoring allows the responsible agencies to identify if any mitigation measure is not being effective and will enable corrective action to be taken. Amandi Energy Limited will confirm the detailed ESHS (and other) information it will require on a monthly basis for the Contractor to insert in the CESMP in accordance with Subclause 5.2 above.

During construction, the Contractor will have the responsibility to ensure ESHS reporting procedures are being undertaken. The Owner will have ultimate responsibility to ensure that these reporting procedures are undertaken and comply with the Owner’s requirements.

6.1 ESHS Inspection and Auditing

The Contractor will be responsible for the auditing of the Contractor's and subcontractors’ Personnel for all activities related to the Works. The Owner will be responsible for inspecting and auditing the Contractors’ performance against the CESMP during construction.

In the event that the Owner identifies an actual or potential non-compliance against its ESHS requirements, the Owner will discuss options and issue either an improvement notice or a stop notice unless the non-compliance has been remedied depending upon the seriousness of the problem. The

individual Notice is a mandatory instruction and shall detail the required corrective actions and timescale needed for the Contractor to return to compliance. Failure to comply with a Notice within a period of time mutually agreed by the Parties, or failure to provide an alternative resolution to raise the above non-compliance may result in penalty clauses, remedial mitigation and/or the Contract being invoked, all subject to the provisions of the Contract. The Contractor is required to keep a register of non-conformance (and near misses) and to ensure close-out of issues relating to the implementation of corrective measures.

Representatives from the Owner, Lenders', the Ministry of Environment or other regulatory bodies may enter an area to make enquires to determine whether the mitigation or ESIA/ESMP conditions are being complied with, together with the relevant conditions of the Environmental Permit. The Contractor will provide assistance to the Owner should any of these representatives come to Site and in the event of Improvement Notices arising from such visits.

6.2 Liaison with Local Communities, Local Administration or Funding Organisations

The Employer will continue to be responsible for liaising with the local communities, administrations and funding organisations including the Lender's Engineer throughout the development of the Project and into construction and operations. Nonetheless, it is likely that the Contractor will have contact with local communities and other Project stakeholders who may regard the Contractor as a representative of the Owner. Consequently, external stakeholders should be treated with courtesy and respect at all times.

The Contractor will establish a grievance mechanism to ensure that all external communications received in relation to the Works are responded to and managed appropriately. The Contractor should diligently record any stakeholder comments or complaints and pass them onto the Owner for response and resolution as soon as practicable. The Contractor will design the grievance mechanism in full accordance with the relevant provisions of the policies, procedures and legislative and regulatory requirements identified in Clause 3.

6.3 Monthly ESHS Progress Reporting

The Contractor shall provide information on the Contractor's organisation and manning of the Contract in line with the Contractor's labour plan. The Contractor shall maintain records and make monthly reports concerning actual numbers of personnel employed on a casual, temporary and permanent basis, skilled and unskilled, male and female, in a suitable format that will enable delineation of roles, as well as any health, safety and welfare of persons, and damage to property, all of which shall be submitted with the monthly progress reports or otherwise as the Owner may reasonably require. The monthly progress report shall include manpower and hour statistics, incident statistics, and ESHS activity performance statistics, and worker grievances (including tracking their resolution).

6.4 ESHS Accident Reporting Requirements

The Contractor is required to have a documented procedure for reporting and handling of incidents including all occupational accidents, near misses, environmental incidents and material damage. Contractor shall send to Owner details of any on-site or off-site chance find, incident or accident as soon as practicable after its occurrence and thereafter a preliminary accident report of any Serious Accident (as defined in the CESMP) within twenty four (24) hours following its occurrence. In

addition, the Contractor is responsible for notifying the relevant regulatory body within the legally stipulated deadline and for any subsequent dealings with those agencies.

Within the time period specified by the CESMP but no later than fifteen (15) Business Days following the Serious Accident, Contractor shall issue a final report to Owner for approval which shall include details of the accident investigation and findings. The accident report shall include all the information required for reporting in accordance with the CESMP. Owner shall review the report within seven (7) Business Days and may request reasonable changes to the accident report or require reasonable additional information. Such additional information or changes shall promptly be made available by the Contractor. Contractor shall as soon as is reasonably possible implement such remedial steps as listed in the accident report. Contractor shall consider all Lost Time Accidents to be defined as a serious accident. An incident register and complaints register will be put in place by the Contractor and maintained by the Contractor's ESHS Manager. These registers will be made available to the Owner on request.

In addition to the obligation to report lost time accidents and in accordance with these Owner's ESHS Requirements, the Contractor agrees that it shall as a matter of policy encourage the Contractor's Personnel to report near misses and accidents that occur outside an Area of Contractor Activity and the Parties acknowledge that accidents referred to in this paragraph shall not be treated as Lost Time Accidents.

If there is a work related death on Site or a death resulting from an injury on Site, Contractor shall immediately suspend work. Contractor shall undertake an investigation and prepare a report with recommendations as to the remedial actions to be taken to prevent future incidents of the nature causing the death. Contractor shall submit the report to the Owner who shall have two (2) days to either approve or reject the report, exercising reasonableness. If the Owner rejects the report, it shall detail the reasons for the rejection. Once the Owner approves the report, Contractor can recommence work. This provision shall apply if there are multiple Lost Time Accidents in a brief period. For sake of clarity, three (3) Lost Time Accidents over a two (2) month span shall constitute multiple Lost Time Accidents in a brief period.

The Contractor shall co-operate with the Owner in providing an appropriate response to any emergency occurring during the execution of the Works and shall immediately take such action as may be necessary and feasible to protect life or the environment and make safe property where such is in imminent peril. The costs incurred by the Contractor in complying with this paragraph shall be evaluated as per the Contract and added to the Contract Price, save where and to the extent that an emergency situation arises solely due to the actions or inactions of the Contractor or where the Contract provides for relief from Costs on other terms (irrespective of whether such right to relief from Costs is immediate or contingent on the emergency continuing for a minimum period).

The Contractor shall at all times take precautions to maintain the health and safety of all persons on the Site and whilst travelling along access roads, having regard to that part of the Site or access roads occupied by the Contractor at the relevant time.

During the implementation of the Project, changes may be required to address unforeseen or unexpected conditions or situations. A change management process will be applied to ensure ESHS issues are addressed as part of any significant changes to project procedures, processes, design or activities. This will be undertaken as part of the CESMP and will be the responsibility of the Contractor's ESHS Manager. The Contractor's ESHS Manager will inform the Owner of any proposed

changes and the Owner may instruct the Contractor to amend procedures accordingly and in accordance with the Contract.

7. ESHS Compliance by Contractor

The Contractor will be deemed not to have complied with the CESMP if:

(a) there is evidence of gross negligence or wilful misconduct resulting in the contravention of any of these Owner's ESHS Requirements;

(b) the Contractor fails to comply with corrective or other instructions issued by the Owner within a reasonable time;

(c) the Contractor fails to respond adequately in a timely manner to complaints from the public, Other Contractor on Site or to action on the part of the Contractor.