Perseus
MINING LIMITED

CENTRAL ASHANTI GOLD LIMITED

ENVIRONMENTAL IMPACT STATEMENT CENTRAL ASHANTI GOLD PROJECT

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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

The Central Ashanti Gold Project (the Project) comprises the development of an open cut mining operation, a process plant and related infrastructure to mine and process ore from defined reserves from a number of associated gold deposits. The Project is located 16 km west of Dunkwa-on-Ofin, near the village of Ayanfuri in the Central Region of Ghana. Ayanfuri lies along the sealed highway from Ghana's second largest city, Kumasi, located 107km by road to the north and the port of Takoradi, located 186 km by road to the south.

A Definitive Feasibility Study completed in July 2009 has defined a 20 million tonne per annum contract mining operation producing 5.5 million tonnes of ore and a process plant with a processing capacity of 5.5 million tonnes per annum (Mtpa) which provides an approximate 10 year life based on the current reserves. Mining operations will be limited to open cut mining only, using conventional excavator/truck mining methods. The process plant is based on a typical gold process flow sheet consisting of Single Stage SAG, flotation and CIL leach.

The first recorded exploration and gold production in the Ayanfuri area dates back to 1906. More recently, between November 1994 and February 2002, the Ayanfuri gold mine produced over 300,000 oz of gold from 23 shallow oxide open pits and heap leach processing with most of the production from six granite hosted ore bodies. The proposed Project is thus being developed within the boundaries of a previous mining site. The mine was placed on a care and maintenance basis until early 2004 when the then owners, Ashanti Goldfields Company, decided to close the mine permanently. As of end 2004, out of an area of approximately 376 hectares disturbed by mining activity, some 290 ha were still in need of rehabilitation, wholly or in part including a heap leach pad area of 133 ha. The proposed new development will therefore take place on a severely disturbed area that can be truly described as a "brownfields" site.

2.0 PROJECT OWNERSHIP

The Central Ashanti Gold Limited (CAGL) will develop the Central Ashanti Gold Project. CAGL is a subsidiary of Perseus Mining Limited (PML) an Australian Stock Exchange listed company. PML completed its acquisition of the historic Ayanfuri Gold Project from Stratsys Investments Limited in 2009. Prior to completion, in December 2008, the name of Stratsys Investments Limited was officially changed to Central Ashanti Gold Limited. The Minerals Commission was informed of the change of name in February, 2009. Licences 1110/1994 are currently in the name Central Ashanti Gold Limited, a Ghanaian registered company.

3.0 EIS PROCEDURES

A Scoping Study and Draft Terms of Reference (TOR) for the Project was presented to the Ghana EPA in November 2008. The TOR was submitted under the name of Stratsys Investments Limited. The Scoping Study and Draft TOR was approved by the EPA and authorisation to commence preparation of an EIS was granted (February 2009).

4.0 ENVIRONMENTAL BASELINE

The environmental baseline studies conducted for the EIA assessed the atmospheric, land (archaeological, flora and fauna, soils and land use), surface water, groundwater hydrology and socio-economic characteristics of the Project with the EPA Terms of Reference documentation.

The various were undertaken numerous visits by four Ghanaian environmental consultants drawn from universities and/or science institutions and three private consultant companies in Ghana under the supervision of Tagit Consult, a Ghanaian environmental consulting company. The various consultants held discussions with project staff during the visits and visited various sites within and around the Project area. Visits to local towns, villages and hamlets and discussions held with village Chiefs, national and local government officials, professional people (i.e. headmasters and teachers) and villagers themselves. Additional baseline information has also been included from studies carried out by Coffey Geotechnics (pit dewatering) and Coffey Geosciences (Tailings Facility design).

Summaries of the environmental baseline conditions within the Project area define the environmental issues associated with the development of the Project, and outline the environmental management and mitigation measures incorporated into the Project design.

5.0 HISTORICAL BACKGROUND

The proposed Project is being developed within the boundaries of a previous mining site that was developed and operated between November 1994 and February 2002. The mine was placed on a care and maintenance basis until early 2004 when the then owners, Ashanti Goldfields Company, decided to close the mine permanently. As of end 2004, out of an area of approximately 376 hectares disturbed by mining activity, some 290 ha were still in need of rehabilitation, wholly or in part including a heap leach pad area of 133 ha. The proposed new development will therefore take place partly on a severely disturbed area that can be described as a “brownfields” site and partly involve greenfield development.

6.0 PHYSICAL, CHEMICAL AND ECOLOGICAL BASELINE

The Project area falls within the wet semi-equatorial climatic region of Ghana characterised by high rainfall, medium to high temperatures and high humidity. It lies within the moist semi-deciduous vegetative zone of Ghana.

The nearest national climatological station operated by the Meteorological Services Agency (MSA) is at Dunkwa-on-Ofin located about 15km east of Ayanfuri. The evaporation data was however obtained from Bogoso about 30km south from Ayanfuri. The stations are considered as being close enough to the Project area to provide relevant information for the climatological assessment.

Rainfall distribution is bimodal. The main season is from March to July and the minor season is from September to November. A short dry spell occurs in August and the major dry season is from December to February. The mean annual rainfall for the Ayanfuri concession was estimated to be in the region of 1451mm (1979 – 2008) with a range of 951 mm to 1829.

The 22-year temperature data for Dunkwa-on-Ofin covering the period 1987 – 2008 shows the monthly average temperature ranged from 24.9^{o}C (January) to 29.7^{o}C (March), while the mean of the monthly average temperature varied from 25.7^{o}C in August to 28.4^{o}C in February/March.

The Project area is entirely rural and ambient air quality is good. There are no specific sources of gaseous or particulate emissions except from traffic on the Dunkwa – Ayanfuri -Bogoso and the Ayanfuri – Sefwi Bekwai highways, the local traffic along the untarred roads of the concession, and scattered seasonal bush burning for preparing farm land. The survey collected Total Suspended Particulate (TSP) for 48 hours and recorded ambient noise levels for 24 hours at three representative locations within the project area – Abnabna and Ayanfuri villages and an area of secondary forest area near Nkonya.

Compared with international standards, dust levels recorded at all sampling locations were below the WB/IFC target of 500 (µg/m^3) for Total Suspended Particulate (TSP) for short-term (24 hrs) period. The highest dust level was recorded at Abnabna on March 31, 2009. The level was a fraction (25 per cent) of the international standard. When compared with EPA guidelines for ambient air quality, the levels recorded at all the location were also below the target, 150 (µg/m^3) for residential and 230 (µg/m^3) for industrial areas. The result of dust at Abnabna (residential) was however, only 16 % lower than the target set at 150 µg/m^3. The lowest level of dust was recorded at the Nkonya forest site area. The result could be attributed to high vegetation cover as pertains in areas under forest cover, isolation from dust generating activities and human influences at the sampling location.

Ambient noise was measured at the same three locations for TSP. The sampling locations could be described as rural for Abnabna and Nkonya and sub-urban for Ayanfuri. The major noise sources included the following;

- Traffic noise from the Dunkwa/Sefwi-Bekwai/Tarkwa highways at Ayanfuri and access to Abnabna
- Public assembly and entertainment from public address systems especially at Ayanfuri, and
- Natural noise in the forested area.

Background noise was highest at Ayanfuri and lowest in the forest site at Nykonya. Abnabna was in between. The maximum noise level for daytime measurement was recorded at Abnabna. It exceeded the EPA and WB/IFC standards applied in this study. The lowest noise levels were recorded at Nkonya forest. For night time noise levels, both maximum and minimum were recorded at Ayanfuri.

The streams in the western half of the main Project area drain into the Ofin River, in the eastern half they drain to the Ankobra River. The two sub-catchments of the Ofin that fall within the project area are the Subin and the Fobin. The sub-catchment for the Ankobra is the Mansi.

The main tributaries of the Subin River are the Aponapon, Bowodinanwu, Asuaa, Danyami and the Nsanka streams. The main tributaries of the Fobin River are the Akesoa, Asuafu, Abnabna, Takrowa, Maninwu, Amantifuawura and the Kyiritwe streams. The tributaries of the Mansi are the Kyiriawewa and Meretwe streams.

The major streams in the project area are mostly perennial. The peak runoff and the runoff volumes for the various return periods from the 5yr to the 100yrs return periods in the Subin and Fobin Rivers have been determined. These ranged from110.31m^3/s for the 5yr and 187.9m^3/s for the 100yr return period for the Subin River. The corresponding values for the Fobin are 183.44m^3/s and 308.21m^3/s. The Mansi tributaries will be largely unaffected by mining operations/

Perseus commissioned the SGS Environmental Laboratory in Ghana (ISO/IEC 17025:2005 Certified) to undertake a quarterly water quality monitoring program for one year (from August 2008) to include sampling of all the major water bodies draining the Ayanfuri area as well as borehole monitoring in the five main villages of the Ayanfuri area.

Based on some 20 sample locations physico-chemical analysis shows that the quality of water is typical of that which is usually found in the wet tropical regions of Ghana. In general, waters in the area exhibit a low in situ conductivity (60 to 278 mS/cm), have a pH acidic to near neutral (5.40 to 7.20), are coloured, contain suspended solids (7.9 to 1945 ppm) in concentrations sometimes higher than standard quoted by the World Health Organisation (W.H.O.) (max of 20 mg/l), a high turbidity up to 530

NTU, a low nutrient content and no trace metals with the exception of iron which is almost always high in West Africa (0.05 to 127 ppm), aluminium (0.02 to 36.8 ppm), and arsenic (<0.003 to 0.53). For iron and aluminium however, very high concentrations are generally associated with high levels of suspended solids and clays.

Microbiological analysis showed that surface waters of the Project area are contaminated as expected and are not suitable for human consumption without prior treatment.

Groundwater occurrence is determined by the underlying Birimian metasediments whose permeability is highly dependent on the secondary permeability obtained from fractures, quartz stringers, stockworks, veins and shear zones which have improved groundwater transmission and storage. In the study area, due to the heterogeneity of the aquifers and their dependence on secondary permeability, flow of groundwater within aquifers occurs predominantly in the fractures and other discontinuities rather than as interstitial flow. Coffey, 2007 assumed the direction of groundwater flow towards the Ofin River to the north, based on terrain analysis (Regional topography).

Static water levels for twenty-five (25) inclined exploration holes from Sun Gold Limited (subsidiary of Perseus Mining LImired) were analysed. Geological sections with plot of static water levels were prepared for selected profiles within the concession. From the sectional maps, the difference in hydraulic heads was used to determine the flow directions. Flow is generally in the direction of low hydraulic gradient. The results showed that groundwater flow is radial within the project area.

The rate of recharge to the aquifers in the study area will require continuous data gathered over a period of years to be estimated. Generally, about 15% of the total precipitation ends up as groundwater, but this varies locally and regionally from 1 to 20%. Previous work carried by Jay Minerals Services Limited (1993) on the Ayanfuri concession estimated the recharge from 3 to 5% of the total annual rainfall.

Drill logs of exploration holes were examined and the depth to the transition zones which are normally considered as the water bearing zones varied between 6 and 92m with a mean of 22.4m. This is indicative on both shallow and deep seated aquifers in the study area.

The pH values for groundwater in the area (five village boreholes) ranged from 5.3 to 6.7 with a mean of 5.8. The total dissolved solids ranged from 55 - 196mg/l, the total hardness ranges from 15 to 124mg/l. Electrical conductivity values (in situ) ranged from 107 - 279 uS/cm with a mean of 199.0Us/cm. The concentration of Manganese was always below 0.05mg/l, Iron ranged from 0.05 to 4.6mg/l, Chloride 7.9 to 26.7 and Sulphate ranged from <1 to 7.5mg/l. Arsenic in all wells was <0.002mg/l.

The survey did not identify any black star or gold star tree species. The Ghana "Star" classification of forest species is a means of classifying such as to their conservation importance; black and gold star species have the highest conservation rating.

The Project area lies within the tropical rain forest zone of the country and the vegetation has been classified by Hall and Swaine (1981) as a Moist Semi-Deciduous forest of the Northwest sub-type. Due to large-scale mining between 1994 and 2001, current vegetation in the area has been severely disturbed and bears very little structural resemblance, if any, to the original primary forest classified by Taylor (1952) as belonging to the Celtis-Triplochiton Association.

Agriculture, particularly food and cash crop farming, has and continues to be another major land use system in the area. Food crops such as plantain and cassava and cash crops, mainly cocoa and oil palm are prevalent in the area. At present, there is no evidence of commercial logging activities but it may be assumed that parts of the Project area must have been logged at some time in the past. This assumption is based on the type of left-over primary forest tree species identified in the area. However, logging with chainsaws by the local people is still evident in the area.

Vegetation types identified in the project area include secondary forests, secondary thickets and swamp vegetation. In some of the backfilled pit areas of re-growth was prevalent and no trees were found in such areas. Species in such areas include ordinary weeds, grasses and ferns such as *Chromolaena odorata*, *Centrosema pubescens*, *Brachiaria deflexa*, *Sporobolus pyramidalis*, *Nephrolepis biserrata* and *Gleichenia linearis*.

Fauna was assessed covering the following taxa of animals: Avifauna (birds), large mammals, small mammals (including bats), and herpetofauna (amphibian and reptiles). The assessment included six field trapping sites - Abnabna and Fobinso pit areas, a reclaimed area at the Fetish pit, the proposed FTSF and plant site areas and a Chirawewa area site. Additional information was obtained by interviewing hunters, bush meat sellers and chop bar operators within the fringe communities.

Apart from birds, the fauna of the Project area is generally very poor. Small terrestrial mammals were caught in only one site (Chirawewa pit). Twenty-eight (28) large mammals were recorded in the study area through direct observation, their spoors being seen, carcasses seen with hunters or chop bar operators and local interviews. There were calls of the tree hyrax and footprints and feeding activities of the bush buck (*Tragilphus scriptus).*

The presence of bats in the area was fairly good although only two species of Ghana's megachiropteran bats were caught. These were Epomops (*Epomops franqueti*) and Epomorphorus *(Epomorphorus gambianus).* Most of the catch was made at the proposed plant site which had not been disturbed by the previous mining and is covered by good cocoa farm of about 18-20 years old interspersed with remnant secondary forest

The herpetofauna (amphibian and reptiles) recorded in the study area was at seven reptile species and three amphibia species. While all the amphibians were seen in the field, two reptile species (Gaboon viper and Chameleon) were not seen but reported to be present by local inhabitants. The commonest venomous snakes in the area were green mamba and black cobra.

The presence of *Afrixalus dorsalis* (Striped Spiny Reed Frog), a very sensitive species to pollution, in the concession is an indication that the study area did not face serious water pollution in the past.

A comprehensive survey of five aquatic habitats focussed on the algae, macro-invertebrate and fishes. The sites were primarily selected in relation to proposed operational facilities locations and tributaries of the Ofin River. Two of the sites will be important downstream monitoring points during and after mine operation. Assessment of the physical riparian habitat showed that none of the sites studied was in pristine condition. At the time of the study all the waters at the sampling sites were turbid and exceeded the WHO guideline of 5NTU for potable water quality. When the waters at the various sites were assessed by the EPT Index (EPT Index that represents macro-invertebrate groups that are sensitive to pollutants in water) it was concluded that none of the sites was severely impacted by human activities. The fishery resource was found to be poor. However, hosts of Buruli Ulcer and Urinary Schistosomiasis were found in the reaches of most sites studied.

A detailed soil survey according to FAO 2006 guidelines for soil description was employed to identify and describe the soils of the project area at the series level. The soils belong to the Bekwai-Nzima/Oda compound association. On a typical topo-sequence, *Bekwai series* occupies the summit and upper slope sites followed by *zima series* on the upper to middle slopes, whiles *Kokofu series* follows on the middle to lower slope sites. The narrow valley bottoms are occupied by alluvial soils of *Oda, Kakum* and *Temang series*. Both *Bekwai and Nzima series* are developed in-situ whereas *Kokofu series* is a colluvial material from slope wash.

In general, the project area has good agricultural soils that are suitable for a wide range of tree and arable crops. The well to moderately well drained soils of *Bekwai, Nzima* and *Kokofu series*, are extensively used for cocoa cultivation, even though, the results of the suitability evaluation showed that oil palm is highly suitable.

The major agricultural land uses are cocoa farming, food crop farming, and bush fallow. The non-agricultural land uses include human settlements (towns, villages and hamlets) and undeveloped inland valleys with swamp vegetation.

In the area potentially earmarked for process and support infrastructure some good cocoa and food crops (plantain, maize, cocoyam, cassava, and rice) occur. The area intended for the tailings and water storage dam is an undeveloped inland swamp valley with a few rice farms. Large livestock farming is of no economic value and there is no organised fishing in rivers and streams in the Project area.

7.0 SOCIOECONOMIC BASELINE

An overview of the socioeconomic status of the two Administrative Districts, the Upper Denkyira and the Wassa Amenfi East that are straddled by the Project area has been prepared. Information on political administration, revenue sources, local economy and development, industry, banking services, etc was obtained.

Agricultural production is the main economic activity in the two Districts and is practised mainly on subsistence level with only a few farmers engaged in plantation agriculture. Development constraints common to both Districts include inefficient transportation and communication systems, low revenue base, inadequate technical and economic infrastructure, poor condition of the built and natural environment, low technology in production and low income levels as a result of subsistence farming and low prices of farm products.

In August/September, 2008 a detailed house to house census was undertaken of eleven villages in the greater project area. Information was obtained on family occupancy, room numbers, construction materials, employment and income levels among other subjects. Of the eleven villages, five are likely to be substantially influenced by the Project. However, no resettlement of any houses in the five villages will be necessary.

A survey in 2009 identified 51 hamlets located within the project area. The majority of these are cocoa farming related hamlets constructed of mud and wattle with an average of five rooms per hamlet. Most of these of the hamlets will have to be considered for relocation.

8.0 SYNOPSIS OF ENVIRONMENTAL IMPACT ASSESSMENT

The EIA for the Project will comply with the new Environmental Assessment Regulations, dated June, 1999 (L.I. 1652) which have superseded Ghana Environmental Impact Assessment Procedures, June, 1995. The Project has been designed to comply with the requirements of the Minerals and Mining Act (Act 703) 2006, with Ghana's Mining and Environmental Guidelines, Final Draft, 1994 and air, noise and water quality guidelines published by the Environmental Protection Agency. Cognisance has also

Land Required for Mining, Processing and Support Facilities		
Facility	**CAGP Area (Ha)**	**Previously Undisturbed Land (Ha) (Greenfield)**
PITS		
Abnabna	49.7	-
AF Gap		
North Esuajah	22.3	-
Fetish North Ramp	32.4	-
Fetish South		
Fobinso North	27.6	-
Fobinso South		
Total Pits	**132**	
Total Haul Roads	12	12
WASTE DUMPS		
Abnabna/AF	57.5	
Fetish	102	
Fobinso North	50	
Esuajah North	97.3	
Total Waste Dumps	**306.8**	
CAGP FACILITIES (New)		
Flotation TSF	339.4	339.4
CIL TSF	13.7	13.7
Process Water Pond	2.5	2.5
Plant Site Area/MC Area	22.3	22.3
Substation	1.7	1.7
Eastern Mine Ore Piles	12	12
Miscellaneous	10	10
ROM Pad/ Magazine	118.7	118.7
Nkonya Access Road	2.6	2.6
Abnabna Road Diversion	14.3	14.3
Asuafa Diversion channel	14.7	14.7
Sediment Control (Inc drains)	4	4
Power line to plant site	8.8	8.8
Total New Facilities	**564.7**	**564.7**
Grand Total	**1,015.5**	**576.7**

The total disturbance of approximately 998ha represents 10.7 % of the of the two ML areas (93.1 km^2). The first major phase involving the construction of the process plant, tailings disposal facility and other support facilities will begin in the southern half of the Project area.

Potential environmental impacts could occur during the construction, operation and post-closure phases of the Project.

There are positive socioeconomic impacts that would occur from the development of the Project. There is, however, a potential for negative environmental and social impacts associated with the construction and operation of the Project. A list of impacts that could occur without adequate levels of environmental and socioeconomic management is presented in the following sections.

11.0 IMPACTS DURING CONSTRUCTION AND OPERATIONS

11.1 CLEARING OF LAND

The construction phase or overall development period will take approximately 120 months. Erosion in general and an increase of suspended solids from clearance and construction activities in the various rivers and streams flowing through, or adjacent to, the Project area concessions are possible. The river affected could be the Ofin and the two main sub catchments of the Ofin that fall within the project area, the Subin and the Fobin, and the several small tributaries of these.

This phase will begin with site preparation activities of the main Project facilities area, planned to occur during the dry season. Care will start as soon as possible to minimise long-term impacts on the landscape of the area. Site preparation activities will involve clearing of vegetation, cutting and sale of marketable timber and use of scrap wood and branches as brush barriers for sediment control where applicable. Topsoil will be stripped and stockpiled for later use during revegetation activities. Some stockpiled topsoil will be used during construction period revegetation activities while the bulk of the topsoil will be maintained for dump closure and final reclamation use. Topsoil stockpiles will be vegetated with native grass to stabilise stockpile outslopes and to minimise erosion and soil loss.

Clearing of the various sites will be a gradual process and will not exceed the surface of the area required for each of the facilities. It will not be necessary to clear the entire surface footprint of the waste dumps in one operation, as waste rock is produced and stored progressively from the beginning to the end of the life of the Project.

All contractors involved in earthwork activities will be required to submit an Environmental Management Plan (EMP) for specific phases of work. The EMP will present a strategy for minimising clearing activities to the extent possible; limiting soil erosion, describing the revegetation requirements for a particular area; and presenting an appropriate inspection program that defines environmental success criteria which will lead to an approved closure of each phase of work.

Stockpiled topsoil will be used for revegetation requirements to stabilise structures such as embankments or structural earth works and to provide a suitable growth medium during reclamation activities. Additional site clearing during operations will also involve segregation and stockpiling of topsoil.

11.2 VISUAL IMPACT OF THE PROJECT

The topography of the Project site consists of low rounded hills ranging from 120 m to 240 m ASL. Two particular sites have been identified as having a significant visual impact.

Specifically, Abnabna village, the portion of the settlement located on the eastern side of the village from which the Abnabna pit waste dump will be visible. The Abnabna pit waste dump will partially reduce noise and lighting impacts of the Abnabna-AF Gap pit and Plant site on the village. The second is the waste dump east of Esuajah North pit. All other major facilities will be located in areas away from populated or highly travelled locations.

11.3 AIRBORNE DUST DURING THE CONSTRUCTION PHASE

The Project site and the access road are both located well away from any major settlement thus reducing the impact on the local inhabitants. This impact can be classified as short term, temporary and reversible. Project planning includes use of water trucks on unsealed roads to assist with dust control during the dry season from December through March.

11.4 AIRBORNE DUST DURING OPERATIONAL PHASE

The potential sources of airborne dust associated with the operational phase of the future mine will be the crushers and associated discharge conveyors and the carbon regeneration kiln; both located within the treatment plant. Impacts from dust emissions should be minimal as the nearest habitation will be Abnabna village (800 m). Concentration of fine particles generated by diesel fired engine exhausts should be within acceptable limits as all equipment to be purchased by the project will be typical for this type of mining operation and will comply with accepted standards through regular maintenance procedures.

Based on the average number of rainy days per year recorded at Dunkwa (30 yr record 1979 – 3008) it is estimated that conditions will be wet 35% (129 days) of the year with a range from 24% (87 days) to 43 % (265 days). This weather pattern will partially assist in damping down airborne particulates, but will not exclude the requirement for water spraying of roads on a regular basis. At other times dust emissions could be significant, particularly during the driest months of the year from December to March where they will reach a maximum due to the contribution of Harmattan dust.

Blasting from the open pits should not be a major problem as none of the pits will be located close to any major human settlements and blasting practise will see the air-blast minimised through the use of stemming and good blasting practise. The project will use modern blasting technologies which enable better control of the sequence of detonations and the quantities of blasting agent to be used, hence reducing the potential of fly rock generation, dust particulates and other nuisances considered poor blasting technique.

All the mine haul roads and access roads will be located away from human settlements. Impact of dust on locally travelled roads can be classified as locally significant, intermittent and reversible. Appropriate mitigation measures will be implemented including routine watering and/or possible treatments with materials such as magnesium chloride.

11.5 GASEOUS EMISSIONS

No noxious gases will be generated from the process plant and the operation of the mine in general. The ore of the Project is not refractory and therefore will not require any oxidation step such as roasting which can produce toxic fumes containing sulphur dioxide and / or arsenic. Diesel engine emissions and Assay Laboratory fume emissions are considered small and controlled by good maintenance and laboratory scrubbers respectively.

11.6 NOISE AND VIBRATION

The operation of the Project will increase the general level of noise and vibration within the vicinity of its operations. Both mining and processing activities will generate noise and vibrations.

The relative remoteness of the various mining areas, the Esuajah North haul road and the plant site from settlements and the existing vegetation cover indicates that noise and vibration will not be a significant issue over the majority of the Project area. The only site of concern could be Abnabna village (east) and Ayanfuri village (north) where sources of noise were and Rear Dump Trucks dumping their loads on the waste dumps at both locations and blasting in the pit.

The design of the waste dumps at both locations is such that they will create barriers to stop sound and light travelling to the villages. Dumping of waste will be unrestricted during daylight hours when noise is not such an issue and at night all dumping will be at lower levels or at other dumps.

Intermittent noise from blasting will be controlled by using controlled blasting technology. Mitigation measures will include making blasting times known to the general public through boards located at Abnabna and Ayanfuri. Noise and vibration levels will be regularly monitored within and around the Project facilities (plant site, mining areas) and the Project area in general.

11.7 IMPACTS ON FLORA AND FAUNA

Development of mining and associated operational facilities will not result in the destruction of any ecologically important areas of vegetation or sensitive habitat. From the flora point of view, all the species encountered were common and occur elsewhere in the region. There are only a few isolated timber trees of marketable size worth salvaging. No rare or endangered species were observed in the Project area as a whole. No tree species of Black and Gold Star classification have been recorded in the CAGL project area.

The terrestrial fauna surveys of the Project area as a whole indicate that fauna diversity of the area is poor and none of the species recorded or observed are endangered or of special conservation importance.

A low diversity of fish species was recorded in the Ofin River tributaries of the project area and fishing is not a major activity in these tributaries. No species of conservation importance were identified. Identification and distribution of benthic organisms did not indicate any particular area of conservation concern.

The development and operation of the Project, given appropriate environmental control measures, is unlikely to have any major adverse effects on the ecological environment of the area. However, CAGL will endeavour to preserve and/or avoid any serious impact on the ecological environment and adopt measures promoting conservation of certain areas.

11.8 SOIL AND LAND USE

The Project impact on soil and land use will be relatively limited in scope relative to the entire Mining Lease as only 998 ha will be affected out of a total Mining Lease area of 93.1km^2 (10.7%). The 998 ha include some forest regrowth areas, undeveloped inland valleys with limited swamps and trunk and feeder roads, as well as farmland. Within the area occupied by Project facilities, there will be a major impact on agricultural land use and the hamlets and farmers living there. CAGL will implement mitigation measures. These will be in the form of resettlement and/or relocation and compensation for the people that will have to move or had farm holdings in the various facility sites.

11.9 SOIL EROSION AND SEDIMENTATION

Land preparation associated with infrastructure development and operation of the Project will remove vegetation and topsoil and induce soil erosion. CAGL will adopt measures to limit these impacts and to promote soil conservation particularly during design and construction of the Project facilities. Erosion control practices will include:

- Land clearance will be limited to the strict minimum.
- EMP's will be developed defining specific measures and "Best Management Practices" (BMP) to be used to minimise soil erosion to the extent possible.
- Drainage from external catchments will be controlled by diversion channels or appropriate holding structures.
- The length and gradient of structure slopes will be maintained at gradients to minimise erosion or lined to prevent erosion.
- Regrading and compaction as appropriate.
- Side drains and road camber will be constructed to ensure adequate drainage.
- If required, use of anti-erosive material on particular structures.
- Concurrent revegetation of disturbed areas will be undertaken as part of the land reclamation program.
- Visual assessment of erosion and analysis of run-off water quality as a preventative measure will be carried out on a routine basis, which will provide rapid evidence of where control measures need implementation or repair.

11.10 DRAINAGE FROM HEAP LEACH PADS

In November 2006, a site audit by a team from the European Union – Mining Sector Support Programme (National EIA and SEA Project) identified elevated levels of arsenic in seepage from sections of the heap leach pads. The audit (unpublished) concluded that the although elevated As concentrations are not widespread, the situation warrants further observation and possibly mitigation measures.

In August 2008, CAGL established a quarterly monitoring programme (sampling and analysis by SGS Environment, Accra) of the drainage from the heap leach area and the receiving streams in order to develop appropriate mitigation measures under its bonded rehabilitation programme for pre-acquisition mining activities. CAGL is proposing to construct a seepage collection ditch that will discharge into a wetland filter where the wetland will under normal conditions effect As consumptions such that World Bank and IFC discharge guidelines are met.

11.11 CHANGES IN TOPOGRAPHY

Changes in topography resulting from mining activities will progressively modify the catchment characteristics of the Ofin River sub-catchment areas. However, the contribution of the Akesoa into the Ofin River is only 0.14 percent. Therefore it is unlikely that major changes will be measured on the Ofin River downstream of the Project area.

11.12 Mine and Operations Effluent

Discharge of mine water into the local streams will be required particularly from the pits located away from area the main Project facility area. Results of analytical testing of groundwater samples from the mining areas have not revealed any major water quality related problems. It is not expected that water that will have to be released to the natural drainage will contain any specific chemical pollutant. Discharge concentrations of suspended solids will be controlled through a series of sediment retention ponds. The design and placement of the ponds, as well as an overall management strategy for Project surface water has been developed for this feasibility study.

All surface flows from the plant site will be directed into the flotation tailings storage facility (FTSF). The FTSF is designed as a contained facility based on at least a 1 in 200 year 72 hour storm event. Impacted water from the FTSF will be utilised as process water to keep the water level in the FTSF at a minimal level.

All sewage effluent will be treated in a package sewage treatment plant located at the plant site while the residential village will remain on the septic system. Treated waste will be pumped to the tailings dam. Sewage from the mine services area will be pumped to the plant site treatment facility.

All workshops will be constructed in a bunded area with a sloping concrete floor and the runoff directed into oil and water separators prior to discharge. Any petroleum-contaminated soils will be treated biologically at a land farm or will be placed in clay lined cells within the waste dumps. All petroleum-based waste products will be regularly collected and appropriately disposed off by the fuel supplier.

11.13 Process Effluent

No effluent will be released to the environment. Discharges of water containing non-acceptable concentrations of cyanide or other pollutants will be prevented by operating all gold extraction and processing operations on 100% water/chemical solutions recycle system. From year four the CIL tailings return solution may exceed the CIL feed requirement and thus be detoxified and discharged into the FTSF at concentrations below 5 ppm CN wad. This level is critical as the flotation of gold will be partially suppressed with process water above this level.

11.14 Overland Runoff

Mitigation measures to minimise overland runoff have been included in the Project design. CAGL will also implement a Surface Water Management Plan (SWMP) which includes design specification for sediment control structures and all surface water conveyance structures.

11.15 Leaching of Waste and Potential of Acid Mine Drainage

Seventy-nine (79) ninety rock samples representing granite and sediment hosted ore and waste from five pits were analysed by an independent laboratory in South Africa for acid rock drainage potential. Only one sample (sediment hosted ore at AF- GAP) was classified as having a strong ARD potential; four samples were classified as medium ARD potential (three at AF-GAP, two ore and one waste and one at Fobinso, waste); and two samples as low AGP potential (one ore at Fobinso and one waste at AF-GAP). All others samples were classified as “ uncertain/possible AGP or NP – 12 samples”, “low NP-18 samples”, “medium NP – samples 14” and “strong NP- 26 samples).

Since the samples from AF-Gap have shown some potential to generate acid CAGL will be proactive and will incorporate AMD cells within the ROM waste dump for full encapsulation of the identified PAF to prevent the AMD from occurring. The mine will undertake continuous monitoring of waste properties and waste dump drainage in general to ensure that such drainage is not having an environmental impact during mining operations.

11.16 IMPACT ON GROUNDWATER RESOURCES

Groundwater resources will be exploited to provide a source of potable water only. It is envisaged that surface runoff and mine water will supply sufficient water for the process even for the start up operations of the Project. The FTSF will be the prime resource for harvesting water for use in the processing operation under normal operating conditions and especially following large rainfall events.

Dewatering of the open pits is likely to have some effect on groundwater levels in the close vicinity of the mine. Localised lowering of the groundwater level within a few hundred metres radius can be expected particularly for the deeper pits. CAGL will install observation bores in Abnabna and Fobinso villages to determine if groundwater levels are decreasing. Appropriate measures will be taken to maintain water supplies in the two villages if groundwater drawdown impacts on the supplies. These bores are in addition to monitoring bores being installed to monitor groundwater conditions around the FTSF and CIL TSF.

11.17 FLOTATION TAILINGS STORAGE FACILITY

The FTSF will be a valley type storage with containment embankments comprising a main embankment and saddle embankments which will surround an area of approximately 339ha at completion. It will contain only flotation tailings. The location selected was deemed suitable for a tailings dam as the soils appeared, from test pit profiles, to be relatively stable. In addition the permeability for this location was low and indicating that movement of water into the groundwater system will be restricted.

Deposition of flotation tailings material is not expected to be a source of pollution to groundwater resources as they will be largely inert and non-acid forming due to separation from the CIL tailings. They will not have any arsenic, cyanide or elevated metals content in the solution. An underdrainage system will be installed to recover water percolating through the tailings. All water recovered from the underdrainage would be collected in a lined return water pond and pumped back to the process plant for reuse in the processing of ore.

The presence of the underdrainage, coupled with the practically impermeable compacted clay liner, specifically built into the underdrainage system itself, will effectively preclude vertical seepage from the FTSF.

11.18 CIL TAILINGS STORAGE FACILITY

Tailings from the Carbon in Leach (CIL) plant will be discharged to the CIL Tailing Storage Facility (CTSF) which has to be located close to the plant. This is also a valley type storage (14ha), with containment embankments common to the FTSF and Process Water Pond. The CTSF is a double HDPE lined facility with underdrainage above the top liner and a leak detection system between the upper and lower liner. To prevent fauna access the entire CTSF is link-mesh fenced with razor wire. During operation the CTSF will be covered with water. Bird balls and netting will be deployed to prevent access to the surface. The underdrainage system incorporated into the design allows for recovery of water from the base of the tailings stack.

12.0 SOCIOECONOMIC IMPACTS

12.1 GENERAL

The development and operation of the Project will have both positive and negative impacts on the socioeconomic structure of the Project area and its environs, as well as impacts at a District and National level. It is considered, however, that the positive impacts will considerably outweigh the negative ones. CAGL is aware that it has a general responsibility to contribute to socioeconomic infrastructure in the communities of the immediate area in which it will be operating. This responsibility will be enacted in co-operation with local communities and local government. It does not mean, however, that CAGL will provide unlimited assistance and fulfil all requests for improvements made by local communities. Assistance will have to be tailored and budgeted according to the economic realities of mine operations and revenue received.

12.2 SOCIAL DEVELOPMENT CONSULTATIVE COMMITTEE

In order to provide a fair and equitable contribution to communities in the project area CAGL is in the process of establishing a Social Development Consultative Committee (SDCC) that contains representatives from five villages (appointed by the villages themselves), representatives from 1) the two District Assemblies, 2) two Members of Parliament, 3) members of local groups such as Youth, Women and Farmers an 4) other local and regional stakeholders in regional and national government agencies and departments.

In April 2009 meetings were held with the Chiefs and Elders at each of the five villages that will be influenced to varying degrees by the Project. They were informed that CAGL wished to hold a public meeting at each village to solicit comments, opinions and expectations should the CAGL be implemented.

The five public meetings were held at from May 19 to 23. Each meeting was formalised under canopies and seating provided for the community. A “top table” at which a Chairman, DCE’s and/or or their appointed representatives, local Assembly persons and the CAGL team were seated. The Chairman at each meeting was an independent person from the appropriate District Assembly or Member of Parliament. Each meeting was recorded on video and minutes produced for each meeting.

All villages and administrations are in favour of the project with the usual caveats about no pollution, fair compensation for crops and building, priority employment of local people, support for village facilities, etc. Local employment is by far the biggest issue. It is noted that the Project is dealing with five villages and the combined requests for assistance is consequently very large. It will be very important to coordinate any infrastructure projects with the two District Assemblies who are showing very keen interest in the project.

An EPA Public Hearing was held at Ayanfuri village in November, 2009. The Project was favourably received. Points raised at the Hearing on CAGL contribution to community development, holding of customary rite have been addressed in this report. CAGL has confirmed that it will establish a Community Development Fund upon start up of mining and processing.

12.3 ASSESSMENT OF POSITIVE IMPACTS

The positive impacts of the Project will relate mainly to the economic advantages, which will have immediate and long term benefits on the sociological environment. This will be achieved in various ways at National, District and Local levels through payment of royalties, taxes and infrastructure impprovements, especially in local villages.

The number of employees employed directly by CAGL will total 232 persons on start-up. Contractors will be employed for mining, drilling, security, vehicle and house maintenance, bus service and catering. Although the number of contractor employees has not been fully determined yet, it is expected that it will exceed 200 persons. Construction activities will also have a positive effect on employment as more than 200 people will be employed to fulfil this task over a period of 12 months.

Construction contractors will be required to source employees locally to the maximum extent possible and provide training. The maximisation of local labour resources and skills will have long– term benefits which can only strengthen community relations and ultimately provide a stable work force and work environment.

12.4 ASSESSMENT OF NEGATIVE IMPACTS

The development and operation of the Project will not require the relocation/resettlement of any major population centre as all major Project facilities will be located at least 500 m from any town or village.
A small segment of the population will be displaced by the Project; these are primarily cocoa growing hamlet communities in the vicinity of the Abnabna, AF Gap and Fobinso pit areas and Plant Site area.

CAGL will initiate a relocation/resettlement program to compensate this displaced population. The program will have two main types of compensation, relocation and resettlement. Relocation will entail those people who desire a payout for crops and/or land and who will relocate to other areas with CAGL assistance. Resettlement will be those people who desire to be moved and provided shelter and land to continue agricultural ventures. CAGL is forming a suitable relocation/resettlement and crop compensation package and developing consensus with the local population to achieve this.

12.5 FARM SURVEYS AND CROP COMPENSATION

CAGL has undertaken a comprehensive survey and crop count estimation in the three major areas that represent the initial active mining and development areas of Abnabna/AF Gap/Fobinso pits and waste dump sites, the Plant site, ROM pad and the Tailings Storage sites. Where compensation becomes payable, the survey data and estimation of compensation will be subject to an external and independent verification procedure. The agreed compensation payment to any farmer will be made in the presence of a member of the Traditional Authority, a member of the District Administration and a Company representative.

12.6 SOCIAL IMPACT OF INCREASE IN POPULATION

A significant influx of people into the area looking for employment by CAGL is most likely and expanding local businesses and services will likely result in undesirable social and economic pressures. These could include inflation of local food and accommodation costs with a converse reduction of availability, a heavy additional burden on the community water resources, sanitation and garbage management, healthcare resources along with unwelcome social problems like prostitution, crime and drunkenness.

12.7 IMPACT ON EXISTING WATER RESOURCES

Communities may find that their current water supply resources will be inadequate to supply increases in demand resulting from the influx of new inhabitants. CAGL is already working closely with local communities assist local infrastructure development programs as a means to minimise such impacts. CAGL has already provided assistance to the villages of Abnabna and Fobinso to improve wells, has substantially assisted Ayanfuri to o meet its obligations under the Government of Ghana/DANIDA programme for the installation of a piped potable water system in the village. Well improvements and repairs have been undertaken, or in progress at Abnabna, Fobinso and Gyaaman.

13.0 ENVIRONMENTAL MANAGEMENT PLANNING

13.1 PERSEUS POLICY ON ENVIRONMENT AND SOCIAL SUSTAINABILITY

CAGL as a subsidiary of Perseus Mining Limited will operate under the Environmental and Social Sustainability Policy of the latter. As such, the Project will operate in full compliance with all applicable Ghanaian environmental regulations. Furthermore, in recognition of the evolving state of the regulatory structure in Ghana, and in recognition of ever increasing requirements from shareholders and financial institutions, the facility will operate in accordance with generally accepted International Environmental Standards and Practices.

Consideration of these objectives will be included in the planning and implementation of all aspects of the operation. Management and employees at all levels will be kept aware of the environmental management responsibilities through proper training and supervision.

13.2 ENVIRONMENTAL MANAGEMENT SYSTEM

The Project will develop an Environmental Management System following the principles contained in ISO14001/ISO14004. The major elements of the Environmental Management System will be:

- Recognition that sound environmental management is essential to successfully operate the facility.
- Accountability of all staff for minimising environmental risk and assuring compliance with regulatory requirements as well as corporate environmental objectives.
- Implementation of monitoring programs to provide early warning of any deficiency or unanticipated performance in environmental safeguards.
- Training and orientation of employees in order to perform their jobs in compliance with sound environmental practices.
- Consideration of environmental factors to be included in all new or modified facilities and in the purchase of equipment and materials.
- An environmental incident reporting system will be established and reports prepared immediately.
- Environmental response planning will be completed to provide the basis for response to environmental incidents, including spill prevention and counter measures plans, monitoring plans and mitigation plans.
- Periodic reviews will be conducted to verify environmental performance and to continuously strive towards improvement.
- Procedures are implemented to assure ongoing dialogue with government entities in connection with regulatory changes which may affect the operation.

13.3 SUSTAINABILITY MANAGEMENT STRUCTURE

The Sustainability Department staff will manage Environment and Community Relations functions and will be controlled by a senior employee as a member of the operational management team. This department will be responsible for the environmental monitoring, rehabilitation, forestry and community relations. CAGL will assist with joint programs that will focus on improved health, education, hygiene, and infrastructure. The total workforce of the Sustainability Department is estimated at 15 people.

13.4 ENVIRONMENTAL MANAGEMENT PLAN

A Provisional Environmental Management Plan will be prepared as part of the EIS in accordance with Ghanaian EIA requirements. Topics to be addressed include Regulatory compliance and government communications, Cyanide management, Spill prevention and counter measures plans Tailings dam failure and protection of downstream water sources, Reporting and recording of ,environmental incidents, Disposal of hazardous materials, Emergency medical and security procedures.

Periodic auditing and reviews will be conducted by internal/external auditors at regular intervals to verify environmental compliance at appropriate levels and to confirm that management responsibilities are in accordance with environmental procedures.

13.5 CLOSURE REHABILITATION PLANNING

CAGL is required by legislation to implement a land rehabilitation program and prepare a decommissioning plan as part of its overall environmental management strategy. When acquiring the Ayanfuri mining property, Perseus also acquired the rehabilitation liabilities of Stratsys Investments Ltd, which in turn had acquired such liabilities from AngloGold Ashanti (Ghana) Limited. Consequently, the Closure Rehabilitation Plan (CRP) will have to address the existing liabilities and those that would newly arise from the development and operation of the Project.

13.6 CLOSURE OBJECTIVES

The broad objectives for mine closure for the Project are that impacts of the operations should be managed and rehabilitated to a standard that minimises or negates restrictions on sequential land use and complies with the laws of the Republic of Ghana. In addition there should be no ongoing liability beyond relinquishment of licences. These objectives are consistent with Perseus's environmental policy which requires that the design, operation and decommissioning of all facilities and associated infrastructure is done to avoid or mitigate adverse environmental impacts, minimise associated long term financial liability and enhance social benefit.

13.7 CRITERIA FOR CLOSURE OBJECTIVES

Basic criteria for meeting the closure objectives as defined by CAGL are presented below:

Community Involvement		Stakeholders will be team members and involved at all stages of the planning process by means of periodic formal meetings. Entrepreneurial local people / businesses will be encouraged to participate in the execution of work programs.
Socioeconomic Impacts		The quality of life of all stakeholders, as measured by quality of living conditions, health services, general infrastructure and per capita income will be measurably higher than exists before commencement of operations, with the improvements to be self funding and sustainable at the completion of operations.
Water Resources		Impacts on surface and groundwater bodies have been identified and remediated during operating life to EPA satisfaction.
Soil Erosion		The suspended solids loading of run-off from site has been managed to comply with Ghanaian regulatory requirements.
Revegetation		Soils have been stabilised to prevent enhanced erosion and where practicable, establishment of a suitable soil structure to promote agricultural post closure land use.
Visual Amenity		Consideration will be given during the design stage.
Physical safety		Drill holes plugged, costeans backfilled, open cuts bunded, or fenced as required
Stability	**Tailings Storage Facility**	It has been demonstrated that the containment structures have been designed with sufficient safety factors to maintain integrity.
	Waste Rock Dumps	It has been demonstrated that the final landform will be compatible with the selected post mining land function.
Residual Contamination		Site remediated to a degree that is protective of human health and the environment.

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13.8 KEY ASSUMPTIONS FOR CLOSURE PLAN

A number of key assumptions will be made when designing the Closure Plan. They will be :

- All the issues have been identified, the order of magnitude of the work required is correct and the planned work program is appropriate.
- Tailings do not have the potential to generate low pH leachate with elevated base metal levels and will not result in deleterious impacts on surface waters and vegetation.
- Waste rock does not have the potential to generate low pH leachate with elevated base metal levels and will not result in deleterious impacts on surface waters and vegetation.
- The operation design incorporates operating and monitoring systems such that potential for ground water contamination does not arise.
- The testing carried out within the planned tailings dam impoundment.
- The current tailings storage facility design which incorporates an under drainage system.
- An expectation that the individual studies and collected data will be consolidated and confirm the current understanding of the broad groundwater regime and verify the current assessment of the impacts of tailings and mine dewatering on the groundwater.
- Suitable rehabilitation materials are available in the quantities required at the unit rates used.
- The final land use will be determined by and will be compatible with community expectations.

13.9 BACKFILLING AND/OR RESHAPING OF PITS

The sequence of mining the pits has allowed for the placement of waste material in pits directly. This cost has been incorporated into the mining operating costs for the backfilling of the existing (brownfield) Fobinso South and Fobinso North pits. This will entail the placement 40M tonnes of waste at an extra haulage cost of $0.50/tonne for a total of USD $20,000,000 (Twenty million). Waste arising from the mining of the (brownfield) Fetish pit will be backfilled into the existing pits of the (brownfield) South Bokitsi pit complex and into the existing (brownfield) Chirawewa Main, East and West pits. The cost of backfilling the Chirawewa and related pits is approximately USD $17,000,000 (Seventeen million). Back filling of pits is expensive but has been selected as an effective alternative to building waste dumps due to the proximity of population, land use application dominating the area, the requirement for rehabilitation of previous mining activities and recognised preferred practise by stakeholders.

The pits that will not be backfilled will be reshaped prior to closure. The reshaping will see the final batter angles reduced to long term stable batters with berms located at 10 meter intervals in the oxide zone of the pit above the final water level in the pit. The pits for reshaping will be filled with water allowed to flow into the pits from the natural runoff system. The end use plan for reshaped pit will see a water body developed for fishery or agriculture. The geotechnical reports completed will be updated regularly with recommendations for the long term pit face stability at closure to be assessed progressively as the pit develops. To ensure public safety is achieved the pits will be double bunded after the pit perimeters have been reshaped to accord with Ghana EPA Akoben Mine Closure requirements. The berms will be cleared of waste rock, dressed with topsoil and seeded for long term stabilization. The overall slope angle will not exceed 65 degrees above the water table or backfilled level. The ramp will be double bunded and made safe restricting vehicle access, further the ramp will be scarified dressed with topsoil and seeded with stabilization vegetation.

13.10 ESTIMATE OF REHABILITATION COSTS

The scope of work, costing and work up of major earthworks and revegetation costs are presented. A scope of work for each major component of rehabilitation and reclamation work at site has been developed. Unit costs have been developed using the costs that have been incurred in the currently active reclamation programs at numerous mines in Ghana and extrapolating those costs to the CAGL Project. Costs have been estimated assuming that the costs will either be incurred during operations or incurred at the end of mine life.

A calculation has been made for the cost of closure and reclamation for each year of mine life. For example, should operations cease at the end of the Development year, the cost of closure (removal of built facilities and reclamation of disturbed areas) is US$6,054,465 (excluding Management and Maintenance, Monitoring of Decommission). If no mining rehabilitation works are undertaken by the end of Year 10, the cumulative cost of closure in Year 11 (after mining has finished) is US$14,407,378 (excluding Management and Maintenance, Monitoring of Decommission). If, however mining rehabilitation cost are expended annually (for a total of US$5,604,940) then the Year 11 expenditure is reduced to US$9.539,033).

13.11 CURRENT STATUS OF RECLAMATION BONDING

In 2007 the EPA accepted the AGC 2004 cost estimate and a reclamation security agreement was signed between the EPA and AGA on August 6 2007. Subsequently Perseus made a cash deposit of US$257,939 to a joint EPA/AGA account and presented the first Bank Guarantee for US$1,000,000 on August 15 2007. A second Bank Guarantee for US$500,000 was arranged in March 2008 and subsequently a third one for the same amount in July 2008. A new Reclamation Bonding Agreement will need to be negotiated with the EPA.

13.12 CAGL AND SOCIAL SUSTAINABILITY

CAGL is the process of developing an Economic and Social Development Plan. The development of an ESDP will be guided by internationally accepted principles. These include:

- The mine and its infrastructure will be planned to minimise the number of communities affected;
- The mine and associated infrastructure programme will be seen as an opportunity to develop the area and improve the livelihoods of the affected communities;
- The communities affected by development will have access to the direct benefits from the mine, for example, training and employment opportunities during the construction and operational phase, access to potable water, electricity, and other services;
- All stakeholders and affected communities will be consulted and involved in the development planning process;
- All outcomes will be negotiated.

ACKNOWLEDGEMENTS

This Environmental Impact Statement has been compiled from information provided by various professional consulting companies and individuals, from discussions with various national, regional and local government departments, traditional authorities and local leaders and inhabitants within the Project area and its environs.

Acknowledgement is made to all those that have contributed to this Environmental Impact Statement including,

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Runge Limited - - Geology and resources, pit optimisations.

Coffey Mining - Geotechnical, hydrogeology, hydrology, TFS designs, mining costs and scheduling.

John Nolan Consulting - Pit, waste dump and haul road design.

Metallurg Pty Ltd - - Metallurgical management.

AMMTEC Ltd - Metallurgical test-work.

Montessura Holdings Pty Ltd - Metallurgical review & specialist float, crusher designs.

BEC Engineering - Electrical engineering.

Southern Mining Consultants Pty Ltd – Preparation of financial models and economic assessment

Graeme Campbell and Associates – Geochemical Characterisation.

SGS Lakefield Research – Laboratory analyses.

Edward Watkin – Independent environmental consultant.

AC & E International - Social assessments.

Tagit Consult – Baseline studies.

Wassa Amenfi East District Administration.

Upper Denkyira District Administration.

Chiefs of Abnabna and Ayanfuri Traditional Areas.

1.0 INTRODUCTION

1.1. BACKGROUND INFORMATION

The Central Ashanti Gold Project (the Project) comprises a part brownfields (on industrially disturbed land) and part greenfields (land that has not been disturbed by industrial activity) development of an open pit mining operation, a process plant and related infrastructure to mine and process ore from defined reserves from a number of associated gold deposits.

1.2. PROJECT OWNERSHIP

The Project will be developed by CAGL, a mining company incorporated in Ghana. CAGL is 100 percent owned by Perseus Mining Limited, which is based in Perth, Western Australia. Following processing of the Mining Lease, the Government of Ghana will become a non-contributory shareholder by right having full entitlement to dividends and will obtain 10% of the share of CAGL in accordance with the Minerals and Mining Act (Act 703), 2006.

1.3. PROJECT LOCATION

The Project is located 16 km west of Dunkwa-on-Ofin, near the village of Ayanfuri in the Central Region of Ghana (Map 1.1). Ayanfuri lies along the sealed highway from Ghana's second largest city, Kumasi, located 107km by road to the north and the port of Takoradi, located 186 km by road to the south. Other cities located on the Takoradi to Kumasi highway include the major mining centres of Obuasi (46 km by road to the north) and Tarkwa (95km by road to the south).

1.4. DEFINITIVE FEASIBILITY STUDY

A Definitive Feasibility Study completed in July 2009 (the Study) has defined a 20 million tonne per annum contract mining operation producing 5.5 million tonnes of ore and a process plant with a processing capacity of 5.5 million tonnes per annum (Mtpa) which provides an approximate 10 year life based on the current reserves.

Mining operations will be limited to open pit mining only, using conventional excavator/truck mining methods. The process plant is based on a typical gold process flow sheet consisting of single stage semi-autogenous grinding (SAG), flotation and CIL leach.

The active Project site will encompass approximately 998 ha, which represents 10.7 % of the two Mining Leases (93.1 km^2) in which development will occur (Map 2.1).

1.5. CHANGE OF NAME

In December 2008 the name of Stratsys Investments Limited was officially changed to Central Ashanti Gold Limited (Appendix 1.5a). The Minerals Commission was officially informed of the change of name in February 2009 (Appendix 1.5b). There is no official letter from the Mineral Commission recognising the name change but subsequent correspondence between the Minerals Commission and Central Ashanti Gold Limited shows that the new name is recognised (Appendix 1.5c). Central Ashanti Gold Limited is a wholly owned subsidiary of Perseus Mining Limited.

1.6. HISTORICAL BACKGROUND

The first recorded exploration and gold production in the Ayanfuri area dates back to 1906. More recently, between November 1994 and February 2002, the Ayanfuri gold mine produced over 300,000 oz of gold from 23 shallow oxide open pits and heap leach processing with most of the production from six granite hosted ore bodies. The proposed Project is thus being developed within the boundaries of a previous mining site. The mine was placed on a care and maintenance basis until early 2004 when the then owners, Ashanti Goldfields Company, decided to close the mine permanently. As of end 2004, out of an area of approximately 389 hectares disturbed by mining activity, some 290 ha were still in need of rehabilitation, wholly or in part including a heap leach pad area of 133 ha. The proposed new development will therefore take place on an area already disturbed by large-scale in many locations (Map 1.2). A summary of the various disturbed areas is provided in Appendix 1.6.

1.7. LEGISLATIVE BACKGROUND

An Environmental Impact Assessment (EIA) for development, projects or undertakings of the type represented by the proposed Project has been a requirement in Ghana since 1989. In June 1995, the EPA set out a new procedure for carrying out EIA's involving gradual phases depending upon the nature, complexity and location of the undertaking (Ghana Environmental Impact Assessment Procedures, June, 1995). In June 1999, the revised procedures were formalised and passed by Parliament as Legislative Instrument 1652 Environmental Assessment Regulations (L.I. 1652). An Environmental Impact Statement (EIS) for the CAGL Project must be submitted to the EPA for review and be approved in order for an Environmental Permit to be issued allowing the Project to proceed on environmental grounds.

Ghana's Mining and Environmental Guidelines Final Draft, 1994 lays out in detail the environmental assessment, management and reporting requirements for both new and operating mines.

The Minerals and Mining Act (Act 703) 2006 (Gazetted March 31, 2006) replaced the previous Minerals and Mining Law, PNDCL 153, 1986. Section 18 of the former provides that:

Forestry and environmental protection
18 - *(1) Before undertaking an activity or operation under a mineral right, the holder of the mineral right shall obtain all necessary approvals and permits required from the Forestry Commission and the Environmental Protection Agency for the protection of natural resources, public health and the environment.*

(2) Without limiting subsection (1), a holder of mineral right shall comply with all applicable Regulations made under this Act and any other enactment for the protection of the environment in so far as relates to exploitation of minerals.

Proposed Legislation - Mining

In support of Act 703, Draft Regulations have been prepared and circulated for comment by interested parties. Those that include specific sections or subsections relevant to environmental and/or social matters are:

1. Draft Mines (Support Services) Regulations 2008, specifically Section 5, subsections 1, 2, and 3 – Environmental obligations of contract miners.
2. Draft Mines (Compensation and Resettlement) Regulations 2008, specifically all Sections 1 - 15.
3. Draft Mineral and Mining Regulations, 2008, specifically Section 11(3)(b) Protection of the environment.
4. Draft Mining Regulations 2008, specifically:

   Part 1, Subdivision 1.3, 1306 Emergency Response Plan,
   Part 2, Subdivision 2.2, 2206 Rehabilitation and Revegetation,
   Part 2, Subdivision 2.7, 2703 Tailings storage facility impoundment, 2708 Plans of tailings storage facilities,
   Subdivision 2.8, 2801-2804, 2807, 2810-2813 Rehabilitation and Mine Closure.

5. Draft Explosives (Mining and Civil) Regulations 2008, specifically Part 12, Monitoring of pollution and environment, and 1201 1202.

It is reasonably assumed that these Draft Regulations (notwithstanding any amendments) will be passed within the early life-of-mine. Thus, it behoves CAGL to be cognisant of the various requirements in planning its mode of operations.

Environmental Impact Assessment

An EIA for development, projects or undertakings has been a requirement in Ghana since 1989. In June 1995, the EPA set out a new procedure for carrying out EIA's involving gradual phases depending upon the nature, complexity and location of the undertaking (Ghana Environmental Impact Assessment Procedures, June, 1995). In June 1999, the revised procedures were formalised and passed by Parliament as Legislative Instrument 1652 Environmental Assessment Regulations (L.I. 1652).

According to the 1999 Environmental Assessment Regulations (LI 1652), the aim of the EIS is to provide a clear assessment of the proposed undertaking as described in the Scoping Report and Terms of Reference. The EIS should address possible direct and indirect impacts of the undertaking on the environment at the pre-construction, construction, operation, decommissioning and post-decommissioning phases. The EIS should also assess the potential impact of the development on the health of the surrounding communities. EIS's for mining and extractive industry projects should include reclamation plans. The process proposed for the Project EIA is provided in Figure 1.1.

The various Acts, Regulations, Procedures and Guidelines directly relevant to impact assessment in Ghana are presented in Table 1.1.

Table 1.1: Legal Framework for Environmental Impact Assessment and Quality in Ghana

Category	Title
Acts	The Environmental Protection Agency Act, 1994
Regulations	Environmental Assessment Regulations, 1999 (LII652)
Procedures	Environmental Impact Assessment Procedures, 1995
Guidelines	Environmental Quality Guidelines for Ambient Air (EPA) no date
	Environmental Quality Guidelines for Ambient Noise (EPA) 1996
	Ghana's Mining and Environmental Guidelines, 1994
	Quality Guidelines for Discharges into Natural Water Bodies (EPA) 1997
	Environmental Assessment in Ghana, A Guide, 1996

Acts

The Environmental Protection Agency Act (1994) establishes the authority, functions, structure and funding of the EPA.

Regulations

Environmental Assessment Regulations 1999 (LII652, sets out the requirements for environmental permitting, Environmental Impact Assessment (EIA), the production of preliminary environmental reports (PERs) and subsequent Environmental Impact Statements (EISs), environmental certificates, Environmental Management Plans (EMPs) and reclamation bonding.

Procedures

Environmental Impact Assessment Procedures (1995) produced by the EPA details the procedures to be adhered to when undertaking an EA.

Guidelines

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

Environmental Quality Guidelines for Ambient Air (EPA) provides advice on maximum permissible levels of a variety of air pollutants.

Environmental Quality Guidelines for Ambient Noise (EPA) provides advice on the maximum permissible noise levels.

Ghana's Mining and Environmental Guidelines (1994) provides guidance on environmental factors that should be considered by mine operators. It includes guidance on EIA/EIS content, EMP production and the contents of a Reclamation and Decommissioning Plan. The Guidelines do not address mining in a Forest Reserve.

Sector Specific Effluent Quality Guidelines for Discharges into Natural Water Bodies (EPA) provides maximum permissible effluent discharge concentrations for a number of parameters. Two sets of guidelines exist, i.e. general and sector specific, the latter including specific milling and mineral processing discharge standards.

Policy Documents

Environmental Impact Assessment is legislated in Ghana through LI 1652 Environmental Assessment Regulations. 1999 (see also Section 1.3.1). The legislation falls under the responsibility of the Ministry of Environment, Science and Technology under whom the EPA are the regulatory body responsible for the implementation of EIA procedures in Ghana. A description of the required process to obtain an environmental permit is presented in the box below:

Schedule I of the Regulations lists all undertakings that require EIA; with Section 5 stipulating mining as one such undertaking. This is applicable to all metal and non-metal mines. Any undertaking listed in Schedule I, is required to be registered, an EIA submitted and approved, and an Environmental Permit issued by the EPA before the undertaking can commence. The standard process for obtaining an Environmental Permit in Ghana can be summarized as follows:

(a) An application for an Environmental Permit must be formally submitted to the EPA, using either form EAI or EA2, dependent on the size and magnitude of the proposed development. Form EA2 is applicable to larger projects and those for mining projects where in almost all instances an EIA would be required.

(b) On receipt of the application, the EPA screens the application and confirms whether the application is; approved, objected to, requires submission of Preliminary Environmental Report (PER), or requires the submission of an Environmental Impact Statement (EIS). The purpose of a PER is to provide the EPA with more information from which the need for an EIS would be evaluated. Where the EPA approves an application, an Environmental Permit would be issued. Where either a PER or EIS is required, this will be notified to the applicant within 25 days.

(c) Where an EIS is required, the first undertaking is to produce a scoping report outlining the extent and terms of reference, including the essen6al issues to be addressed in the EIA. The scoping report is submitted to the EPA who in turn will notify the applicant, within 25 days, whether the report has been approved. Should the report not be approved, the applicant may revise and re-submit.

(d) Where the EPA accepts the scoping report, the applicant is required to:

(a) give notice of the proposed undertaking to the relevant Ministries, government department and

organizations of relevance to the undertaking;

(b) *advertise in at least one national paper;*

(c) *make the scoping report available for inspection by the public in the locality of the proposed undertaking.*

(d) *An EIS is also required based on this approved report. The EIS comprises the following sections:*

- *EA Report (the EIA);*
- *Environmental Management Plan (EMP);*
- *Reclamation Plan;*
- *Provisional Decommissioning Plan.*

(e) *Twelve copies of the completed draft EIS should be submitted to the EPA, and other Agencies as directed by the EPA, for review.*

(f) *On receipt of the draft EIS the EPA will, in accordance with Schedule 4 of LI 1652, publish notice of the report in the mass media. The cost is borne by the applicant. Where it is considered necessary by the EPA, a public hearing will also be held.*

(g) *The draft E1S is then subject to review by the EPA, and recommendations arising from the public hearing would be considered. The applicant is notified whether the report is acceptable or whether it needs to be revised or additional surveys undertaken. Where the draft E1S is accepted, the Environmental Permit win be issued on receipt of electronic and eight hard cover copies of the approved E1S report. .*

(h) *The period to determine an application for an Environmental Permit shall take no more than 90 days, except where a public hearing is held or a PER is required. The 90 days also excludes the time taken to prepare and submit the E1S. Also at this stage, for mining projects, the EPA requires a reclamation bond to be posted based on the Costed Reclamation Plan within the E1S.*

(i) *Where an Environmental Permit is granted, it is valid for 18 months and failure to commence the operation of the undertaking within this time would render the permit invalid. For mining projects, operations are considered to be the commencement of the construction phase.*

(j) *Where activities are initiated, an environmental certificate is required within 24 months of the date of commencement of the operations. An environmental certificate requires the following to be submitted to the EPA:*

- *evidence of the commencement of operations;*
- *acquisition of other permits and approvals where appropriate;*
- *compliance with mitigation commitments stipulated in the E1S;*
- *a certificate fee.*

(k) *For mining project the EPA also required the following for the duration of the operations:*

- *monthly monitoring returns;*
- *an annual environmental report, initially every twelve months after the commencement of operations and thereafter, every calendar year;*
- *an EMP, eighteen months after the commencement of operations and thereafter every three years.*

(l) *The EPA may suspend or revoke an environmental permit or certificate, if it is necessary.*

Land and Resettlement

A mixture of common law and customary land law governs land tenure and title in Ghana. Land holdings in Ghana are classified as follows:[1]

- Customary owned
- State owned

1 World Bank/Republic of Ghana Ministry of Lands and Forestry Ghana Land Administration Project, Resettlement Policy Framework.

- Customary owned but state managed lands (also known as vested lands)

Within and around the CAGL Project Area, Customary Ownership is the predominant landholding out of the three types of land holding mentioned above.

Customary ownership occurs where the right to use or to dispose of use-rights over land is governed by the customary laws of the land owning community, based purely on recognition by the community of the legitimacy of the holding. Rules governing, the acquisition and transmission of these rights, which vary from community to community depending on social structures and customary practices, are normally not documented but are generally understood by community members.

The Allodial title, equivalent to common law freehold rights, forms the basis of all land rights in Ghana. Allodial rights are vested either in a stool, a clan, a family, an earth priest or a private individual person. Lesser interests, such as tenancies, licenses and pledges, emanate from the Allodial title.

Customary land is managed by a custodian (a chief or a head of clan or family) together with a, council of principal elders appointed in accordance with the customary law of the land owning community. They are accountable to the members of the land owning community for their stewardship. All grants of land rights by the custodian require the concurrence of at least two of the principal elders for the grant to be valid. Customary ownership predominates in the Project Area, which is legally vested in the government.

State land includes tracts specifically acquired by government under an appropriate enactment using the state powers of eminent domain. Currently, the principal acquiring legislation is the State Lands Act of 1962, Act 125, for public purposes or in the public interest.

Vested lands are lands owned by a stool or skin, but managed by the state on behalf of the land owning stool or skin. Under such ownership the legal rights to sell, lease, manage, collect rent, is taken away from the customary landowners by the application of specific laws on that land and vested in the state. The landowners retain the equitable interest in the land i.e. the right to enjoy the benefits from the land.

The doctrine of eminent domain gives the Government the power to seize private property - including stool, skin or family land for public use, by proving that doing so will be in the best interests of its citizens. The Government has used the power in the past to establish state farms, the Volta Lake project, and other infrastructure projects. Under eminent domain legislation and the Constitution (Article 20), the Government is required to pay compensation for improvements to land, but not for land itself, or for associated inconvenience. The practice commonly employed by mining companies, whose lease rights supersede those of local land users, is to provide one-time payment for surface rights.

Resettlement is not specifically addressed by current Ghanaian legislation. However, the Draft Mines (Compensation and Resettlement) Regulations 2008 is pending legislation providing procedures for resettlement and relocation programmes by mining companies.

1.8. SCOPING REPORT & TERMS OF REFERENCE

The EIA process for the Project began in late 2008 when a draft Scoping Study and Draft Terms of Reference (TOR) for the Project and dated November 2008 was presented to the Ghana EPA for review and comment. The TOR was submitted under the name of Stratsys Investments Limited.

The Scoping Study and Draft TOR for the EIA were accepted by the EPA and authorisation to commence preparation of an EIS was granted (Letter from EPA, Reference CM42, dated February 4, 2009 - Appendix 1.9).

1.9. PREPARATION OF THE ENVIRONMENTAL BASELINE STUDIES

The environmental baseline studies were undertaken in March through May 2009. Individual national consultants drawn from the private sector, universities and government institutions were utilised. The environmental baseline studies provided a detailed description of the existing atmospheric, water (hydrology and water quality), biological (flora and fauna), land (soils and land use), and socio-economic characteristics of the Project Area.

1.10. OBJECTIVES OF THE EIS

The objectives of this EIS are as follows:

1. To provide a detailed description of the proposed CAGL Project as well as the findings of the environmental and socio-economic baseline studies.
2. To assess the significance of environmental and socio-economic issues associated with the development, operation and closure of the proposed Project.[2]
3. To provide a description of mitigation measures to reduce potential negative impacts and enhance positive impacts of the proposed Project.
4. To provide a Monitoring Programme to be implemented during the entire life of the proposed Project to monitor the impact on the environment.
5. To provide a Provisional Environmental Management Plan to minimise the impact of the mine on the surrounding environment.
6. To provide an acceptable Closure and Decommissioning Plan to minimise the impact of the proposed Project on the surrounding environment once the mine is closed.
7. To provide a Conceptual Rehabilitation Plan for implementation during the operation of the proposed Project.
8. To meet the requirements of the EPA for the permitting of CAGL's mine in Ghana.

1.11. INTERNATIONAL GUIDELINES

The design of the Project and its subsequent implementation has taken into consideration various guidelines published by the World Bank Group/International Finance Corporation. These include the Environmental, Health & Safety Guidelines – Mining (December 2007) and the Performance Standards on Social and Environmental Sustainability (July 2006). Further, the principles contained in the "Equator Principles" have also been used as additional benchmarks for project design and implementation of environmental and social sustainability. The Communities Consultation programme that is in progress has drawn extensively on the principles and guidelines described in "The Community Development

[2] A Public Hearing was held following submission of the Draft EIS in mid-September 2009. This has enabled feedback from stakeholders to be taken fully into consideration in the preparation of this report. Feedback from the public hearing is discussed in Section 3.10.15 of this document. Communication has also been on-going with the EPA, Minerals Commission and Minerals Commission Inspectorate Division throughout the EIA process via meetings held in Accra. Feedback from these meetings and site visit has been addressed and incorporated into the overall project design and the assessment presented within this EIS report.

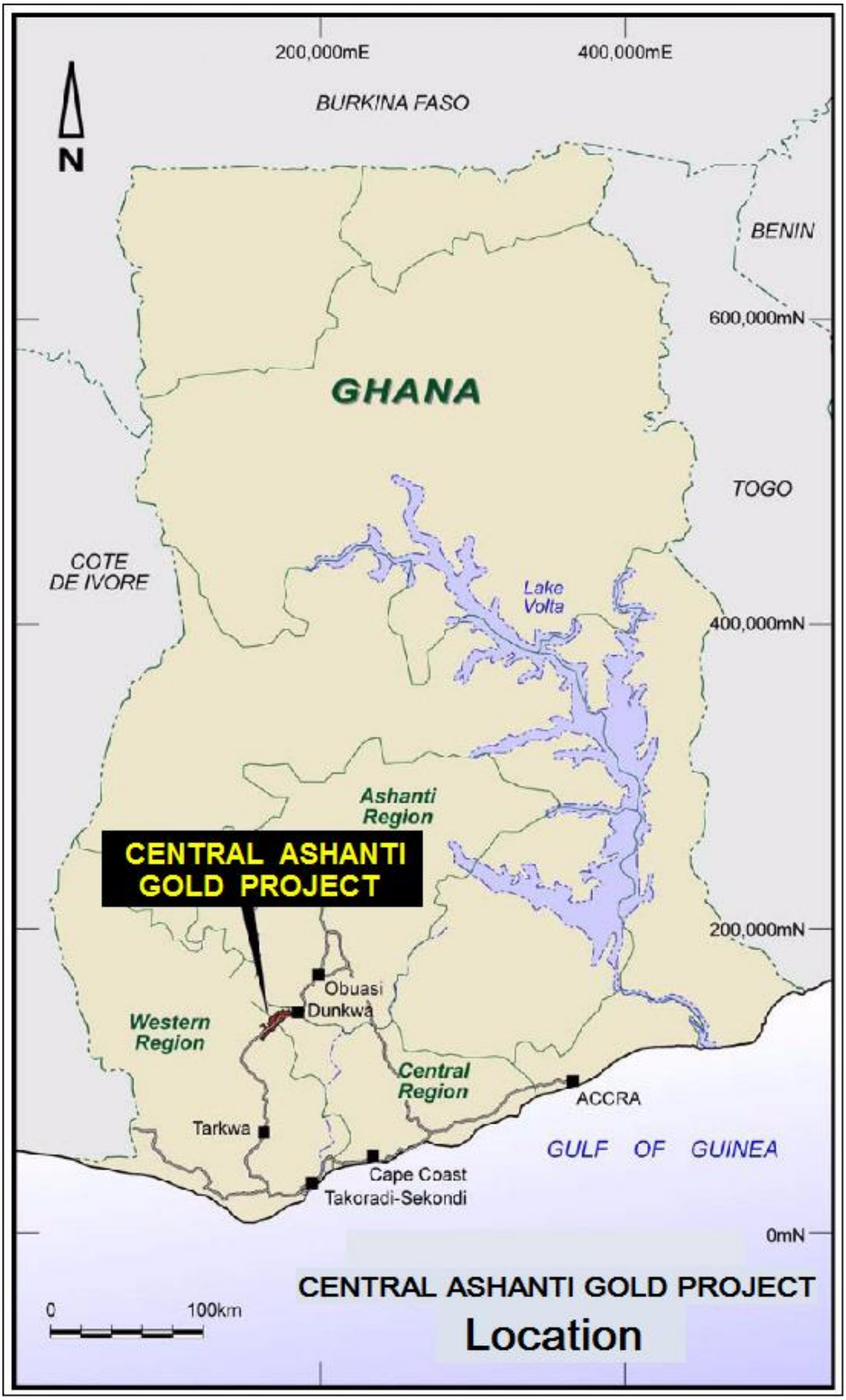
Toolkit" jointly produced by the International Council on Mining & Metals, World Bank and ESMAP and published as ESMAP Formal Report Series, Report No. 310/05, October 2005.

1.12. LAYOUT OF THE DOCUMENT

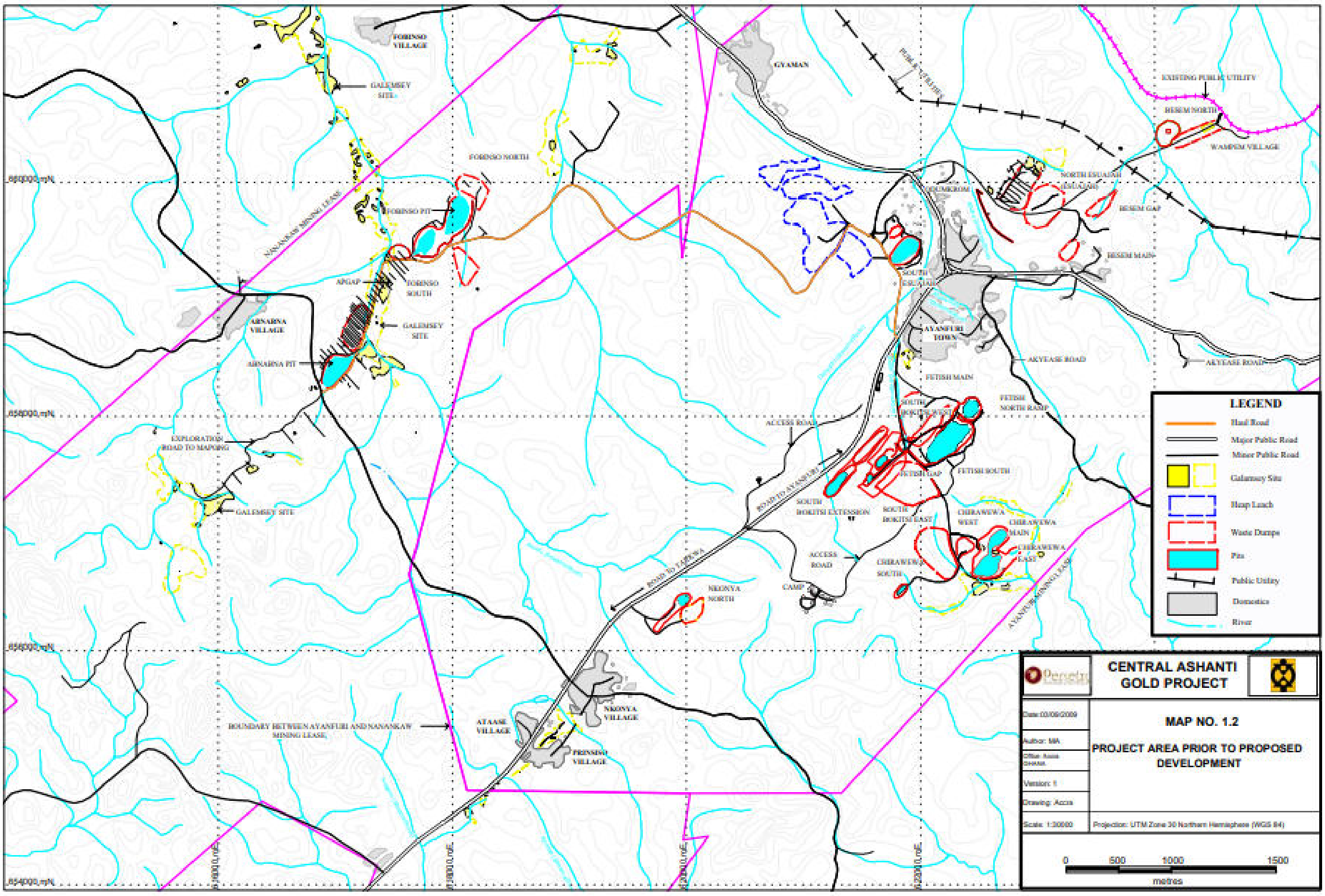
The document consists of a series of chapters describing various aspects of the EIS:

Chapter 1:	Introduction (this chapter)	Chapter 6:	Monitoring Programmes
Chapter 2:	Description of the Project	Chapter 7:	Provisional Environmental Management Plan
Chapter 3:	Baseline Studies	Chapter 8:	Closure and Decommissioning Aspects
Chapter 4:	Assessment of Impacts	Chapter 9:	Conceptual Rehabilitation Plan
Chapter 5:	Mitigation Measures		

Map 1.1: General Location of the CAGL Project



Map 1.2: Project Area Prior to Proposed Development



2.0 PROJECT DESCRIPTION

2.1 INTRODUCTION

The Project will consist of construction, operation, and decommissioning (including reclamation) phases for a conventional open cut mining operation owned by Central Ashanti Gold Limited (CAGL). Five (5) gold deposits named as Abnabna, AF Gap, Fobinso, Esuajah North and Fetish will be mined. Ore will be treated by the Gravity Flotation Intensive Leach (GFIL) process.

The Project description that follows has been based on information extracted from the Detailed Feasibility Study prepared by Mintrex, a mining engineering specialist that is the consulting division of Holtfreters Pty Ltd – Engineers and Project Managers – with headquarters based in Western Australia.

Other information has been included following the review of the Scoping Report and Terms of Reference by the EPA. In addition, information relevant to the environmental aspects of the Project has been inserted, where appropriate, in various paragraphs of this chapter.

2.2 PROJECT OWNERSHIP

The Project will be developed by CAGL, a mining company incorporated in Ghana. CAGL is 100 percent owned by Perseus Mining Limited, which is based in Perth, Western Australia. Following processing of the Mining Lease, the Government of Ghana will become a non-contributory shareholder by right having full entitlement to dividends and will obtain 10% of the share of CAGL in accordance with the Minerals and Mining Act (Act 703), 2006.

2.3 PROJECT LOCATION

The Project is located 16 km west of Dunkwa-on-Ofin, near the village of Ayanfuri in the Central Region of Ghana (Map 1.1). Ayanfuri lies along the sealed highway from Ghana's second largest city, Kumasi, located 107km by road to the north and the port of Takoradi, located 186 km by road to the south. Other cities located on the Takoradi to Kumasi highway include the major mining centres of Obuasi (46 km by road to the north) and Tarkwa (95km by road to the south).

2.4 CAGL LEASES

The current CAGL Mine Leases are located in the Central Region of Southern Ghana and are located on the eastern flank of the highly prospective Ashanti Belt. They are located 6.3km west to 30.7km south west of Dunkwa-on-Ofin and 30km to 57km south west of Obuasi.

Currently, the Company holds two Mining Leases – the Ayanfuri Mining Lease and the Nanankaw Mining Lease (Map 2.1). The two Leases are 42.9 km^2 and 43.93 km^2 respectively. It also holds one Prospecting Licence, Dadieso PL (29.33 km^2 which abuts the southern end of the Nanankaw ML (Map 2.1). The Mineral Commission have provided a letter of confirmation of the 12 month extension of the ML's date from the date of the letter of confirmation 23rd June 2009. The Minerals Commission records all three items under Registration No. 1110/1994.

Project development will occur within the southern half of the Ayanfuri ML and the northern arm of the Nanankaw ML.

2.5 HISTORICAL DEVELOPMENT

The first recorded exploration and production in the area occurred in 1906; however, detrital gold deposits were probably exploited for many centuries to supply the Ghanaian palaces and more recently the European traders. Considerable exploration and small scale mining was undertaken during the 1898-1901 gold rush, mainly around Princiso and Ataasi. The Ataasi shear zone hosted gold deposit is located proximal to and below the Princiso village located 5km south west of the town of Ayanfuri. The Ataasi mine recorded production of over 13,000oz of gold between 1906 and 1908.

Three principle phases of exploration have been undertaken at Ayanfuri since 1988. The first was initial discovery and predevelopment drilling undertaken by Cluff Mining plc ("Cluff"), the second was the exploration of secondary targets to locate additional ore feed undertaken by Ashanti Goldfields Corporation Limited ("Ashanti") after they acquired Cluff and the third phase was the post mine closure exploration undertaken by Perseus Mining Limited ("Perseus") during the acquisition from AngloGold Ashanti Limited ("AGA").

The Ayanfuri gold mine produced over 300,000 oz of gold from 23 shallow oxide open pits and heap leach processing between 1994 and 2001, with most of the production from six granite hosted ore bodies ranging from 200m to 500m long and 30m to 120m wide. The Ayanfuri heap leach operation was limited to processing oxide ore and ceased operations when gold prices were around US$270 per ounce and most of the oxide ore in the larger deposits was depleted.

There was a widely held industry assumption that the Ayanfuri mine only had limited sulphide potential due to weaker sulphide gold grades. Perseus undertook a statistical review of the oxide and limited sulphide drill data and concluded that the grade averages were in fact similar and that there were no notable horizons of oxide enrichment. Subsequent deeper drilling by Perseus resulted in the discovery of an additional 1.8Moz of gold within 12 months.

2.6 GEOLOGY OF THE AREA

2.6.1 Regional Geology

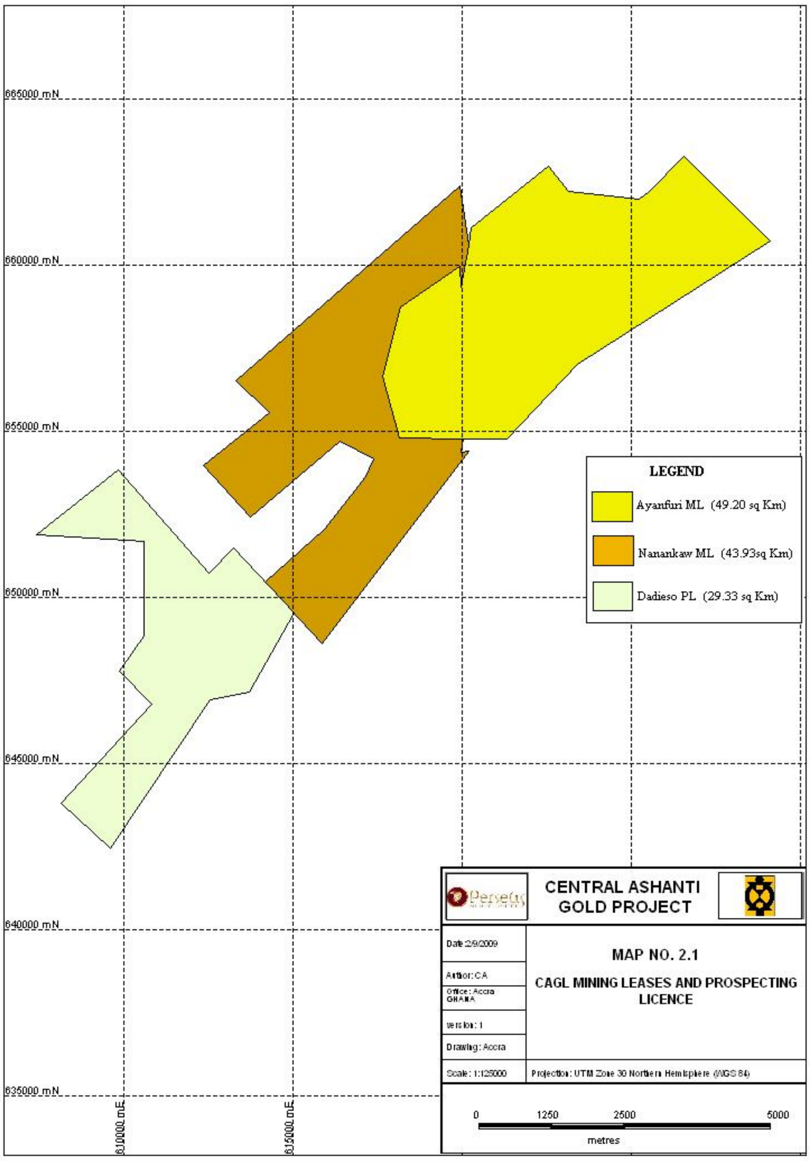
The Central Ashanti group of deposits is situated on the Obuasi – Akropong portion of the Ashanti Gold Belt in Ghana, West Africa some 25km-65km south west of the world class Obuasi Au deposit.

The property is underlain principally by Paleoproterozoic Birimian flysch-type metasediments consisting of dacitic volcaniclastics, greywackes plus argillaceous (phyllitic) sediments, intensely folded, faulted and metamorphosed to upper greenschist facies. Numerous small "Basin-type" or "Cape Coast-type" granite bodies have intruded the sediments along several regional structures. The intrusive shapes vary from nearly ovoid plugs 200m to 400m long by 40m to 150m wide to relatively long (+2,000m) narrow (50m-100m) sills or dykes.

2.6.2 Local Geology

Gold occurs at Ayanfuri both in classic Ashanti-style sediment hosted shear zones, and within granitic plugs and sills or dykes situated along two or three regional shear structures. In excess of 24 known gold occurrences occur on the Ayanfuri property. Granitic intrusives host the majority of these and more than 80% of the known gold resource. While the latter deposits formed in a predominantly ductile regime with generally discontinuous, pinch and swell higher grade (on average) gold shoots, the granite hosted occurrences developed in a brittle rock and tend to be significantly broader with more evenly distributed, though lower grade gold tenor.

Map 2.1: CAGL Mining Leases and Prospecting Licence (Minerals Commission 1110/1994)



Most of the known gold resource at Ayanfuri is hosted by the granite plugs and sills or dykes, which occur along the same structures that contain the sediment shear hosted gold occurrences.

The bulk grade of the granitoid hosted gold resource defined to date in six deposits is just under 1.5 g/t Au, while that defined in sediments averages more than 1.8 g/t Au.

Gold mineralisation occurs in two to three generations of quartz veins and stockworks with individual veins millimetres to centimetres in thickness and rarely more than a metre thick. The gold is associated with < 3% pyrite, lesser arsenopyrite and traces of sphalerite, chalcopyrite, galena and rutile. Gold occurs as very fine grains often along sulphide grain boundaries and in fractures in sulphides, usually at or near vein margins and coarse visible gold is occasionally observed in the quartz. Higher grade gold intercepts often tend to be associated with very coarse arsenopyrite +/- sphalerite, chalcopyrite and galena.

2.7 MINERAL RESOURCE STATEMENT

The Mineral Resource estimates for the Central Ashanti Project were prepared by Runge between January and March 2009. The project comprises a number of discrete Au resources as shown in table 2.1. Many of the resources are within deposits which have been previously mined to shallow levels by open pit. A total Proved and Probable Mineral Reserve of 55.5Mt at 1.20g/t for 2.1Moz has been defined.

The CAGL resource estimation has been assigned a resource classification based on the assessment criteria in the Australian Code for Reporting of Identified Mineral Resources and Ore Reserves, published by the Joint Ore Reserves Committee (JORC) in September 1999. The resource estimate has been extensively validated both visually and with various statistical methods and is considered to be robust. During the validation, investigation and review of the appropriate methods of resource classification were considered in detail.

Table 2.1: CAGL: Mineral Resource Estimate (Gold) - Total Resource Summary > Than 0.4g/t Au

Deposit	Measured			Indicated			Inferred			Total		
	Tonnes (000's)	Au g/t	Au Ounces (000's)	Tonnes (000's)	Au g/t	Au Ounces (000's)	Tonnes (000's)	Au g/t	Au Ounces (000's)	Tonnes (000's)	Au g/t	Au Ounces (000's)
Abnabna/Fobinso	19,990	1.30	867	20,520	1.10	719	16,320	1.00	514	**56,840**	**1.10**	**2,099**
Esuajah North				20,170	0.90	578	9,230	0.70	214	**29,400**	**0.80**	**792**
Esuajah South				6,900	1.70	377	5,590	1.80	315	**12,480**	**1.70**	**692**
Fetish				17,480	1.10	598	8,070	1.40	360	**25,550**	**1.20**	**958**
DFS Resources	**19,990**	**1.30**	**867**	**65,080**	**1.10**	**2,272**	**39,210**	**1.10**	**1,402**	**124,280**	**1.10**	**4,541**
Ataasi				340	2.60	28	200	2.80	18	**540**	**2.70**	**46**
Chirawewa				0	0.00	0	12,520	0.80	341	**12,520**	**0.80**	**341**
Mampon				0	0.00	0	6,880	0.90	209	**6,880**	**0.90**	**209**
Dadieso				0	0.00	0	3,200	1.60	162	**3,200**	**1.60**	**162**
Other Resources				**340**	**2.60**	**28**	**22,800**	**1.00**	**730**	**23,140**	**1.00**	**758**
Total	**19,990**	**1.30**	**867**	**65,420**	**1.10**	**2,300**	**62,000**	**1.10**	**2,132**	**147,410**	**1.10**	**5,300**

2.8 SPATIAL REQUIREMENTS

2.8.1 Factors Determining Project Size

Many factors may affect the size of the CAGL Project. It is especially important that these factors be considered when determining the potential size of the area required for the mine pits. The DFS is based on the expected gold price, the proven ore reserves, recovery of gold from the ore and the expected cost to build and operate the Project. While it is possible that the Project size could reduce, there is an equal or better potential to increase the Project size.

The following is a list of typical factors that may change the Project size:

- Gold price - has increased since the DFS and could expand the Project;
- Capital Cost,
- Operating cost,
- Increase in ore reserves due to knowledge gained during mining.

All these factors and more will be revised in the detailed design and budget for the operation. However, as occurs with many gold mines, the ore reserves often increase as more information is gained during the actual mining. Normally, this would result in a revision of the impact statement and environmental permit. For the purposes of this Impact Statement where it pertains to the pits, there has been an estimate made as to the maximum size of the pits in the foreseeable circumstances.

2.8.2 Minimum and Maximum Project Size Development

For the purpose of this environmental assessment, the land take required for maximum development scenario of mining and the various infrastructures will be approximately 1016 ha, which represents 10.9 % of the two ML areas (93.1 km^2). The approximate total area of land required by the various project facilities is presented in table 2.2.

The total land take of 1016 ha is made up of 132 ha resulting from the expansion of three existing pits and the development of the new AF-Gap pit, 307 ha from the construction of new rock waste dumps and 566 ha from the construction of new facilities required for ore processing, tailings disposal and various operations support facilities. The largest facility will be the flotation tailings storage facility at 339 ha.

The projected requirement of previously undisturbed land (greenfield) for the Project is 565 ha (Table 2.2).

At the time of the AGC decision to close out the Ayanfuri Project in 2004, approximately 376 ha had been utilised since operations began in early 1994. Utilisation had largely comprised 154 ha of pits, 73 ha of waste dumps and 133 ha of heap leach material within the Ayanfuri and Nanankaw Mining Leases. The CAGL Project will directly incorporate approximately 156 ha of formerly active areas (pits and waste dumps) into the development of the new project.

2.9 LOCATION OF VARIOUS FACILITIES

The location of the various facilities that constitute the Project is shown in Map 2.2.

2.10 PROJECT IMPLEMENTATION

The project construction will be managed by the Perseus Mining Ltd Project Manager for the Central Ashanti Gold Project. The General Manager–Operations in Ghana has now been appointed.

The project implementation is based on a Lump Sum Turn Key contract to be undertaken by a joint venture between DRA Mineral Projects, South Africa (Plant Design and Control Engineers) and Group 5 (an international construction company). The majority, if not all, of the construction subcontractors will be Ghanaian companies.

In reference to the engineering, equipment and material selection, construction of, and ultimate operation of the Central Ashanti Gold Mine, Central Ashanti Gold Limited will comply with:

1) All requirements of the Minerals and Mining Act 2006 (Act 703), all regulations under the Act and subsequent new regulations when gazetted by Parliament. Similarly a review of any Ghanaian standards appropriate to the operation shall be undertaken prior to commencement of processing.

2) The Project will adhere to all mining safety requirements of the Draft Mining Regulations 2008 Part 5 (Safety of Workman).

The Project is expected to take 12 months to commencement of commissioning from the award of the Environmental Protection Agency permit.

Table 2.2 Land Area Required Mining, Process and Support Facilities

Facility	AGC Area (Ha)	Not in Project	CAGP Area (Ha)	Increase Brownfield	Decrease Brownfield	Greenfield
PITS						
Abnabna	8		49.7	29		
AF Gap						
Besem North	15	15				
Besem Gap (part of Esuajah North Dump)	5					
Besem Main (part of Esuajah North Dump)	5					
South Bokitsi West (Backfilled)	4				4	
South Bokitsi W. Extension (Backfilled)	4				4	
South Bokitsi East (Backfilled)	3				3	
South Bokitsi East Ext (Backfilled)	1				1	
Chirawa Main (Backfilled)	25				25	
Chirawa South	1	1				
Chirawa West (Backfilled)	10				10	
Chirawa East (Backfilled)	2				2	
North Esuajah	15		22.3	3		
South Esuajah	5	5				
Fetish Main (Backfilled & rehabilitated)	15	15				
Fetish	17.5		32.4	5.5		
Fobinso North (Backfilled)	7					
Fobinso South (Backfilled)	6.4		27.6		47	
Nkonya	5	5				
Total Pit	**154**	**41**	**132**	37.5	96	
HAUL ROADS	**16**	**16**	**12**			**12**
WASTE DUMPS						
Abnabna/AF	5		57.5			32
Besem North	5	5				
Chirawewa	11	11				
North Esuajah	18		97.3			48
South Esuajah	1	1				
Fetish Main (Rehabilitated)	6				25	
Fetish	15		102		45	74
Fobinso North	3.5		50			49.5
Fobinso South	3.5	3.5				
Nkonya	5	5				
Total Waste Dumps	73	25.5	306.8		70	203.5
Leach Pads	**133**	**133**				
CAGP FACILITIES (New)						
Flotation TSF			339.4			339.4
CIL TSF			13.7			13.7
Process Water Pond			2.5			2.5
Plant Site Area/MC Area			22.3			22.3
Substation			1.7			1.7
Eastern Mine Ore Piles			12			12
Miscellaneous			10			10
ROM Pad/ Magazine			118.7			118.7
Nkonya Access Road			2.6			2.6
Abnabna Road Diversion			14.3			14.3
Asuafa Diversion channel			14.7			14.7
Sediment Control (Inc drains)			4			4
Power line to plant site			8.8			8.8
Total New Facilities			**564.7**			**564.7**
Grand Total	**376**	**190**	**1016**	**38**	**166**	**780**

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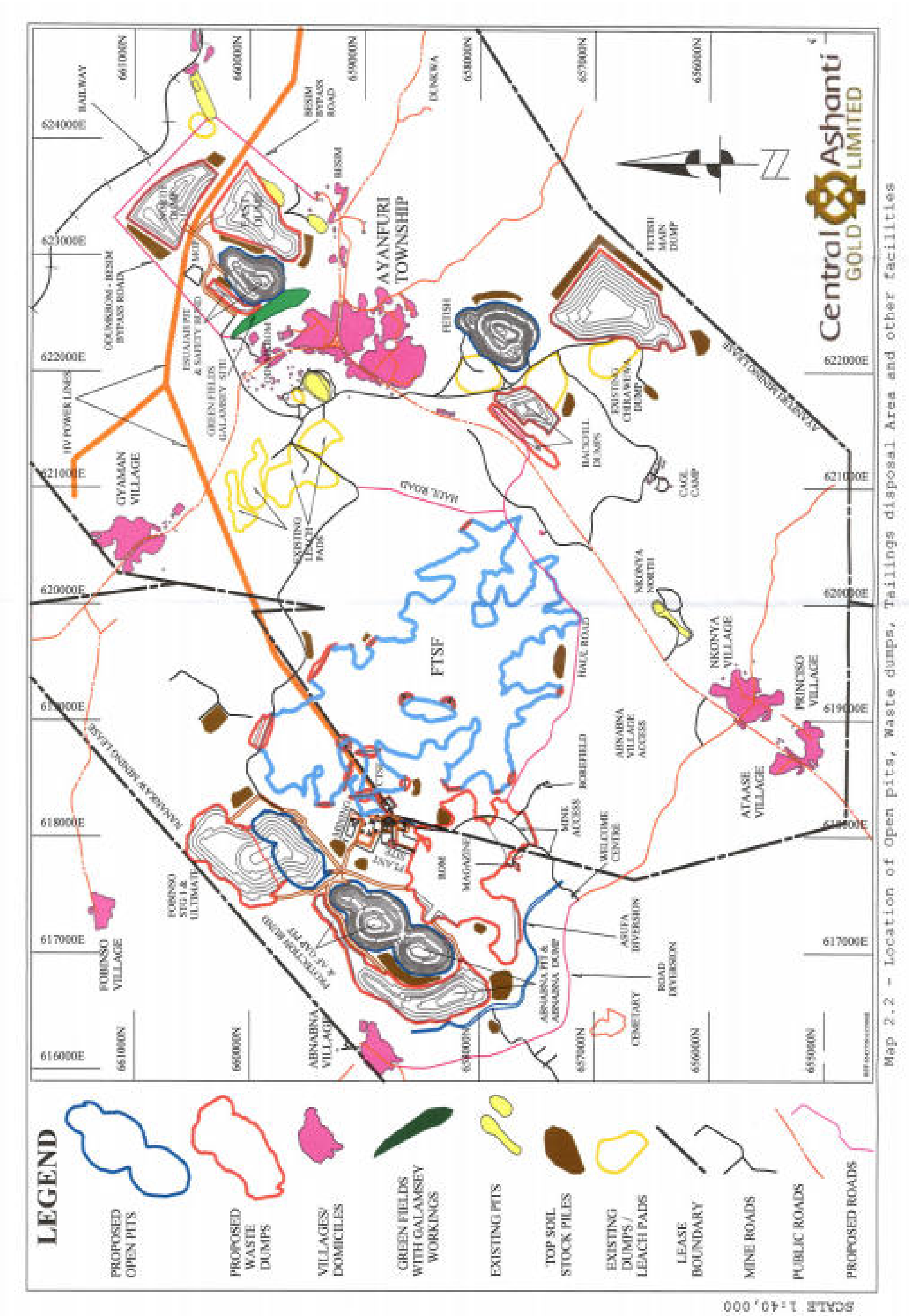
Map 2.2: Location of Open Pits, Waste Dumps, Tailings Disposal Area and Other Facilities



2.11 SITE PREPARATION AND CONSTRUCTION PHASE

2.11.1 General

The construction phase or overall development time will take approximately 12 months. This phase will begin with site preparation activities and mining of 2.1M^3 to obtain waste material for construction purposes. This phase is typically planned to occur during the first dry period of Year 2010. This should ensure that impact due to soil erosion is minimised, particularly in regard to a potential increase in the level of suspended solids in the local water bodies.

The major construction phase will include the following sequential steps:

1. Compensation of farms and negotiated access to the site for the western area only.
2. Preparation of the access road to the main Project site which will involve development of a temporary access road cut from near the Fobinso pit to the plant site approximately 800m.
3. Clearing and earthworks for the infrastructure development at the plant site.
4. Delivery to site of plant components and erection.
5. Compensation for mining areas commencement of mining at AF-Gap.
6. Development of haul roads and mine infrastructure.
7. Tailings Dam embankment and CIL Tails TSF.
8. Refurbishment of the current accommodation village.
9. Construction of offices mess and infrastructure at the site.
10. Commissioning and commencement of operations.

Site preparation activities will involve clearing of vegetation, cutting and sale of marketable timber, use of scrap wood and branches as brush barriers for sediment control where applicable, and chipping of unsuitable or excess wood and branches for mulch. The Concessionaire of the Abnabna Off Reserve Stool Land for harvesting of economic trees is Amigros International Co. Ltd, P.O. Box 8265 Accra North, Accra.

Topsoil is a valuable natural resource and as such, topsoil will be stripped and stockpiled for later use during revegetation activities. Some stockpiled topsoil will be used during construction period revegetation activities while the bulk of the topsoil will be maintained for dump closure and final reclamation use. Topsoil stockpiles will be vegetated with native grasses (e.g. *Panicum maximum*, *Cynodon nlemfuensis*, *Chloris gayana*, *Andropogon gayanus*, *Bracharia ruziziensis, Tripsacum luxum, Setaria sphacelata* and *Cenchrus ciliaris)* to stabilise stockpile outslopes and to minimise erosion and soil loss.

Clearing of the various sites will be a gradual process and will not exceed the surface of the area required for each of the facilities. It will not be necessary to clear the entire surface footprint of the waste dumps in one operation, as waste rock is produced and stored progressively from the beginning to the end of the life of the Project.

Site preparation activities that involve clearing, grubbing and topsoil stripping and stockpiling will be co-ordinated by the Environment Officer to minimise any negative impacts on local communities and the environment in general.

All contractors involved in earthwork activities will be required to submit an Environmental Management Plan (EMP) for specific phases of work. The EMP will present a strategy for minimising clearing activities to the extent possible; limiting soil erosion, describing the revegetation requirements for a particular area; and presenting an appropriate inspection program that defines environmental success criteria which will lead to an approved closure of each phase of work.

Stockpiled topsoil will be used for revegetation requirements to stabilise structures such as embankments or structural earth works and to provide a suitable growth medium during reclamation activities. Additional site clearing during operations will also involve segregation and stockpiling of topsoil (see Map 2.2 for proposed topsoil stockpile locations).

2.11.2 Access to the Project Area

The existing main access is from the dirt road which begins at Nkonya village on the Ayanfuri to Bogoso bitumen highway and which serves Abnabna village (Map 2.2) and other villages beyond. The junction at Nkonya is not considered suitable for heavy vehicle traffic that will serve the Project during construction and operation. Slow moving and turning traffic onto the current access road could provide a hazard to fast moving traffic from the north because of the road grade. Additionally, the Nkonya junction is an active area with taxi stands, commercial businesses and chop bars (see photo below).

Nkonya Junction - photo looking to road to Abnabna village

A new intersection with the highway will be constructed approximately 350 metres north of the existing junction to improve road safety visibility and to move it away from the Nkonya village activities. This upgrade will require the construction of approximately 0.8 km of new road to link up with the existing dirt road (Map 2.2) and has been designed by the Department of Feeder Roads.

The existing dirt road will then be upgraded for 2.1 km to an eight metre wide gravel, all weather, and free draining carriageway. Culverts will be required to be installed for the several small unnamed stream crossings that the road will traverses. Fill material for the upgrade will be obtained either from an excavated mining pit, or excess material from the plant site earthworks.

At the end of the 2.1 km upgrade the road will be split into two new roads. They will be a 1.9 km plant site access road and a 3.4 km Abnabna village access road. These two roads are required to eliminate access through the mine working areas. The new road alignments are shown on the overall project layout plan (Map 2.2).

2.11.3 Clearing Activities

Preparation of the various sites for Project facilities (waste dumps, two tailings dams, treatment plant and mine service area) will start concurrently to the construction of the access road upgrade. In the greenfield areas (see table 2.2) this will involve activities such as felling of trees, clearing of vegetation, stockpiling of wood and branches, where applicable segregation and stockpiling of topsoil and where necessary surface compaction. Stockpiled topsoil will also be used for early revegetation purposes required to stabilise certain structures such as embankments or earth mounds. In previously highly disturbed areas (see table 2.2) activities will be on a lesser scale. The location of the topsoil storage areas is shown on Map 2.2.

The activities of clearing, grubbing and topsoil segregation will be co-ordinated by CAGL's Environmental Department to minimise the negative impacts on the environment and local community.

It must be pointed out that deforestation or vegetation clearance of the various sites will be a gradual process and will not exceed the surface of the area required for each of the Project facilities. For example, it will not be necessary to clear the entire surface of the waste dumps as waste rocks are produced and stored progressively from the beginning to the end of the life of the Project. Similarly, mining of the northern deposits and associated clearing activities will not start before year three of the Project.

2.11.4 Construction Accommodation

The existing exploration camp will be upgraded to serve as single status accommodation camp for CAGL personnel. Contractor construction staff will use hotel accommodation and private rental accommodation in Dunkwa-on-Ofin.

2.11.5 Sources of Construction Material

The Project will require various types of construction materials. These are listed as follows:

- The tailings embankment and other stabilisation structures will be constructed using waste material from the Abnabna/ AF Gap and Fobinso open pits and low permeability fill from borrows located within the valley of the tailings and water storage facilities. Waste material will also be used for the construction of the access and site roads.
- Small quantities of sands and gravels are available from the areas worked by illegal miners near the AF Gap Pit. The area where these materials are present will be excavated as part of the mining in the AF Gap Pit.
- Other materials such as concrete, reinforcing steel, tankage, mechanical equipment, instrumentation, building fitting, etc., will be purchased locally where available or imported where quality and/or quantities of items are not available within Ghana.
- Other materials such as concrete, reinforcing steel, tankage, mechanical equipment, instrumentation, building fitting, etc., will be purchased locally where available or imported where quality and/or quantities are not available within Ghana.

2.12 MINING AND WASTE DISPOSAL

2.12.1 Introduction

The mining study has been managed by Perseus staff with the assistance of Runge Mining, Coffey Geotechnics and Coffey Mining as well as selected independent consultants. This approach was adopted as it ensures the ownership of the mine design remains with Perseus. The mining study has been compiled by Perseus with contributions as follows:

- Resource review and preparation for optimisation by Runge Mining;
- Optimisation input parameters by Perseus Mining Team (PMT);
- Optimisation works completed by Runge Mining;
- Pit Design and Scheduling completed by PMT assisted by independent Consultants;
- Operating Costs: earthmoving by Coffey Mining, other by PMT;
- Capital estimates: earthmoving by Coffey Mining, other by PMT; and
- Report preparation jointly prepared by Coffey Mining and PMT.

The resource models have been updated and utilised to identify areas for metallurgical sampling to provide input into the updated metallurgical recovery model.

Coffey Mining were commissioned to train site geological staff in geotechnical logging resulting in all core drilling being logged and orientated allowing for a comprehensive geotechnical database for the DFS geotechnical assessment of the wall conditions. This work was coupled with specifically located drill holes to provide samples for rock quality assessment and to finalise the data set for the geotechnical wall slopes assessment completed by Coffey.

Coffey Geotechnics were commissioned to complete a DFS assessment of the groundwater conditions and to make recommendations for the dewatering of the pits.

2.12.2 Mining Method and Equipment

Under the supervision of CAGL's Mining Manager and Production Superintendent, the mining will be undertaken by a mining contractor, selected through a tender process, who will be responsible for site preparation, haul-road construction and maintenance, load and haul of ore to the ROM pad and waste material to form waste dump. The technical services comprising of mine planning, production scheduling, grade control, surveying and the monitoring of the contract mining operations will be undertaken by CAGP personnel.

Due to the nature of the mineralisation and likely annual movement quantities, a conventional backhoe excavator/ haul truck mining method is considered the most appropriate for the Project. Mining of the ore and waste will utilise 120 to200t size hydraulic excavators in a backhoe configuration.

The different ore material types and waste boundaries would be delineated on each bench based on the RC grade control sampling results and the resultant geological modelling and interpretation. Bench and face mapping, for grade control as well as for geotechnical reasons, should be a routine task in finalising the ore and waste boundaries to be marked out for excavation. The mining operation will excavate and load the ore and waste in accordance with the marked ore and waste boundaries and ensure minimum contamination and maximum recovery of ore.

The scheduling of the excavation of different parts of the pit is dependent on the need for blending of ore to meet the ore grade and throughput targets and other constraints such as space availability on the ROM pad and rehandling stockpiles.

The existing access roads developed during the previous mining operations and recent exploration period will provide initial access to the mining site. Permanent haul roads, nominally 25m wide, will be developed utilising waste from the initial phases of the operation.

On commencement of mining in an area the procedure will be:

The Contractor shall clear the site for the mine area and the waste dumps in accordance with approved designs. Clearing shall consist of cutting trees, stumps and brush to approximately ground level and disposal of the cleared material by removal to locations as directed by the CAGL Mining Manager. During the clearing operations as little as possible of the surface material shall be removed or disturbed unless grubbing or topsoil stripping is directed by the CAGL Mining Manager.

Grubbing shall be carried out over selected portions of the mine and waste dump areas where directed by the Superintendent. All stumps, roots, scrub and similar organic matter shall be grubbed out to a depth of 100 to 300mm below the natural surface level by suitable means and removed to locations directed by the CAGL Mining Manager.

- Where practical, topsoil[1] will be stripped from the footprint areas of the pits and waste dumps, prior to mining. The topsoil will either be stockpiled for later use, or hauled directly onto profiled waste areas for rehabilitation. Stockpiles will be limited to a height of 2 metres in order to reduce the potential for soil microbial degradation that may occur if topsoil is placed in high piles.
- Waste stripping will then commence. Waste will be dumped at the designated waste dump;
- Ore will be hauled straight to the ROM pad or dumped on mine ore stockpile for rehandling using smaller haulage trucks; and
- The operation of the Abnabna, AF Gap and Fobinso pits will be managed together to maximise the flexibility of earth moving, blasting and grade control.
- The mining operation will be based on two 10-hour shifts per day and 12 days in every fortnight. Saturday and Sunday will be scheduled as non-working days.

2.12.3 Grade Control and Ore Blending

Grade Control drilling will be undertaken using RC drills owned and operated by the primary mining contractor. Based on the expected variability of the deposit, the pattern dimensions are

[1] Topsoil (defined here as composed of O, A and B soil horizons) will have an inherent variability across the Project area due to effects of topography and soil leaching. The combined thickness of the three layers will determine practically how much topsoil can be salvaged by heavy equipment.

expected to be 10 x 20m, and 20m deep. The application of grade control drilling will vary depending on the cut-off grade strategy applying at the time and on which part of the ore body.

The primary requirement for ore blending is expected to maintain a reasonably steady sulphur head grade for optimal performance of the flotation cells. To achieve these requirements, tipping ex-pit ore onto ROM stockpiles and then blending them into the crusher with a Front End Loader will be undertaken.

2.12.4 Drill and Blast

The Contractor shall be responsible for the marking out of blast patterns as approved through relevant Blast Approval Notices.

The Contractor shall be responsible for protecting all drilling areas including the erection and maintenance of barricades, signs, lights or any other warning devices.

The Contractor shall provide efficient dust suppression units on all of its drill rigs used for production and miscellaneous drilling. Dust suppression units shall be installed, adjusted and maintained in accordance with the manufacturer's specifications and shall be used at all times that a drill rig is being used. Care shall be taken to ensure that dust extraction operate effectively when drilling angled holes.

The Contractor shall schedule its drilling and blasting operations to accommodate the CAGL's overall production requirements and shall allow for any under utilisation of its drilling equipment due to mismatch in its drilling and loading and hauling capacities.

CAGL may require the sampling of drill cuttings from blast holes in the laterite material for the purpose of grade control. The Contractor should allow for the fitting of a suitable sample collection system approved by the CAGL Mining Manager to sufficient blast hole drill rigs provided for the Works. The provision of sampling consumables and the collection of the samples will be the responsibility of the Company.

The Contractor shall be responsible for ensuring that the Blast Exclusion Zone is clear of all personnel, visitors and members of the public during the blasting operations and that all necessary precautions for the proper protection of all persons, the Works and all property have been taken.

In the event that a blast already tied in is postponed by the Contractor, whether under his own volition or under the direction of the CAGL Mining Manager, the Contractor shall:

- provide and install suitable barricades and protect the charged area in daylight hours until it is fired; or
- provide guards for the blast during the hours of darkness until fired

The Contractor shall promptly clean up all debris from benches and working areas arising from blasting operations.

Rock fragmentation will be undertaken by free digging or drilling and blasting as required. To be able to achieve production targets, the fresh rock will have to be blasted due to the intact rock strength. To minimise the effect of the blasting on the slopes, control blasting must be used. Different techniques are available like pre-splitting, buffer rows, trimming or a combination of

techniques. The use of a particular blasting technique will vary throughout pit life depending upon rock conditions in the particular pit.
The pit configuration bench height and waste material type suit small in-the-hole hammer (ITH) or hydraulic top hammer drill rigs for the waste material drilling operations. Smaller top hammer drill rigs will be used during pit establishment /pioneering works, in ore mining areas and near final wall limits. Drill burden, spacing and sub-drill design will be varied depending on the rock weathering, joint structures and hardness.

Selection of explosive type will depend on the presence of any ground water and the success with which recommended dewatering operations are carried out. Given that the water table at the Project will be encountered at nominally 30m below the surface, use of ammonium nitrate fuel oil (ANFO) has been assumed to be limited to the material above the water table with a waterproof emulsion product required for the remainder of the ore body.

Based upon the hole diameter, bench height and powder factor parameters provided by CAGL the following blast designs have been derived for the purposes of vibration prediction calculations (Table 2.3)

Table 2.3: Nominal Blast Designs

Hole Diameter (mm)	Hole Depth (m)	Stemming Length (m)	Subdrill (m)	Spacing (m)	Burden (m)	Dry Hole ANFO kg/hole	Wet Hole Emulsion kg/hole	Dry Powder Factor (kg/bcm)	Wet Powder Factor (kg/bcm)
102	5	2.4	0.8	3.5	3.0	22.6	33.0	0.43	0.63
127	10	3.0	1.1	4.0	3.5	83.5	122.2	0.60	0.87

It should be noted that spacing, burden and powder factor are not inputs for the vibration prediction and are for indicative purposes only. It is assumed that wet holes will not be predicted and will consequently have the same pattern size as dry hole blasts.

The Contractor shall make prevention of fly rock it's the first priority in performing the charging of blast holes. In addition the Contractor shall incorporate the following into its procedures, methods and standards as a minimum:

- A disciplined and recorded process of confirming and if necessary, correcting blast hole depths immediately prior to charging;
- A disciplined and recorded process of confirming adequate burden on all holes and if necessary, either reducing charge weight or stacking imported burden;
- A disciplined and recorded process to ensure that adequate stemming is provide for all holes;
- A process to limit toe blasting unless absolutely essential;
- A process to ensure that secondary breaking is performed by mechanical means wherever possible.

2.12.5 Load and Haul

Efficiency studies indicate mining of the ore and waste utilising 120-200t size hydraulic excavators in a backhoe configuration. The scheduling of the excavation of different parts of the pit is dependent on the need for blending of ore to meet the ore grade and throughput targets and other constraints such as space availability on the ROM pad and rehandling stockpiles.

As a standard practice, the pit areas and the waste dump foot prints will be cleared of vegetation and topsoil and subsoil will be stockpiled adjacent to the pits or waste dumps to allow progressive rehabilitation to be undertaken where feasible.

It is a requirement of CAGL that the Contractor conduct its mining operations in the zones requiring selective mining in such a way as to reduce to a practical minimum, both the amount of dilution of ore due to waste included in ore mined, and the amount of ore included in waste.

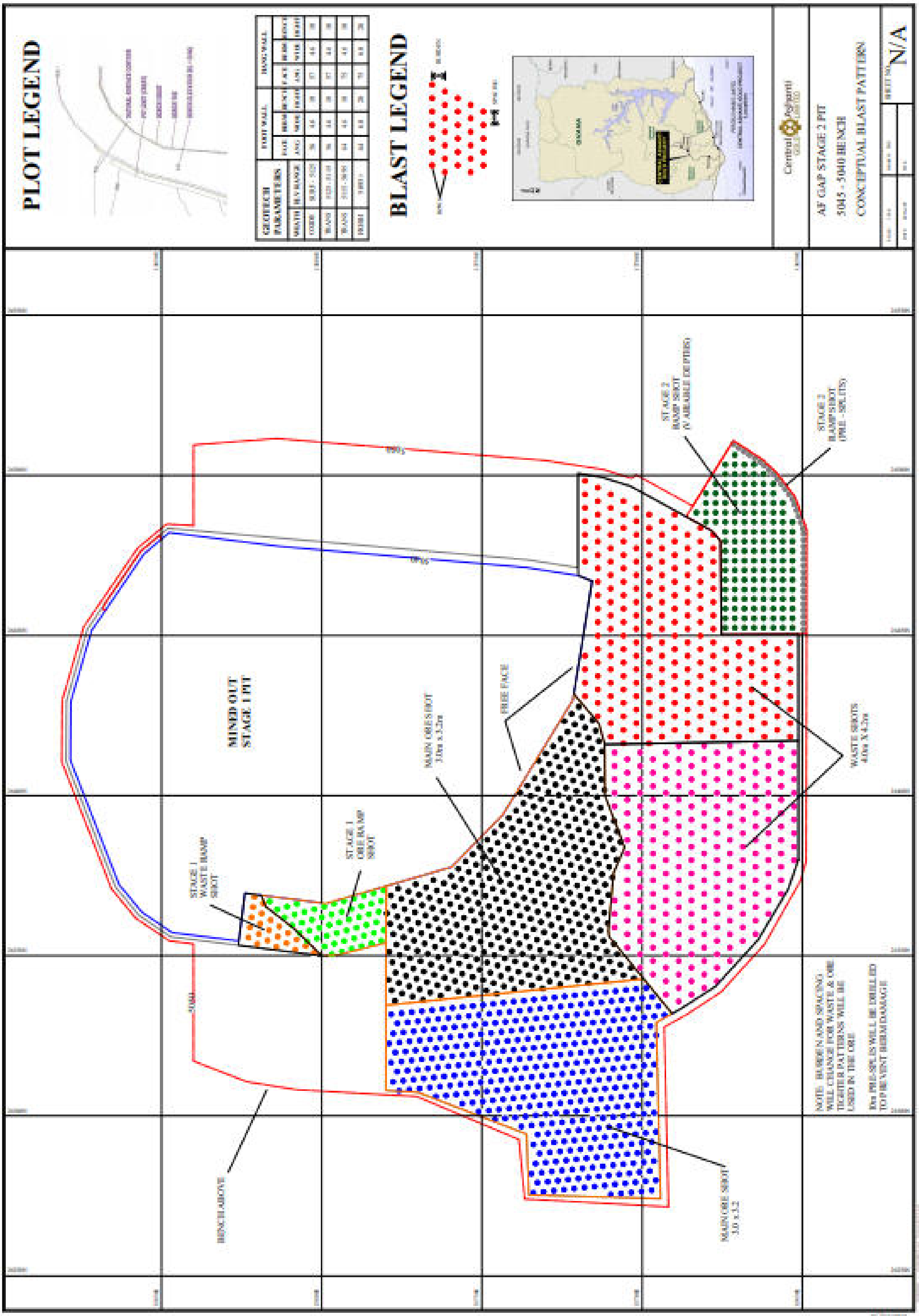
The Contractor shall provide for any delays and interruptions caused to its operations by all the activities carried out by the Mining Manager in the collection of geological data and direction of mining operations in any zone requiring selective mining.

The Contractor shall be responsible for maintenance of correct operating levels from bench marks developed with reference to the existing site survey control.

All ore boundaries will be mined according to the direction and to the satisfaction of the CAGL Mining Manager.

The Contractor shall develop a procedure and mechanism that records and ensures that all material hauled is dumped at the planned destination for that material type and to report any deviation to the CAGL Mining Manager within twenty four (24) hours of any occurrence.

Blank page A3 Conceptual Blast Pattern.



2.12.6 General Pit Design

Final and staged pits for each deposit have been designed based on the basis of various pit shell optimisation factors. The selection of the pit shells were made by taking into account various factors including the relative relationship between strip ratios, recovered ounces and incremental value or cost per recovered ounce. Another important consideration on shell selection was the physical shells and their interaction with the already mined out areas. This physical factor made the possibility of justifying pit staging impractical in some of the pits with mined out areas.

Pits are designed to allow the use of 100t-class off-highway dump trucks. These trucks have a physical width of 6.1m. Road widths are based on a safety factor of 1.6 times the truck width plus an additional 5m for safety bunds and drains. So a dual lane road will be (6.1m x 1.6) + 5m. In pit roads are design for life-of-pit only.

The general location of all the designed pits in relation to each other and the process plant are shown in Map 2.2. A general summary of various pit characteristics at AGC cessation of mining and the new dimensions when CAGL ceases mining is presented in table 2.4 below.

Table 2.4: Summary of Current Pit Dimensions (post AGC Mining) and Final Dimensions post CAGL mining.

Pit	AGC Area (ha)	CAGL Final (ha)[1]	CAGL Final +20m (ha)[2]	AGC Perimeter (m)	CAGL Perimeter (m)	AGC Depth (m)	CAGLMax Depth (m)
Abnabna	8.2	34.4	49.7	1100	3178	65	146
AF GAP	n/a			n/a		n/a	243
Esuajah Nth	15.3	18.6	22.3	2000	2000	0	196
Fobinso (S&N)	12.4	22.9	27.6	1820	2315	65	160
Fetish	17.5	28.1	32.4	1500	2175	Not known	238

1: Actual pit area. 2: Total area including provision for safety bund 20m from pit crest.

2.12.7 Abnabna and AF Gap Pits

The existing Abnabna pit is illustrated in the photograph below.

The main Abnabna – AF Gap deposits are mined in two stages, until both merge to form a single pit (Stage 3). The phased development of the Abnabna and AF-Gap pits and their subsequent merger into a single pit is illustrated in Figures 2.1, 2.2 and 2.3.

AF Gap and Abnabna Stage 1 pits are the main source of waste for the construction for the backfill of low areas on the eastern edge of the final pit and the construction of the ROM pad base to the east. The ramp exits have thus been located on the eastern side of the pits to provide short haul to the most of the waste destinations as well as to the ROM pad.

The AF Gap and Abnabna Stage 2 pits are also circular in shape to follow the optimisation shells. As with Stage 1, the pit exits are on the eastern side to allow for short haul distance for the construction of the remainder of the ROM pad and other construction areas as well as ore to the ROM pad during the life of the pit.

Waste mined during the final stages of AF Gap and Abnabna pits will be placed on the Fobinso waste dump and also used to backfill the Fobinso pit (see section 2.12.14). The main pit ramp has been designed to exit on the eastern side to provide for short haulage distance to the waste dump as well as ore to the ROM pad.

A three dimensional view of the Abnabna and AF-Gap pits at end of pit life is shown following this section (Figure 2.4a) along with an isometric 3D cutaway along strike, Figure 2.4b. Figure 2.4a shows the final pit in relation to the plant, construction contractor sites and to the ROM pad.

Typical x-sections of the Abnabna and AF Gap pits depicting the planned three stages of mining follow this section. For each pit they are labelled Sheets A 25900E and B 25900E. Each sheet shows the existing surface level of the area, the original level of mineral oxidation and the remaining area of oxidation below the existing surface level and that part which will be mined. The benches to be developed during mining are also shown.

The final depth of the pit resulting from the merger of Abnabna and AF-Gap is 146 m (Table 2.4). The final surface area is estimated to be 34.4 ha and actual pit perimeter has been estimated at 1100m.

Photo of Existing Abnabna Pit

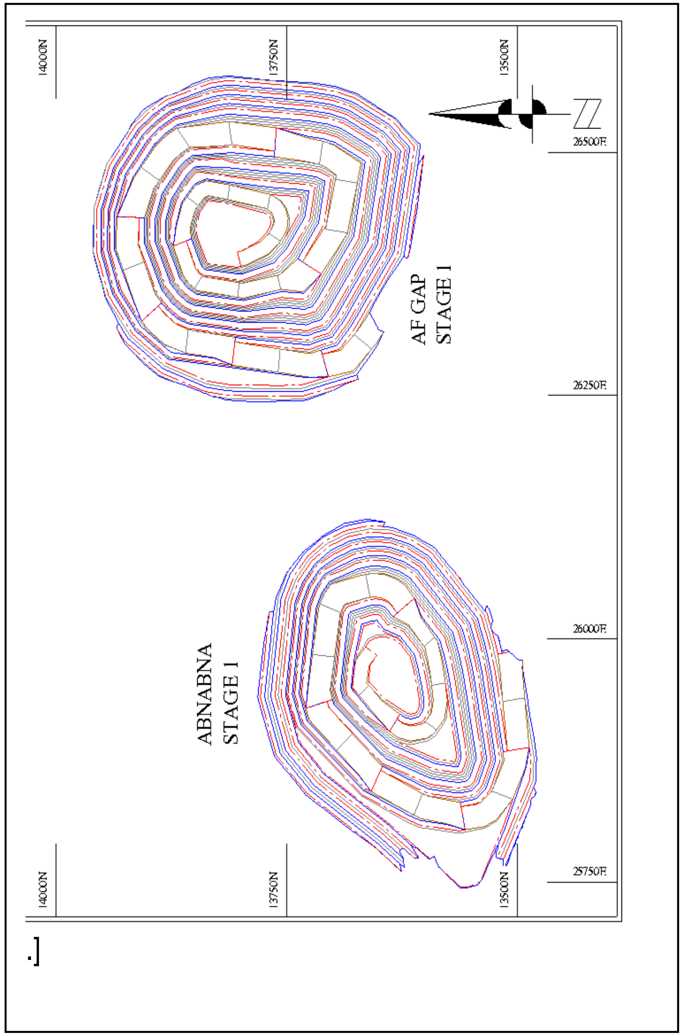


Figure 2.1: Abnabna and AF Gap Stage 1

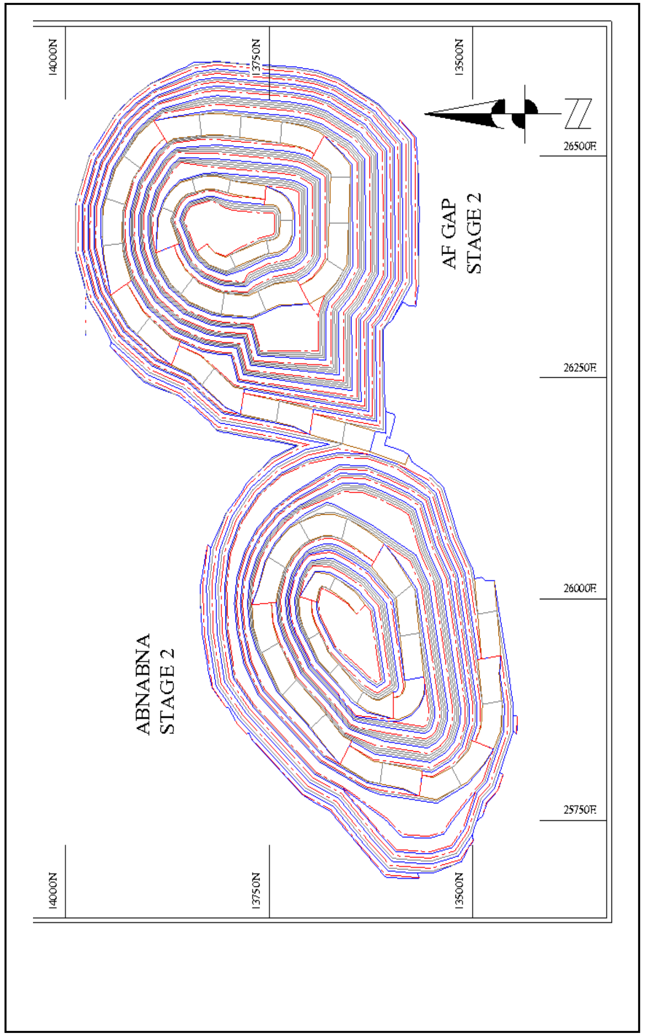


Figure 2.2: Abnabna and AF Gap Stage 2

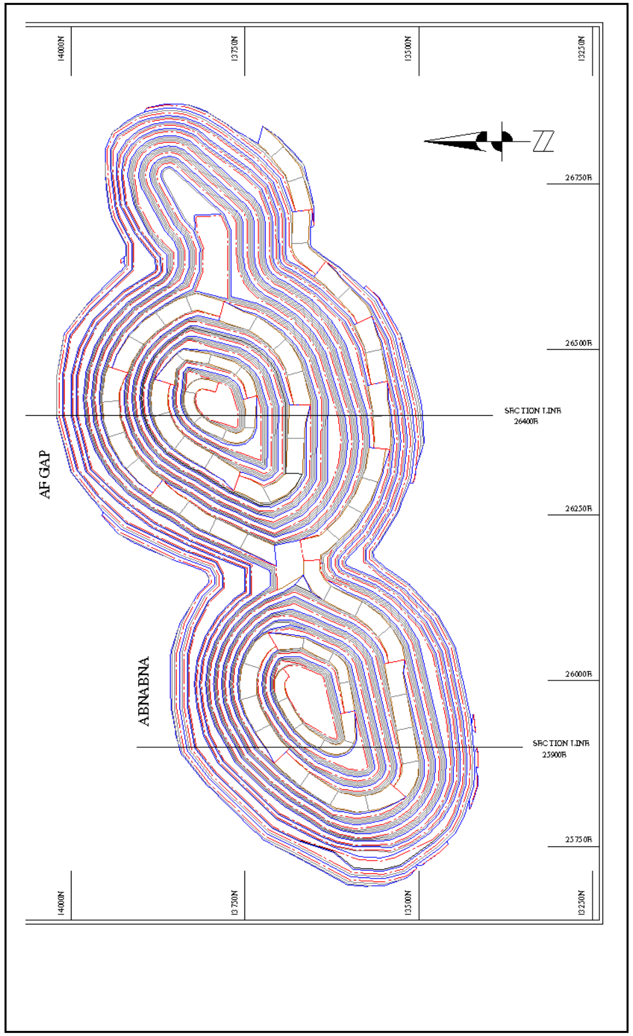


Figure 2.3: Abnabna and AF Gap Stage 3

Figure 2.4a : 3D Overview Western Pit

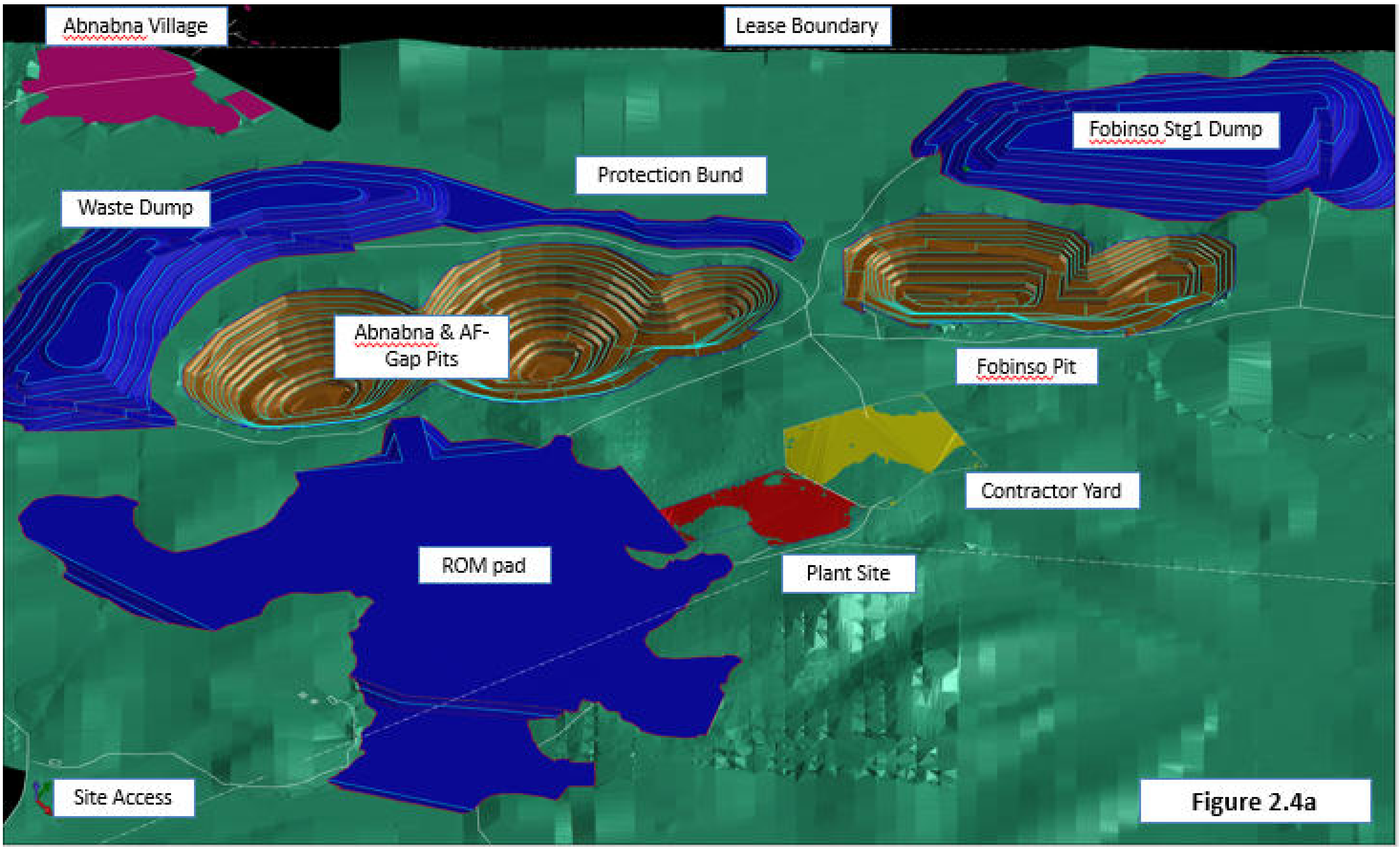
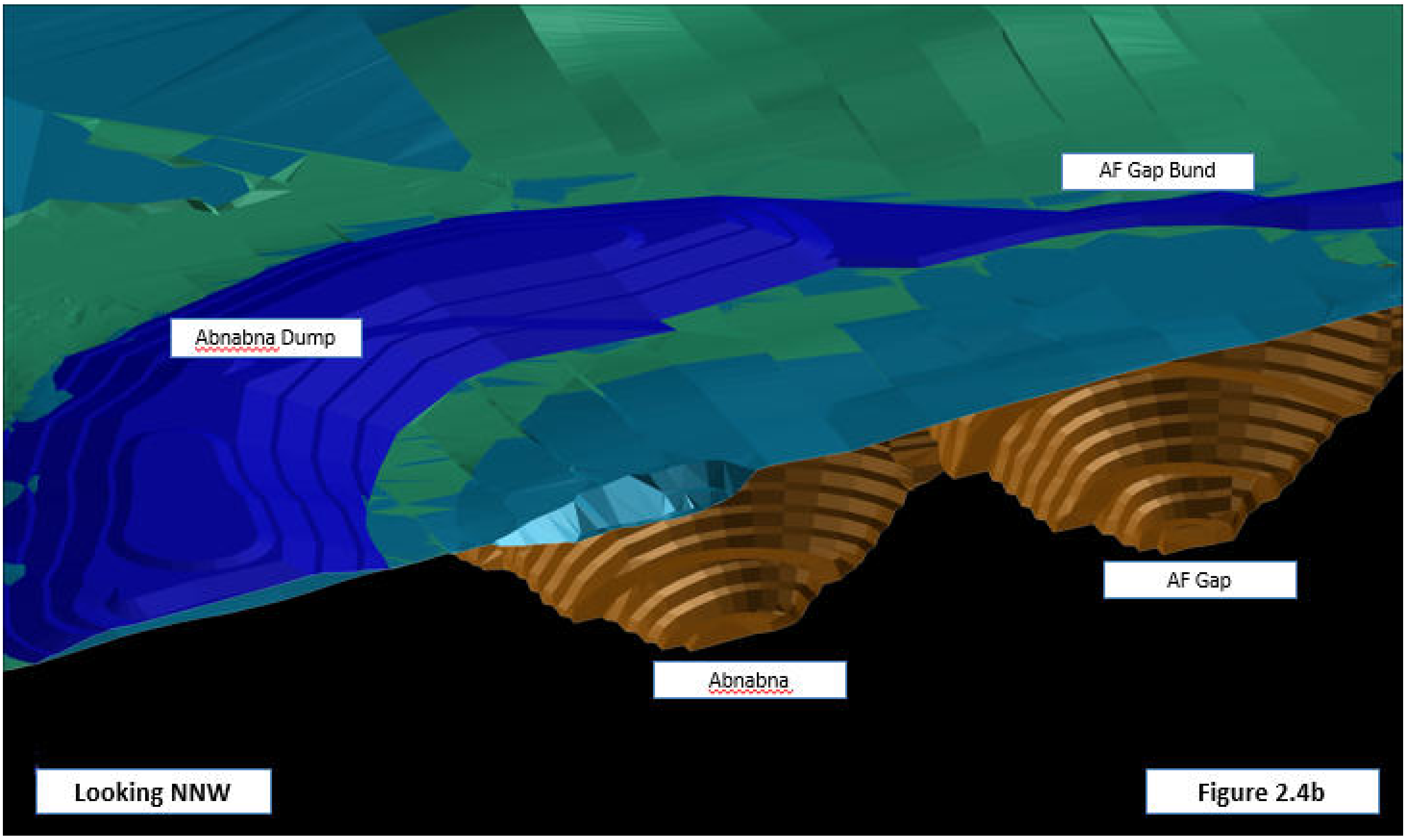


Figure 2.4b: 3D Long Section Abnabna – AF Gap



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Blank page for Abnabna section B

Blank page for AF Gap section A

Blank page for AF Gap section B

2.12.8 Fobinso Pit

The existing Fobinso North and Fobinso South pits are shown in the photographs below.

The Fobinso deposit is mined in two stages, split into a north and south section following the final pit shell as illustrated in Figure 2.5. Once mined out and after final sterilisation drilling Stage 1 (the south section) will be backfilled with material from Stage 2 (the north section). Once Stage 2 is mined out and after sterilisation drilling, Stage 2 will be backfilled with material from AF Gap and Abnabna pits. Consequently, the whole of the existing Fobinso South and Fobinso North pits will be ultimately be backfilled and suitable for reclamation.

A three dimensional view of the Fobinso pit at end of pit life is presented in the preceding Figure 2.4a along with an isometric 3D cutaway along strike, Figure 2.4c (follows Figure 2.5).

Typical x-sections of the Fobinso pit is shown on Fobinso Sheet A – 27500 E and Sheet B 27300 N. The sheets show the existing surface level of the area, the original level of mineral oxidation and the remaining area of oxidation below the existing surface level and that part which will be mined. The benches developed during mining are also shown. A second x-section of the pit , 27300N, depicts the final configuration with backfilled pit surface. The final depth of the pit prior to backfilling is 160m (Table 2.4). The final surface area prior to back filling is estimated to be 22.9 ha and actual pit perimeter has been estimated at 2,315m.

Photo of Existing Fobinso South Pit

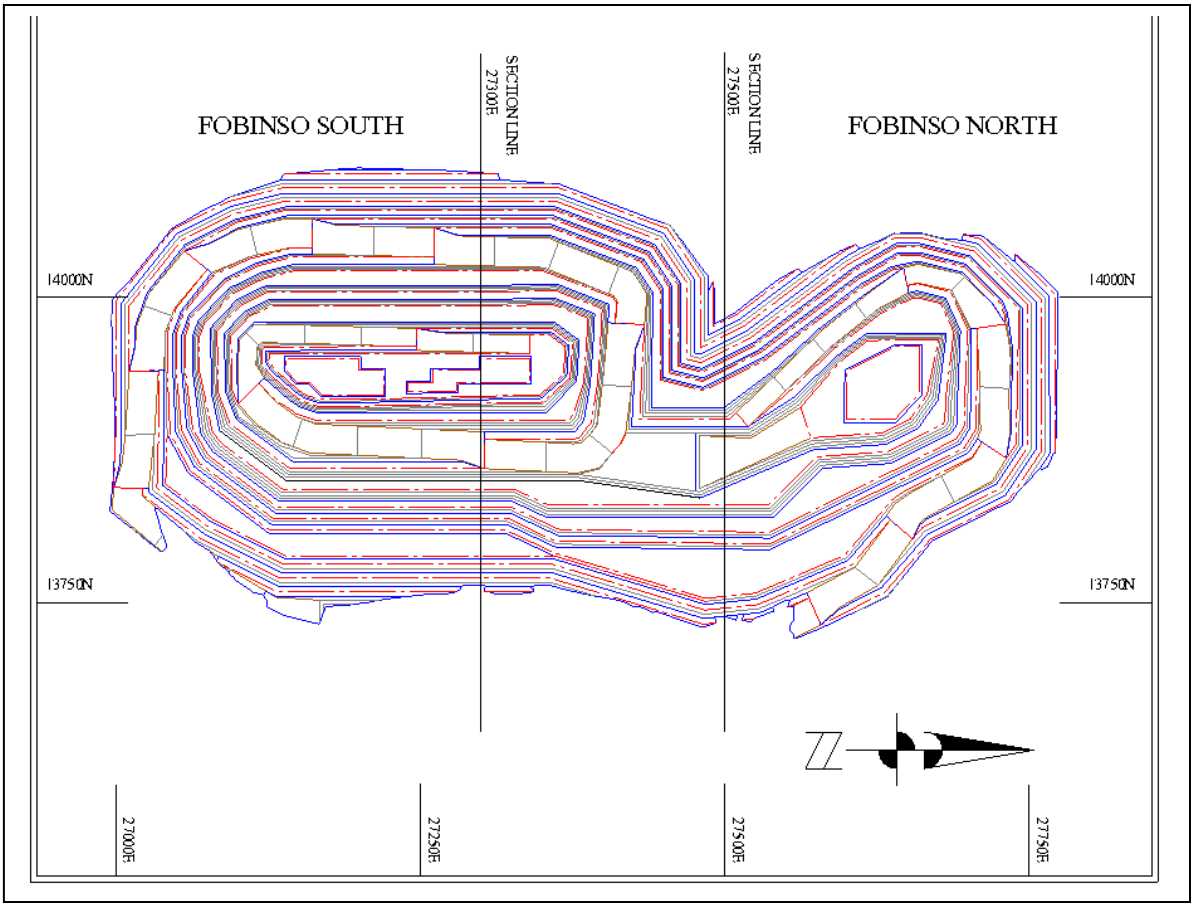
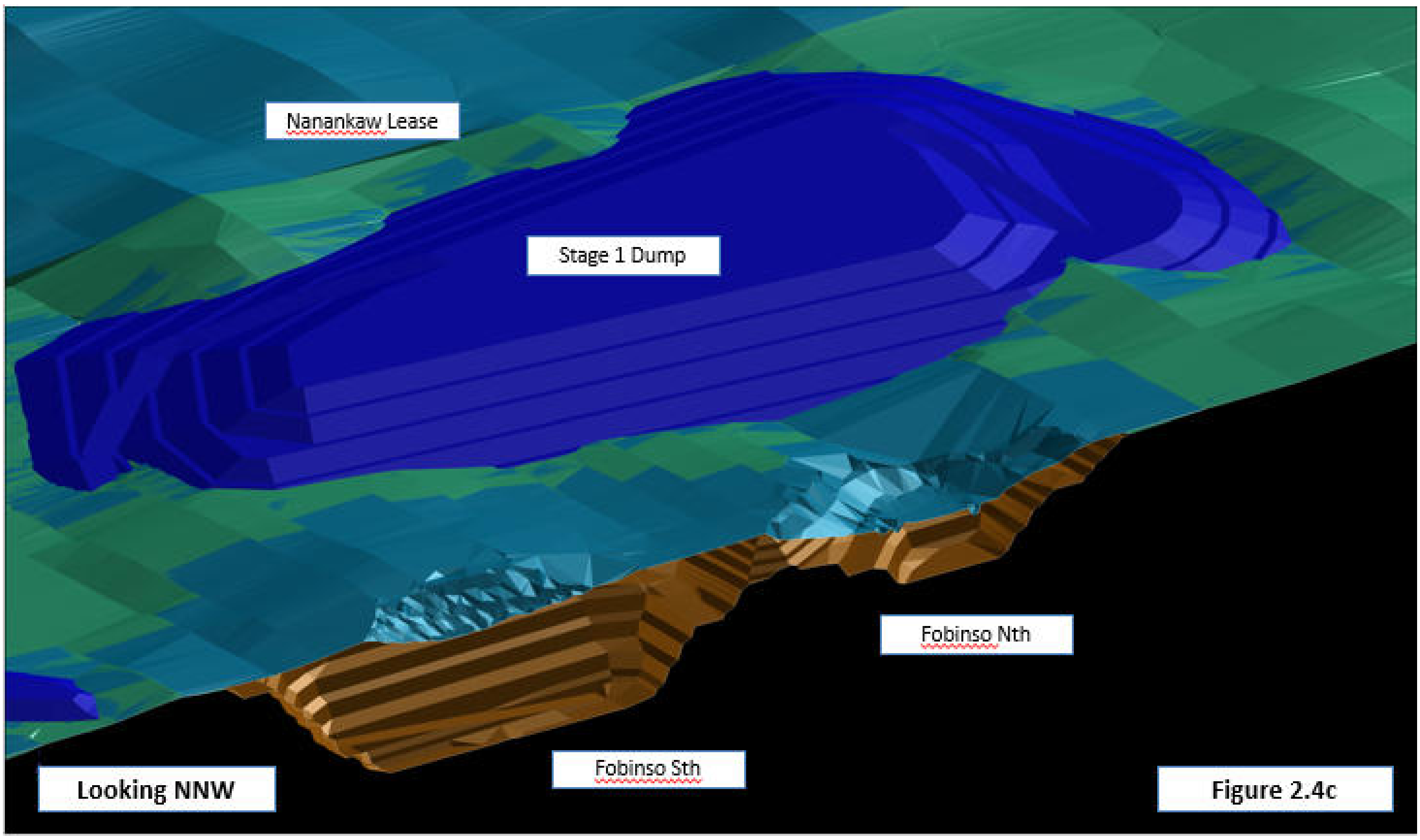


Figure 2.5: Fobinso Pit design Stages

Figure 2.4C: Fobinso 3D long section cutaway



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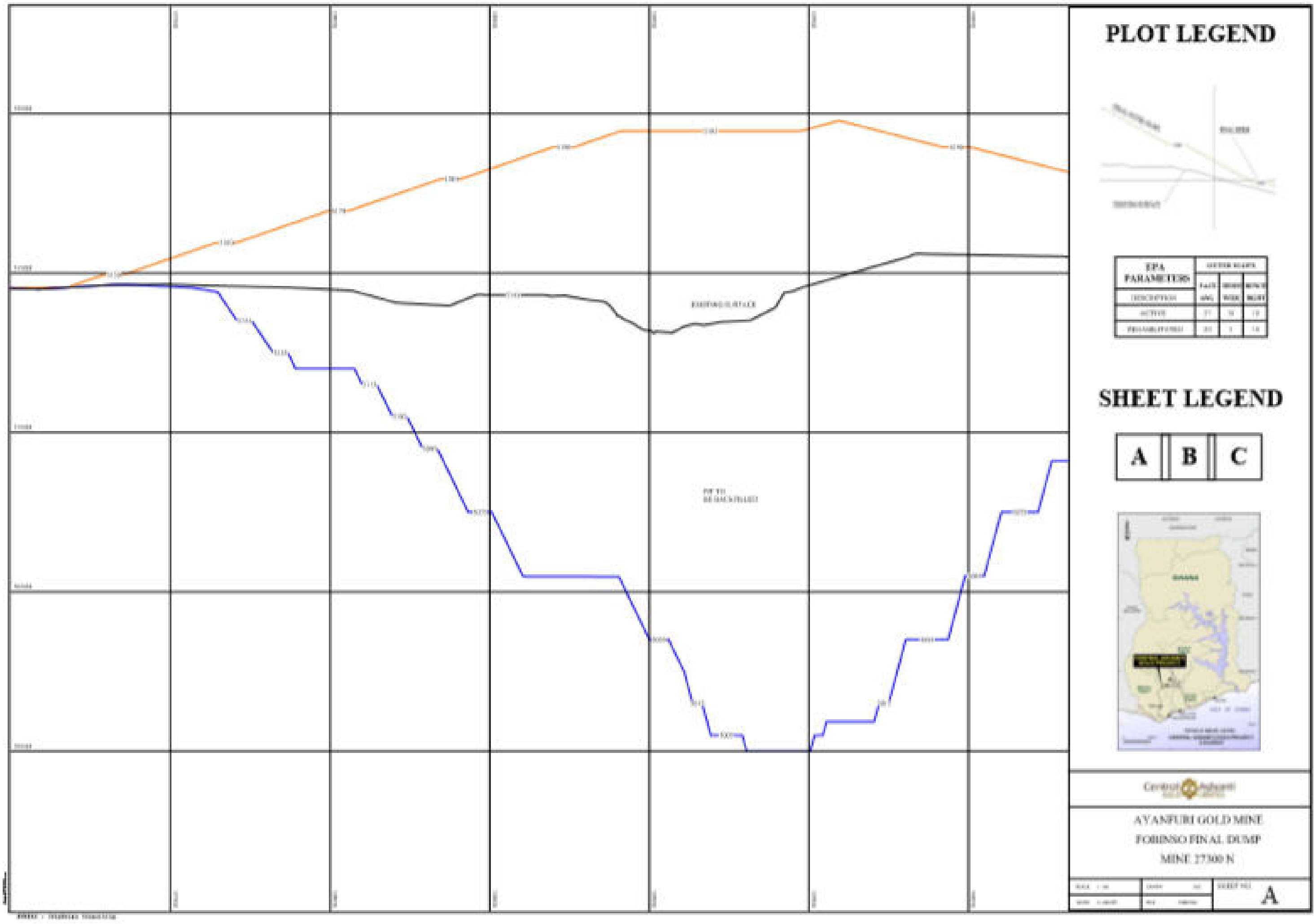
Blank page for Fobinso section A. 27500E

Fobinso backfill section waste dump 27300 N



2.12.9 Fetish Pit

The Fetish deposit will be mined in two stages. Stage 1, which is illustrated in Figure 2.5a, does not strictly follow the optimal pit shell in the south western corner between surface to 160.5 mRL due to previous mining activity. This has the advantage of greater wall stability. Stage 2 is the final stage pit and incorporates the smaller existing excavation to the north.

The Fetish Stage 2 pit is illustrated in Figure 2.5b. Stage 2 shares a section of wall with Stage 1 in the south western corner of the final pit design until 150mRL is reached. Stage 2 incorporates the smaller existing excavation to the north. The pit exit is also to the south as this allows for direct haulage to the waste dumps and ore stockpiles. Ore will then be transported to the ROM pad by 10 wheel semi trailers.

A three dimensional view of the Fetish pit at end of pit life is presented at the end of this section Figure 2.6a. This figure shows the pits relationship to the Fetish waste dump (the backfilled Chirawewa) and the other smaller backfilled pits of the South Bokitsi pit complex. A 3D isometric cutaway along strike is shown in Figure 2.6c.

Typical x-sections of the Fetish pit are shown Fetish Sheets 5100 North A and B at the end of this section. Each sheet shows the existing surface level of the area, the original level of mineral oxidation and the remaining area of oxidation below the existing surface level and that part which will be mined. The benches to be developed during mining are also shown. The pit will be mined to a depth of 238 m (Table 2.4). The final surface area has been estimated at 28.1 hectares with a pit perimeter of 2175 m.

Photo of the Existing Fetish Pit

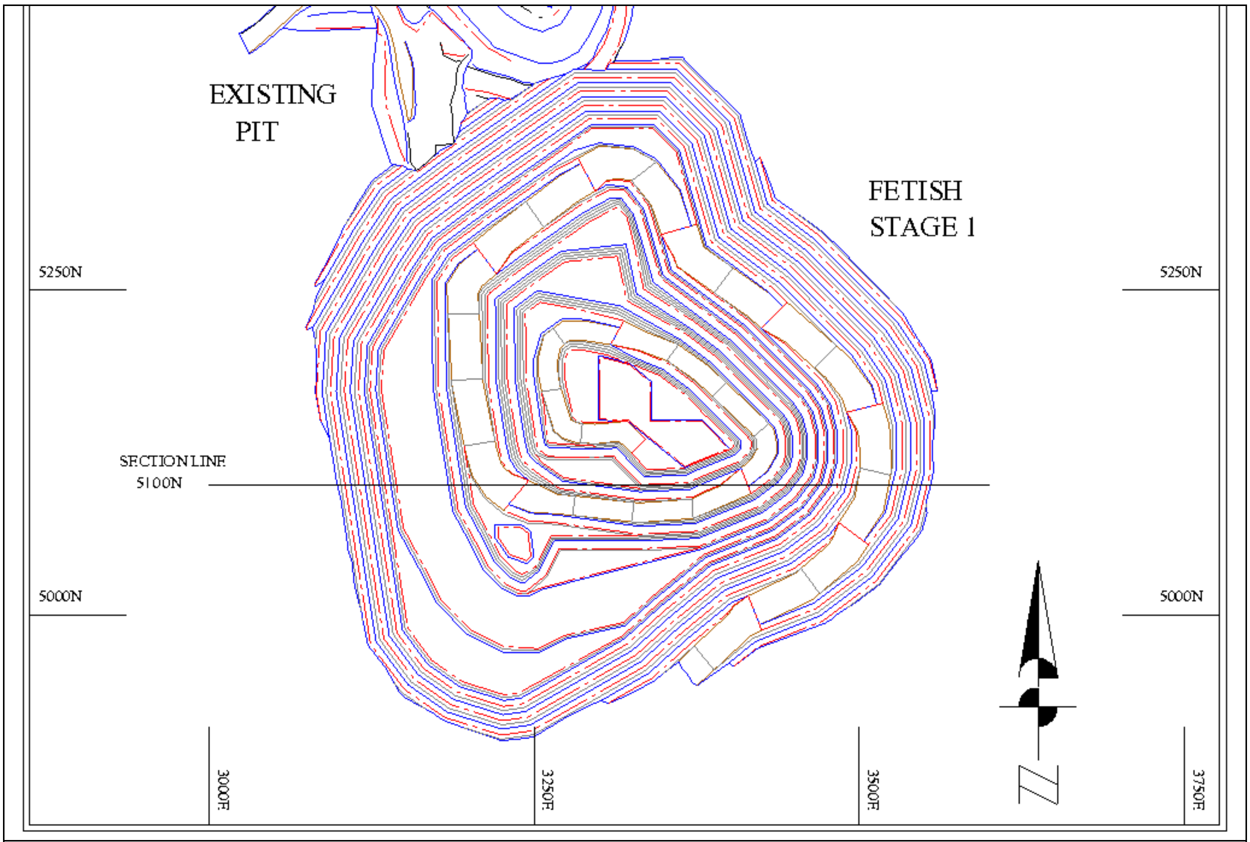


Figure 2.5a: Fetish Stage 1 Pit Design

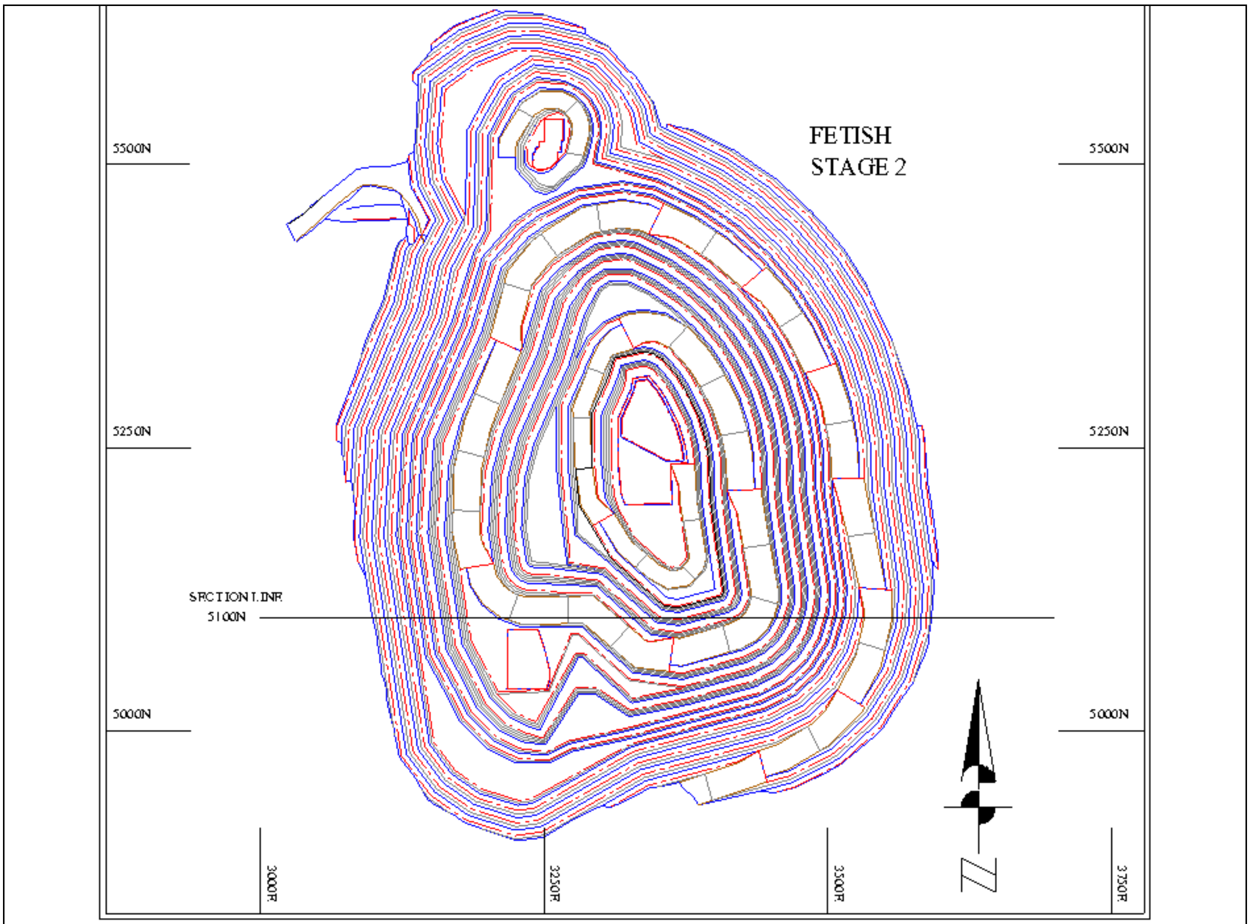


Figure 2.5b: Fetish Stage 2 Pit Design

Figure2.6a: 3D Overview Fetish pit

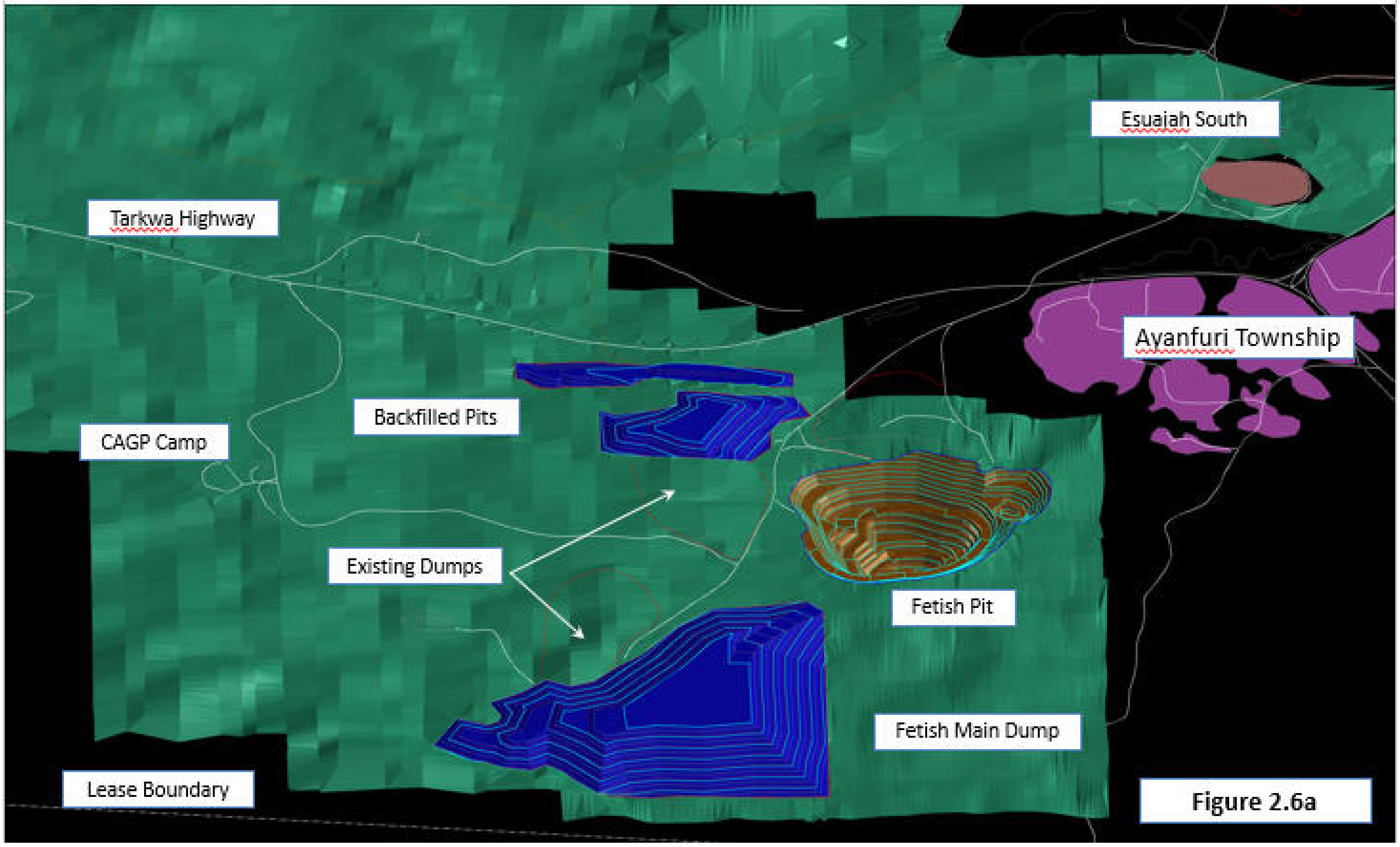
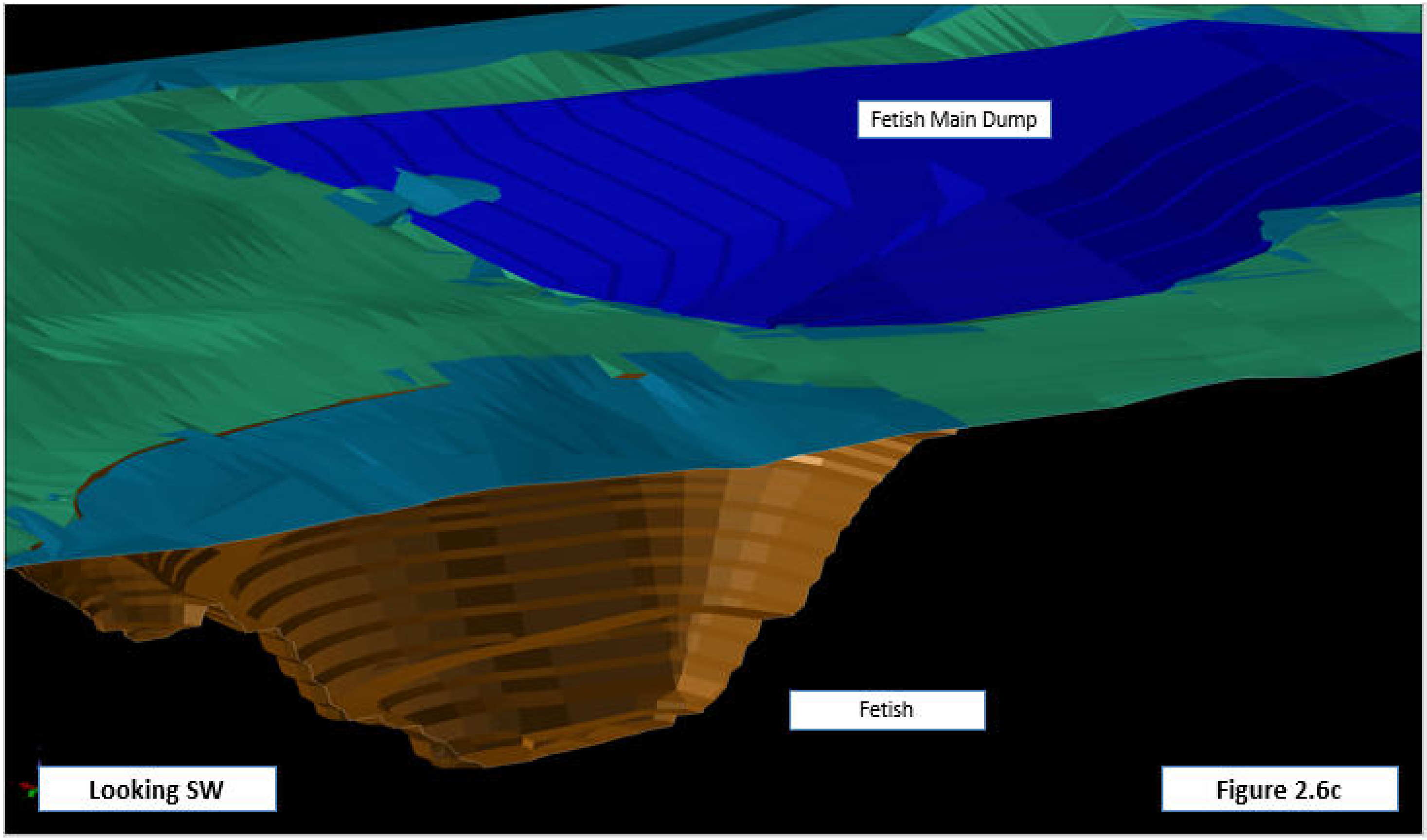
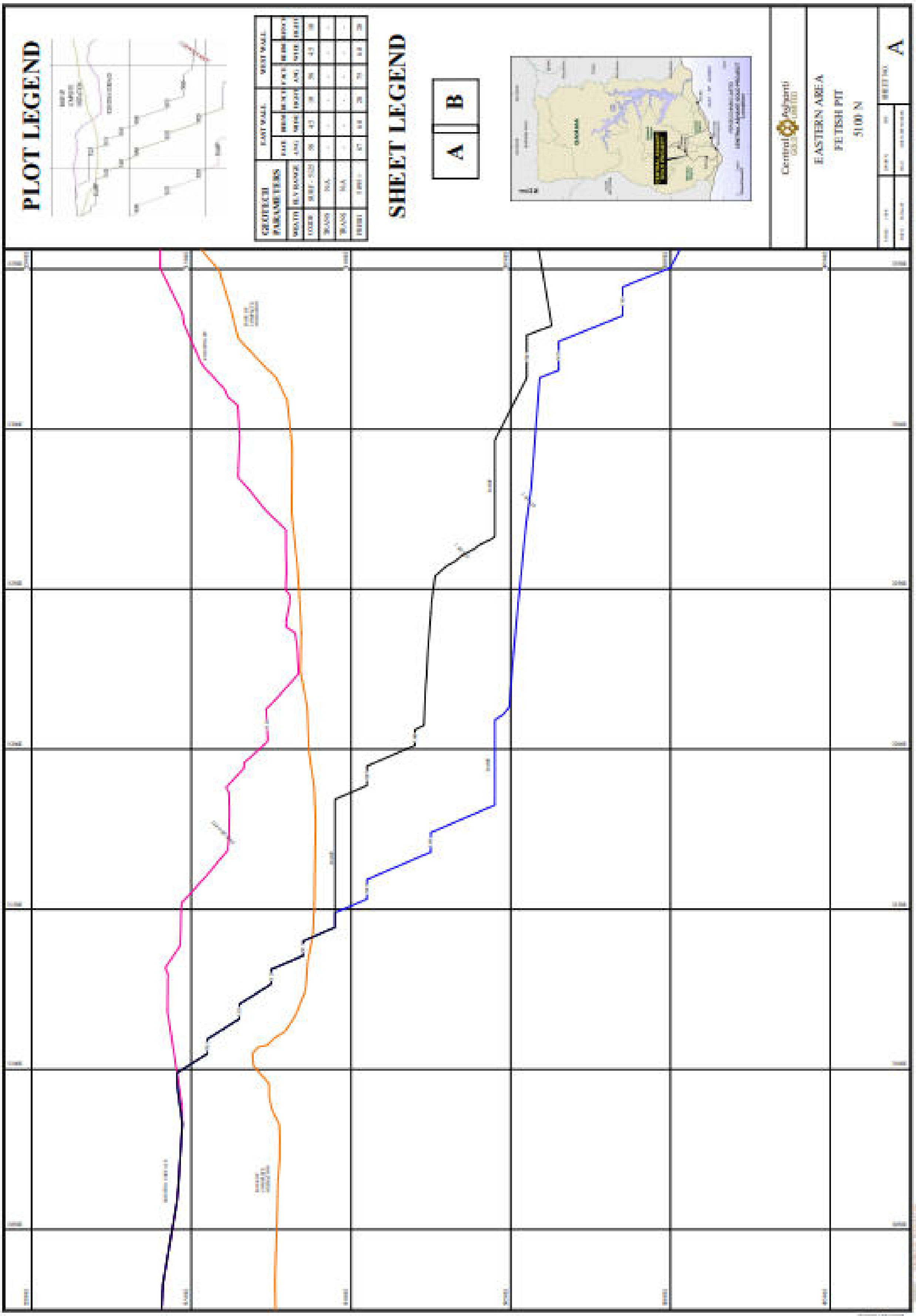


Figure 2.6c: Fetish pit 3D cutaway along strike



Fetish section 5100N A



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2.12.10 Esuajah North Pit

The Esuajah North pit is situated approximately northwest of Ayanfuri village (Map 2.2). The pit was previously backfilled by AGC and revegetated (see photograph below). It will be mined in one stage as illustrated in Figure 2.7.

Photo of the Backfilled Esuajah North Pit

CAGL has determined an ore reserve beneath the backfill pit and also beneath part of the original waste dump that had also been revegetated. The backfill will be removed, as will part of the waste dump and placed on the Esuajah North dump. (Map 2.2).

The Esuajah North waste dump has been split into two areas, one to the north of the pit, the other to the east of the pit to avoid the infilling of a wetland tributary of the Asuaa stream. The east waste dump construction will involve the incorporation of the existing Besem waste dumps and the existing Esuajah North waste dump constructed during the previous mining operation into one dump. The east dump (main dump) will have an average height of 35m above the surrounding area (21m in the SW, 45m in the NW, 35m in the NE and SE). A bund wall will be constructed within 10m off the toe of the waste dump using fresh rock material to prevent sediments from being washed into the Asuaa stream. The north dump will have an average height of 30m above the surrounding area and the SW corner will abut an existing hill.

The minimum distance between the final toe of the east waste dump and the closest dwellings south-east of the dump is maintained at approximately 250m. The final toe of the north dump will be about 750m from the dwellings located at north the old Besem North pit.

The Esuajah North pit is planned to be mined in Years 3 through Year 8. The southern edge of the pit and the east waste dump do cut off existing Ayanfuri-Besem village access road. Farmers from Odumkrom currently use this road to access their farms. A pedestrian access will be provided from west of the Esuajah North pit and along the northern edge of the north waste dump to connect the existing access (Map 2.2). In addition, a bypass road will be constructed along the eastern edge of the main waste dump (east of the Esuajah North pit) to link up the Besim village access to the Ayanfuri-Dunkwa highway.

A three dimensional view of the Esuajah North pit and the waste dumps at end of pit life is follows the end of this section (Figure 2.7a). This figure shows the relationship of the pit and the split waste dump to Ayanfuri village.

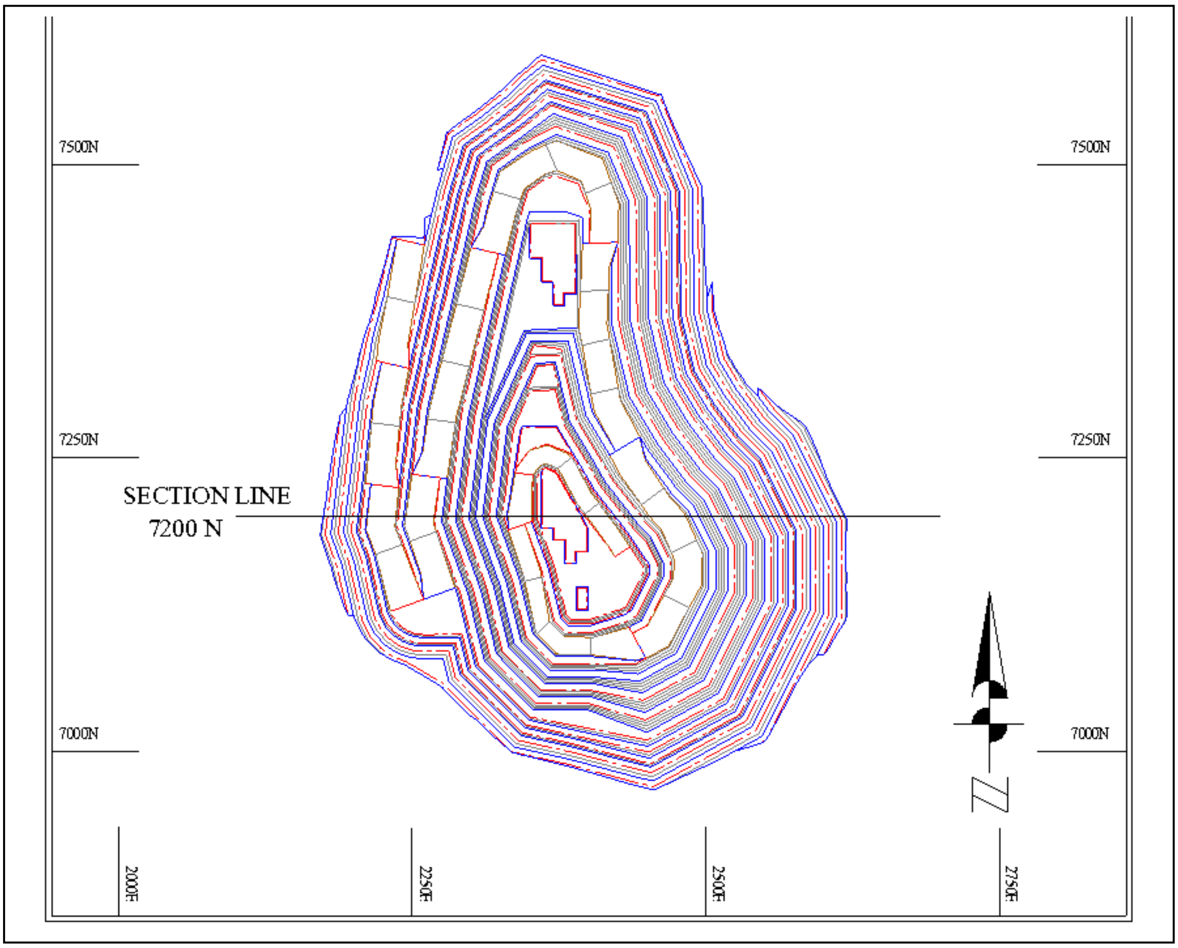


Figure 2.7: Esuajah North Pit Design

Representative x-sections of the Esuajah North pit are shown on Esuajah 7200 North Sheets A and B. Each sheet shows the existing surface level of the area, the original level of mineral oxidation and the remaining area of oxidation below the existing surface level and that part which will be mined. The benches to be developed during mining are also shown. The final depth of the pit will be 196 m and final surface area has been estimated 18.6 hectares with a perimeter of 2,000m. (Table 2.4).

Figure 2.7a: Esuajah North 3D Overview

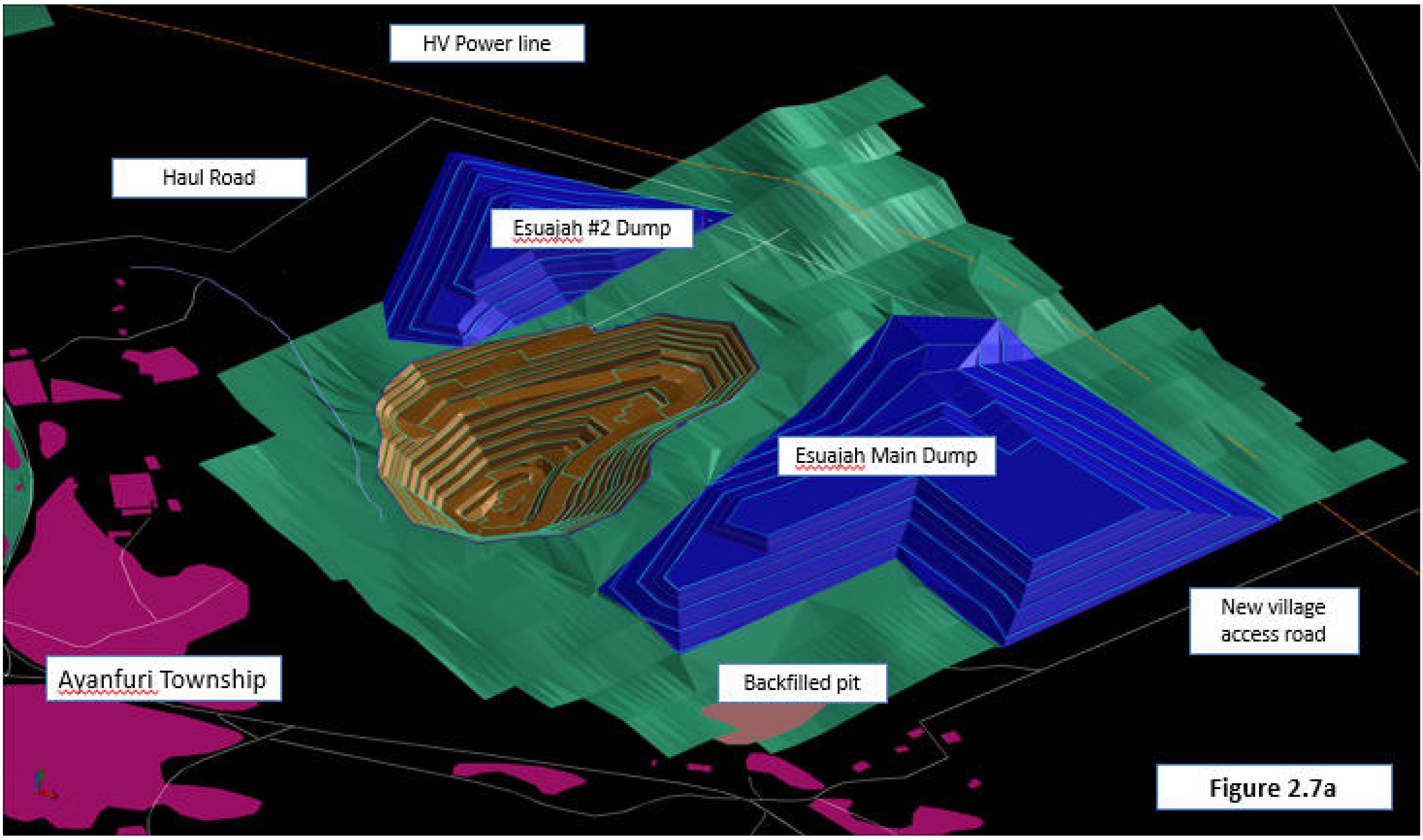
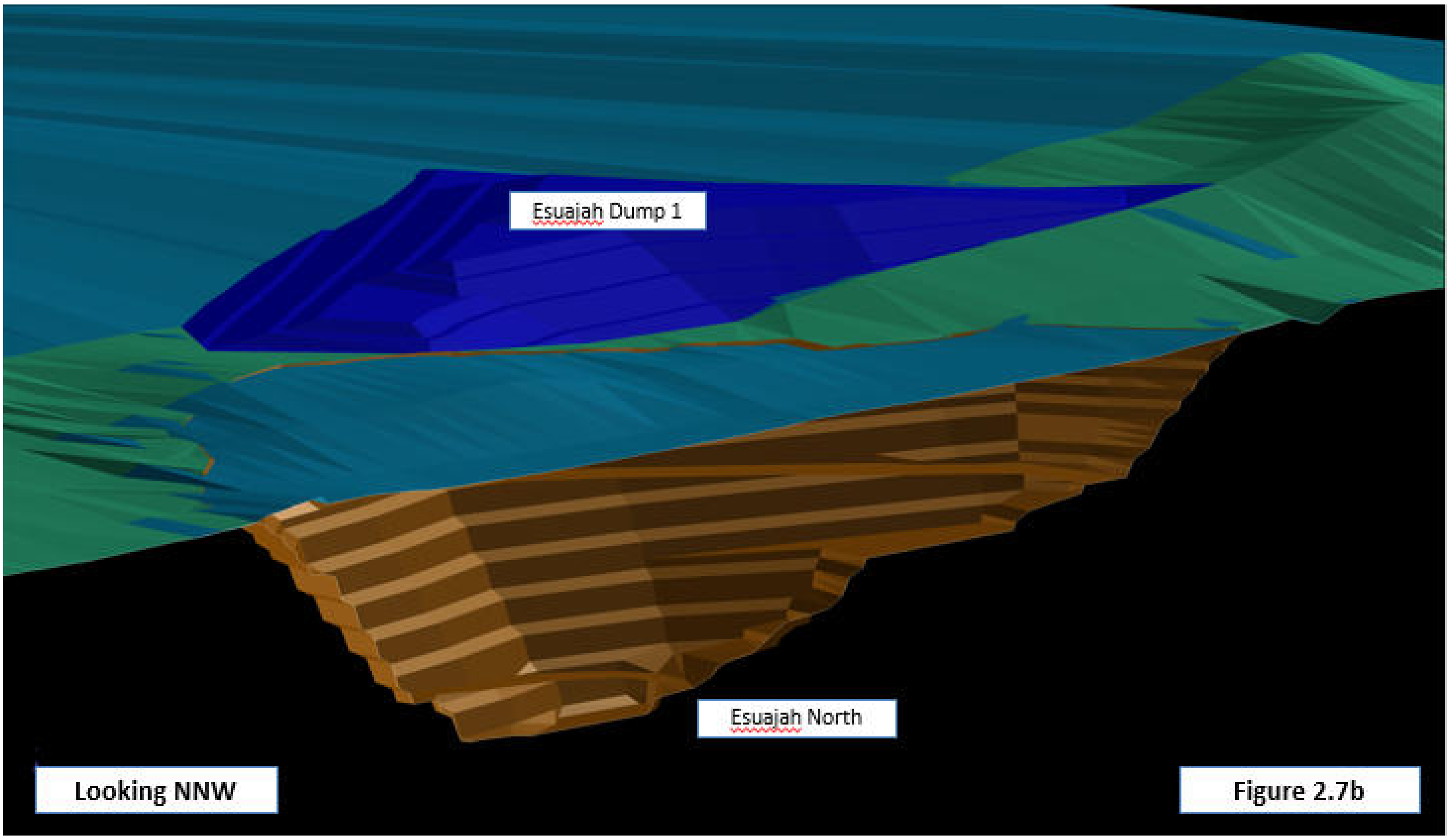
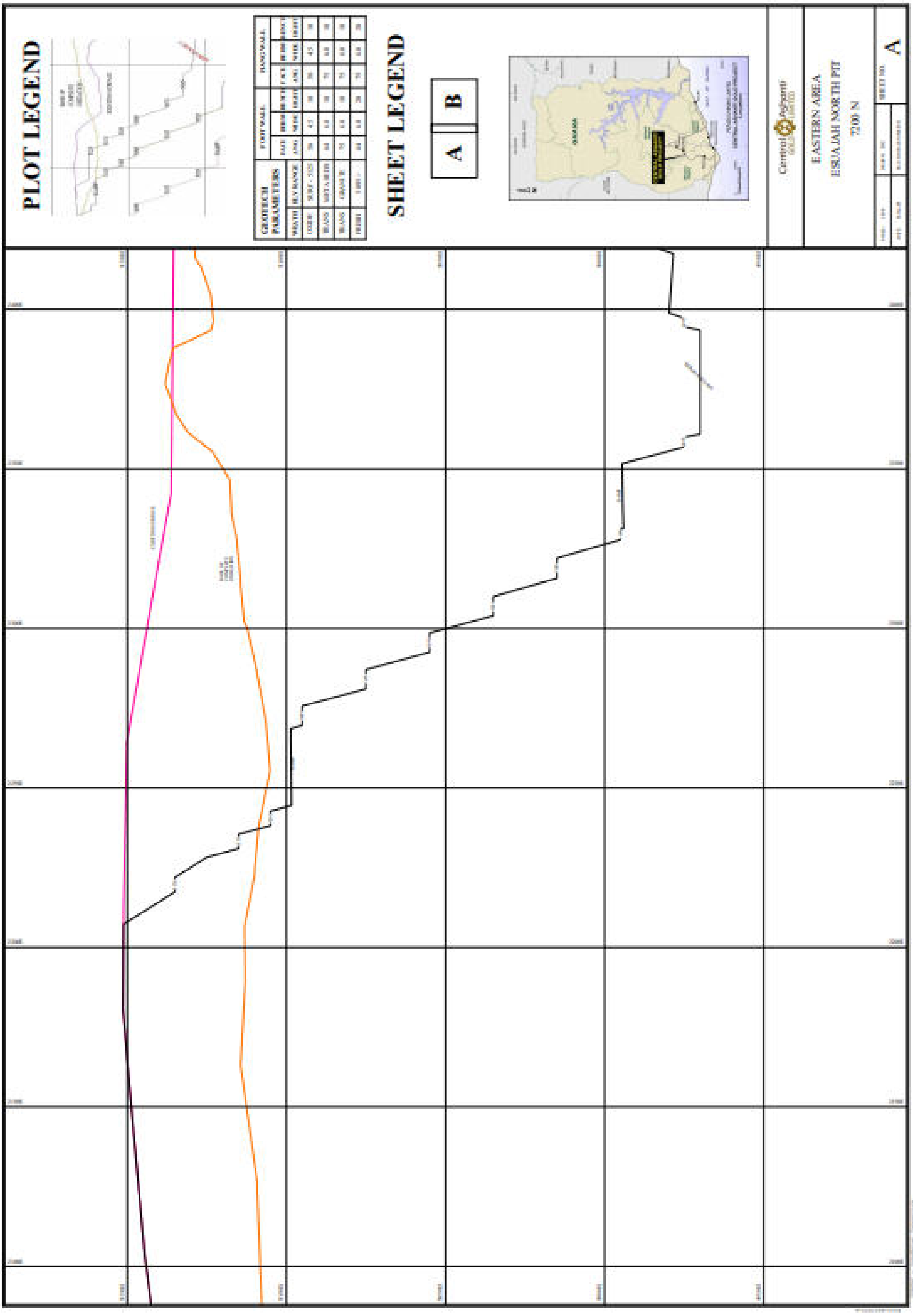


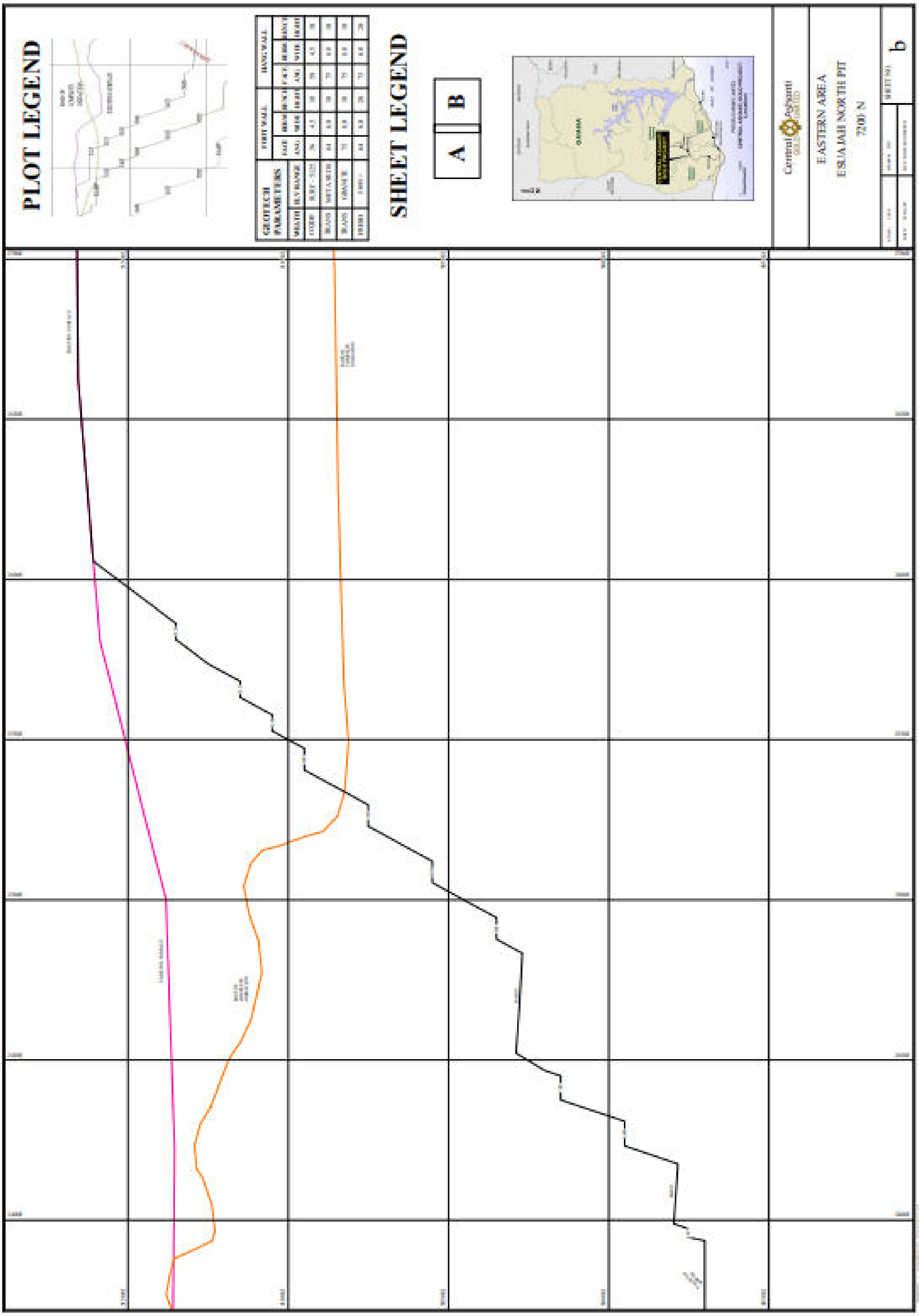
Figure 2.7b: Esuajah North 3D CUTAWAY ALONG STRIKE



Esuajah North section 7200N A



Esuajah North section 7200N B



2.12.11 Mining Rate and Production Schedule

Schedule Targets and Constraints

In the formulation of the mining production schedule consideration is given to a number of guiding factors which essentially influence the determination of the appropriate schedule. These are discussed below:

Mining Production

The primary objective of the schedule is to satisfy the planned mill feed target of 5.5 Mt of ore per annum.

Pre-stripping is to be carried out to enable the achievement of mill feed targets. Pre-stripping will be limited to the Abnabna and AF Gap pits (Tables 2.5 and 2.6). The waste and ore production rates in this period are anticipated to be slower than future planned rates to enable account for optimisation of mining establishment procedures, familiarisation with ground conditions and operator training factors. To the greatest possible extent, CAGL intends to employ local people as equipment operators and for other mine positions, an intensive training period will be required for these people.

A further requirement of the pre-strip mining is to provide suitable waste material for infrastructure work and the creation of an initial ore stockpile of approximately 400,000t prior to process plant start-up.

Mill Feed

The mining schedule targets a mill feed rate of 5.5 Mtpa of high grade primary ore material. The low grade material is stockpiled and fed in years where the schedule constraints prevent the delivery of 5.5 Mtpa of high grade material.

The Contractor will develop and implement procedures that prevent oversize rock from entering the ore stream at the crusher.

The Contractor shall conduct its operation in such a way that crusher feed material is not lost during crusher feeding, stockpiling, re-handling, sorting of tramp material, secondary breaking of crusher feed material and waste dumping.

The Contractor shall sort all oversize material from all crusher feed material. Oversize crusher feed material shall be re-sized by secondary breaking to a size that complies with the minimum ore size requirement and to suit feed to the crushers.

Secondary breakage shall be by mechanical means and during daylight hours unless specifically approved in writing by the CAGL Mining Manager.

Oversize material shall not be allowed to accumulate in the open pit, crushers, stockpiles or elsewhere on the Site. The Contractor shall schedule its secondary breakage so that oversize is broken within seven (7) days of being sorted and either fed through the crusher or otherwise removed as approved by the CAGL Mining Manager.

The Contractor shall pay particular care when secondary breaking oversize and toe in the open pit to ensure that ore is broken separately to waste. Loss and dilution of crusher feed material shall be minimised.

ROM Pad

During the initial pre-stripping and early mining phase there will be a need to stockpile ore (approximately 400,000 tonnes) while the plant is being built. The ROM is situated to the south of the Plant area (Map 2.2). Suitable flat land is available adjacent to the plant site for storage.

Provision has been made for a ROM stockpile to allow blending to optimise plant performance. ROM ore will be delivered by haul trucks and dumped either on the ROM pad or directly into the 200 tonne capacity crusher feed bin. The ROM pad will be constructed with mine waste and will have a footprint of 113 ha.

A crushed ore "dead" stockpile will allow the majority of ore to be delivered direct to the crusher, which will minimise re-handling costs and provide a reserve stockpile of crushed ore to ensure crusher maintenance can be scheduled without interruptions to the mill operations.

2.12.12 Estimated Mining Production Schedule

The mining schedule managed to achieve the targets within the prescribed constraints. Tables 2.5a, 2.5b and 2.5c show the planned annual material movements resulting from the mining production and mill feed schedules.

2.12.13 Pit Dewatering and Drainage

The Hydrogeological assessment (Appendix 2.12.3) has been completed by Coffey Geotechnics. The findings have shown that the expected groundwater inflows to the pits will be less than 10% of the total dewatering requirements. The main source of dewatering requirements will be direct precipitation.

The pumping requirement has been determined to meet the daily groundwater requirements and to pump out the water from a 100 year return interval 24 hour maximum rainfall event in 33 hours.

The main pumps have been sized to pump directly to the FTSF without the need for staging pumps and tanks.

Table 2.5a: Summary of Material Movement Tonnes by Deposit Area

			Total	Pre-Prod	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Yr 10
AF Gap	Ore	kt	**14,696**	190	3,807	1,689	2,243	2,007	1,369	676	2,122	592		
	Waste	kt	**39,803**	2,014	5,179	6,562	7,876	6,105	6,491	4,102	1,413	63		
	Total	kt	**54,500**	2,205	8,986	8,251	10,118	8,112	7,860	4,777	3,535	655		
Abnabna	Ore	kt	**9,743**	0	1,563	1,747	2,336	622	2,162	1,314				
	Waste	kt	**21,562**	415	3,812	3,716	4,376	6,056	3,032	154				
	Total	kt	**31,305**	415	5,376	5,464	6,712	6,677	5,194	1,468				
Fobinso	Ore	kt	**5,407**		422	3,214	588	1,020	164					
	Waste	kt	**15,953**		6,768	5,951	379	2,790	64					
	Total	kt	**21,360**		7,190	9,165	967	3,810	228					
Esuajah	Ore	kt	**11,948**				737	2,715	2,720	3,633	1,154	988		
	Waste	kt	**15,241**				5,193	4,251	2,872	2,438	285	201		
	Total	kt	**27,189**				5,930	6,966	5,592	6,072	1,440	1,189		
Fetish	Ore	kt	**13,704**						204	1,571	2,549	2,388	3,309	3,683
	Waste	kt	**34,575**						3,194	5,176	4,922	11,859	7,973	1,452
	Total	kt	**48,280**						3,398	6,747	7,471	14,247	11,282	5,135
ALL	**Ore**	**kt**	**55,499**	**190**	**5,792**	**6,650**	**5,904**	**6,363**	**6,619**	**7,194**	**5,826**	**3,968**	**3,309**	**3,683**
	Waste	**kt**	**127,134**	**2,429**	**15,759**	**16,229**	**17,823**	**19,202**	**15,653**	**11,870**	**6,620**	**12,124**	**7,973**	**1,452**
	Total	**kt**	**182,632**	**2,620**	**21,552**	**22,879**	**23,727**	**25,565**	**22,272**	**19,064**	**12,446**	**16,092**	**11,282**	**5,135**

Table 2.5b: Summary of Material Movement Volume by Deposit Area

			Total	Pre-Prod	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Yr 10
AF Gap	Ore	kbcm	**5,441**	94	1,472	623	822	758	482	237	745	208		
	Waste	kbcm	**16,626**	1,143	2,237	2,828	3,413	2,467	2,447	1,538	529	23		
	Total	kbcm	**22,067**	1,238	3,709	3,451	4,235	3,225	2,928	1,775	1,274	231		
Abnabna	Ore	kbcm	**3,500**	0	616	621	820	223	759	461				
	Waste	kbcm	**9,016**	221	1,744	1,610	1,909	2,344	1,134	55				
	Total	kbcm	**12,516**	221	2,361	2,230	2,729	2,566	1,893	516				
Fobinso	Ore	kbcm	**2,042**		216	1,153	206	409	58					
	Waste	kbcm	**7,124**		3,315	2,348	185	1,253	24					
	Total	kbcm	**9,166**		3,532	3,501	391	1,661	82					
Esuajah	Ore	kbcm	**4,479**				307	1,026	1,007	1,346	428	366		
North	Waste	kbcm	**7,202**				3,045	1,938	1,120	917	106	75		
	Total	kbcm	**11,681**				3,352	2,964	2,127	2,263	534	441		
Fetish	Ore	kbcm	**5,009**						107	612	918	874	1,182	1,315
	Waste	kbcm	**14,978**						1,680	2,447	2,173	5,138	2,998	542
	Total	kbcm	**19,987**						1,787	3,060	3,091	6,012	4,179	1,857
ALL	**Ore**	**kbcm**	**20,471**	**94**	**2,305**	**2,397**	**2,156**	**2,415**	**2,412**	**2,656**	**2,090**	**1,448**	**1,182**	**1,315**
	Waste	**kbcm**	**54,946**	**1,364**	**7,297**	**6,785**	**8,551**	**8,002**	**6,405**	**4,958**	**2,809**	**5,236**	**2,998**	**542**
	Total	**kbcm**	**75,417**	**1,459**	**9,602**	**9,182**	**10,707**	**10,417**	**8,818**	**7,614**	**4,899**	**6,684**	**4,179**	**1,857**

Table 2.5c: Ore Stockpile Closing Balances

			PreProd	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Yr 10	Yr 11
Primary	Qty	kt		49	462	147	45		49					
	Grade	g/t		1.57	1.48	1.13	1.16		1.02					
Primary/Transitional	Qty	kt	0	196	354				122					
	Grade	g/t	1.90	1.44	1.39				1.17					
Oxide	Qty	kt	55		0	3	0	1	1	1				
	Grade	g/t	1.23		1.02	0.95		0.96	0.96	0.96				
Oxide/Transitional	Qty	kt	87	44	20	52	4	1	1	6				
	Grade	g/t	1.53	1.65	1.25	1.09	0.81	0.78	1.07	1.30				
Total high grade Stockpiles	Qty	kt	142	289	836	202	50	1	174	6				
	Grade	g/t	1.41	1.49	1.44	1.11	1.13	0.86	1.13	1.27				
Primary	Qty	kt		247	669	1,491	2,206	3,231	4,634	5,120	3,796	1,887	70	
	Grade	g/t		0.60	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	
Primary/Transitional	Qty	kt	0	85	118	123	161	171	204	204	214	50	50	
	Grade	g/t	0.61	0.61	0.61	0.62	0.62	0.62	0.62	0.62	0.62	0.60	0.60	
Oxide	Qty	kt	22	80	94	169	183	258	267	267	133	133	133	
	Grade	g/t	0.59	0.62	0.62	0.61	0.60	0.59	0.59	0.59	0.57	0.57	0.57	
Oxide/Transitional	Qty	kt	26	165	236	301	390	431	453	453	286	136	136	
	Grade	g/t	0.60	0.60	0.60	0.60	0.61	0.60	0.60	0.60	0.60	0.59	0.59	
Total low grade Stockpiles	Qty	kt	48	577	1,118	2,084	2,941	4,091	5,557	6,044	4,429	2,205	389	
	Grade	g/t	0.60	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.59	
Total stockpiles	**Qty**	**kt**	**190**	**865**	**1,953**	**2,286**	**2,990**	**4,092**	**5,731**	**6,050**	**4,429**	**2,205**	**389**	
	Grad	**g/t**	**1.21**	**0.90**	**0.96**	**0.65**	**0.62**	**0.61**	**0.63**	**0.61**	**0.61**	**0.61**	**0.59**	

2.12.14 Waste Dumps

2.12.14.1 General

Waste mined will be placed on the natural topography after available topsoil within the footprint area has been stripped. Waste dumps height for Abnabna, Fobinso, Fetish and Esuajah North will be 25m, 50m, 70m and 35m respectively and are designed not to significantly exceed the general height of surrounding landforms. The locations of the various waste dumps are shown in Map 2.2.

2.12.14.2 Acid Generation Potential

General

Whether or not acid mine drainage will be generated is largely a function of the mineralogy, the availability of each acid generating and neutralising mineral present, the physical characteristics of the material and the environmental setting.

Sample Selection

Selection of sample type and number of samples from CAGL exploration drill cores was based on a several factors including:

- A detailed knowledge of CAGL project area geology and comparison with other areas in Ghana that have (e.g. Bogoso) or have not (e.g.Obotan) generated acid rock drainage. The geological setting of the CAGP area is the same as the latter.
- A matrix based on the presence of granite hosted ore and waste and sediment hosted ore and hosted waste, and sulphide range of 0, 3, 1 and <5% for each of the five proposed pits was constructed and evaluated. Non-occurring combinations were eliminated and samples selected from drill cores representing the known geological combinations.
- Identification of samples that would be considered representative of ore and waste geology was undertaken by a fully competent professional geologist with wide experience of West African geology and Ghana in particular. The geologist was supported in his selection by a person with a wide international experience of ARD.

Sample selection was approximately evenly split between the Abnabna, AF Gap, Fobinso, Fetish and Esuajah North (Appendix 2.11). An example of the Abnabna sampling locations is presented in the Abnabna 25910 E section (Figure 2.9) at the end of this section. The figures for the sampling locations in the other pits are presented in Appendix 2.11.

Seventy-nine samples of waste and ore were analysed for Acid Generating Potential (AGP) and for Neutralising Potential (NP) using the Modified ABA test[2]. The analysis was done by SGS Lakefield Research (Pty) Ltd, South Africa on samples selected by CAGL. SGS Laboratory Services Ghana acted as an intermediary. The net neutralising potential (NP-AP) has been used as a general indicator of the potential for acid generation.

Results of Analysis

The results of the AGP analysis are summarised in Table 2.6a. The locations of the samples that exhibited high (1), medium (4) and low (2) AGP are shown in table 2.6b. The one sample that showed strong AGP was from of narrow zone of mineralized sediments (wacke) adjacent to the mineralized granite in the AF Gap deposit that contained trace to 0.5% sulphide. Volumetrically, this rock type would present a very small portion of the in-pit material,

Based on the above results, ore and waste rock management techniques are as follows:Most ore will be processed immediately and hence will pose no risk in terms of mining acid runoff. Any potential issues with the residual tailings are adequately dealt with in the tailings impoundment design;

[2] Lawrence, R.W. and Wang, Y. (1997), *Determination of Neutralization Potential in the Prediction of Acid Rock Drainage*, Proc. 4th International Conference on Acid Rock Drainage, Vancouver, BC, p449-464.

- Any high-grade ore that is stockpiled is stockpiled for a relatively short period, and hence poses low risk. Low grade ore stockpiles will be constructed in such a way to allow runoff to be collected, contained and tested prior to release to the surrounding environment (if clean), or pumped into the tailings impoundment (if acidic);
- During pre-production the geologists will work closely with the environmental staff to identify waste materials with the potential to provide ARD. These waste rocks will be tested to determine the potential for ARD. The geologists will develop expertise in selecting waste that may have ARD potential. Any waste that the geologists are suspicious about will be encapsulated. A secondary aim of this programme is to calibrate in-situ Sulphur assays with potential AP. This can then use blast hole samples for Sulphur to predict potential acid potential;
- Any AF Gap waste with acid generating potential will be encapsulated internally within the waste dump itself hence surrounded by low permeability material, with specific seepage water management.
- Waste rock that has not been specifically identified with acid potential will be evenly blended throughout the dumps, thus relying on the overall net neutralisation potential to neutralise any isolated areas of potential acid generation.

Table 2.6a: Summary of Acid Generation Potential for CAGL Ore and Waste Samples

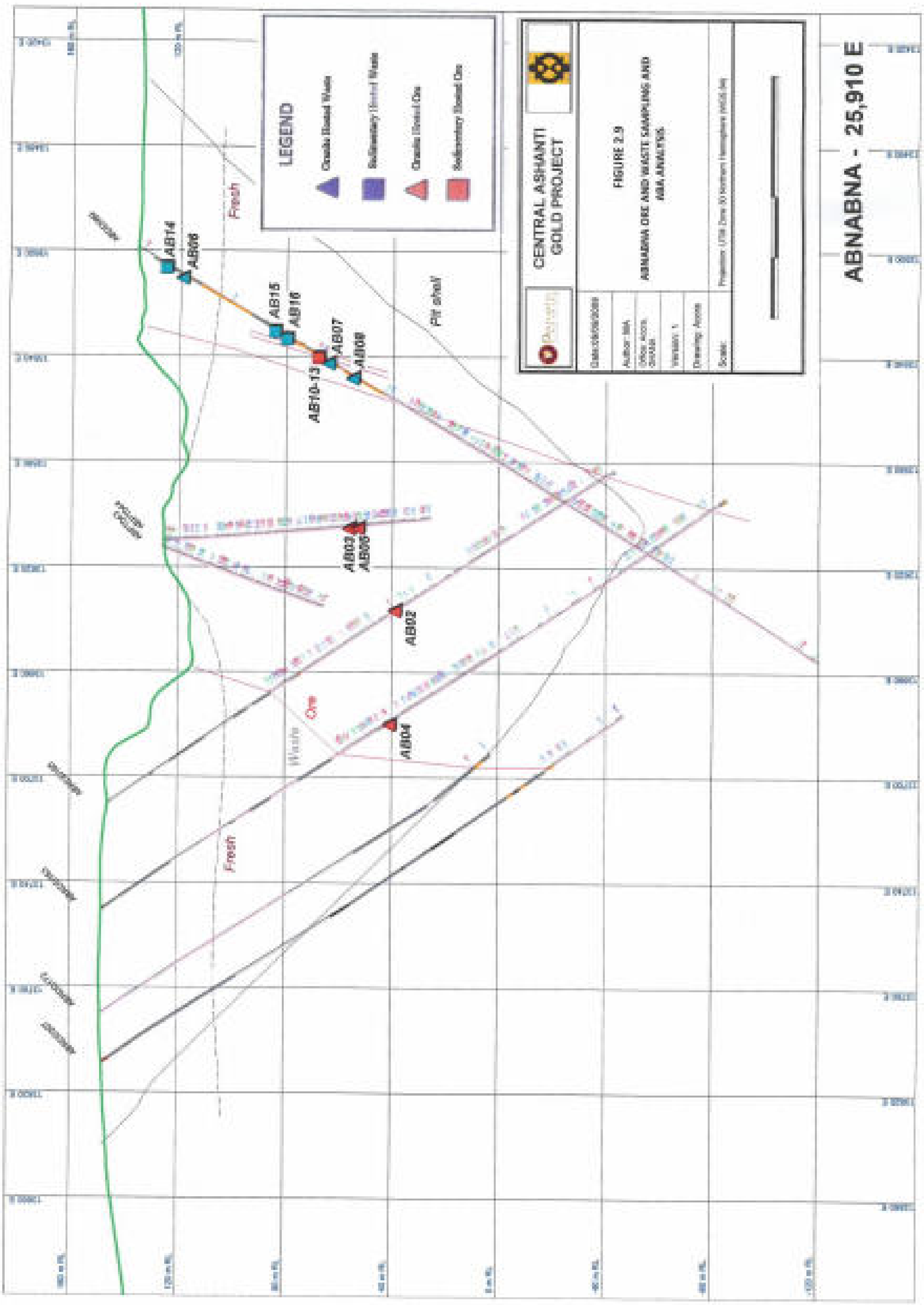
Acid Generation Potential (AGP)	Sample Identifiers by Drill Hole Number	General Reasons for Classification (with some exceptions)
Strong AGP	ABDD101 (87.1-87.4)	Sulphide>0.3%, Negative net NP(<-20) NP/AP ratio <1
Medium AGP	ADD065 (61.09-61.29); ABRDD208(113.96-114.20); ABRD340(134.7-135.28); ABDD102(47-48.5)	Sulphide >0.2% Negative net NP(>-20) NP/AP ratio <1
Low AGP	ABRDD208(92-93)*; FBDD020(71.63-71.93)	Sulphide <0.3% Low NP Negative net NP NP/AP ratio <1
Uncertain possible AGP or NP	ABRDD165(129.32.129.8); ADD036(205.05-205.30); AKRDD227(133.48-134);ADD115(114-114.63);AKRC068(78-80);ADD118(32.22-32.48);ADD118-(103.0-103.5);ADD065(80.63-81.08);ABRDD338(77.2-77.7);ABRDD340(133.0-133.52);FBDD039(80.0-80.28);FBDD008(192.46-192.76)	Low AP Low NP NP/AP ratio between 1and 3
Low NP	ABDD089(11.90-12.16); ABDD089(19.60-19.97); ABDD013(7-8)*; AKRC009(30-32);ADD074(6.76-6.87)*; AKRC068(16-18) AKRC065(18-20)AKRDD116(8-12); ADD008(4.57-12.19)*; ADD009(8-8.12)*;ADRDD105(3-4);ABDD102 (38.0-39-5); ABDD032(31.88-31.98);ABDD101(33.5-35); FBDD009 (32.00-33.21); FBDD009(25.91-26.90); FBDD039(11-12.5)* ; AFRC012(32-36)	Sulphide <0.1% Low NP
Medium NP	ABDD089(64.4-64.7);ABDD089(60.29-60.49);ADD036(213.58-213.87); ADD086(116.3-11684);ADD086(139.48-140.00);ADD074(158.8-159.3); ADD065(37-37.55);ADD007(86.59-86.79);ADD007(104-104.63);ABDD102(135.55-136.73);ABDD102(123.52-123.80); ABDD102(11653-116.82);FBDD039(92.42-92.64);FBDD038(84.16-84.72)	Sulphide <0.5% Positive net NP (>10) NP/AP ratio >3
Strong NP	ABDD089(79.96-80.46); ABDD089(94.28-94.50); ABPT044(74.26-74.76); ABRDD163(129.20-129.67); ABDD089(83.51-83.76); ABDD089(80.74-81); ABDD089(78.42-78.76);ABPT044(69.30-69.79);ADBB089(79.68-79.93); ADD074(119.19-119.48);ADD086(126.49-126.99);ADD115(129-129.54); ADD074(283.74-284);ADD007(85.16-85.41);ADD007(76.18-76.84); ADD065(86.65-87;AKRDD103(89.90);AKRC(047(76-78); ABDD102(115.91-116.53); ABDD032(195.0-109.5);;FBDD008(146.32-146.62); FBDD039(187.05-187.65);FBDD039(125.51-126.41); FBDD038(123.13-123.38); FBDD008(193.58-193.86); FBDD039(156.12.157.7)	Strongly positive net NP(>20) NP/AP ratio >4 High carbonate

*The NP on these samples may be underestimated due to possible stored acidity, as indicated by a paste pH value of less than 5.5.

Table 2.6b: Sample Locations for Strong, Medium and Low AGP Samples

AGP Description	Hole Number	Location
Strong AGP	ABDD101	Located at 26320E in AF-Gap pit, the sample location is 52m below the surface. Sulphide >0.3%
Medium AGP	ADD 065	Located at 7280N in Esuajah North pit, the sample location is 53m below the surface. Sulphide >0.2%.
	ABRDD208	Located at 26320E in AF-Gap pit, the sample location is 88m below the surface. Sulphide >0.2%.
	ABRDD340	Located at 26320E in AF-Gap pit, the sample location is 108m below the surface. Sulphide >0.2%.
	ABDD102	Located at 26320E in AF-Gap pit, the sample location is 36m below the surface. Sulphide >0.2%.
Low AGP	ABRDD208	Located at 26320E in AF-Gap pit, the sample location is 71m below the surface. Sulphide <0.3%.
	FBDD020	Located at 27120E in Fobinso pit, the sample location is 55m below the surface. Sulphide <0.3%.

Abnabna Ore and Waste Sampling Locations for Acid Rock Drainage ABA Analysis



2.12.14.3 Waste Rock Dump Design Parameters

The design parameters that have been used for the waste rock dumps are as follows:

Table 2.7: Design Parameters for Waste Rock Dumps

Name	Base Area (ha)	Maximum Height (m)	Bench Ave. Heights (m)	Battered Slopes (°)	Berm Width (m)	Overall Slope (°)
Abnabna/AF Gap	57.5	25	10	20	5 - 6	17
Fobinso stage 1[1]	50	50	10	20	5 – 6	17
Fetish	102	70	10	20	5 – 6	17
Esuajah North	97.3	35	10	20	5 - 6	17
Total Base Area	306.8	-	-	-	-	-

1. Ultimate dump covers the pit therefore shares area with pit

2.12.14.4 Construction Method

Any marketable timber occurring within the footprint of a waste dump will be harvested prior to dumping (see section 2.11.1) and topsoil stockpiled. Waste will be dumped initially at the repose angle of the waste material (generally between 35° - 37°). The waste dumps will then be progressively rehabilitated by pushing down or re-shaping the batters of completed dump lifts to the design angle of 20° (as soon as each dump lift becomes inactive), covering with topsoil and planting of vegetation. Where practical, rock bunds (to serve as "velocity reducer") or sediment ponds will be constructed at the toe of the waste dump (downstream) to prevent the potential release of any contaminants or sediments by surface runoff from the waste dumps into the nearby stream catchment.

2.12.14.5 Waste Rock Areas

The Abnabna Dump (Map 2.2) has been designed to maintain and average height of 25m on the Abnabna village side (see figure below). It will have a final footprint of 37 ha. One purpose of its location and design is to reduce potential impact of noise on Abnabna village. A reference x-section of the Abnabna dump in relation to the Abnabna pit follows this section.

The Fobinso Dump (Map 2.2) has the largest capacity and will rise 50m above the surrounding area and the final foot print covers the mined out Fobinso pit (see reference x-section following this section. This dump will be initially constructed outside the footprint of the Fobinso pit until this pit is complete.

The Fetish Main Dump (Map 2.2) backfills the existing Chirawewa pit then a small valley before abutting up to an existing rehabilitated waste dump. It will have a final height of 70m in the NE corner, 40m in the NW and 50m in the SE and SW corners and a footprint of 102 ha. A reference x-section of the Fetish dump follows this section.

The Fetish Backfill Dumps are designed to rehabilitate the area affected by the previous mining. The two South Bokitsi pits adjacent to the highway will be filled to 5m above natural surface to control drainage in the area. The second dump will fill in a small pit to the south of an existing dump before marrying into this dump.

The Esuajah North Dump (Map 2.2) is to be built in two sections, one to the north of the pit, the other to the east (Map 2.2). The combined footprint of the two sections will be 97.3 ha and the height of each will not exceed 35m. A reference x-section of the Esuajah North dump follows this section.

A three dimensional view of each of the above dumps is illustrated in the three dimensional figures for the respective pits provided above.
Both Fetish and Esuajah North will have an ore stockpile close to the pit from where ore will be transported to the plant by semi-trailers. The base of these stockpiles will be built with mine waste and sheeted with low grade ore to minimise dilution.

The AF Gap Bund is a secondary waste rock disposal area that provides protection from the Abnabna stream in the event of a flood (Map 2.2). The dump will be approximately 5m high.

2.12.14.6 Waste Dump Volumes and Disposal Destinations

Table 2.8 shows the estimated ex-pit waste volumes and where the waste from each pit will be placed, including backfilling of existing pits.

2.12.14.7 Waste Dump Volumes Drainages

Surface runoff from the waste dump tops and the batters will be collected and directed of the waste dumps via rock fill drains. These drains will flow to diversion channels located at the base of the waste dumps and will report to sediment ponds prior to discharge to local watercourses. Water retaining berms will be constructed on the crests of the waste dumps and on each bench. A fuller discussion on site water management is presented in section 2.18.6

Table 2.8: Rock Waste Source and Destination Volumes

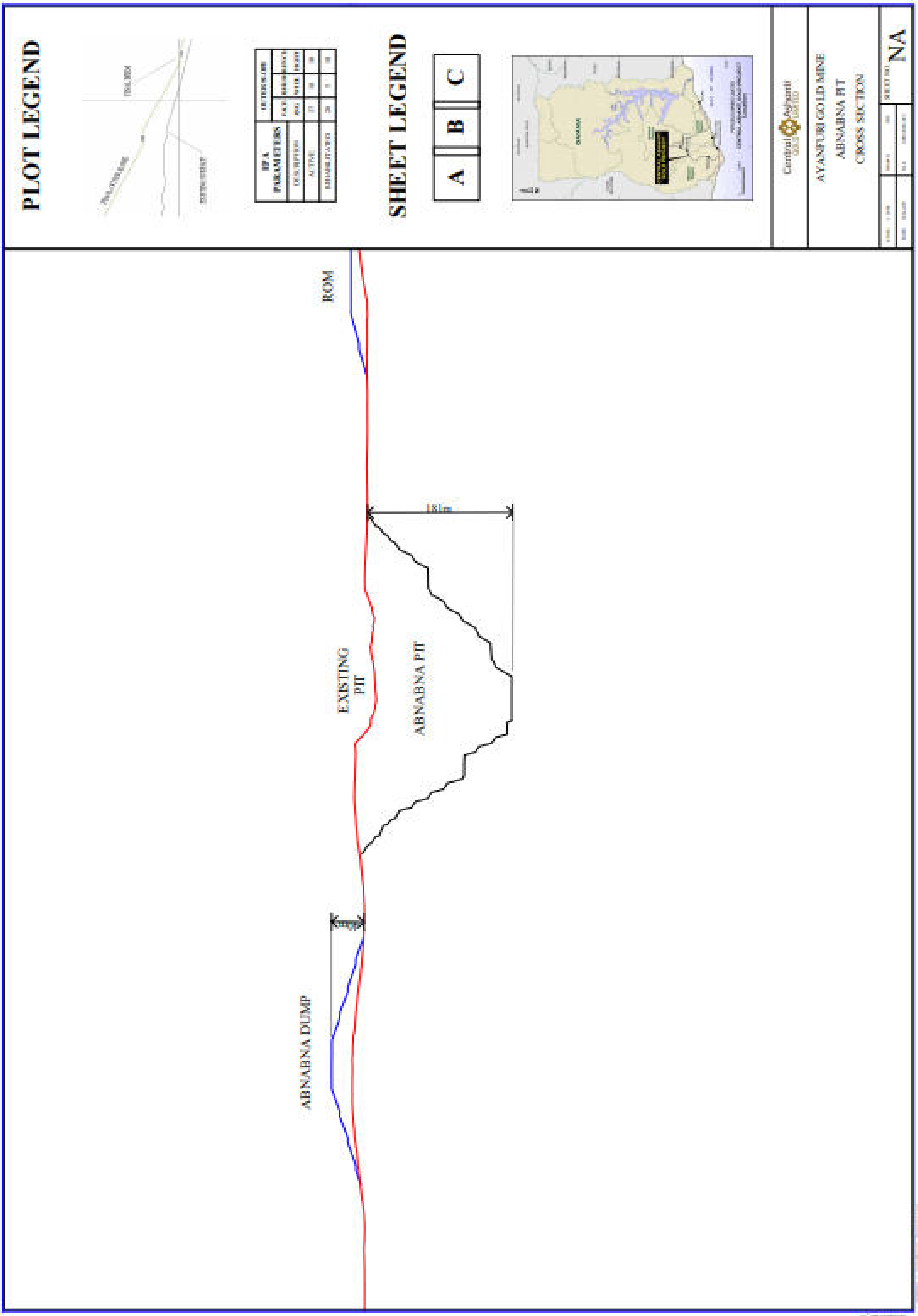
	Waste Source			Waste Destination	
Location	**Name**	**Vol. (Mbcm)**	**Vol. (Mlcm)**	**Name**	**Vol. (Mlcm)**
Abnabna & AF Gap	Abnabna 1	2.1	2.7	ROM Pad	4.0
	Abnabna 2	2.2	2.9	FTSF Embankments	0.5
	AF Gap 1	3.2	4.2	Abnabna (west)	4.6
	AF Gap 2	4.1	5.3	Protection Bund (north)	0.5
	ABN - AFG 3	1.2	1.6	Fobinso Ultimate	7
Sub Total		***12.8***	***16.6***		***16.6***
Fobinso & ABN - AFG3	Fobinso 1	5.7	7.4	ROM Pad	4
	Fobinso 2	1.4	1.8	Fobinso dump 1	9.5
	ABN - AFG 3	12.8	16.6	Fobinso Pit Backfill (Stage 1)	5.5
				Fobinso Pit Backfill (Stage 2)	3.7
				Fobinso Ultimate	3.2
Sub Total		***19.9***	***25.9***		***25.9***
Fetish	Fetish 1	5.8	7.5	Fetish Main Dump	16.2
	Fetish 2	8.7	11.3	Fetish Backfill Dumps	2.6
Sub Total		***14.5***	***18.9***		***18.8***
Esuajah North	Esuajah Nth	6.2	8.1	Esuajah North Dumps	8.1
Sub Total		***6.2***	***8.1***		***8.1***
TOTAL	**All pits**	**53.4**	**69.4**	**All Dumps**	**69.4**

2.12.15 Haul Roads

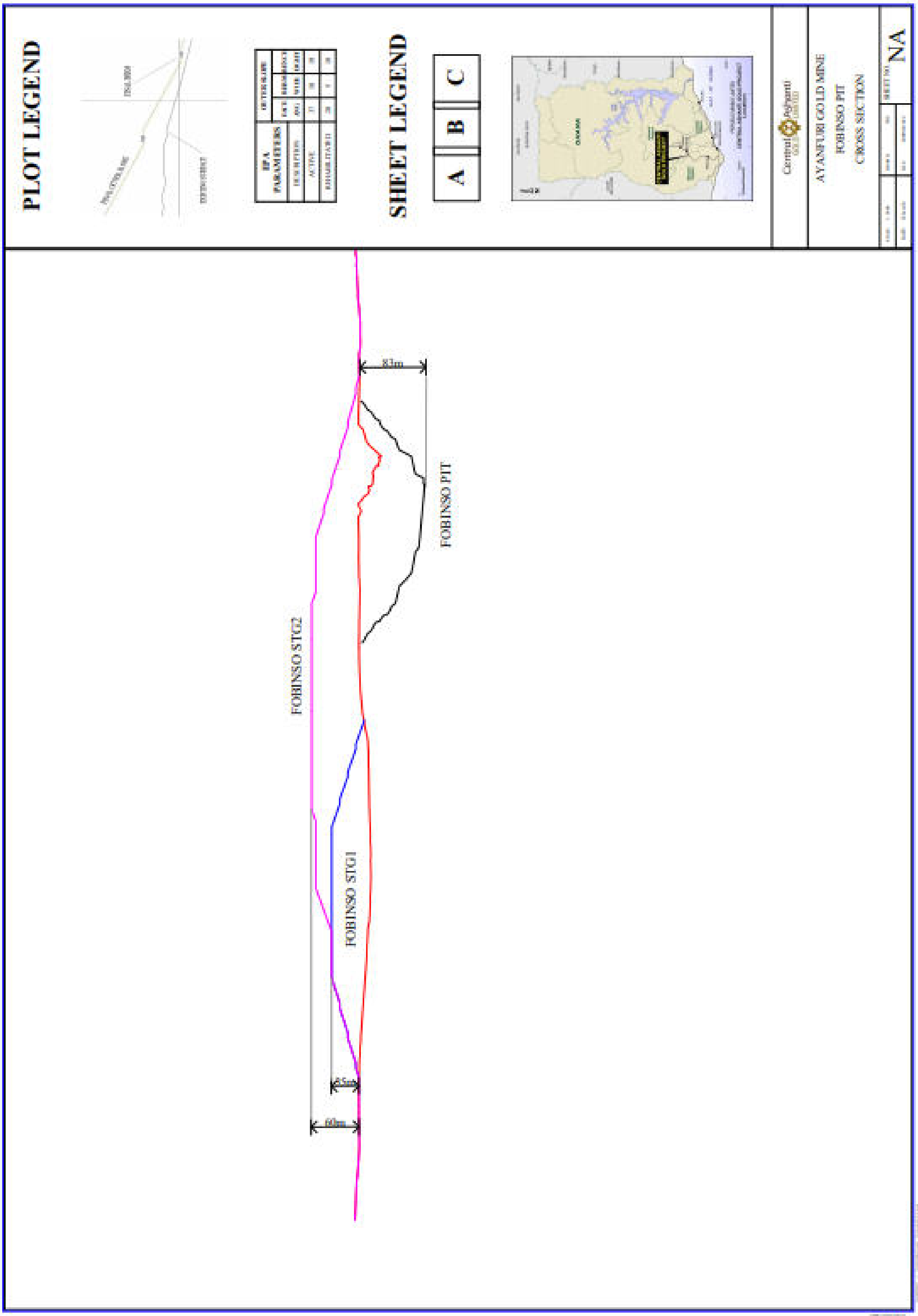
Mine haul roads are generally designed for the exclusive use of Rear Dump Trucks (RDT). Light vehicle traffic associated with the mine operations will also use the haul roads. All mine roads will be private roads with restricted access and policed. Ghana mining legislation and regulations requires a mining company to police public safety around the mine thus, for safety reasons, no public traffic of any sort will be permitted on these roads. Haul roads within the mining area will be

30m wide which includes drainage which gives a running width of 25m. These are dual lane roads to allow for safe passing of haul trucks and overtaking.

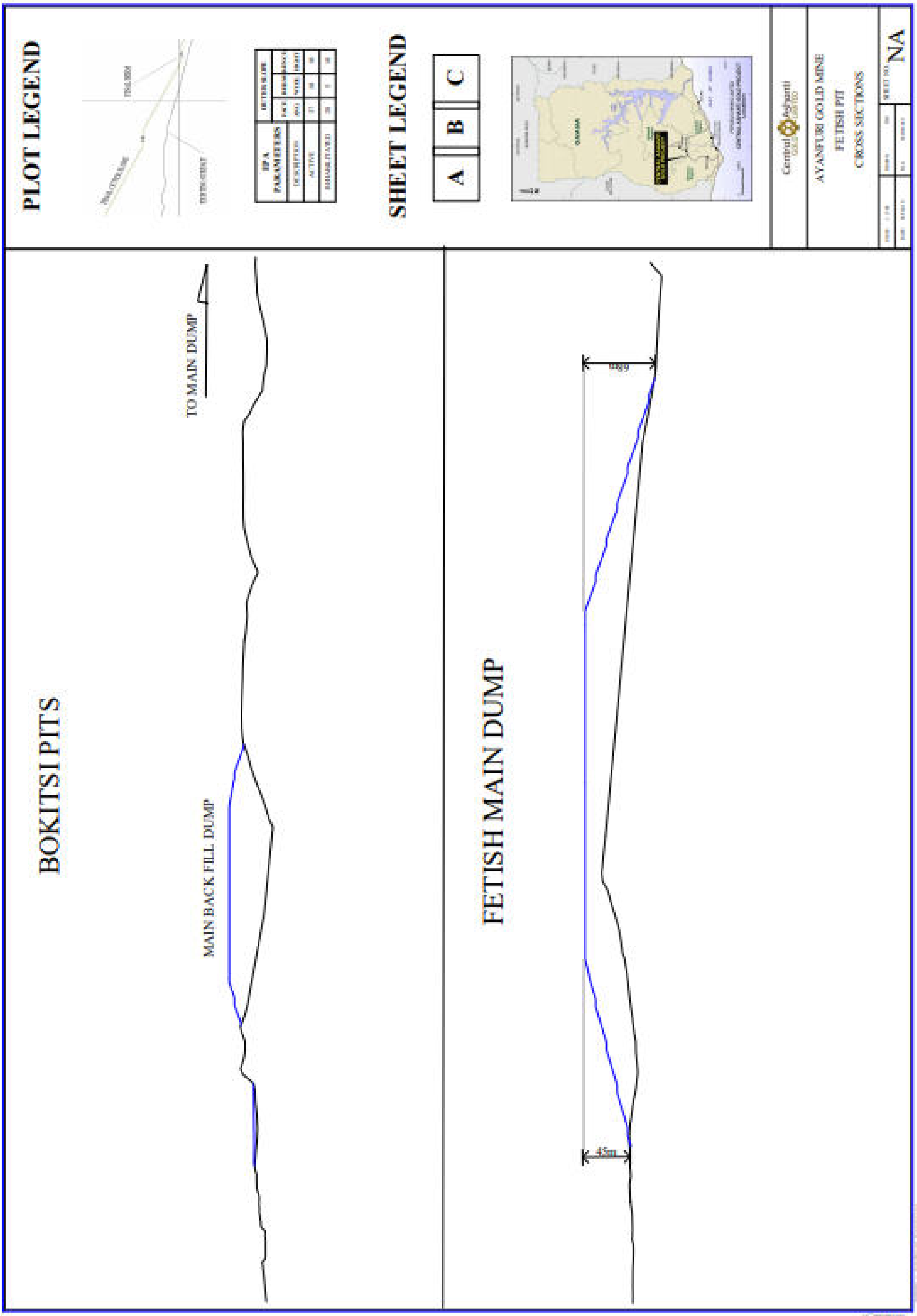
Abnabna dump x-section



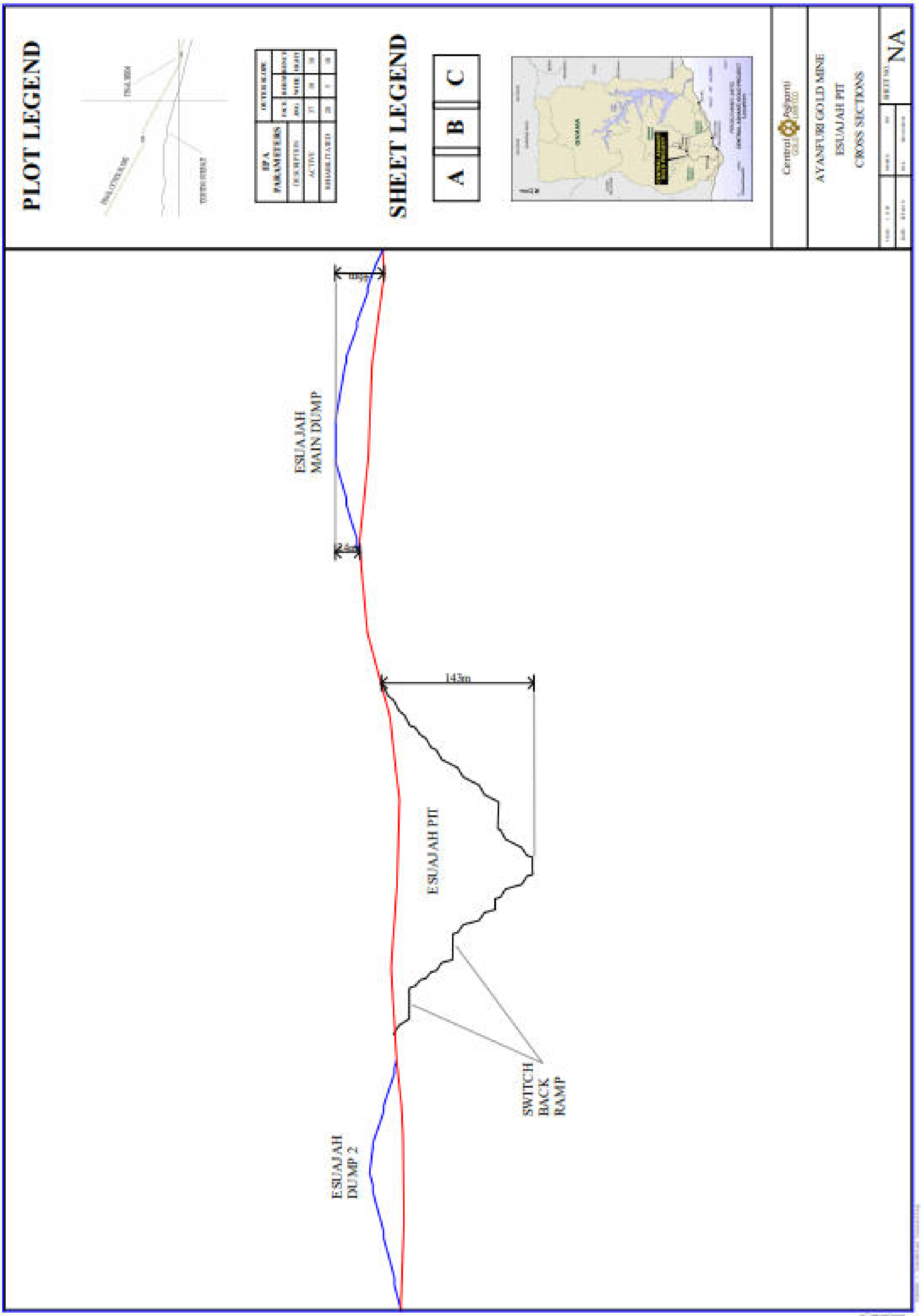
Fobinso dump x-section



Fetish dump x-section



Esuajah North dump x-section



These roads are constructed to a life-of-mine standard and suitable for use after mine closure with appropriate periodic maintenance (see section 8.9.10 for after closure use or reclamation). All mine roads will be maintained regularly with a grader. Standard mine site road rules will apply on all mine roads.

As ore will also be mined from the Esuajah North and Fetish pits 12m wide haul roads that merge on the western side of the Ayanfuri – Tarkwa highway will be constructed. As these haul roads cross gazetted public roads, illumination of the intersection together with a 24 hour manned spotter's hut will control the crossings. The ore haulage trucks will be licence 10 wheel rigid axle trucks and undergo regular roadworthy inspections by CAGP.

2.12.16 Road Maintenance, Dust, Noise and Vibration Control

The mining contractor will be responsible for regular maintenance of the private roads, the in-pit roads and pit floors. This includes the suppression of dust using water trucks. A provision for an adequate number of water trucks for the purpose of water spraying will be included in the contractors' scope of work.

The Contractor shall carry out its operations in such a way that nuisance from dust is such that no valid complaints are received by CAGL from the local community. Dust generated from areas not disturbed by the Contractor is not included within this responsibility as part of the Works, but may be carried out at the request of the Mining Manager.

The Contractor shall carry out its operations in such a manner as to ensure that noise from its mining activities does not result in valid public complaints regarding noise.

The Contractor shall select its Equipment and carry out and maintain sound dampening and exhaust muffling modifications to its Equipment so as to ensure that its operations shall conform to any Statutory Regulations for noise abatement.

In the event of a complaint being received regarding excessive noise, blast vibrations or dust the Contractor shall investigate the complaint. The Contractor shall provide the CAGL Mining Manager with a detailed report within twenty-four (24) hours of the complaint. This report shall include, but not necessarily be limited to, the following information:

- full details of the nature of the complaint;
- an assessment of the validity of the complaint;
- a full description of the relevant operations and prevailing weather conditions at the time;
- details of suppression or abatement measures in place at the time; and
- details of corrective action being taken or to be taken to eliminate future complaints.

2.13 MINING CONTRACTORS INFRASTRUCTURE

The Mining Contractor is responsible for establishing all of the facilities required to support his operation (see figure on following page). CAGL will provide access to an area located adjacent to the plant site for the Contractors exclusive use.

2.13.1 Mining Area Access Control

The mining contractor's area will have a 10m^2 gatehouse which will control access to the mine by means of a boom gate on the road outside the mining contractor's area and will also control access to and from the mining contractor's yard. The mining contractors laydown area is located immediately north of the processing plant. This area will contain

2.13.2 Mining Contractor Facilities

Facilities for the mining contractor will comprise the following:

- An office with a floor area of about 110m^2;
- A mining plant workshop and store will be one building divided into three sections with a total internal floor area of 400m^2. The building will include two service bays for earthmoving equipment, a secure storage annex and a welding annex. The building will be constructed from steel structural members and steel sheeting;
- The mining workshop will be located adjacent to a 200m^2 wash down slab and waste oil management facility;
- Vehicle wash down area incorporating a silt and oil trap and an oil separator to remove any contaminant oil;
- Waste oil management facility the mining contractor will manage for the safe removal of waste oil by using an SOS service from suppliers of waste oils;
- A fuel farm and lube facilities;
- Ablutions block.

2.13.3 Magazine and Explosives Plant

The mine contractor will be responsible for drilling and blasting and will have control over the explosives magazine and plant. The magazines and the explosive plant to prepare emulsion when and where required will be sub-contracted by the mine contractor to a reputable explosives manufacturer and supplier.

Two options are being considered for the location of the Bulk Explosive store and Magazine.

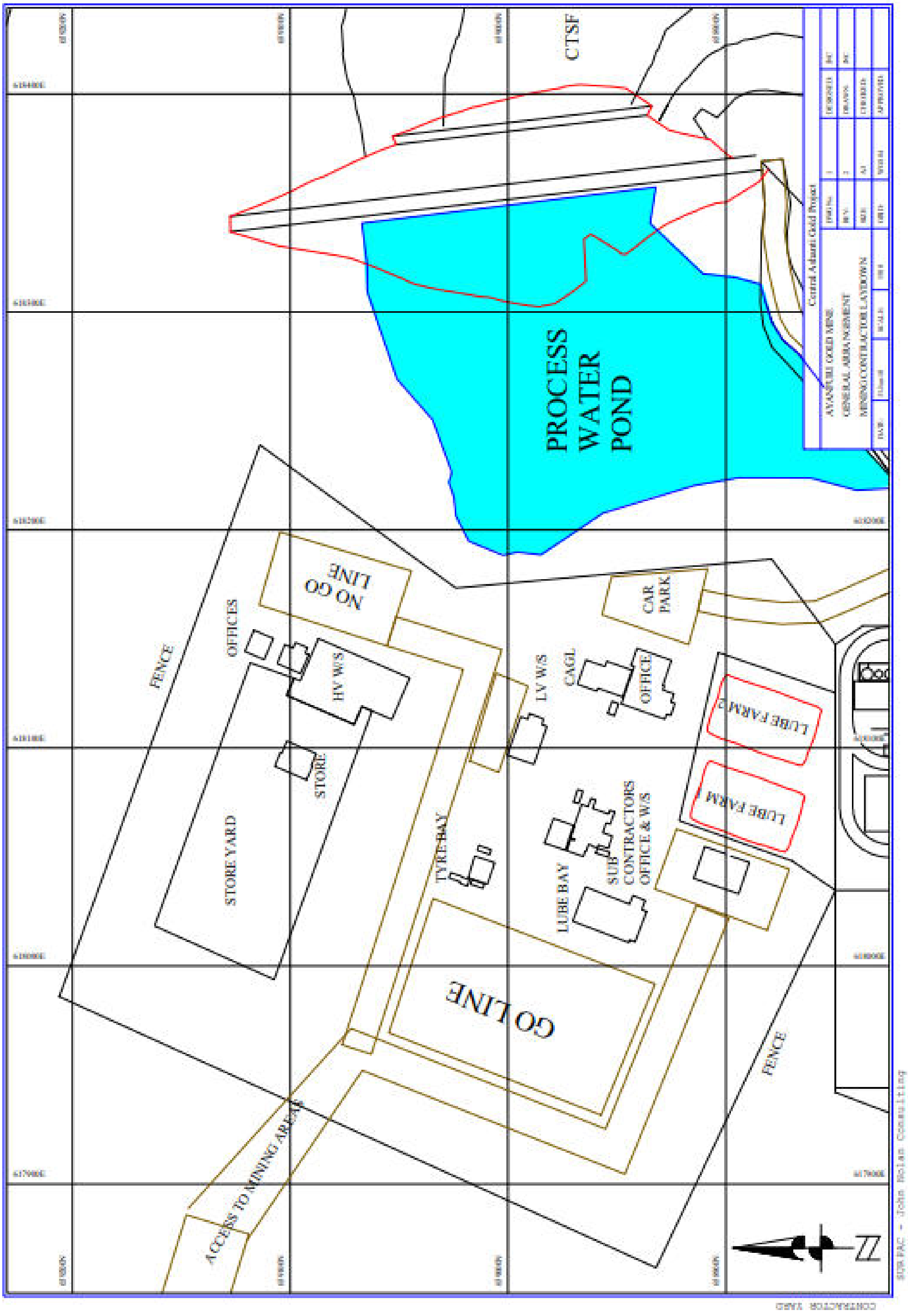
- Option 1 is located at approximately 657,625mN and 617,675mE and can be accessed from the ROM pad and close to the power line that services the Welcome Centre /security hut at the mine site entrance.
- Option 2 is located at approximately 657,975mN and 618,480mE and is adjacent to a TSF embankment and accessed by either the TSF service road or the East pits haul road.

The site will be fenced, bunded, lighted, have 24 hour security and operated in accordance with Explosive Regulation 1970, L.I.666.

2.13.4 Ammonium Nitrate Storage

Ammonium nitrate will be stored in a 270m^2 shed in the mining contractor's yard. Access to this shed will be restricted by a locked perimeter fence within the yard. Ammonium nitrate will not be stored in an explosive form and will not be mixed with fuel oil to form explosives until it is in the explosives mixing truck at the blast site.

Mining contractor yard figure



2.14 PROCESS PLANT DESCRIPTION

2.14.1 Introduction

The process plant Process Flow Diagram (PFD) has been developed from the Process Design Criteria (PDC) prepared by Metallurgy Pty Ltd (Metallurgy). The PDC has been used by Mintrex to develop the PFD and process plant design. Mintrex have worked with Metallurg and Perseus to design a simple and robust plant. The PFD is presented in the figure following this page.

2.14.2 Engineering Design Philosophy

The design of the treatment plant reflects:

- A process flow diagram based on the requirements set out in the design criteria.
- Selected equipment shall be designed for process requirement.
- A control philosophy for a plant with an appropriate level of automation and remote control facilities, supplemented by sufficient alarming, safety features and diagnostics to facilitate troubleshooting.

The proposed flow diagram has been selected to suit the various ore bodies associated with the Project. The major characteristics of the plant design are listed below:

- Primary gyratory crusher and open stockpile followed by a single stage SAG mill and pebble crusher to achieve a design grind of 80% passing 212 microns. Gravity circuit on cyclone underflow consisting of two centrifugal concentrators and an Intensive Leach Reactor for the gravity concentrate.
- Rougher Flotation Circuit consisting of seven naturally aspirated tank cells.
- Concentrate thickener followed by regrind to a design grind of 80% passing 45 microns.
- CIL circuit consists of one pre-leach tank and six adsorption tanks.
- Dedicated tailing storage cells for the both the flotation tail and the CIL tail.

2.14.3 Treatment Plant Overview[3]

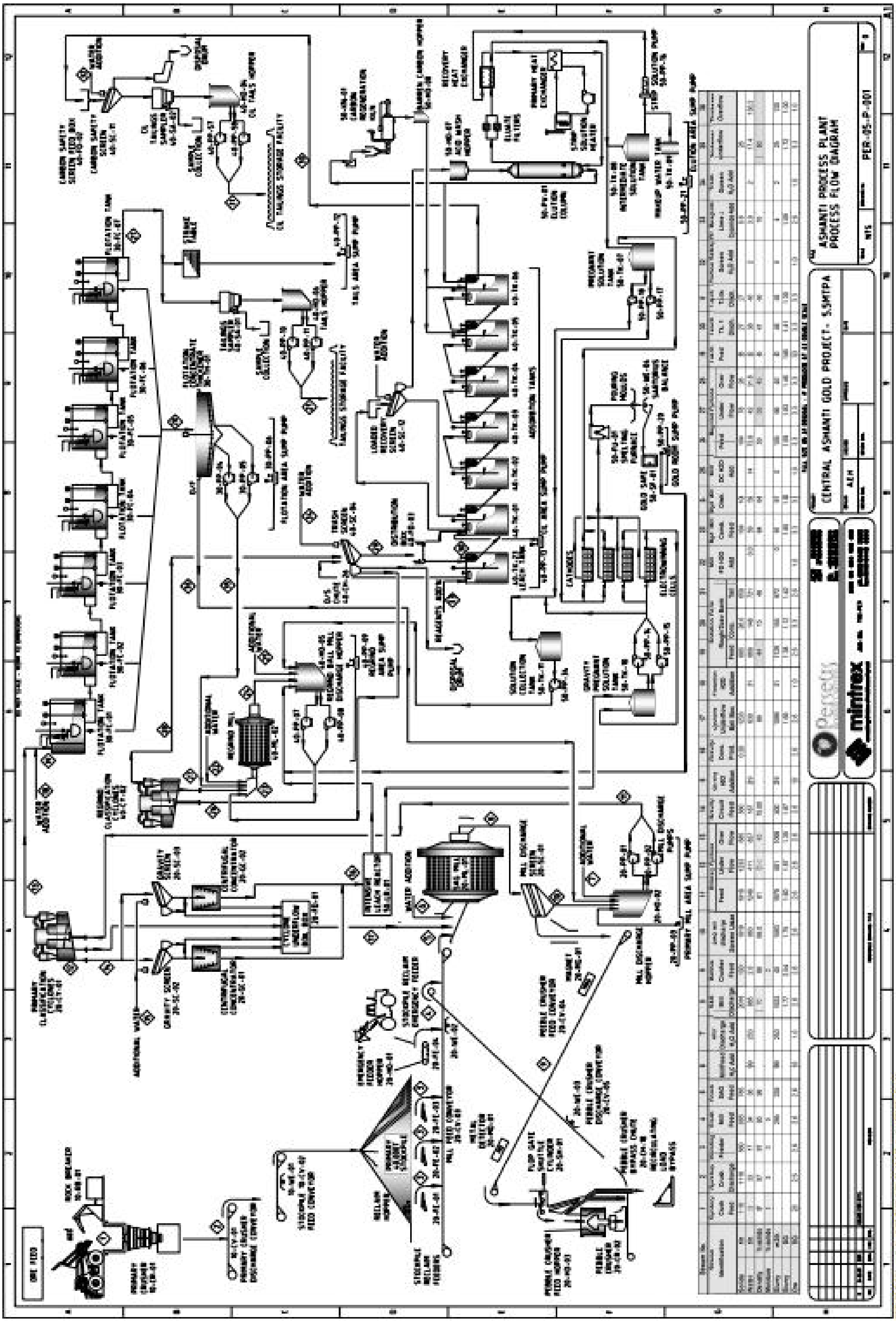
The treatment plant will process combinations of oxide, transition and primary ores from the various pits at a nominal capacity of 5.5Mtpa. The treatment plant is based on:

- Single stage crushing,
- Semi Autogenous Grinding (SAG),
- Gravity recovery of free gold from a portion of the cyclone underflow,
- Intensive leaching of the gravity concentrate,
- Rougher flotation with 7 cells, pre-thickening and then one concentrate regrind mill,
- A 7 stage concentrate CIL circuit.

The stripping plant includes a 3 tonne Anglo-American elution circuit with elution column, 4 electrowinning cells, removal of the gold deposition from the stainless cathodes with high pressure water sprays, smelting of the product and a carbon regeneration kiln.

[3] This abbreviated description is provided for general understanding only and does not represent a detailed design description.

Process flow chart



2.14.4 Crushing Plant

Run of mine ore will be delivered to the plant in 100 tonne rear dump haul trucks (Caterpillar 777 or equivalent). The ROM bin will have a capacity of 150t to allow these trucks to direct dump to the crusher. A primary gyratory crusher will crush the run of mine ore to a nominal 80% passing 125mm. It is proposed to run the crusher for 24 hours per day, 7 days per week. The primary crusher will be housed in a steel structure with a steel ROM hopper and concrete retaining wall. The crusher will be located adjacent to a 14m high ROM stockpile.

A rock breaker installed at the crusher will break any oversized rock that lodges in the crusher and would otherwise not pass through. The crushed rock will collect in a surge chamber under the crusher and will be fed in a controlled manner onto the crusher product conveyor by a sacrificial belt conveyor. A 190m long, 1,200mm wide conveyor will deliver the primary crushed ore to a surge stockpile, with a total capacity of 40,000t and a live capacity of 7000t.

2.14.5 Stockpile and Reclaim

The stockpile will be built over a tunnel with a three discharge chutes along its length with three vibrating feeders which will reclaim crushed ore. An additional emergency apron feeder located beneath a reclaim bin at the edge of the stockpile, will enable front end loader reclaim from the primary stockpile in the event of emergency or low stockpile levels.

2.14.6 Grinding and Classification

The vibrating feeders under the primary stockpile as described above will provide a controlled feed onto the 165m long, 1,200mm wide mill feed conveyor that will feed the SAG Mill. The SAG mill feed conveyor will provide a nominal 685tph instantaneous feed rate to the SAG mill feed chute.

A 9.75 metre diameter by 5.95 metre long effective grinding length (EGL) SAG mill is proposed for the primary grinding duty.

The discharge from the SAG mill will flow to a vibrating screen with a 12mm nominal aperture. Underflow from the vibrating screen will collect in the mill discharge hopper. The oversize material (scats) will pass over the vibrating screen, where sprays will wash the material to clean off any remaining slurry, prior to collecting onto the pebble crusher feed conveyor which will transfer the material to the pebble crusher.

The slurry in the mill discharge hopper will be pumped to a cluster of eight 650mm cyclones, six operating, two spare, mounted on a tower adjacent to the SAG mill. The cyclones will classify the slurry to a nominal P_{80} of minus 212 micron with coarse material remaining in closed circuit in the SAG mill.

2.14.7 Gravity Circuit

The two centrifugal gravity concentrators are located directly below the gravity screens and will act as a gravity rougher, removing an expected 213kg/hour of concentrate. The concentrates will then be feed into the Intensive Leach Reactor with a batch size of 7000kg/ batch and subjected to high intensity cyanidation.

The pregnant solution recovered from the reactor will be fed to a pregnant solution tank and recirculated around the two dedicated electrowinning cells for recovery of gold to stainless steel wool cathodes. The gold will be removed from the stainless steel wool cathodes by high pressure water blasting and then filtered in a pressure filter prior to drying. The leached tailing solids from the reactor will be pumped to the regrind mill discharge hopper.

2.14.8 Rougher Flotation Circuit

The classified slurry from the primary cyclone overflow will be directed to rougher flotation cells. The flotation cells consist of seven naturally aspirated tanks. The 3.8% w/w concentrate will gravity feed into the 8 m diameter high rate flotation concentrate thickener at a feed rate of 26.0t/h. Concentrate will then be pumped from the thickener underflow into the regrind mill discharge hopper. The flotation tails will gravity feed to the flotation tails hopper via a crosscut sampler before being discharged to the dedicated flotation tailings dam.

2.14.9 Regrind Mill Circuit

A 2.7 metre diameter, 4.75 metre long effective grinding length (EGL) ball mill is proposed for the regrinding duty with an operating capacity of 26.2t/h.

The concentrate from the regrind mill discharge hopper is pumped to the regrind cyclone cluster of six cyclones by duty and standby discharge pumps, which will each have separate suction lines from a common hopper. The cyclone underflow returns to the feed chute for the regrind mill and the overflow at 45% solids, gravity feeds to the trash screen located on the top of the leach tanks.

2.14.10 Carbon in Leach

The classified slurry from the regrind cyclone overflow will be directed to the trash screen with the ability to discharge the concentrate into either CIL tank 1 or 2. Oversize material from the trash screens will be returned to the regrind mill feed chute with the option of bypassing the trash screen when needed to a disposal drum at ground level.

The leach train will comprise of seven tanks, with a total combined nominal capacity of 1110m^3, providing a slurry residence time in the leach circuit of 30 hours with a slurry density of 45% solids by weight. The tanks will be interconnected with launders and slurry will flow by gravity through the tank train. The circuit configuration will be the first tank as pre-leach followed by six adsorption stages.

Each tank will be fitted with mechanically wiped carbon retention screens. Carbon will be held in all tanks except the first tank where the carbon retention screen will act as a safety screen to prevent oversize material entering the carbon tanks in the event of cyclone roping and a trash screen overflow or failure. All tanks will be fitted with agitators with hollow shafts allowing either oxygen or low pressure air injection into the slurry.

Each tank will be equipped with airlifts. These will be used to advance the carbon, except in the case of tank 1 and tank 2 which will be fitted with recessed impeller pumps. In tank 1 the pump will be used to move the slurry from that tank over the trash screen in the event that tank becomes contaminated. The recessed impeller pump in tank 2 will be used to pump slurry over the carbon removal screen to enable carbon to be removed from the circuit.

Carbon will enter the circuit at CIL tank 7 and will be advanced counter-current to the slurry flow by pumping slurry with airlifts from CIL tank 7 to CIL tank 6. The carbon will be retained by the intertank screens in tank CIL 6 and the slurry will flow by gravity back to tank CIL 7. This counter-current process will be repeated until the carbon eventually reaches CIL tank 2, the first adsorption tank.

A recessed impeller pump will be used to transfer slurry and loaded carbon to the loaded carbon recovery screen mounted above the carbon elution column. The loaded carbon, reporting as screen oversize, will gravitate to the acid wash hopper located above the elution columns and the screen undersize slurry will return to CIL tank 2. This hopper will be used to acid wash the carbon on those occasions that acid washing is required.

The discharge from CIL tank 7 will gravity feed via a crosscut sampler onto the carbon safety screen, which is mounted directly over the CIL tails hopper. CIL tails will be pumped to the dedicated CIL tailings dam located adjacent to the process water pond.

A 1t tower crane located centrally within the wet plant will facilitate removal of the screens for maintenance and cleaning. The crane will be arranged so that it can also be used for removing agitator shafts and gearboxes and provide general maintenance and operations cranage capacity throughout the wet plant.

The tanks will be constructed on concrete ring beams within a concrete bunded containment structure with a sump pump. The sump pump will collect any plant spillage and direct it to CIL tank 1.

Free Gold Recovery

Metallurgical testwork identified that slightly more than 30% of the gold would be amenable to gravity recovery. Thus two continuous gravity concentrators have been included in the process facility. The gravity gold concentrate will be processed through an inline intensive leach reactor that operates as a closed circuit with the electro-win circuit dissolving the gold with the gold rich cyanide liquor sent directly to the electro-win circuit. The solid and solution tails from the inline intensive leach reactor will be sent to the CIL circuit for further extraction of the remaining gold.

2.14.11 Process Plant Tailings

Two tailings streams will be discharged from the Process Plant each directed to dedicated tailings storage facilities.

2.14.11.1 Flotation Tailings Handling

The flotation tailings will be discharged at 40% solids and will be discharged sub-aerially to maximise the settled density of the tailings within the facility. The discharge from the flotation circuit will gravitate to the tailings sampler, and the discharge from the tailings sampler will gravity feed to the tailings hopper which is located directly below the sampler.

Due to the processing method, this tailing stream will not contain cyanide. In addition as illustrated in Graeme Campbell Associates report, “Central Ashanti Project: Geochemical Characterisation of Flotation-Tailings-Slurry Sample”, Appendix 2.16.9 there will not be elevated levels of unwanted metals present. For example the tailings in diluted slurry form will contain As levels not greater than 0.1 mg/L whilst the final concentrated solids will contain As levels not greater than 1.5mg/L.

These concentrations of this key element, tailings being characterised as non-acid forming and benign (see 2.16.9) and therefore will not require any additional treatment, so consequently the storage facility is unlined. A detailed description of the Flotation Tailings Storage Facility is provided in section 2.16.

2.14.11.2 CIL Tailings Handling

The CIL tailings will be also be discharged at 40% solids. They will be discharged sub-aqueously into the facility to minimise the potential for development of acidic conditions and with the expected weak acid dissociable cyanide (WADCN) content of 400 ppm and free cyanide (Free CN) of around 50 ppm. To minimise any seepage potential from this facility it will be HDPE lined. It will also be securely fenced and bird netted to exclude wildlife.

The CIL TSF has a solids capacity of 10 years. From years 1 to 3 exposure to sunlight, the best and most cost effective form of cyanide degradation will be utilised. After three years of operation, controlled recycling of CIL tailings solution will need to commence to ensure adequate space is maintained for storage of solids. At this point in time a cyanide destruction circuit is required and shall be constructed for use in year 4 and beyond. The Cyanide Destruction Circuit (CDC) will be a SO_2/Air circuit which will treat a bleed stream from the removed CIL tailings solution. The treated solution will be used in the plant. The CDC will be located adjacent to the CIL tanks in the process plant.

A detailed description of the CIL TSF is provided in section 2.17.

2.14.12 Elution

The acid wash and rinse cycles will be performed as required in the 6m^3 capacity rubber lined carbon storage vessel that will be located beneath the loaded carbon removal screen. Following the rinse cycle the carbon in the storage hopper will be dumped into the elution column. The elution column will have a volumetric capacity of 6m^3.

The elution strip is based on the Anglo-American circuit process. The strip solution will be injected with caustic and then be preheated by the in-line strip solution heater to reach a solution temperature of 140^{o}C. The hot strip solution will then be introduced to the bottom of the elution column.

Elution of the gold from the carbon is expected to take about 6 hours and pregnant liquor will be collected into the pregnant liquor tank. The pregnant liquor tank will have two liquor pumps, a pregnant solution pump and a barren solution pump. The pregnant solution pump will feed the two dedicated electrowinning cells in the circuit.

The four electrowinning cells, two dedicated to the gravity circuit, and two to the CIL circuit, will be fitted with stainless steel anodes and stainless steel wool cathodes. A direct current will be passed through the cells between the electrodes and the electrolytic action will cause the gold in solution to plate out on the cathodes. The gold will be removed from the stainless steel wool cathodes by high pressure water blasting and then filtered in a pressure filter to dry.
Barren carbon from the elution columns will be transferred into the regeneration kiln feed hopper by water injection at the completion of the elution cycle. From this hopper the carbon is either regenerated or transferred into a carbon kibble by water injection. The rotary kiln feed chute will drain any residual and interstitial water from the carbon prior to it entering the kiln. Kiln off-gases will also be used to dry the carbon before it enters the kiln.

2.14.13 Gold Production

The filtered dried gold sludge recovered from the cathodes of the elution/electrowinning circuit and the ILR electrowinning circuit will be direct smelted with fluxes in a furnace to produce doré bars.

The gold room design is based on full security surveillance by a security guard and a second level of surveillance by remote control CCTV cameras, with viewing facilities in the Process Manager and Security Foreman offices. Toilet and crib rooms will be provided within the secure area to minimise entries and access to the gold room will be via proximity card and turnstile.

2.15 REAGENTS

2.15.1 General

Typical reagents and material will be required for the operation of the proposed treatment process. These are sodium cyanide, lime, caustic, hydrochloric acid, activated carbon and flocculant. All these will be stored according to the compatibility guidelines of AS/NZS 3833 (Appendix 2.15.1) in a secure area located within the plant site. A short description of these reagents is provided below.

2.15.2 Sodium Cyanide

Sodium cyanide is classified as a highly dangerous substance and as such shall be transported and handled accordingly. Cyanide will be delivered as solid briquettes in 1 tonne sealed wooden boxes with internal plastic linings, in large batches on approximately a quarterly cycle to minimise frequency of transport risk, and stored away from any acidic substances in a secure area located within the plant perimeter.

All operations related to cyanide handling will be highly regulated, proceduralised and under the supervision of a qualified person.

Approximately twice a week a documented procedure to mix cyanide is carried out in the process plant reagents mixing area. Several of the 1 tonne boxes are opened, the bag removed and the bags contents transferred into a cyanide mixing tank via a bag splitter. The mixing tank contains water and caustic to control pH prior. The briquettes and water are mixed to dissolve the briquettes. Once completed, the cyanide solution is then transferred into the cyanide storage tank, directly below it. The cyanide storage tank will be contained within a concrete bund with a collection sump to recover spillage. The bund will have the capacity to retain the entire tanks contents in the highly unlikely event of a spill. The sump pump will recover minor spillage and deliver it to the solution collection tank.

At site an emergency spill control function will be available to assist with any spillage that occurs outside of the controlled area. This will be a mobile (likely trailer mounted) spill kit with various neutralisation agents, safety equipment and other required apparatus.

CAGL understands the principles of "The International Cyanide Management Code" (www.cyanidecode.org) as such will manage the storage and handling accordingly (Table 2.9).

Table 2.9: International Cyanide Management Code - Principles And Standards Of Practice	
1. PRODUCTION	
Encourage responsible cyanide manufacturing by purchasing from manufacturers who operate in a safe and environmentally protective manner.	
Standards of Practice	1.1 Purchase cyanide from manufacturers employing appropriate practices and procedures to limit exposure of their workforce to cyanide and to prevent releases of cyanide to the environment.
2. TRANSPORTATION	
Protect communities and the environment during cyanide transport.	
Standards of Practice	2.1 Establish clear lines of responsibility for safety, security, release prevention, training and emergency response in written agreements with producers, distributors and transporters. 2.2 Require that cyanide transporters implement appropriate emergency response plans and capabilities, and employ adequate measures for cyanide management.
3. HANDLING AND STORAGE	
Protect workers and the environment during cyanide handling and storage.	
Standards of Practice	3.1 Design and construct unloading, storage and mixing facilities consistent with sound, accepted engineering practices and quality control and quality assurance procedures, spill prevention and spill containment measures. 3.2 Operate unloading, storage and mixing facilities using inspections, preventive maintenance and contingency plans to prevent or contain releases and control and respond to worker exposures.
4. OPERATIONS	
Manage cyanide process solutions and waste streams to protect human health and the environment.	
Standards of Practice	4.1 Implement management and operating systems designed to protect human health and the environment including contingency planning and inspection and preventive maintenance procedures. 4.2 Introduce management and operating systems to minimize cyanide use, thereby limiting concentrations of cyanide in mill tailings. 4.3 Implement a comprehensive water management program to protect against unintentional releases. 4.4 Implement measures to protect birds, other wildlife and livestock from adverse effects of cyanide process solutions. 4.5 Implement measures to protect fish and wildlife from direct and indirect discharges of cyanide process solutions to surface water. 4.6 Implement measures designed to manage seepage from cyanide facilities to protect the beneficial uses of ground water. 4.7 Provide spill prevention or containment measures for process tanks and pipelines. 4.8 Implement quality control/quality assurance procedures to confirm that cyanide facilities are constructed according to accepted engineering standards and specifications. 4.9 Implement monitoring programs to evaluate the effects of cyanide use on wildlife, surface and ground water quality.
5. DECOMMISSIONING	
Protect communities and the environment from cyanide through development and implementation of decommissioning plans for cyanide facilities.	
Standards of Practice	5.1 Plan and implement procedures for effective decommissioning of cyanide facilities to protect human health, wildlife and livestock. 5.2 Establish an assurance mechanism capable of fully funding cyanide-related decommissioning activities.
6. WORKER SAFETY	
Protect workers' health and safety from exposure to cyanide.	

Table 2.9 continued: International Cyanide Management Code - Principles And Standards Of Practice	
Standards of Practice	6.1 Identify potential cyanide exposure scenarios and take measures as necessary to eliminate, reduce and control them. 6.2 Operate and monitor cyanide facilities to protect worker health and safety and periodically evaluate the effectiveness of health and safety measures. 6.3 Develop and implement emergency response plans and procedures to respond to worker exposure to cyanide.
7. EMERGENCY RESPONSE	
Protect communities and the environment through the development of emergency response strategies and capabilities.	
Standards of Practice	7.1 Prepare detailed emergency response plans for potential cyanide releases. 7.2 Involve site personnel and stakeholders in the planning process. 7.3 Designate appropriate personnel and commit necessary equipment and resources for emergency response. 7.4 Develop procedures for internal and external emergency notification and reporting. 7.5 Incorporate into response plans monitoring elements and remediation measures that account for the additional hazards of using cyanide treatment chemicals. 7.6 Periodically evaluate response procedures and capabilities and revise them as needed.
8. TRAINING	
Train workers and emergency response personnel to manage cyanide in a safe and environmentally protective manner.	
Standards of Practice	8.1 Train workers to understand the hazards associated with cyanide use. 8.2 Train appropriate personnel to operate the facility according to systems and procedures that protect human health, the community and the environment. 8.3 Train appropriate workers and personnel to respond to worker exposures and environmental releases of cyanide.
9. DIALOGUE	
Engage in public consultation and disclosure.	
Standards of Practice	9.1 Provide stakeholders the opportunity to communicate issues of concern. 9.2 Initiate dialogue describing cyanide management procedures and responsively address identified concerns. 9.3 Make appropriate operational and environmental information regarding cyanide available to stakeholders.

2.15.3 Hydrated Lime

Hydrated lime will be delivered in 800 kg bulki bags which will be transported to the mine by road on flat bed trucks. The bulk bags will be broken, at the rate of one bag every second day, in a semi-enclosed bag splitter. Hydrated lime will be metered via a rotary valve directly into a mixing tank with agitator of capacity 25m^3 to form milk of lime. The mixing tank will serve as the storage tank due to the low daily consumption when the level in the tank gets low a new batch will be prepared.

2.15.4 Sodium Hydroxide (Caustic)

Caustic will be delivered in 25 kg bags or 1.1 tonne bulki bags and will be manually added to the caustic mixing tank. Caustic will be mixed to a 50% w/v solution with raw water. Caustic will be dosed into the strip solution tank during preparation and mixing of the strip solution via a dedicated variable speed, positive displacement pump.

2.15.5 Hydrochloric Acid

Hydrochloric Acid will be delivered in 1000 L reinforced bulk containers which will be transported to the site by road in sea containers. Upon unloading the sea containers, the bulk containers will be stored in a concrete containment structure adjacent to, but separated from, the stripping plant.

The stored bulk containers as well as the one that is in service are all located in this containment structure. A dosing pump will meter the concentrated acid, from one of the bulk containers into the acid wash pump suction to achieve 3% w/w HCl for acid washing of the carbon.

2.15.6 Copper Sulphate

Copper Sulphate will be delivered in 1.1 tonne bulk bags. The bulk bags will be lifted by monorail hoist to an enclosed bag breaker above a mixing tank. Copper Sulphate will be mixed to a 15% w/v solution with raw water before being pumped to a storage tank. It will then be dosed into the flotation circuit.

2.15.7 Potassium Amyl Xanthate

Potassium Amyl Xanthate will be delivered in 900kg bulk bags. The bulk bags will be lifted by monorail hoist to an enclosed bag breaker above a mixing tank. Potassium Amyl Xanthate will be mixed to a 15% w/v solution with raw water. The solution will then be dosed into the flotation circuit.

2.15.8 Methyl Iso Butyl Carbinol

Methyl Iso Butyl Carbinol will be delivered in 200L drums and pumped, using a dosing pump to the flotation cells.

2.15.9 Flocculant

Flocculant will be received in bulk bags and lifted by chain hoist to the bag breaker/surge hopper of a package mixing plant. It will be blown into a cyclone mixer and mixed to a solution strength of 0.25% w/v with raw water and then aged in the mixing tank. It will then be transferred to a storage tank from which it will be distributed to the intensive leach reactor and the flotation concentrate thickener by metering pumps. The solution will be diluted with raw water to a solution strength of 0.025% w/v prior to the flotation concentrate thickener.

2.15.10 Activated Carbon

Activated carbon will be delivered in 600kg bulk boxes which will be transported to the site by road in containers. When required, carbon will be hoisted up to the top of CIL tank 6 and broken directly into the tank.

2.15.11 Oxygen

Oxygen will be provided by a Pressure Swing Adsorption (PSA) plant capable of providing oxygen at 35 m^3/hr or roughly 1 t/day of oxygen.

2.16 TAILINGS STORAGE FACILITIES DESCRIPTION AND SYSTEM[4]

2.16.1 Background Information

The different types of tailings storages options that were assessed for the Central Ashanti Gold Project comprised:

1. In pit tailings storage was considered but no pits are available for this option at this point in time. The pits on the western side of the Project area will be mined out by years 5 and once this is completed an investigation of this option for later operations can be undertaken.
2. Conventional stand alone Paddock Type Storage with upstream or centreline and downstream construction.
3. Valley Type Storage.
4. Central Thickened / Paste Discharge (cone disposal).
5. Integrated Waste Landform, which comprises a TSF located within a waste rock storage.

An economic ranking and risk ranking was undertaken on each type of facility and this resulted in the selection valley type storage as the most all round beneficial design (see section 2.27.2 table 210 for complete assessment).

2.16.2 Selection of TSF Option

The selected type of FTSF for the CAGP allows all the tailings to be contained in one area and not deposited at several locations across the site. The selected site is close to the process plant (Map 2.2). This minimises the length of lines for pumping and piping of tailings slurry and return water. A benefit of this is that should there be an accidental tailings discharge from pipeline leaks or ruptures, such discharge would be confined within the immediate working area of the project. A more distant location would necessitate more piping and a greater risk of any spillage affecting farmlands and/or natural areas. The FTSF alley type also allows the maximum use to be made of the existing site topography and therefore limits the requirements for mine waste for embankment construction.

The proposed site was selected following technical and environmental assessments and social considerations during the prefeasibility study phase and the subsequent DFS phase. Those assessments and social considerations examined a number of tailings storage options, configurations and locations within the project area (see section 2.27 and Map 2.6) for further information on the four locations considered for tailings storage. Informal discussions were held with the Chiefs of Abnabna and Ayanfuri at which the potential locations of various facilities were pointed out to them. The discussions focussed on the FTSF rather than the CIL TSF as it is the larger of the TSF's by orders of magnitude and both are located in the same area, one butted against the other. The proposed location was not raised by them as an issue. The greatest concern was the location of the Plant facilities as both wanted the facilities located on their lands.

The impact on flora and fauna is therefore confined to one area, rather than being spread out over several areas as would be required if alternative smaller sites were selected to meet the project tailings storage capacity requirements.

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[4] This section is an abbreviated version of the report: Design Document Tailings Storage Facility Ayanfuri, Ghana prepared by C. Lane of Coffey Mining.

The selected site is also close to the process plant and thus the risk to the environment posed by accidental tailings discharge from pipeline leaks or ruptures is also reduced.

The selected site, design and operation of the FTSF have been aimed at:

1. Minimising the impact of the Central Ashanti Gold Project on the native vegetation.
2. Minimising the impact on the local community.
3. Optimising the removal of surface water for return to the processing plant.
4. Optimising the recovery of water percolating through the tailings stack for return to the processing plant through the underdrainage and minimising the potential for seepage through the floor of the TSF.
5. Maximising tailings density and storage capacity by undertaking cyclic deposition.

2.16.3 TSF Design Considerations

The following considerations have been incorporated into the tailings storage design for the selected site for the FTSF:

(i) Traffic compaction of the in-situ clayey materials which line the floor of the TSF, where exposed as part of the construction.

(ii) Decants to recovery supernatant water for reuse in the process plant.

(iii) An underdrainage system to recover water percolating through the tailings stack during operation and post closure.

(iv) Starter embankments from compacted clay placed against mine waste.

(v) Mine waste from the open pit will be used in the construction of the embankments to support the compacted clay.

(vi) A seepage cut-off and underdrainage system is incorporated into the design to limit potential seepage losses from the site and recover seepage for reuse in the process plant.

(vii) Staged embankment construction will be undertaken utilising the downstream construction method. Staged construction will provide additional capacity on an as required basis.

(viii) The storage life has been estimated based on a production rate of 5,500,000 tonnes of tailings per annum for a minimum 10 year mine life.

(ix) Tailings in the form of slurry will be discharged sub-aerially and spirally around the storage from the perimeter embankments and benches cut into the topography surround the TSF, as appropriate. Tailings will be deposited in discrete layers from one or more discharges at 40% solids to promote low velocity discharge. The active discharge points will be regularly moved to ensure that an even development of the tailings beach.

(x) Tailings discharge or spigotting will be carried out such that the sloped beaches that are formed will be controlled to ensure that any surface water pond, which is formed from the liberation of water from the deposited tailings slurry, is maintained around the decant facilities.

(xi) Beach slopes are expected to be in the range of 0.5% to 1% and in the event steeper beach slopes form there is sufficient mine waste to either create finger walls, perpendicular to the perimeter embankment, to allow tailings deposition to extend further into the facility and thus maximise the use of the storage volume within the depressed cone formed in the centre of the facility or raised the perimeter embankments.

(xii) During operations the tailings storage area will assume the form of a truncated prism with a depressed cone in the top surface (see section 2.16.20 for final surface shape). The facility will have the potential to contain a considerable body of water during a rainstorm. The minimum Total Freeboard is 500 mm which comprises operational freeboard (the distance between the embankment crest level and the maximum allowable tailings solids level immediately adjacent to the embankment wall) plus an additional minimum 200 mm which represents the maximum water level after the design storm, of 1 in 200 year 72 hour storm, which equates to 300 mm or a volume of 1,029,000m^3 above the normal operating pond level. The normal operating pond level should therefore be no more than 800 mm below the embankment crest level. The design was done by Coffey Mining Consultants and also complies with the requirements of Australian National Committee on Large Dams (ANCOLD) design criteria and the dam shall be operated to ensure ANCOLD requirements are met until such time as the spillway is constructed at the closure of the project.

(xiii) On decommissioning, the FTSF will remain a permanent feature of the landscape but completely enclosed by natural hills and constructed embankments comprising compacted clay with a waste rock support. The tailings will drain to an increasingly stable mass. The current plan, at this stage, for these areas to be covered with waste rock and soil.

2.16.4 Landform

The FTSF area is characterised by a low lying gently sloping valley which in many places is a swamp surrounded by gently undulating topography which forms the containment for the proposed FTSF. The main embankment is to be located across a narrow swamp area between ridges. The saddle embankments are located in gently undulating topography.

Vegetation comprises a mix of dense natural vegetation in the drainage lines, interspersed with farmland comprising cocoa plantations, cassava and banana crops. The drainage lines are well defined but poorly drained with dense natural vegetation. Apart from scattered farmland there is no existing development on the site. The distribution of the major crops (cocoa, oil palm, mixed crops including cassava and plantain) in the three corridors delineated for crop compensation purposes (Mining, Plant Site and FTSF) is depicted in Map 4.1 in Chapter 4.

The area (hectares) of each major crop in each of the three corridors is presented in table 2.10. The total number of hectares on which crops are being grown is 381.2. Cocoa farming is by far the greatest farming activity, 342.2 ha out of the total cropping area. The largest cocoa growing area occurs in the designated Plant Site corridor followed by the Mining corridor and lastly FTSF corridor. Oil palm growing is the second largest crop grown, 27.73 ha.

Table 2.10: Area of Major Crops (Ha) and Their Distribution in Planning Corridors

Item	Block	Cocoa Farm	Oil Palm Farm	Mixed Farm	New Farm	Bush Area	Total Area
1	FTSF Corridor	71.56	4.54	4.21	2.03	0	82.36
2	Mining Corridor	96.64	10.63	1.38	0.48	0.02	109.15
3	Plant Site Corridor	173.60	12.57	2.15	0.93	2.40	192.12
	Total	**342.2**	**27.73**	**7.75**	**3.45**	**2.43**	**383.63**

2.16.5 Seismicity

The available data on seismic activity in Ghana sourced during the design work for the FTSF comprises:

- The Natural Hazard Risk in Africa document, shows the earthquake intensity information is limited to the southern and south-eastern corner of Ghana;
- The Ghana Building Code[6] Part 3, Structural Loads and Procedures.

Based on the details presented in these documents it appears that the largest earthquake magnitude, close to the site is Modified Mercalli Scale Degree VI (acceleration 0.0052 g to 0.0102 g), which according to the Code would be *"felt by all and result in falling plaster and chimneys and small damage"*. In accordance with the Code Ayanfuri falls into Seismic Zone 2 with a range of horizontal ground acceleration of greater than 0.03 g to 0.06 g with an assigned horizontal design ground acceleration of 0.04 g.

Available seismic data, for Ayanfuri from the National Earthquake Information Centre (NEIC) in relation to the seismic data points, and the small number of points mean that there is insufficient seismic data available to undertake a probabilistic seismic risk assessment and assign a seismic coefficient for a 1 in 1,000 year average exceedance probability (AEP) or to determine a maximum design earthquake (MDE).

2.16.6 Geology and Soils

The ground conditions comprise a subsurface profile of a combination of materials, with not all materials being present within each location investigated. The dominant layers making up the soil profiles are presented below.

Layer/Unit (Unified Soil Classification and Rock Type as appropriate)	Typical Depth to Top of Layer (m)	Typical Layer Thickness (m)	Description/Remarks
Silty Sand with a thin veneer of topsoil.	0.00	Variable and ranges from 0.20 to 1.25	Typically medium dense, brown, fine to medium grained, low plasticity with organic material (plant roots)
Clayey Gravel	0.2 to 1.25	Variable and ranges from 0.50 to 1.50	Typically medium dense, orange, fine to coarse grained, medium plasticity fines.
Greywacke / Phyllite	0.70 to 2.75	Varies to > 35m	Typically extremely weathered, very low strength, mottled yellow / orange / brown.

It should not be assumed that the surface layers, silty sand and clayey gravel have a uniform thickness across the site or are present in all locations. The Greywacke / Phyllite is the rock encountered at the base of the test pits and this extends to depths of 20 m to 40 m below ground level. It is extremely weathered, and in layman's terms it is effectively a very stiff to hard clay, which is present across the entire FTSF area.

2.16.7 Hydrogeology

Hydrogeological studies of the mine area have been undertaken by Coffey Geotechnics Pty Ltd (Coffey Geotechnics) and its report is attached as Appendix 2.12.13.

The results of the hydrogeological investigations indicate that the groundwater systems in the area comprise a fractured rock aquifer, with groundwater predominantly occurring within discrete fracture zones within mineralised and un-mineralised fresh bedrock units. The overlying shallower weathered bedrock profiles tend to form a confining unit to this aquifer, and the shallow Quaternary sediments associated with drainage lines, if saturated, would be too thin to form useful aquifers but may form perched aquifers that support remnant vegetation. At least on a large scale, the groundwater flow would be heterogeneous and fracture-flow dominated and may also be compartmentalised into separate strip aquifers across the site. The existing open-pits currently act as groundwater sinks, with general radial flow of groundwater towards these pits. With further mining the pits are expected to continue to act as a groundwater sinks, both during and following mining.

Hydrogeological studies of the weathered rock in the existing pits adjacent to the FTSF site indicated rock mass permeability in the order of 0.1 m/day to 0.01 m/day (1.16 x 10^{-6} m/sec 1.16 x 10^{-7} m/sec). It should be noted that higher values are associated with the structural features within the pits and indications are that the rock mass permeability as a whole is probably as low as 0.001 m/day (1.0 x 10^{-8} m/sec) beneath the TSF.

In situ falling head permeability testing has confirmed that the Greywacke / Phyllite, the rock type in the FTSF area has an average in situ permeability of 2.35 x 10^{-8} m/sec. On the basis of the foregoing a rock mass permeability of 1.0 x 10^{-8} m/sec has been adopted for seepage modelling purposes for the TSF. The TSF is effectively underlain by in situ soils (clayey sand / sandy clay) to depths varying from 0.80 m to 3.00 m followed by weathered rock (phyllite and greywacke) and fresh rock at depths of more than 35 m. In order to limit the potential seepage through the floor of the TSF, an underdrainage system has been incorporated into the design. Seepage cut-offs, excavated into weathered rock, are included in the design for all perimeter embankments to minimise the potential for seepage flow under the containment embankments.

2.16.8 Hydrological Characteristics

2.16.8.1 Surface Water

The FTSF is located in an area of 'sheet' flow with drainage lines from ephemeral stream flow into the site (see also section 3.2.1). There are defined drainage lines within the FTSF footprint. There are no permanent streams within the FTSF footprint as such, but swampy areas which retain water following wet season flows. The major drainage line within the FTSF footprint will have an embankment constructed across it during the initial construction and will be covered with tailings during the operation. Incident rainfall into the FTSF will be captured and discharged to the return water storage for use in the process plant. The return water storage facility to the north of the FTSF also stores water recovered from the decant and underdrainage system. The return water storage has a capacity of approximately 6,000 m^3. Post closure the spillways will be constructed to allow excess water to drain from the FTSF.

2.16.8.2 Design Floods

The facility will have the potential to contain a considerable body of water during a rainstorm. The minimum Total Freeboard is 500 mm which comprises operational freeboard (the distance between the embankment crest level and the maximum allowable tailings solids level immediately adjacent to the embankment wall) plus an additional minimum 200 mm which represents the maximum water level after the design storm, 1 in 200 year 72 hour storm, which equates to 300 mm or a volume of 1,029,000m^3 above the normal operating pond level. The normal operating pond level should therefore be no more than 800 mm below the embankment crest level.

2.16.9 Tailings Geochemical Analysis

The results of geochemical testing of the metallurgical testing have been taken into account during the design. The geochemical testing and evaluation was undertaken by Graeme Campbell & Associates and reference should be made to the documents titled 'Geochemical Characterisation of Process-Tailings-Slurry Sample [Static Test work] Implications for Process-Tailings Management' dated August 2009. This is provided in Appendix 2.16.9.

The test work results for the slurry sample of Flotation-Tailings earlier provided for testing are presented in tables 2.11 to 2.14. The Flotation-Tailings-Solids sample was devoid of sulphide-minerals (viz. Sulphide-S value of 0.02 %), and has a calcareous (ankeritic) gangue. The contents of minor-elements are below, or close to, those typically recorded for unmineralised soils, sediments, and rocks. The Flotation-Tailings-Slurry-Water sample was mildly-alkaline (pH 8-9), and of potable-salinity with concentrations of minor-elements either below, or close to, their respective detection-limits.

In summary, the results of this work indicate that the FTSF tailings are non-acid forming (NAF) and have less than 0.1 mg/L As, thus will be benign within the operating FTSF and after closure.

Table 2.11 Acid-Base-Analysis / Net-Acid-Generation Results for Flotation-Tailings-Solids Sample

GCA Number	TOTAL-S (%)	SO4-S (%)	Sulphide-S (%)	CO3-C kg H_2SO_4/tonne	ANC	NAPP	NAG	NAG pH	AFP Category
					kg H2SO4 /tonne				
GCA8166	0.03 (0.03)	<0.01 (<0.01)	0.02	0.50 (0.52)	39 (39)	nc	<0.5 (<0.5)	7.6 (7.6)	NAF

ANC = Acid-Neutralisation Capacity; NAPP = Net-Acid-Producing Potential; AFP = Acid-Formation Potential; NAF = Non-Acid Forming;
NAG = Net-Acid Generation; nc = not calculated.
All results expressed on a dry-weight basis, except for NAG-pH.
Values in parentheses represent duplicates.

Table 2.13: Mineralogical Results for Flotation-Tailings-Solids Sample

Component	Abundance	% Composition
Quartz	Major	20 - 50
Albite	Major	20 - 50
Muscovite	Minor	10 - 20
Ankerite	Accessory	2 - 10
Chlorite	Accessory	2 - 10
Pyrite	trace	< 2
Arsenopyrite	trace	< 2

Table 2.12: Multi-Element-Analysis Results for Flotation-Tailings-Solids Sample

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %) GCA8166	AV.-CRUSTAL ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI) GCA8166
Al	6.6%	8.2%	0
Fe	1.2%	4.1%	2
Na	3.1%	2.3%	0
K	1.3%	2.1%	0
Mg	0.34%	2.3%	0
Ca	1.1%	4.1%	0
Ag	<0.2	0.07	0
Cu	9	50	0
Zn	27	75	0
Cd	<0.1	0.11	0
Pb	4	14	0
Cr	120	100	0
Ni	160	80	0
Co	4.0	20	0
Mn	170	950	0
Hg	<0.01	0.05	0
Sn	0.9	2.2	0
Sr	310	370	0
Ba	400	500	0
Th	1.9	12	0
U	0.61	2.4	0
Tl	0.24	0.6	0
V	31	160	0
As	41	1.5	**4**
Bi	0.07	0.048	0
Sb	1.2	0.2	2
Se	0.02	0.05	0
Mo	21	1.5	**3**
B	<50	10	0
P	270	1,000	0
F	300	950	0

Table 2.14: Analysis Results for Flotation-Tailings-Slurry-Water Sample

Element/ Parameter	Flotation-Tailings-Slurry-Water	Element/ Parameter	Flotation-Tailings-Slurry-Water
Major-Parameters		***Minor-Ions***	
pH	8.3	Fe	0.26
EC [µS/cm]	830	Cu	0.02
TDS(gravimetric)	530	Ni	0.08
		Zn	0.04
Major-Ions		Co	0.0004
		Al	0.07
Na	140	Cd	0.00004
K	21	Pb	<0.0005
Mg	12	Cr	0.03
Ca	35	Hg	<0.0001
Cl	170	As	0.062
SO4	43	Sb	0.016
HCO3	190	Bi	<0.000005
CO3	<1	Se	0.0017
OH	<5	B	0.13
		Mo	0.052
Nitrogen-Forms		P	<0.1
		F	0.8
NH3-N	<0.1	Ag	<0.00001
NO3-N	0.23	Ba	0.016
		Sr	0.28
		Tl	0.00003
		V	<0.01
		Sn	<0.0001
		U	0.0023
		Th	0.000022
		Mn	0.07

2.16.10 FTSF Water Balance Analysis

Preliminary water balance studies were undertaken for the FTSF design as part of this study. Rainfall data for the water balance analyses were obtained from the Ghana Meteorological Services Department in Dunkwa-on-Ofin which has rainfall records from 1963 to 2007. Evaporation data for the site is not available and the evaporation data for the water balance was extrapolated for the site. For the purposes of these water balance analyses only, the following assumptions were made:

- Total FTSF catchment area, including area below the drainage diversion at RL203 m 4,520,000 m^2;
- Pool area and wet tailings beaches covering the tailings storage area;
- Underdrainage recovery fixed at 1,000 m^3 per day, approximately 33% of the maximum capacity of the underdrainage;
- Seepage losses constrained at 1.0 x 10^{-8} m/sec; and
- Retained moisture varying with the density of the *in situ* tailings.

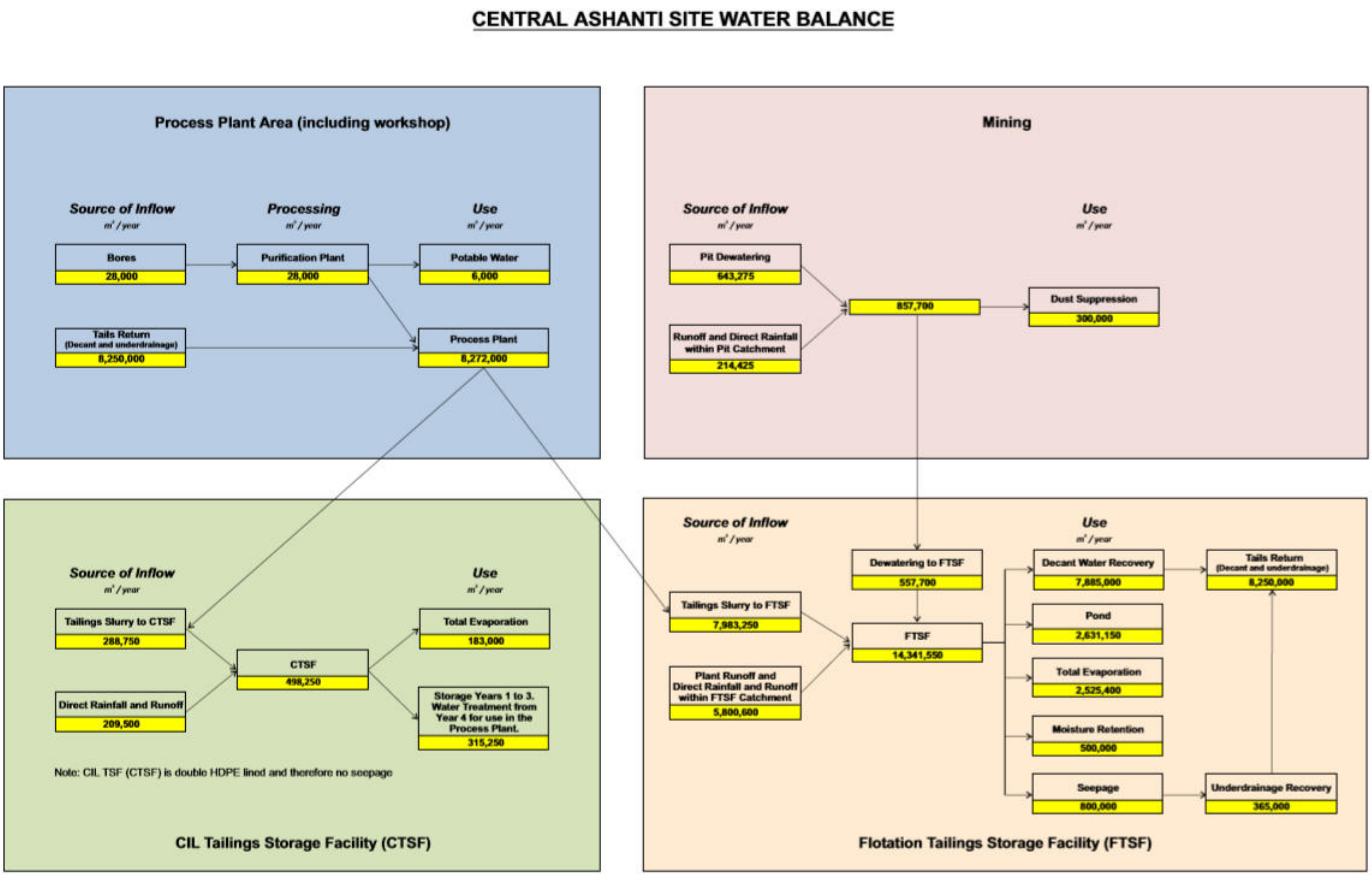
The results of the water balance analyses, based on a slurry density of 40% solids, using average rainfall conditions and average evaporation indicate that water recovery will vary according to the management of the FTSF, that is the percentage of the tailings area occupied by the pond and the running (wet tailings) beaches. For average climatic conditions, and assuming no dry tailings beaches, with start up water of 1,340,000 m^3 and underdrainage returning approximately 1,000 m^3 per day the water balance will be positive for Years, 1 to 6, then negative for Years 7 to 10. If, following commissioning, the project were to experience 2 years of the lowest annual rainfall additional make up water of 1,000,000 m^3 would be required in Year 1 and make up water of 3,900,000 m^3 would be required in Year 2. Makeup water would come from pit dewatering in advance of when mining is actually required.

A generalised water balance for the Project is presented on the following page. The figure depicts the water flow between mining area, process plant area, CIL TSF and the FTSF in an average year of operation. The actual water which is available for return to the plant from bores and tailings return may vary considerably from the figures presented in these water balance analyses, since water available for return to the plant will be a function of:

- The actual slurry density at the time of operation;
- Continuity of tailings discharge;
- Distance of the discharge point on the perimeter embankment to the decant or decant pond, if any, since it is expected the majority of any supernatant water will move towards the gravity decant and be discharged to the water return storage pond, together with water recovered by the underdrainage,
- Size of the pond and running beaches from where evaporation is maximised;
- Weather conditions prevailing at the time of operation; and
- The efficiency of the underdrainage and decant when operating.

The FTSF should be the prime resource for harvesting water for use in the processing operation under normal operating conditions and especially following large rainfall events. Water recovered from the FTSF facility will be returned to the processing plant and make up water, as required, will be added to the circuit.

Water balance diagram



The underdrainage is designed to recover water from the base of the deposited tailings stack and assist with consolidation of the tailings. The presence of the underdrainage, coupled with the practically impermeable in-situ weathered rock, effectively a clay liner, underlying the underdrainage, will effectively minimise vertical seepage from the FTSF. It should also be noted that the impact of the consolidation of the tailings maybe a reduction in the volume of water flow through the underdrainage system to an amount which is less than the full design flow capacity of the underdrainage. If the results of this consolidation constrain the seepage to a rate which is lower than, say 1.0 x 10^{-6} m/sec, then the water available for recovery through the underdrainage would decrease. This reduction in flow through the underdrainage does not imply that seepage through the clay liner will occur.

Water recovered from the facility (decant and underdrainage) will be returned to the processing plant via the return water storage with make-up water added to the circuit in the raw water tanks.

2.16.11 FTST Area and Height

At RL 193m which is the starter embankment crest level (Stage 1), the footprint is 342ha. At RL203m, the final embankment crest level (Stage 2), the footprint will be 343ha. The additional hectare is due to several embankments being raised by downstream lifts rather than upstream. The Stage 1 height is 19m and Stage 2 height is 29m.

The footprint area is the total footprint area of the FTSF at the designated RL or contour level around the entire area at that contour level which includes embankments etc.

The area occupied by the tailings with the crest at RL193 m is 225.3 hectares, this area excludes the embankments and allows for the beach freeboard and the slope of the tailings beach. The head of the beach will be at RL193 m with the toe of the beach at a much lower level

2.16.12 FTSF Capacity

The potential storage capacity of the FTSF site has been assessed at approximately 42,000,000 m^3 at a minimum density of 1.25 t/m^3 given a plant throughput of 52,500,000 tonnes.

At an average beach slope of 1 in 200, the fall on the tailings beach will be approximately 7.5 m from the embankment to the centre of the TSF.

2.16.13 FTSF Wall Angles

The FTSF embankments will have design slopes of 1:1.5 (vertical to horizontal) for the inner (upstream) slope. The outer (downstream) slope will be formed by traffic compacted waste rock storage, which is to be placed approximately 1:3 (V:H) on the main embankment and 1:2.75 (V:H) on the saddle embankments until such time as reshaping is undertaken to achieve the final design slopes for rehabilitation.

2.16.14 FTSF Construction Materials

The predominant construction material for the main embankment and saddle embankments will be highly weathered oxidised waste rock materials (clayey/silt materials with some gravels and sand) sourced from the Fobinso waste dumps created by the previous mining operation. If required this material will be supplemented with some highly weathered oxidised waste rock materials from prestripping of the oxide zones of the open pits, as part of the proposed new mining operation. These materials will be sourced from the existing Fobinso and Abnabna waste dumps.

2.16.15 FTSF Construction Methods

2.16.15.1 General

The starter embankment construction for the FTSF, the CIL TSF and Process Water Pond will be undertaken using compacted clay with mine waste in the case of the FTSF. The clay materials will be sourced from mine waste and within the FTSF impoundment. A seepage cut-off must be excavated into weathered rock to minimise the potential for seepage flow under all the containment embankments. Additional perimeter saddle embankments, constructed during the various stages of the life of the FTSF will have similar seepage cut-off's installed. Design drawings for the FTSF follow the end of this section.

The design concept for the FTSF also incorporates water recovery systems comprising an underdrainage system and a number of decant facilities (see 2.16.16.1). The underdrainage is designed to recover water from the base of the deposited tailings stack and assist with consolidation of the tailings. The presence of the underdrainage, coupled with the practically impermeable compacted clay liner, underlying the underdrainage, will effectively preclude vertical seepage from the FTSF. The decant system comprises a decant access and decant structure comprising competent, hard, durable select filter rock.

The depth to the weathered rock varies across the embankment alignment as a function of the depth of overburden soils and the topography. Based on the results of the test pit excavations, undertaken as part of the investigations for the tailings storage facility, it can reasonably be expected that the depth to weathered rock will range from 0.20 m to 3.00 m below ground level. As such the depth to weathered rock is variable. Hence the Scope of Work specifications for the seepage cut off trench stipulate that:

- Preparation of the foundation for the cut-off trench under the containment embankments will be by excavating to a nominal depth as shown on the Drawings or into weathered rock as directed by the Company's Geotechnical Engineer. The depth shall be increased if gravels or sands are present in the excavation so the base of the excavation is in competent low permeability material or rock. Side batters shall have a minimum slope of 2:1 (V:H).

- Ripping may be necessary to construct the cut-off excavation. Blasting in the tailings storage area is not anticipated. No blasting or excavation into or through any competent rock shall be undertaken unless approval has been received from the Company's Geotechnical Engineer.

Specifying that the seepage cut-off excavation will be taken into weathered rock is normal construction practice.

In summary the construction requires the Contractor to complete the following works:

2.16.15.2 Foundation preparation for the Embankments

- Excavate the internal base of the proposed FTSF containment embankments to the design depth as shown on the Drawings. Clayey gravel having a maximum particle size of less than 75mm and meeting the other requirements for the embankment clayey gravel, shall be separately stockpiled as directed. Material not meeting this requirement shall be kept separate from the clayey gravel.

- Tyne, moisture condition and proof compact the surface of the excavation to a minimum density ratio of 95% of standard compaction.

- Any filling required to replace soft or excessively deflecting areas, or to raise the level of the excavation shall be placed in layers and compacted to a minimum density ratio of 95% of standard compaction.
- Prepare the foundation for the cut-off trench under the containment embankments by excavating to a nominal depth as shown on the Drawings or into weathered rock as directed by the Company's Geotechnical Engineer. The depth shall be increased if gravels or sands are present in the excavation so the base of the excavation is in competent low permeability material or rock. Side batters shall have a minimum slope of 2:1 (V:H).
- Ripping may be necessary to construct the cut-off excavation. Blasting in the tailings storage area is not anticipated. No blasting or excavation into or through any competent rock shall be undertaken unless approval has been received from the Company's Geotechnical Engineer.
- When backfilling the excavated cut-off trench, the trench shall be left in a clean and suitable condition to allow an uninterrupted placement of fill. No fill shall be placed in the cut-off until the base of all excavations has been inspected and approved by the Company's Geotechnical Engineer.
- Allow for keeping water from the foundation by pumping, dewatering, or other suitable means, and adequately dispose of it clear of the works. Excavate the internal base of the proposed TSF containment embankments to the design depth as shown on the Drawings. Clayey gravel having a maximum particle size of less than 75mm and meeting the other requirements for the embankment clayey gravel, shall be separately stockpiled as directed. Material not meeting this requirement shall be kept separate from the clayey gravel.

2.16.15.3 Preparation for the FTSF Floor

The foundation preparation for the FTSF floor will begin with the clearing of large trees from the valley area occupied by the FTSF. Topsoil will be removed from above the immediate designated underdrainage route (Drawing MWP00333AB Figure 2 FTSF General Arrangement that follows this section) to a nominal depth of 150mm below the natural ground surface.

All investigation boreholes, groundwater and sterilisation holes drilled in the area of the proposed FTSF will be sealed and accurate records kept of all holes filled. The route within the FTSF to receive underdrainage pipe work shall be graded smooth and be free of any rock, cobbles and other deleterious materials that could damage the pipe work.

The rationale for not stripping and subsequently rolling the whole FTSF area is that extensive i*n situ* falling head permeability testing has confirmed that the Greywacke/Phyllite, the rock type underlying the FTSF area has an average *in situ* permeability of 2.35 x 10^{-8} m/sec. On the basis of the foregoing a rock mass permeability of 1.0 x 10^{-8} m/sec has been adopted for seepage modelling purposes for the TSF. The TSF is effectively underlain by *in situ* soils (clayey sand / sandy clay) to depths varying from 0.80 m to 3.00 m followed by weathered rock (Phyllite and greywacke) and fresh rock at depths of more than 35 m. In simple terms, the Greywacke/Phyllite is effectively a very stiff to hard clay underlying the entire FTSF area.

Underdrainage pipe work will be installed into the trench excavated for such purpose. The underdrainage cover comprising clean fine gravel will be placed around the pipe work and then a protection layer comprising the coarse aggregate / crushed rock placed over the cover layer and pipe work as shown on in Drawing MWP00333AB-04: Section and Details – Underdrainage following this section.

FTSF dwg1

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2.16.16 Water Recovery System

2.16.16.1 Decant

A system of three (3) decant locations are to be installed in the FTSF to facilitate surface water recovery. Each decant system has filter rock ring and a separate return water pipelines. Pumps may be shared between decant locations.

Access to the actual decant structure for light vehicles and maintenance equipment will be via a decant access roadways constructed from mine waste. The decants are to be raised as the perimeter embankments are raised.

2.16.16.2 Underdrainage

The underdrainage is designed to recover water from the base of the deposited tailings stack and assist with the rate of consolidation of the tailings (Appendix 2.16.15). The presence of the underdrainage, coupled with the virtually impermeable compacted clay liner underlying is expected to effectively preclude vertical seepage from the FTSF.

2.16.16.3 Liners

A compacted clay cut-off is to be constructed beneath each embankment. The natural in-situ clay liner in the floor of the FTSF will be traffic compacted. The presence of an underdrainage system, which is designed to create “zero piezometric pressure” above the in-situ weathered rock in the floor of the FTSF, and to capture the flow of fluids from the tailings stack such that there is reduced probability for seepage through the floor of the FTSF.

2.16.17 Stability and Qualitative Risk Assessment of FTSF

The stability and qualitative risk assessments of the FTSF are discussed in Chapter 5, Mitigation.

2.16.18 Instrumentation and Monitoring

Twelve monitoring boreholes will be installed to monitor the FTSF and CIL TSF facilities. The location (including GPS coordinates is shown on the figure following this section). Four (4) groundwater monitoring bores (BH 5, 6, 7 and 8) will be located downstream of the main FTSF embankment. Additional borehole monitoring locations (7) covering the main saddle embankments are also shown (BH 9, 11, 12, 13, 14, 15 and 16). Only one additional borehole (BH 10) will be installed to monitor the CIL TSF facility due to the limited size of the facility, its common border with the FTSF and its close proximity to BH16.

Installed boreholes will be sampled prior to construction and on a quarterly basis after commissioning. A monitoring program will be established including water level readings and the taking of water samples for water quality testing purposes. Collected information will be reviewed regularly and reported in an annual FTSF audit.

2.16.19 Emergency Action Plan

An emergency action plan has been developed specifically for the FTSF. Due to the presence of the large volume waste rock in the main embankment of the FTSF the likelihood of any likely failure impacts are considered to be negligible.

Borehole location map.

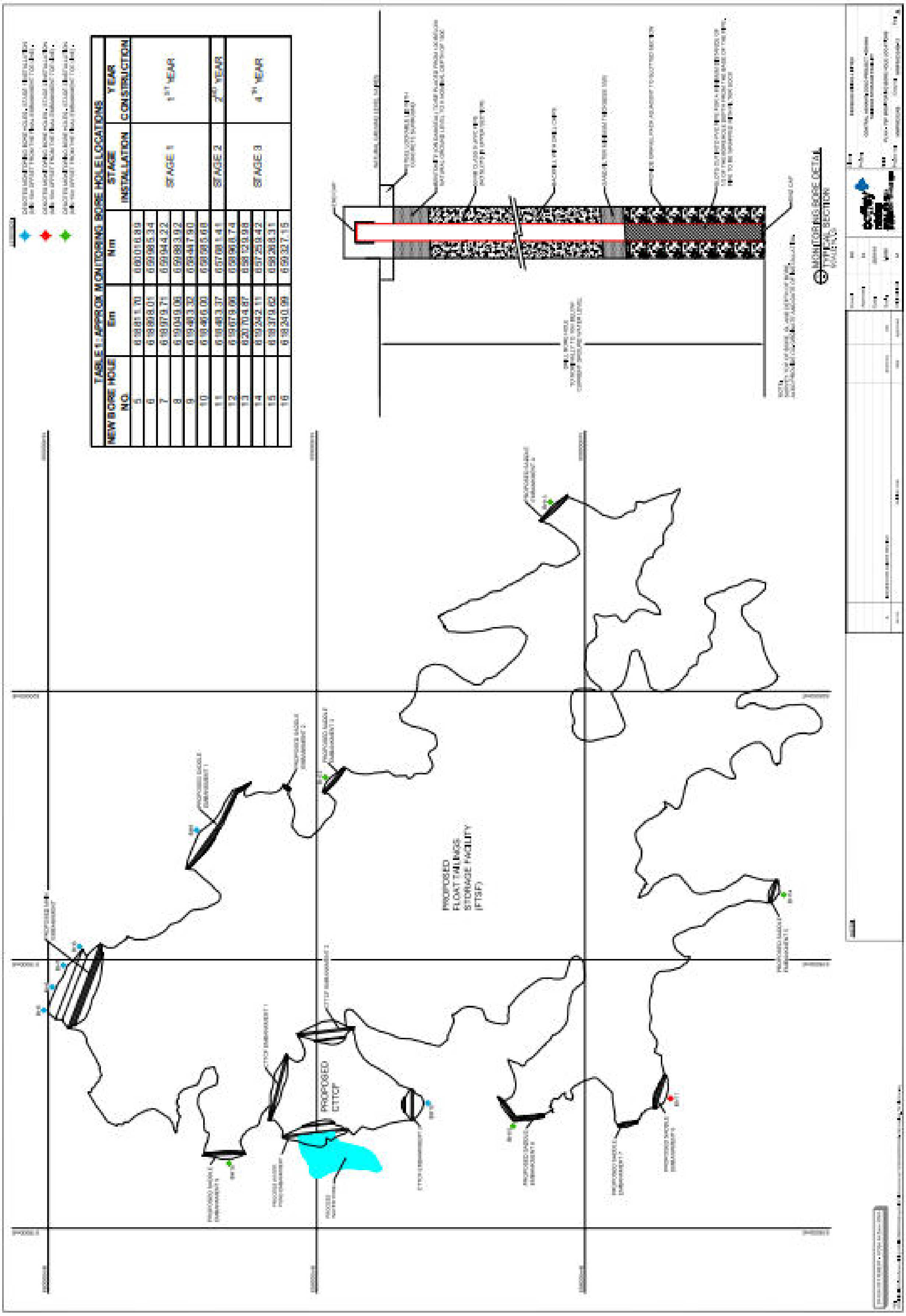


TABLE 1: APPROX MONITORING BORE HOLE LOCATIONS				
NEW BORE HOLE NO.	Em	Nm	STAGE INSTALLATION	YEAR CONSTRUCTION
5	618811.70	660016.89	STAGE 1	1ST YEAR
6	618898.01	659985.34		
7	618979.71	659944.22		
8	619049.06	659883.92		
9	619483.32	659447.90		
10	618466.00	658585.68		
11	618483.37	657681.41	STAGE 2	2ND YEAR
12	619679.66	658968.74	STAGE 3	4TH YEAR
13	620704.87	658129.98		
14	619242.11	657259.42		
15	618379.62	658268.31		
16	618240.99	659327.15		

2.16.20 Closure of FTSF

The FTSF will utilize a spigot discharge system to place the flotation tails during the life of the mine. The spigot discharge system will see spigots opened at locations to maintain a permanent pond at the return water catchment points. This method of discharge will cause the top surface of the FTSF to have a concave slope and form a basin in the centre and upper reaches of the valley with a spillway to discharge runoff to the adjacent drainage lines to the west of the process plant.

Prior to closure the spigot discharge system will be located at the centre of the FTSF to place flotation tails to develop a convex surface of the FTSF. This will prevent the accumulation of a water pond on the final tailings surface. The FTSF cover will then be placed to stabilize the flotation tails surface. The permanent return water pond will be filled.

The underdrainage system can be fitted with airlocks to prevent entry of air into the base of the tailings stack at closure. Once the tailings have drained and the flow from the underdrainage pipes is significantly reduced the outfall pipes will be capped, sealed and buried. In the event of premature closure of the project the same closure approach can be adopted.

The decommissioning plan for the FSTF will form part of the Closure and Decommissioning Plan that will have to be submitted for approval by the EPA and the Mines Inspectorate.

2.16.21 Rehabilitation of FTSF

The FTSF will remain a permanent feature of the landscape but completely enclosed by natural hills and constructed embankments comprising compacted clay with a waste rock support. The tailings will drain to an increasingly stable mass. The current plan is for the final convex FTSF surface is to be covered with waste rock and soil. The placed depth of each material will be provided in the closure plan being dependent on the rehabilitation trials and the land use desired by the local communities (see next paragraph).

Rehabilitation trials will be undertaken during the life of the storage to determine the most efficient method to rehabilitate the surface of the tailings. The results of these trials will be used to design the most suitable cover which will be placed over the tailings surface. Grasses, shrubs and trees can be planted on the exposed beach areas. Alternatively, and subject to appropriate studies prior to the closure of the FTSF these beaches might be available for agriculture. Consultation as to end land use will be undertaken with the Project Consultative Committee, committee consisting of representatives of the local communities (see Chapter 3.10.11).

2.17 CIL TAILINGS STORAGE FACILITY[5]

2.17.1 General Description

The CIL Tailings Storage Facility (CIL TSF) is also valley type storage with containment embankments common to the FTSF and Process Water Pond (see following map and figures for location and design details). The CIL TSF is located approximately 350m north east of the plant site. It will have a footprint area of 12 ha.

CIL tailings from the Carbon in Leach (CIL) plant will be discharged to the CIL TSF at approximately 40% solids with the expected weak acid dissociable cyanide (WADCN) content of

[5] At the request of EPA the original terminology for the Concentrate Tailings Storage Facility (CTSF) was changed to CIL Tailings Storage Facility (CIL TSF) abbreviated to CTSF. Some technical drawings (in part) still show the word “Concentrate Tailings Storage Facility” instead of CIL Tailings Storage Facility or CIL TSF

around 450 ppm and free cyanide (Free CN) of around 350 ppm. The purpose of the CIL TSF to is separate and contain those process tailings that may have a pollutant potential (elevated heavy metals) (Table 14a) and to prevent cyanide contamination of the larger FTSF. In this way, environmental management of process tailings is greatly enhanced during operations and after project closure.

The CIL TSF is a double HDPE lined facility with underdrainage above the top liner and a leak detection system between the upper and lower liner. During operation the CIL TSF will be covered with water. Bird balls and netting will be deployed to prevent access to the surface.

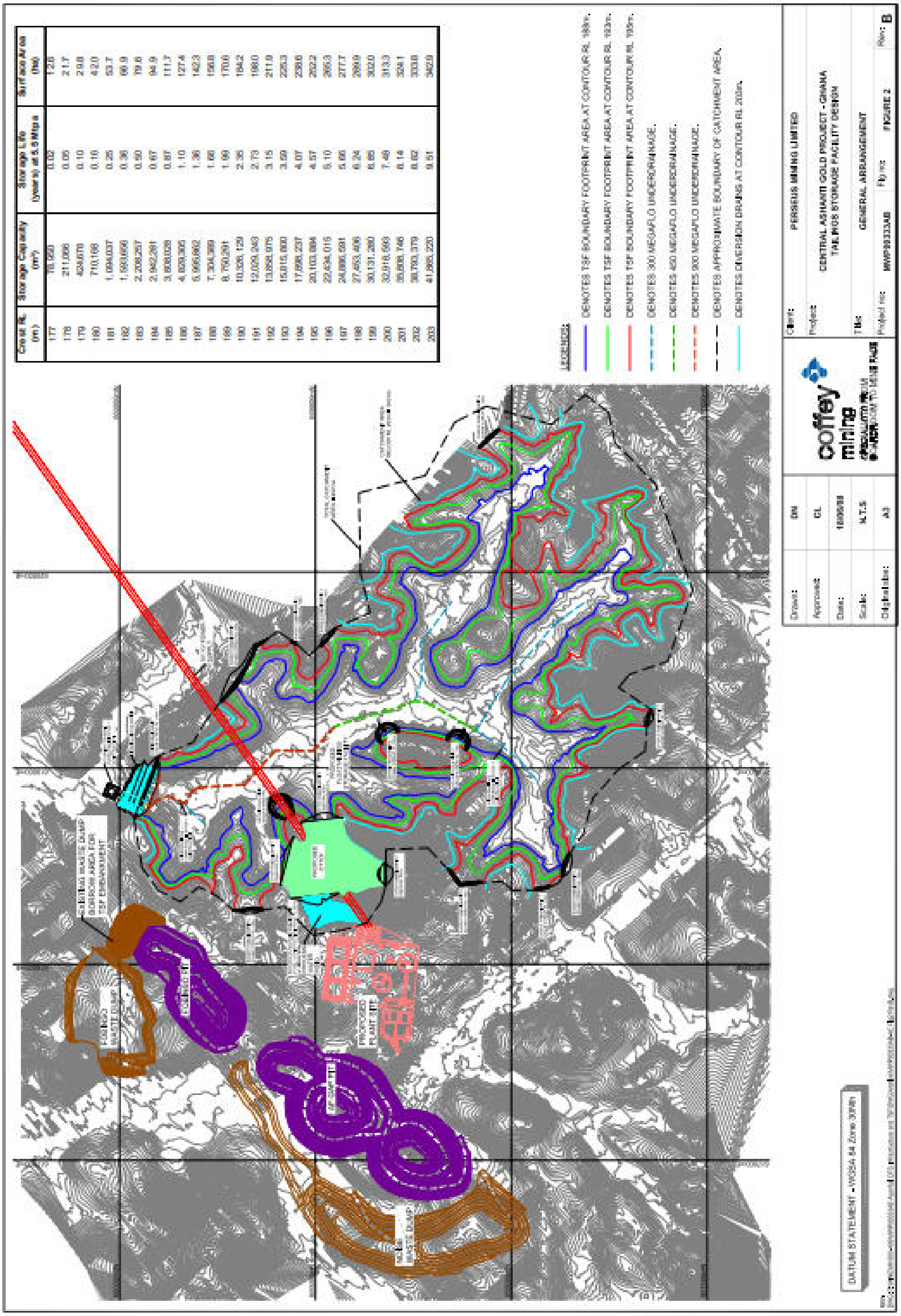
The containment embankment for the CIL TSF will be built to its final height of 19 m in the valley centre in the Stage 1 construction phase. At closure, the surface of the CIL TSF will be covered first with a geotextile, then with a layer of clean free draining sand, 1m thick (minimum), hydraulically placed over the geotextile. Water will then be withdrawn from the upper half of the sand layer to allow a HDPE liner to be placed over the sand. Additional sand will then be placed over the HDPE liner and soil placed over the sand.

The CIL tailings will be pumped to the CIL TSF within a HDPE lined bunded drain passing east then north to the CIL TSF. The drain will slope back to the CIL sump at the plant and from the confluence slope towards the CIL TSF, thus no additional sumps and pumps will be required. The bunded drain will contain the CIL TSF discharge HDPE pipeline and the return solution tails pipelines (HDPE).

Table 14a: Composition of CIL Tailings-Slurry-Water

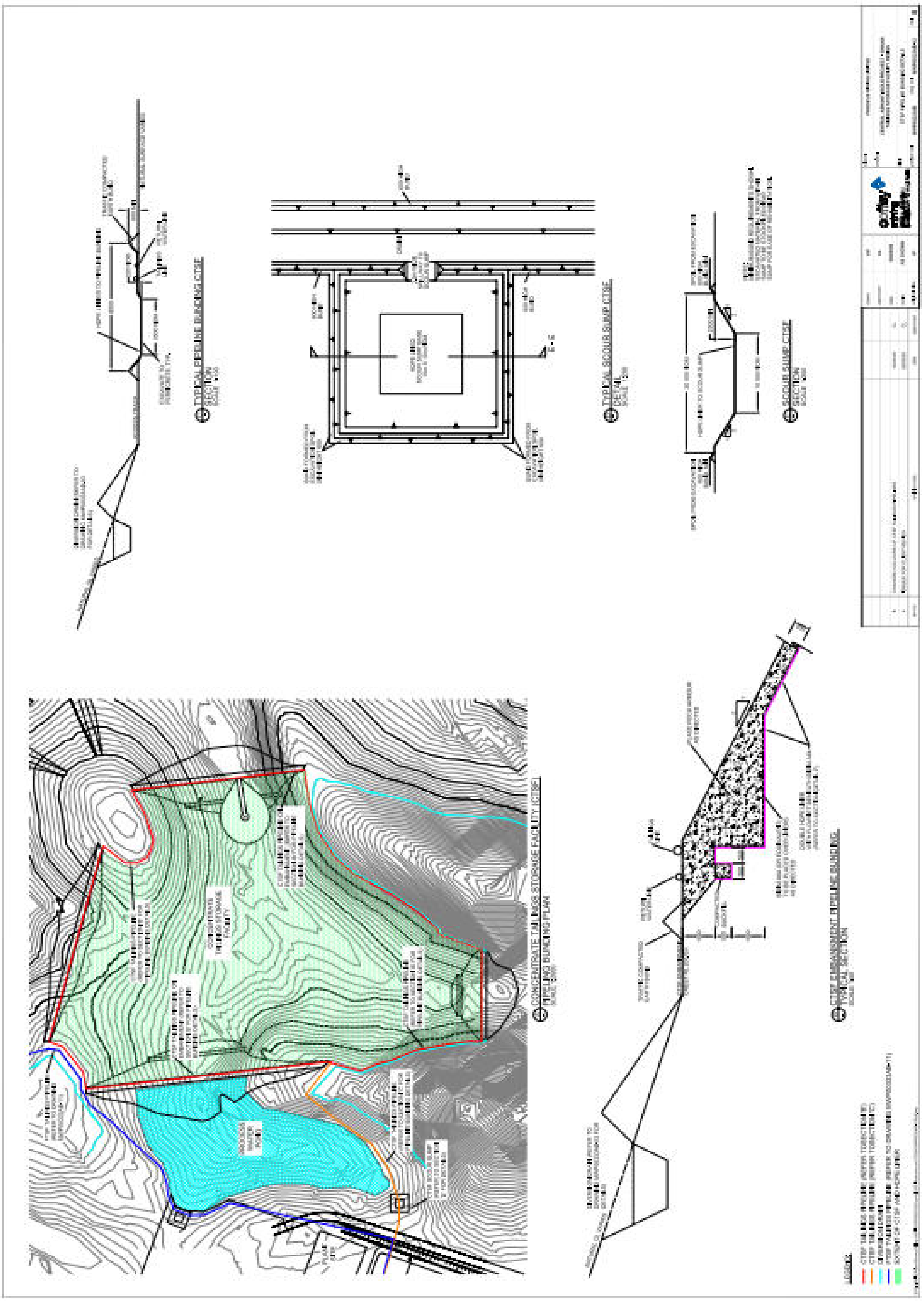
Element / Parameter	**Element/Parameter Value**
Major-Parameters	
pH	10.6
EC [µS/cm]	6500
TDS(gravimetric)	4800
Major-Ions	***(mg/L)***
Cl	780
SO4	590
HCO3	80
CO3	75
OH	12
Fe	230
Cu	10
Ni	0.34
Zn	7.5
Co	0.50
As	369
Sb	17
Ag	1.3
Cyanide Forms	***(mg/L)***
Thiocyanate (SCN)	240
Total Cyanide (CN)	610
Weak Acid Dissociable Cyanide (WADCN)	450

Location of the CIL Tailings Storage Facility



Crest RL (m)	Storage Capacity (m³)	Storage Life (years) at 5.5Mtpa	Surface Area (ha)
177	78,050	0.02	12.6
178	211,089	0.05	21.7
179	424,870	0.10	29.8
180	710,199	0.16	42.0
181	1,094,037	0.25	53.7
182	1,583,899	0.36	66.9
183	2,208,257	0.50	79.6
184	2,962,281	0.67	94.9
185	3,808,028	0.87	111.7
186	4,859,305	1.10	127.4
187	5,995,862	1.36	142.3
188	7,304,289	1.66	156.8
189	8,750,241	1.99	170.6
190	10,326,129	2.35	184.2
191	12,029,243	2.73	198.0
192	13,858,975	3.15	211.9
193	15,815,800	3.59	225.3
194	17,898,237	4.07	238.6
195	20,103,894	4.57	252.2
196	22,434,015	5.10	265.3
197	24,886,591	5.66	277.7
198	27,453,406	6.24	289.9
199	30,131,280	6.85	302.0
200	32,916,569	7.48	313.3
201	35,806,746	8.14	324.1
202	38,793,379	8.82	333.8
203	41,865,220	9.51	342.9

CIL TSF Pipeline Bunding details



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CIL TSF Design Features Including Final Capping

2.17.2 QA for FTSF and CIL TSF

CAGL as operator of the project makes the following commitments:

(i) The FTSF and CTTCF will be constructed in accordance with the specifications and drawings. Construction will be supervised and monitored by personnel with experience in this type of construction. Details of construction will be provided in a construction report.

(ii) The FTSF and CTTCF will be managed and operated in general accordance with the Operation Manuals, which will be reviewed on an annual basis and updated as required. Independent audits will be performed on an annual basis.

(iii) A groundwater monitoring programme will be initiated around the FTSF and CIL TSF.

2.18 WATER SUPPLY, SITE DRAINAGE AND SEWERAGE

2.18.1 Rainfall Catchment of the Project Area

The project is located in the sub-tropical inter-convergence zone with two distinct wet seasons. The rainfall exceeds the evaporation pan for most of the seasons thus surface water is prevalent except during the end of the dry season. The local topography is typical of the rolling hills of the lowlands of Ghana deeply cut with creeks and rivers supporting the intensive peak rainfall intensities in excess of 160mm within 24 hours. The plant site has been located on a local topographical high with the tailings dam on one side, a seasonal creek to the south, a smaller tributary to the east and the Abnabna pit to the west. The FTSF dam will provide return process water to meet the plant requirements.

2.18.2 Water Availability for Process Plant

It is proposed to initiate FTSF dam construction sufficiently in advance of project start-up in order to ensure that effective catchment is achieved to provide sufficient water to commence the project and effective water return immediately from the tailings dam. To achieve the availability of water required in the early stages of the project it will be necessary to pump all runoff initially to the tailings dam to maximise the start up stored water volume.

2.18.3 Raw Water Supply - Groundwater

The raw water supply for the project will be obtained from groundwater located upstream of the proposed diversion drain on the Asuafu stream (section 2.18.9). The bores will be installed adjacent to the plant access road and will pump to a raw water storage tank located on the plant site. Other groundwater sources include pit dewatering bores and bores placed downstream of the dam walls, beside and within the swamp areas.

Raw water will be used in the following areas:

- Elution water;
- Reagent make-up;
- Cooling water;
- Process water make-up;
- Dust suppression.

2.18.4 Contaminated Water Recovery

Water collected in silt traps arranged around the plant will be pumped to either the process water dam or to the tailings dam decant area. Water from the tailings dam decant will be pumped to the process water dam to meet the plant demand requirements. The pipelines from the silt traps and from the FTSF decant will be constructed from high-density polyethylene pipe. The pipelines will be laid above ground.

2.18.5 Plant Potable Water

A small pump at the raw water tank will deliver water via a filtering system to the potable water tank. A pressure-controlled potable water pump will draw filtered water from the potable water tank and deliver it to the plant and buildings through the Chlorination and UV sterilisation plant. Potable water will be reticulated to the plant emergency shower and eyewash facilities, the administration and plant area buildings and the mining contractor's area.

2.18.6 Site Drainage

2.18.6.1 General

Site drainage plans have been prepared to collect and divert surface runoff (Appendix 2.18.10 – Coffey Drainage Management Plan). The drainage management for the Project has been designed such that clean runoff water from areas upslope of the project infrastructure is diverted, where possible, around the site via diversion drains. Where drainage diversion is not possible (i.e. some areas upstream of the pits), runoff will be collected in pump sumps and either used in dust suppression, as process water or disposed of downstream if water quality guidelines are met. A general arrangement plan provided in Map 2.4 presents location details of various project infrastructure, and proposed drainage lines and sumps. A figure depicting drainage patterns for the immediate Project are follows section 2.18.10.2 below.

2.18.6.2 Plant Area

A plant site general arrangement plan follows this section. Areas such as the Gravity Flotation Intensive Leach circuit and reagent mixing tanks within the plant area have been designed as 'closed' systems. Runoff from the general plant area will drain to a collection sump. Runoff collected in this sump will be piped under gravity to a plant runoff collection to the north west of the ROM. The plant runoff collection area will be bound by access roads on 2 sides and the adjacent plant and ROM. A section of road will comprise select filter rock in order to allow collected runoff water to filter through to a pump sump located immediately downstream.

Runoff from areas to the east of the plant site will be diverted to the process water dam located immediately to the north east of the pit via trapezoidal drains. Overflow from the process water dam will be diverted via a spillway to the north west away from the plant area to the Fobinso North Area.

The process water dam will be unlined and therefore in order to minimise the potential for seepage from this dam, 'softening' foundation materials and causing settlement of plant footings, the water level within the dam will need to be controlled (i.e. be less than RL195m). Low permeability cufoffs will need to be installed at the location of major structures (i.e. tanks and mill) in order to divert groundwater away from these areas. These cut-offs will comprise Elcoseal geo-membrane installed in vertical trenches excavated through the gravel soil strata into weathered phyllite. The geo-membrane will need to be adequately lapped at the base and between membrane panels.

Runoff from area to the north and north west of the plant area will be diverted by trapezoidal drains to the pump sump west of the plant or north towards the Fobinso North area.

2.18.6.3 Pits

The pits will require earth bunds in upstream areas in order that runoff from extended catchments upstream does not flow over the pit rim. The earth bunds should be compacted and have adequate foundation preparation including a seepage cut-off. Pump sumps may be established upstream of these bunds. Water collected in the sumps will either be used in dust suppression, as process water or disposed of downstream if water quality guidelines are met. Where sumps are required, allowance for a design capacity to store a 1 in 100 year average recurrence interval storm event of 24 hours duration, and adopting a volumetric runoff coefficient of 0.8.

Diversion bunds and haul roads etc will be used to divert runoff to the sumps and where possible runoff will diverted around the ends of the pits. It is proposed to infill low areas with mine waste and provide lined drains to divert runoff around the pits in lieu of drainage collection and pumping.

2.18.6.4 Asuafu Stream Diversion

The Asuafu stream (Maps 2.1 and 32.1) passes through the planned mine site location. The intended placement of the ROM pad interrupts this stream and effectively creates a catchment area behind it. A diversion channel is planned to prevent build up of water in the catchment by redirecting the water into the Abnabna stream that runs along the western side of Abnabna - AF Gap pit. (Map 2.2). The diversion channel required will be approximately 2.3kms long and will traverse in a north westerly direction around the south western end of the Abnabna Pit and discharge into the main Asuafu Stream channel approximately 1.5kms upstream from natural confluence of the tributary and the main channel.

The upstream ROM pad fill will also act as a causeway for the main plant site access road. Therefore the placement of the fill must be compacted to a standard that will not allow water to penetrate and erode the embankment. The finished embankment will be rock armoured with fresh rock from the starter pits.

The diversion drain inlet will have an elevation of 187 mRL and will be the drain will be formed in two sections. The first section is 1600m long with a designed peak flow rate of 25m^3/sec whilst the second is 670m long with a designed peak flow rate of 29m^3/sec, both have a gradient of -0.13%.

Where the first section of the diversion channel empties into a natural swampy low spot adjacent to the south western arm of the ROM pad, this section will be constructed in a similar manner to the upstream plant site access causeway. Due to the existing ground conditions, a silt trap that can be cleaned out in the dry season, will be constructed using gabion baskets.

The diversion channel batter slopes will be at 1.5:1 for a height of 2.2m above the base, slopes above this will suit the oxide ground conditions found in the pits, and a face angle of 57 degrees will be used. A 2m wide catch berm will be placed 2m from the surface as an added safety measure.

The inlet of the diversion channel crosses the main plant site access road and this area will be constructed with gabion baskets to form a spillway and allow all weather access.

A bund will be constructed along the western wall of Abnabna - AF Gap pits to prevent the diverted Asuafu stream from entering the pits. This bund will also act as a noise attenuation bund for the nearby Abnabna village.

2.18.6.5 Erosion and Sediment Control

The following miscellaneous erosion and sediment control measures are included as part of the drainage plans:

- Provision of silt traps downstream of main drainage lines and waste dump drop structures in order to reduce sediment load to the downstream environment. It is recommended that silt traps for small catchment areas (i.e. not main diversion) are initially sized on the basis of nominally of 1.3m^3 of silt/ha of catchment area (Appendix 2.18.10 – page 5). This sizing criteria should be checked during the first year of project development.
- Rock lining of channels when design channel velocities are greater than 1m/s.
- Provision of drop structures for disposal of runoff from waste dumps. The drop structures should be rock lined and a silt trap provide at the base of the drop structure prior to discharge downstream.
- Land disturbance will be kept to a minimum at the Asuafu Stream channel and floodplain. This includes excavation of silt traps near the channel and on the flood plain, as construction of the traps may lead to an increase in sediment transport downstream (i.e. from disturbed ground and earthworks).
- Periodic maintenance of drainage structures and cleaning out of silt traps will be required. Silt collected in the silt traps will be disposed of to topsoil stockpiles.

2.18.7 Plant Sewage

Sewage systems will be required for the plant site ablutions, the administration office ablutions and the medical centre workshop/maintenance office ablutions. The treatment and disposal of sewage will be through a package treatment plant with treated effluent pumped to the FTSF.

A packaged sewage treatment plant using aerobic treatment will be installed on the Plant site. There are many different makes and models of packaged sewage treatment plants, each with a slightly different treatment technique, but each type provides a treatment unit or biological zone where the sewage comes into contact with micro-organisms that break down the organic matter in the sewage. Final selection of the plant type has yet to be determined.

The selected packaged plant will be required to conform to one of more standards such as Australian Standard AS 1547:2000 Onsite Domestic Wastewater Management, Australian Standard AS 1546:3 2001 Onsite domestic wastewater treatment units – Aerated wastewater treatment systems, the USA National Sanitation Foundation (NSF) International Standard NSF 40 - 1996, or European Union Standard - EN12566-3 2005. The selected standard will depend in part upon the sourcing of the packaged plant.

2.18.8 Accommodation Camp Sewage

The former senior camp now used primarily by exploration related personnel uses a septic tank disposal system. This system will be maintained during construction and afterward when the camp reverts to senior staff status.

General Drainage Management Plan for Phase 1 Area

CAGL Drainage Management Plan for Plant Site

2.19 PLANT SITE BUILDINGS

2.19.1 Administration Building

The main administration building will be located immediately outside the process plant security fence. The building area will be approximately 710m^2. It will provide office for a variety of personnel including the General Manager – Operations and other senior staff. The location of this building and other Plant site buildings is depicted in the figure that follows this section. The location of this building and other is shown on the figure following the end of this section.

2.19.2 Security Building

The security building, which is approximately 90m^2 in internal area, will house the security manager and duty security guards. The building will straddle the security fence and be adjacent to the main security gates for vehicle entry. The building will provide controlled access to the mine site. The other end will be a breezeway for pedestrian access with turnstiles controlling access and egress. The centre of the building will house the security staff.

Vehicles will enter the plant site through a motorised entry gate immediately adjacent to the security building which will be remotely controlled from mine vehicles or, in the case of visitors, by the gatekeeper following security checks.

2.19.3 First Aid Building

The First Aid building, which is approximately 110m^2 in internal area, will house the nursing sister and the doctor when he is visiting. One end of the building will act as a garage for the ambulance. The medical clinic includes:

- Doctors office,
- Treatment Room and Emergency room,
- Supply and storage room,
- Toilets/Changing room,
- Waiting rooms.

2.19.4 Laboratory

The laboratory building is approximately 150m^2 of internal area. The laboratory building comprises a wet laboratory only with no allowance for sample preparation or grade control assays. One end of the building will have a lunch room and store and the other end of the building will house the offices, the AA machine and the fume cupboards. The offices will accommodate the Chemist and laboratory foreman.

2.19.5 Plant Office

The plant office building is approximately 480m^2 of internal area. The building will include office areas, storage and a meeting room arranged around an open plan office area in the centre. This office, which will be located adjacent to the workshop and store, will be used as the construction office during the construction phase of the project.

2.19.6 Process Control Rooms

The main process control room will be a 6m sea container, lined and air conditioned and fitted with windows along both long sides, through which the operators will be able to view the SAG mill on one side and the Flotation/CIL circuits on the other. The control room will be mounted adjacent to the regrind cyclone with access via the milling gravity tower and the adjoining walkway which connects the leaching tanks to the regrind cyclone.

A second control room is located on top of the primary crusher steel work. All associated work with the crushing plant will be controlled from this control room which includes the primary crusher, rock breaker, stock pile feed conveyor and the trucks offloading into the ROM bin. It will be lined, air conditioned and fitted with windows.

2.19.7 Plant Workshop and Store

The plant workshop and store is approximately 430m^2 of total area. The plant workshop and store will be one building divided into several sections. The building will include three separate secure storage areas, a mechanical workshop, an electrical workshop and warehouse store.

An external wash down area will be provided for the workshop with a small fenced area to contain the lubricating oils, degreasers and cleaning fluids etc that will be used on site. The building will be annexed with secure and open covered storage area. It will be divided into two areas one for the stores and the other, a lay down area for the workshop.

2.19.8 Gold Room Building

The gold room will be a steel clad building which is approximately 190m^2 in total area. The building will house the electrowinning cells, smelting furnace, safe, associated equipment and a desk for the gold room foreman. The electrowinning cells will be located on a mezzanine floor so that the liquor can gravitate from the cells back to the liquor tank. All operations in the Gold room will be subject to full time CCTV surveillance with security alarms.

2.19.9 Amenities Blocks

Two Amenities blocks will be provided on site.

2.20 SENIOR CAMP ACCOMMODATION

This facility will be refurbished, including converting the houses to single status rooms complete with ensuites and made ready for the CAGL permanent senior staff to occupy during construction and operations. The camp, other than the kitchen diner, pool etc, is generally habitable although is not considered to be of a standard suitable for the start up of a major mining operation. The kitchen/diner is a shell only, requiring complete refurbishment as is the standby power station.

2.21 POWER SUPPLY

BEC Engineering (BEC) has been engaged by Perseus Mining Ltd to carry out preliminary design to enable the Bankable Feasibility Study to be completed for the power supply component of the Project. Meetings have been held with the GRIDCo VRA and ECG to have them assist in developing the options available and provide information on costs and details to enable a preferred option to be determined.

The project will utilise the GRIDCO VRA option to supply electrical power requirements for the project via a 4 km line from the existing VRA line.

Emergency generators will be provided on site in the event of mains power failure. The emergency power will supply security, first aid, tails pumps and emergency lighting until mains power is restored.

2.22 FUEL STORAGE AND FUELLING STATIONS

The storage of fuel and the distribution of petroleum products will be sub-contracted to a petroleum company. The petroleum product supplier will own, maintain and operate a tank farm of approximately 0.5 M litre of diesel oil. A second tank farm of smaller capacity will be provided for storage of gasoline used by the company and contractors. All tanks will be installed within a containment area to prevent ground spillage in the event of a tank leak.

The heavy and light vehicle fuelling station will be supplied and manned by the fuel supply contractor. The heavy vehicle fuelling station will primarily fuel the mine haulage fleet. Four stations are proposed with facilities to dispense diesel, lubricating and hydraulic oil, air and water.

The contract for supply will include the waste oil management system. The supplier will store, remove and recycle the spent oils.

2.23 COMMUNICATIONS

There is no telecommunication infrastructure in the immediate Central Ashanti area at the current time. It is expected that telecommunications will be established by satellite link and will be powered off the plant power supply. This will provide voice, email and internet traffic.

A conventional VHF radio system with hand held radios and chargers will be provided for site coverage. Radio communications will be via separate channels for mining, process plant and an emergency channel.

2.24 FIRE SERVICES

In order to minimise the number of services it is proposed to provide firewater via the raw water system.

2.25 NON-MINING WASTE

The various type of waste identified are:

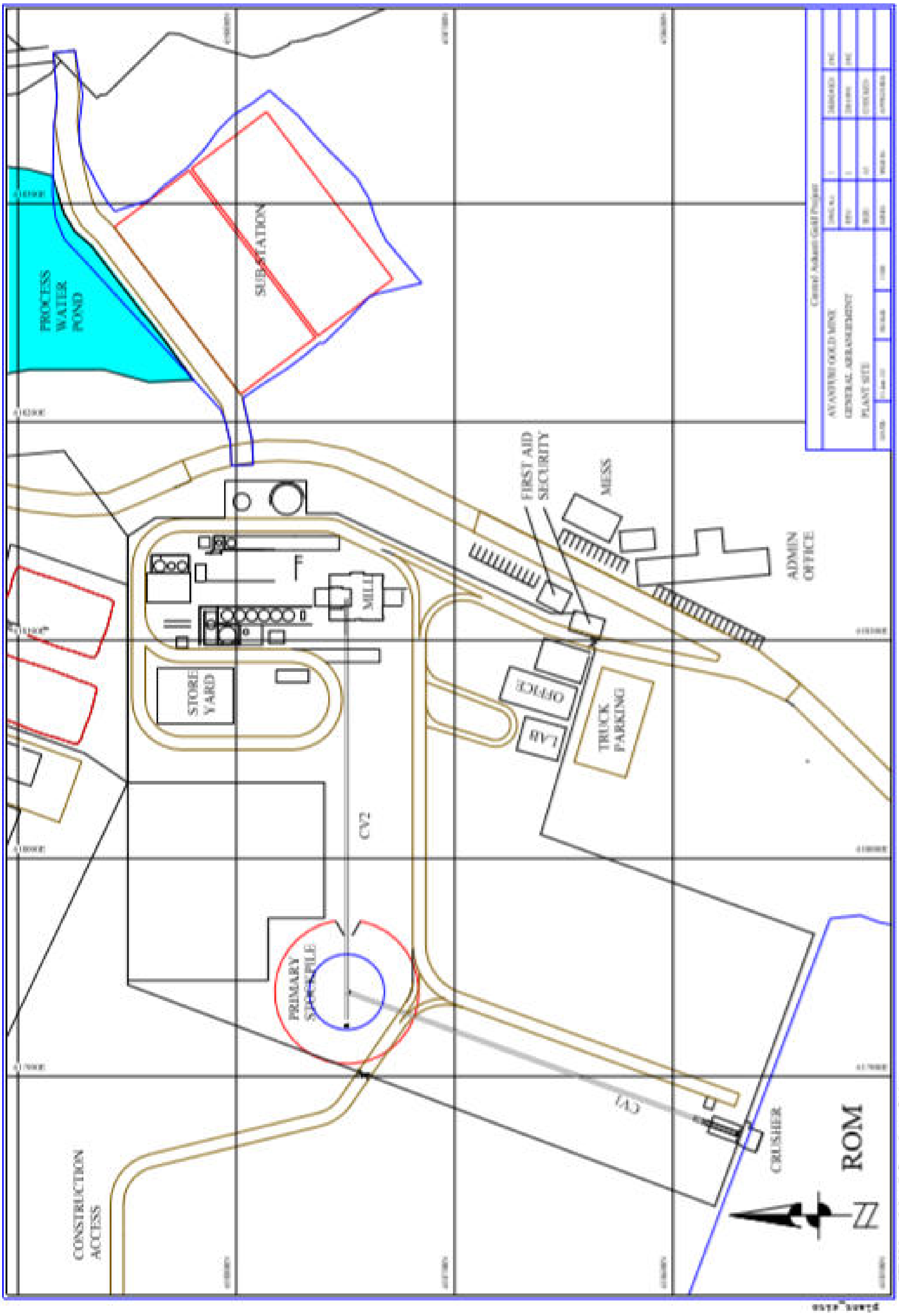
Office and *Household Waste:*

This type of waste will be produced by administration and technical offices, the canteens and households living at the accommodation village. The main items will be paper, office and domestic packaging and canteen waste.

Non-toxic Industrial Wastes:

This category of waste includes heavy and light equipment tyres, worn metallic parts and fittings and packaging material for non toxic products (plastics containers, wood, etc).

Plant site general arrangement



Waste oils:

Waste oils, oil filters and other small oil containers and grease will be produced at the plant and at the light and heavy vehicle workshop.

Hazardous Industrial Wastes:

This category of waste will consist of cyanide packaging that will be returned to the supplier. Other hazardous waste can be produced in smaller quantities such as refinery slags and cupels but they are recycled within the system (added to the milling circuit).

Laboratory Waste:

The on-site laboratory will only undertake sample preparation or environmental analyses by physical means. Consequently, no laboratory chemical wastes will be generated.

Clinical Waste:

Waste generated at the small clinic will be office waste and nursing station waste. The latter will be such items as swabs, tissues, bandages, and capsule packaging and sharps.

Non-mining waste impacts and management are discussed in detail in chapters 4.0 and 5.0.

2.26 MANPOWER FOR THE PROJECT

2.26.1 Number of Employees

The number of employees who will work directly for CAGL is currently estimated at 232 persons, made of senior staff and junior employees (Table 2.15). Contractors will be employed for mining, laboratory, security, vehicle and house maintenance, bus service and catering responsibilities. Though the number of contractor's employees has not been fully determined yet, it is expected that it could well exceed 200 persons. Total employment created is expected to exceed 425 persons.

2.26.2 Employment Philosophy and Training

Given the remote location of the Project, it is intended that the operations will be self-sufficient in as many areas as possible. To ease the transition into operations, CAGL will recruit senior personnel who are already familiar with gold processing operations. To the maximum degree possible personnel will be sourced from within Ghana. However, a small group of expatriates (approximately 4) will be required for both training and selected management roles in order to develop a competent operations and maintenance team which will be able to service the operation with minimal external support.

It is the intention of CAGL to encourage economic development within the local community and Ghana in general. Local contracts will therefore be let wherever possible and CAGL will work actively with existing and emerging companies to achieve this aim.

Of great importance throughout the Project will be the emphasis that CAGL will place on training local personnel. Experienced Ghanaian staff should be sourced to fill shift leader and plant maintenance roles since most of the workforce will be sourced from local villages with no prior mining experience.

Table 2.15: Personnel Numbers by Category and Department				
	Personnel Numbers			
Department	**Expatriate**	**Ghanaian-Salary**	**Ghanaian-Wage**	**Total**
Management	1	1	-	2
Mining	-	18	14	32
Process	-	18	38	56
Maintenance	2	11	19	32
Commercial (incl OH&S	1	11	21	33
Sustainability	-	7	8	15
Security*	-	7	55	62
Total	**4**	**73**	**155**	**232**

CAGL proposes to develop the local community and promote local employment through the educational and career-based training programme. The process will commence through intelligence testing of the available and willing potential employees. The control mechanisms and testing systems will be managed to minimise the potential for individuals to manipulate the procedure and outcomes. The selected prospective employees will then be provided schooling to enhance their communication skills. The streaming and training for specific job requirements will be co-ordinated with the operational training staff.

2.27 ALTERNATIVES TO THE PROJECT

2.27.1 General

A number of alternatives were considered in the early stages of the project planning. Various alternatives were screened out based on a range of financial, social, technical or environmental constraints. Alternatives included, but were not limited to the placement of infrastructure, the mining process and the decision whether to mine or not ("no-go" alternative). A review of Project alternatives is presented in table 2.16.

2.27.2 Selection of Tailings Disposal Method

An evaluation was undertaken of the suitability of each of seven proven tailings disposal methods for the CAGP. The seven methods are presented in table 2.17. A critique of the advantages and disadvantages of each method in relation to the CAGP is also presented. The most economic and least risk method is the in-pit disposal of tailings. This method is not, however, a viable option for the CAGP. This option is not available at this time as the available pits all have potential to be mined. The second most economical and least risk option is the valley fill method. After due consideration of the various disposal methods, this method was chosen for the CAGP.

2.27.3 Selection of Tailings Disposal Site

Four areas were evaluated for the disposal of tailings. They were 1) Asuafa, 2) Akesoa East, 3) Nkonya East and Akesoa Central (Map 2.6). The area of each is 320 ha, 130 ha, 230 ha and 320 ha respectively. The advantages and disadvantages of each were assessed as discussed below. However, a common advantage to all four areas was that no village resettlement would be necessary.

Asuafa Site

The Asuafa tailings site was assessed as having numerous disadvantages namely:

1. It would encompass two major tributaries, the Asuafu and one unnamed (Map 2.6).

2. It would result in extensive wetland and farmland loss in the area of the tributaries.
3. It would result in the loss of the only secondary forest area within the active Project area.
4. It would require extensive high volume water management.
5. It would require a major diversion of the road from Nkonya to Abnabna and villages beyond.
6. A large number of embankment dams would be required.
7. It would result in a major facility upstream of the Abnabna, and AF-Gap pits and the Plant site.
8. Numerous hamlets would require relocation.
9. Its eastern face would parallel the Ayanfuri – Bogoso national for approximately 1400 m and would be approximately 80 m from the highway at its nearest point.

Nkonya East

The Nkonya tailings site was assessed as having numerous disadvantages namely:

1. The area of land available is too small and a second TSF would be required.
2. The tailings and return water pipelines would traverse the Ayanfuri to Bogoso national highway.
3. The pipelines would be at least 3.1 km long.
4. It would require the diversion of the Nkonya - Dabiesem road.
5. It would be relatively close (approximately 490 m) to Nkonya village.
6. The existing Senior Camp would have to be relocated.

Akesoa East

An advantage of the Akesoa East site is that only a few hamlets would need to be relocated.

The Akesoa East tailings site was assessed as having numerous disadvantages namely:

1. The area of land available is too small and a second TSF would be required.
2. The tailings and water return pipelines would be at least 1.3 km long.

Akesoa Central

The Akesoa Central tailings site was assessed as having several advantages namely:

1. It has sufficient capacity, without being excessive, for planned life-of-mine.
2. Relatively few hamlets (8) would need to be relocated (Map 4.1).
3. Area of farms to be compensated is only 82 ha.
4. The tailings and return water pipelines would be approximately 200 m from the Plant site.

The disadvantage was assessed as its impact on the Akesoa subcatchment of the Fobin River catchment, including the wetland area within the FTSF footprint.

Other Areas

There is insufficient land area for a TSF north and north-west of the Akesoa Central and Akesoa East due to the Nanankaw mining lease boundary and the Ayanfuri- Sefwi Bekwau highway respectively. The land area west of the Nkonya – Abnabna access road is also considered unsuitable. CAGL has major exploration programme in the area with an identified deposit.

Table 2.16 Alternatives Identified in the Early Phases of Project Planning

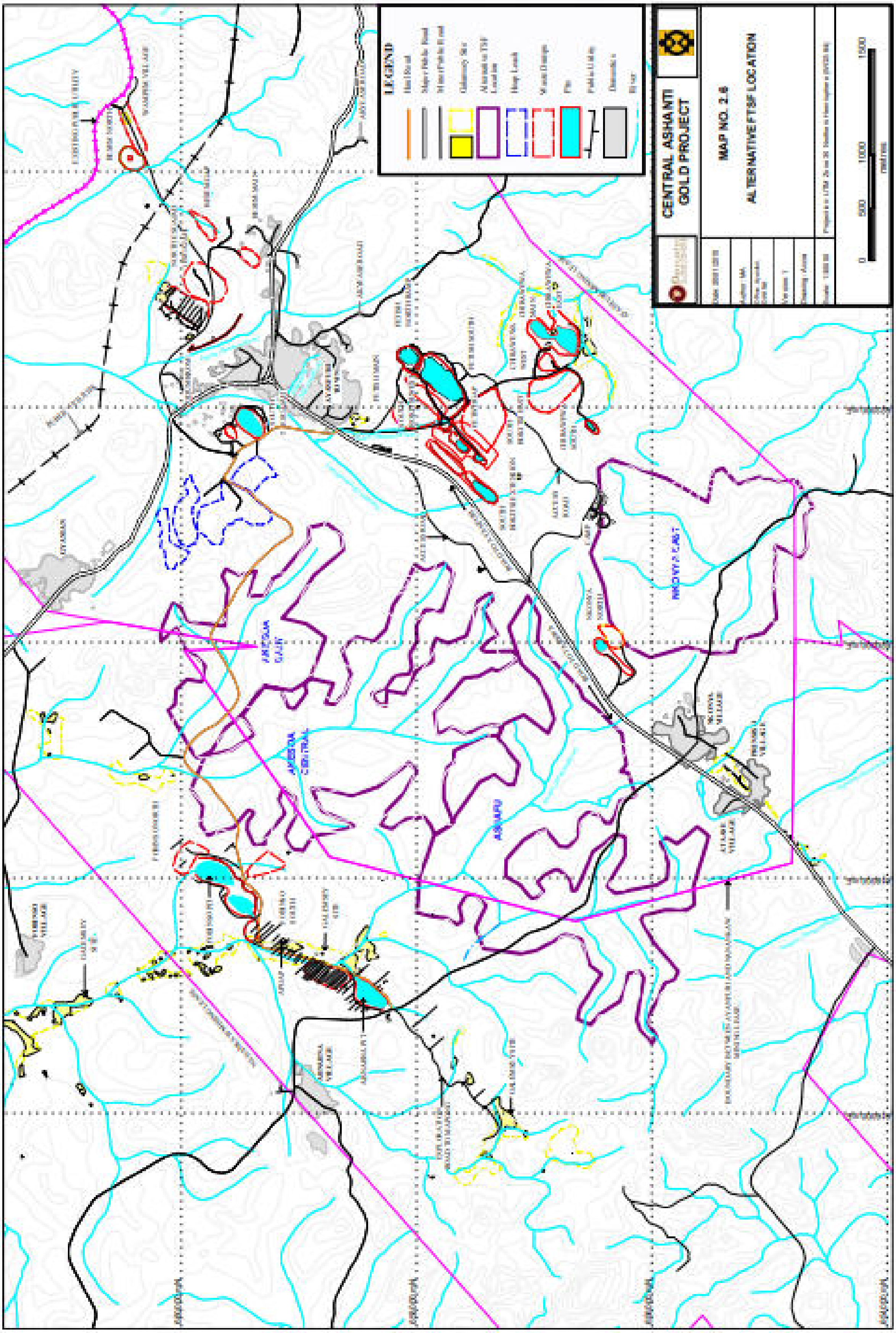
Project Element	Alternatives Considered	Selected Option(s)
Project Development	The project poses a number of potential positive and negative environmental (biophysical and social) impacts. The aim of the EIA is to quantify the potential impacts and provide insight into their significance. This would allow mitigation measures to be designed/implemented should there be no significant factors to prevent project development.	Should the findings of the EIA show that the project poses highly significant environment (social and biophysical) impacts the "no development" option will be considered. Project development pending the findings of the EIA. This EIA has not found any significant environmental and social impacts to prevent the Project (e.g. large-scale resettlement).
Alignment of access road	Existing access to the Project site is from the Ayanfuri–Bogoso highway at Nkonya village. Based on the potential impact on residents and traffic safety considerations, consideration was given to the development of a diversion. Alternatives therefore included leaving the status quo or constructing a new road.	Based on the safety of local residents, it was proposed to avoid Nkonya by constructing a bypass from just north of the present intersection to join up with existing access away from the village.
Pit Sites	Due to the position and grade of the ore deposits, it was not possible to move the five proposed pit sites.	Proposed Pit Sites are Abnabna, AF Gap Fobinso, Esuajah North and Fetish.
Location of Waste Rock Dumps	A number of locations were considered for placement of the mine waste dumps	Waste rock dump for each pit selected on geotechnical information, least impact on local streams, and on least exposure of communities to noise and dust impacts.
Waste Rock Disposal	Backfilling of pits	Fobinso to be backfilled after mining and and old pits namely South Bokitsi Complex and Chirawewa to be backfilled
Tailings Disposal 1	Consideration was given to a number of positions for the proposed Tailings Storage Facility.	See discussion below.
Tailings Disposal 2	Flotation tailings and CIL tailings treated as separate disposal streams and sent to separate FTSF	Flotation tailings will be benign and non-acid forming. CIL tailings with cyanide and trace metals will be contained in lined HDPE lined and capped. ~~TSF.~~
Treatment Plant	A number of options for the placement of the Treatment Plant were explored.	The originally selected site was moved based on better ground conditions. The new site would also be further away from a forested area.

Table 2.17: Evaluation of Various Tailings Disposal Designs for CAGL Project

TSF Option	Economic Ranking+	Risk Ranking*	Comment
In-pit TSF	1	1	Requires pits to be available for tailings storage. This option is generally not available to start up projects. Progressive rehabilitation is not possible. Post closure erosion risk is negligible. Mine voids are filled. **This option is not available at this time as the available pits all have potential to be mined.**
Paddock (upstream raising using tailings)	2	3	Progressive rehabilitation of outer embankment is possible. Post closure erosion has a high risk of uncontrolled release of tailings unless the cover design is adequate to reduce the risk erosion. **This option is not viable as it would require multiple sites creating a large area of disturbance and the use of tailings for embankment construction is not considered suitable for tropical environments do to the high erosion potential. This option is uneconomic because of the multiple sites and risks associated with long distances for pumping and piping of the tailings and return water.**
Paddock (upstream raising using mine waste)	2	3	Progressive rehabilitation of outer embankment is possible. Some post closure erosion potential but this is limited where the composition of the downstream cover design is carefully considered at the time of construction and maintenance or design changes are implemented during operation to reduce the risk of erosion. Post closure erosion risks could be negligible. **This option is not viable as it would require multiple sites creating a large area of disturbance and the use of mine waste for embankment construction is not considered economic because of the long haul distances. This option is uneconomic due to use of the multiple sites and risks associated with long distances for pumping and piping of the tailings and return water.**
Paddock centreline or downstream raising using mine waste	3	3	Progressive rehabilitation is not possible. Post closure erosion potential unless the composition of the downstream cover design is carefully considered at the time of construction and is adequate to reduce the risk of erosion. **This option is not viable as it would require multiple sites, creating a large area of disturbance. Use of mine waste for embankment construction is not considered economic because of the long haul distances. This option is uneconomic due to the multiple sites and risks associated with long distances for pumping and piping of the tailings and return water.**
Valley storage	2	2	Progressive rehabilitation of outer embankment is possible. Depending on the size and location of the valley TSF the risk ranking will generally remain in the medium category, depending on the consequences of embankment failure. This type of facility may require on going management, post closure, to maintain the operation of spillways etc. **This option is viable as it would require one site. Although the area of disturbance is large it is not as large as the use of multiple sites. Limited quantities of mine waste are required for embankment construction.**
CTD and Paste tailings to surface storage	3	1	Progressive rehabilitation of outer embankment is possible. CTD has the attraction of low overall height in terms of stability but the tailings occupy a large area which can give rise to water management problems during operation. On large projects the costs of rehabilitation are as much as 33% of the whole of life costs. Post closure erosion risks are negligible. **This option is not viable as it would require a very large area of disturbance, much larger than multiple sites of other options.**
Integrated waste landform TSF	2	3	Progressive rehabilitation is possible. Post closure erosion possible but this is limited where the composition of the downstream cover design is carefully considered at the time of construction and maintenance or design changes are implemented during operation to reduce the risk of erosion. Post closure release of tailings eliminated due to encapsulation within the waste rock storage. **This option is not viable as it would require multiple sites creating a large area of disturbance and the use of mine waste for embankment construction. This option is uneconomic because of the multiple sites and risks associated with long distances for pumping and piping of the tailings and return water.**

Notes: Economic ranking is based on whole of life costs, where 1 = low whole of life cost, 2 = medium whole of life cost, 3 = high whole of life cost.
Risk ranking is based on operational and post closure risks, where 1 = low risk both during operation and post operation, 2 = medium risk both during operation and post operation, 3 = high risk both during operation and post operation.

Map 2.6 alternative FTSF locations



3.0 BASELINE INFORMATION

3.1 THE ATMOSPHERIC ENVIRONMENT

3.1.1 Climate

3.1.1.1 General Climatic Conditions

The study area falls within the wet semi equatorial climatic region of Ghana characterised by high rainfall, medium to high temperatures and high humidity. It lies within the moist semi deciduous vegetative zone of Ghana where the dry season is clearly marked with the original forest tree species cut and taken over by secondary tree species.

The climate of the Project Area is determined by the movement of air masses which differ in air moisture and relative stability rather than temperature. Like most parts of the country, two main physical phenomena, the equatorial trough and the associated Inter Tropical Boundary (ITB) influence the climatic conditions of the area. The ITB influences the attraction of alternate air masses from the north and the south called the northeast trade winds and the southwest monsoon winds respectively. The northeast trade winds are associated with a dry cool wind known as the harmattan, which affects this part of Ghana during the months of November to February.

3.1.1.2 Sources of Climatological Information

The nearest national climatological station operated by the Meteorological Services Agency (MSA) is at Dunkwa-on-Ofin located about 15km east of Ayanfuri. The evaporation data was, however, obtained from Bogoso about 30km from Ayanfuri.

The stations are considered as being close enough to the project area to provide relevant information for the climatological assessment.

3.1.1.3 Rainfall

The rainfall events in the area are often intense, torrential and stormy. The resultant runoffs are very intense and short lived and accompanied by massive sheet erosion of loose soil material, especially where the vegetative cover is removed. Rainfall distribution is bimodal. The main season is from March to July and the minor season is from September to November. A short dry spell occurs in August and the major dry season is from December to February.

The description of the rainfall pattern and amount within the project area is based on data obtained from Dunkwa-on-Ofin, which has current and consistent 30 year duration rainfall records from 1979 to 2008. The mean rainfall values for Dunkwa-on-Ofin therefore provide a good estimate of the areal rainfall over the Ayanfuri concession[1]

3.1.1.4 Annual Rainfall Characteristics

The mean annual rainfall for the Ayanfuri concession was estimated to be in the region of 1451mm. The ten year mean annual rainfall is as shown in table 31.1.

The short statistical description of annual rainfall based on the above records suggests that:

- there is considerable variations in annual rainfall from year to year;
- the least amount of annual rainfall was recorded in year 2000 whilst the highest was in 1984; andlike most parts of Ghana, the project area exhibited more dryness towards the year 2000.

[1] The rainfall data and the statistical summaries have been retained on file).

Table 31.1: 10-year Annual Rainfall Data for Dunkwa-on-Ofin		
Climatic Station	**10-Year Period**	**Annual Rainfall Range mm**
Dunkwa-on-Ofin	1979 – 1988	1040 – 1829
	1989 – 1998	1132 – 1648
	1999 - 2008	951 - 1708

3.1.1.5 Monthly Rainfall Characteristics

The statistical summary of the mean monthly rainfall is presented in table 31.2. The analyses of the monthly rainfall data suggest that of the two rainfall seasons, the first period, March – July accounts for about 57.3% while the second period, September – November accounts for 28.9% making a total of 86.2%. The mean monthly rainfall is presented graphically as figure 31.1.

Table 31.2: Mean Monthly Rainfall at Dunkwa-on-Ofin (1979 - 2008)	
Month	**Mean Monthly Rainfall mm**
January	17.5
February	49.0
March	129.3
April	169.4
May	188.1
June	215.8
July	139.9
August	98.1
September	163.6
October	181.6
November	79.3
December	39.8
Total	1471.4

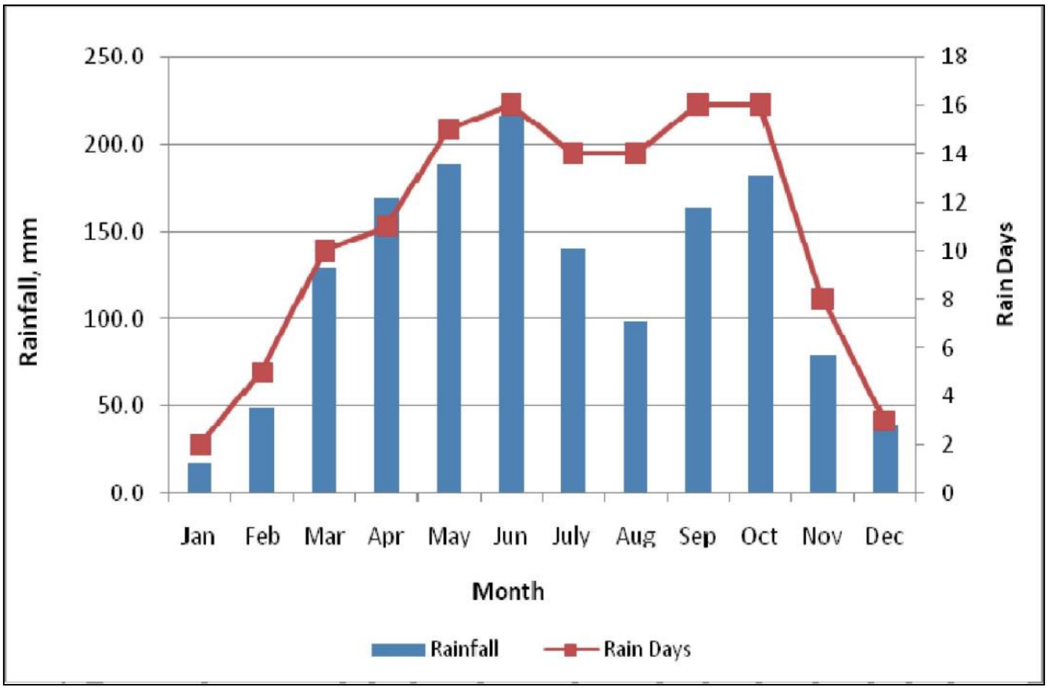


Figure 31.1: Mean Monthly Rainfall & Rain Days Data for the Project Area

3.1.1.6 Diurnal Variation in Rainfall and Number of Rainy Days

The duration of rainfall in the area is in the range of 2 - 3 hours on the average and rarely exceeds 12hours. The highest daily rainfall figures are generally recorded in April, May & June and with occasional exceptional events in March or October, which represent the beginning and end of the two rainfall periods. The mean daily rainfall is 11.2mm with a range of 0.0mm – 118.6mm. These values are based on daily rainfall data recorded at Dunkwa-on-Ofin for the period 1979 - 2008.

The 30 year record of rain days is presented in Appendix 3.1.1.6. The average number of rain days per year for the 30 year period is 129days with a yearly range of 87days – 156days as shown in table 31.3. The mean monthly number of rain days is further illustrated graphically in figure 31.1.

Table 31.3: Statistical Summary of Number of Rainy Day/ Month for Dunkwa-on-Ofin (1979– 2008)

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	TOTAL
Mean	2	5	10	11	15	16	14	14	16	16	8	3	129
Min	0	0	3	7	11	0	0	0	7	8	0	0	87
Max	5	10	16	17	20	23	24	25	26	23	15	9	156

June, September and October recorded the highest number of rain days of 16days each followed by May (15days), representing the peak of the two wet seasons as against 2days for January representing the dry season.

Table 31.4 presents the frequency of occurrence of rainfall in Dunkwa–on-Ofin for the period 1979 to 2008, and is further illustrated in figure 31.2.

Table 31.4: Frequency of Occurrences of Rainfall at Dunkwa-on-Ofin

Daily Rainfall (mm)	Frequency (Days)	% Frequency (Days)	% Cumulative Frequency (Days)
100+	11	0.12	0.12
90 – 100	15	0.16	0.28
80 – 90	6	0.07	0.35
70 – 80	18	0.20	0.54
60 – 70	27	0.29	0.83
50 – 60	49	0.53	1.37
40 – 50	98	1.06	2.43
30 – 40	164	1.78	4.20
20 – 30	341	3.70	7.90
10 – 20	610	6.61	14.51
0 – 10	2382	25.81	40.32
0	5507	59.68	100.00
Total	**9228**	**100.00**	**-**

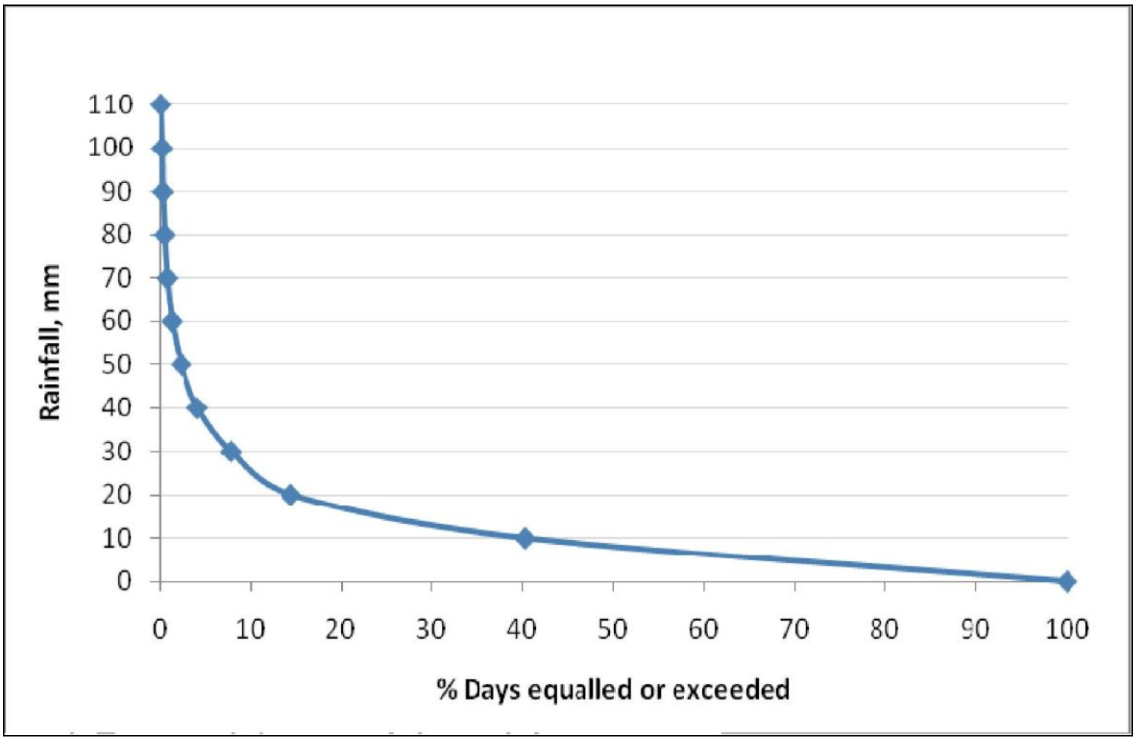


Figure 31.2: Frequency of Occurrence of Rainfall at Dunkwa-on-Ofin

3.1.1.7 Rainfall Return Periods

The highest actual rainfall recorded at Dunkwa-on-Ofin for the period 1979 to 2008 was measured in September 1979 and produced 118.6mm of rain. Table 31.5 shows the maximum yearly rainfall event recorded for each year during the 30year period.

The annual daily maximum rainfall data spanning the 30years at Dunkwa-on-Ofin was used to estimate for the 2year, 5year, 10year, 20year, 50year, and 100year return periods using the Weibull formula and the Gumbel probability plot, and the results are as shown in table 31.6.

3.1.1.8 Temperature

The 22year temperature data for Dunkwa-on-Ofin covering the period 1987 – 2008 was assessed and the statistical summary is produced in table 31.7. The monthly average temperature values and the statistical summary are given in Table A3 in the Annex. The monthly average temperature ranged from 24.9°C (January) to 29.7°C (March), while the mean of the monthly average temperature varied from 25.7°C in August to 28.4°C in February/March.

3.1.1.9 Relative Humidity

The mean monthly relative humidity at Dunkwa-on-Ofin for the period 1990 to 2008 is used to describe humidity conditions over the concession (see Table A4 in the annex). The mean monthly relative humidity increases from a minimum value of 50.0% in January to a maximum of 88.5% in July and ranges mainly from 74.4% – 85.1% as shown in table 31.8.

Table 31.5: Daily Maximum Rainfall Data for Dunkwa-on-Ofin

Year	Date of Event	Rainfall Amount, mm
1979	25.09.1979	118.6
1980	12.09.1980	109.5
1981	24.10.1981	76.7
1982	03.10.1982	57.9
1983	28.05.1983	66.3
1984	05.07.1984	74.4
1985	12.10.1985	53.3
1986	07.03.1986	73.9
1987	26.06.1987	72.4
1988	03.03.1988	72.4
1989	03.07.1989	80.6
1990	19.06.1990	90.0
1991	13.05.1991	63.1
1992	21.05.1992	55.2
1993	30.07.1993	91.5
1994	12.04.1994	95.2
1995	15.04.1995	71.5
1996	15.05.1996	72.9
1997	11.06.1997	93.6
1998	10.05.1998	117.0
1999	04.03.1999	64.7
2000	22.08.2000	77.8
2001	18.06.2001	117.7
2002	15.04.2002	72.2
2003	07.06.2003	80.6
2004	29.10.2004	62.7
2005	26.09.2005	65.0
2006	01.12.2006	91.5
2007	10.08.2007	64.2
2008	06.10.2008	105.1

Table 31.6: Daily Rainfall Maxima Recurrence Period

Return Period, year	Rainfall Amount, mm
2	78
5	101
10	110
	121
50	129
100	144

Table 31. 7: Mean Monthly Temperature °C at Dunkwa-on-Ofin (1987 – 2008)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Mean	26.6	28.4	28.4	28.3	27.9	26.9	26.0	25.7	26.3	26.9	27.3	26.8	27.1
Min	24.9	26.7	27.1	27.3	27.3	26.4	25.1	25.1	25.7	26.3	26.1	26.1	26.8
Max	28.5	29.4	29.7	29.1	28.4	27.3	27.0	29.5	26.9	27.5	28.1	27.9	27.7

Table 31.8: Mean Monthly Relative Humidity (%) at Dunkwa-on-Ofin (1990 – 2008)													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Mean	74.4	74.8	77.2	79.3	81.4	83.6	85.1	84.6	83.5	81.9	79.7	81.0	80.5
Min	50.0	71.0	75.0	77.0	79.5	81.5	83.0	82.0	82.0	79.5	77.5	79.0	76.4
Max	81.5	79.0	79.0	82.0	84.0	85.5	88.5	87.0	85.0	83.5	82.0	83.5	83.4

3.1.1.10 Evaporation

The evaporation data assessed is based on data for Bogoso about 30km from Dunkwa-on-Ofin for the period 1994 – 2004. The mean monthly pan evaporation rate is estimated to be 132mm, which translates into 1,582mm/year. The details are provided in table 31.9.

Table 31.9: Mean Monthly Pan Evaporation (mm) at Bogoso													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean**
Mean Monthly Evaporation	185	148	138	110	104	111	115	141	142	121	120	147	132

3.1.2 Air Quality

3.1.2.1 Objectives

The objectives of the survey were:

- To establish the current dust levels for Total Suspended Particulate (TSP) at three representative locations; and
- To determine noise levels at three representative locations for both day and night.

These objectives are a part of broader objective of the Project which is to ensure that all aspects of its operations are duly accounted for and potential adverse impacts are mitigated to ensure sustainable development.

3.1.2.2 Sample Locations

Three locations, Abnabna and Ayanfuri communities and Nkonya forest were selected within the project area for sampling baseline dust and noise levels (Map 31.1).

3.1.2.3 Selection Criteria

The locations were selected based on the following;

- Suitability of location to collect representative samples for dust and noise;
- Suitability of location as receptor for dust and noise during operational phase of the Mine;
- Potential exposure of village or community to noisy machinery and dusty activities.

Abnabna village and Ayanfuri Town are populated areas, therefore dust and noise levels recorded would reflect the impact of human activities as part of the baseline. Nkonya forest on the other hand is uninhabited and therefore would provide results that reflect background conditions, with very limited human contribution.

3.1.2.4 Geographical co-ordinates

The geographical co-ordinates of the sampling locations were recorded with Etrex ® Global Positioning System (GPS) device. The results are provided table 31.10.

Table 31.10: Location and GPS Co-ordinates (UTM) of Noise and Dust Sampling Sites

Name	Sample Code	Location	GPS Co-ordinates	
			N	E
Abnabna village	PD11, PD12	Uncompleted concrete structure close to borehole (photo 1)	616235	659009
Ayanfuri town	PD21,PD22	Island/roundabout at the junction of major trunk roads (photo 2)	622247	659252
Nkonya forest	PD31,PD32	About 110 m from main road and along footpath (photo 3)	619407	656677

3.1.2.5 Description of Sampling Locations

Abnabna Village

Abnabna is a village about 2.5 km off the main Ayanfuri trunk road and accessed by an unsealed road from Nkonya village junction.

The dust and noise level monitors were mounted by an uncompleted concrete structure located at 4 m away from the village's borehole along the access road. The sampling location is coded PD 11 for sample collected during day 1 and PD12 for samples collected on day 2.

Dust sampling at Abnabna

Noise monitoring at Abnabna

Ayanfuri Township

Ayanfuri is about 15 km west of Dunkwa-on-Offin and lies along the main Tarkwa – Dunkwa trunk road. It is pre-dominantly a commercial town with well developed infrastructure. It is also a junction town that links some major towns like Dunkwa-on-Offin, Sefwi Bekwai and Daiso.

The sampling site was located within an island (roundabout) where the main road branches to the other major towns. The sampling location is coded PD 21 for sample collected during day 1 and PD22 for samples collected on day 2.

Dust sampling at Ayanfuri

Noise monitoring at Ayanfuri

Nkonya Forest

The Nkonya forest area is a secondary forest located to the south of the Nkonya village. The forest lies along the main Ayanfuri trunk road and is accessed by a feeder road that branches off the main road. The sampling location was about 0.39 km from the main road and about 1 m from a footpath/farm track used by farmers and hunters. The location is about 1.1 km from a proposed Tailing Storage Facility, and about 1.6 km from the proposed ROM pad. A proposed plant access road will be about 1.7 km from the sampling location. The sampling location is coded PD 31 for sample collected during day 1 and PD32 for samples collected on day 2.

Dust sampling at Nkonya forest

Noise monitoring at Nkonya forest

3.1.2.6 Dust Sampling Methodology

Dust samples were collected using five (5) Casella Cel low flow dust-sampling units. These sampling units were set to pump two litres of air per minute (2 L/min). All pumped air was passed over a pre-weighed 0.8 µm filter. The filter retains all airborne dust larger than 0.8 µm. The instrument was calibrated each time before use, using its internal calibration functions. The “General methods for the sampling of respirable and total inhalable dust, Methods for the determination of hazardous substances 14/3, 2000” (MDHS, 2000), was used in the sampling exercise.

As a standard procedure, all the filters sent to the project site including used and unused (kept as control) were weighed prior to sampling and thereafter. The ‘control’ filters are used to confirm accuracy of storage and efficiency in weighing technique. All the filters were weighed with a five-digit Sartorius Balance Model BP 210 D with an accuracy of ± 20 micrograms. They were weighed in triplicate to ensure accuracy. After sampling, all filters were removed from the Dust Sampling Units and re-weighed.

In order to calculate the micrograms of dust per cubic meter ($\mu g/m^3$) for each sample, the following formula was used:

$$\mu g/m^3 = \frac{\text{Net dust weight x 1000 x 1000}}{\text{Flow Rate x Sample time}}$$

3.1.2.7 Noise Sampling Methodology

Noise levels were recorded with a Quest® Technologies Sound Level Meter (Model 1900). The equipment was calibrated before noise measurements were taken. It was mounted on a tripod and raised to about a metre high. The monitor was inclined prior to recording noise level.

3.1.2.8 Dust Results

Dust samples were collected over 2 days, from March 31 to April 1, 2009. At all the locations the wind direction and prevailing weather condition were noted. After sampling, all filters were removed and kept in sealed containers for weighing at the SGS MASLAB. Dust levels recorded at the various sampling locations and their dates are provided in table 31.11.

Table 31.11: Results of Dust Sampling at three locations in CAGL Project Area

Location	Site Code	Filter Number	Dust Conc. ($\mu g/m^3$)	Weather condition	Duration 24hrs	Date
Abnabna	PD11	5	125.0	There weather was fair throughout the monitoring period from 31st March to 2nd April 2009	x	31st Mar – 1st Apr 2009
Ayanfuri	PD21	4	68.6		x	31st Mar – 1st Apr 2009
Nkonya	PD31	3	55.6		x	31st Mar – 1st Apr 2009
Abnabna	PD12	7	116.0		x	1st Apr – 2nd Apr 2009
Ayanfuri	PD22	6	93.8		x	1st Apr – 2nd Apr 2009
Nkonya	PD32	2	34.7		x	1st Apr – 2nd Apr 2009
	Blank	11	-		-	31st Mar – 1st Apr 2009
	Blank	14	-		-	1st Apr – 2nd Apr 2009

WB/IFC Standard for Total Suspended Particulate for short-term 24 hrs = 500 ($\mu g/m^3$)
Ghana EPA Ambient Air Quality Guidelines for 24 hrs(Industrial = 230 $\mu g/m^3$), (Residential = 150 $\mu g/m^3$)
All dust measurement levels are normalised cubic metre

3.1.2.9 Dust Discussion

Compared with international standards, dust levels recorded at all sampling locations were below the WB/IFC target of 500 (µg/m^3) for Total Suspended Particulate (TSP) for short-term (24 hrs) period. The highest dust level was recorded at Abnabna on March 31, 2009. The level was a fraction (25 per cent) of the international standard. When compared with EPA guidelines for ambient air quality, the levels recorded at all the location were also below the target, 150 (µg/m^3) for residential and 230 (µg/m^3) for industrial areas. The result of dust at Abnabna (residential) was however, only 16 % lower than the target set at 150 µg/m^3.

Given that the main access to Abnabna and link roads within the village are unsealed, it is likely that dust generated by human and vehicular traffic and/or dust blown from the unsealed surfaces by wind currents accounted for the relatively high dust recorded at Abnabna compared to the other locations.

The dust level at Ayanfuri was the next after Abnabna. The level could be attributed to human activity and especially vehicular movement around the sampling location, as it is a junction for vehicles plying Dunkwa, Sefwi Bekwai, Daiso and Tarkwa. These roads are sealed; therefore dust generation is relatively minimal compared with Abnabna.

The lowest level of dust was recorded at Nkonya forest. The result could be attributed to high vegetation cover as pertains in areas under forest cover, isolation from dust generating activities and human influences at the sampling location. The results reflect background dust levels.

3.1.2.10 Noise Results

Ambient noise level was recorded during 24-hour period at 10 minutes interval at all three locations. Summary of the results are presented in table 31.12.

Field data was analysed statistically to obtain relevant parameters including the maximum, minimum and average noise levels for the sampling locations over 24 hours. The results of the analysis are provided in table 31.13. Data captured by the sound level meter and analysed is also provided in table 31.13. The results are also presented graphically in figures 31.3 and 31.4 and discussed.

Table 31.12: Summary of Noise Levels in dB(A) at Sampling Locations

Location	Statistical Function	A-weighted sound pressure level recorded over 24-hours		
		Total	Day	Night
Abnabna	Count	144	96.0	48.0
	Mean	58.5	60.6	54.3
	Maximum	91.5	91.5	61.8
	Minimum	47.0	50.5	47.0
	Standard Deviation	6.2	6.3	3.2
Ayanfuri	Count	144	96.0	48.0
	Mean	59.8	64.9	49.4
	Maximum	82.0	82.0	66.6
	Minimum	36.3	50.1	36.3
	Standard Deviation	10.8	7.7	8.3
Nkonya	Count	144	96.0	48.0
	Mean	47.4	47.3	47.6
	Maximum	60.9	60.9	58.2
	Minimum	32.0	32.0	40.2
	Standard Deviation	6.1	6.9	4.1

Table 31.13: Noise Monitoring results – Analysed from Sound Level Meter

Site	L_{max} dB(A)	L_{min} dB(A)	L_{eq} dB(A)	L_{90} dB(A)	L_{10} dB(A)
Abnabna	87.2	45.6	55.1	55.6	67.9
Ayanfuri	84.9	42.9	58.5	60.0	74.4
Nkonya	67.9	31.9	47.0	41.1	54.9

3.1.2.11 EPA/WB-IFC Zoning

The Ghana EPA has a classification scheme, A to E for various noise receptors and their permissible noise levels for both day (06h.00 to 22h.00) and night (22h.00 – 06h.00). Based on the scheme Abnabna village falls into Zone A; residential areas with negligible or infrequent transportation. Ayanfuri could be classified as C1; areas with some commercial or light industry, places of entertainment or public assembly, and places of worship such as churches and mosques. Forest areas have not been classified under this scheme; however under WB/IFC categorisation provided the area could be classified under conservation area, given the forest accommodates very little human activity.

The sampling locations could be described as rural for Abnabna and Nkonya and sub-urban for Ayanfuri. The major noise sources included the following;

- Traffic noise from the Dunkwa/Sefwi-Bekwai/Tarkwa highways at Ayanfuri and access to Abnabna;
- Public assembly and entertainment from public address systems especially at Ayanfuri; and
- Shrill noise from forest birds, insects and rodents at Nkonya forest.

From table 31.13 the background noise was highest at Ayanfuri and lowest at Nkonya forest. Abnabna was in between. The daytime noise level recorded at all the locations and how they compare with the EPA and WB/IFC targets are graphically represented in figures 31.3 and 31.4.

The maximum noise level for daytime measurement was recorded at Abnabna. It exceeded the EPA and WB/IFC standards applied in this study. The lowest noise levels were recorded at Nkonya forest. For night time noise levels, both maximum and minimum were recorded at Ayanfuri.

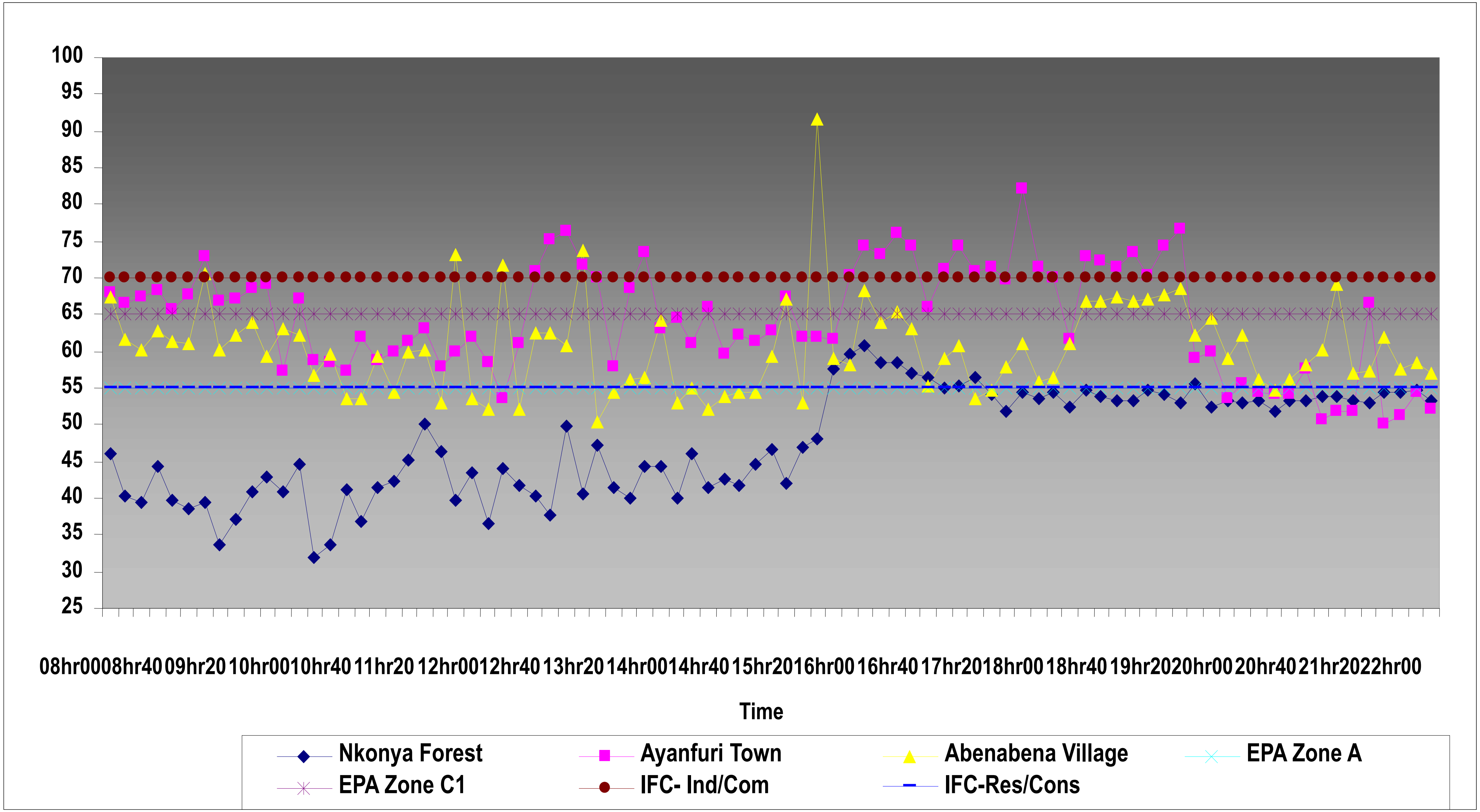


Figure 31.3: Noise Monitoring Results for Daytime

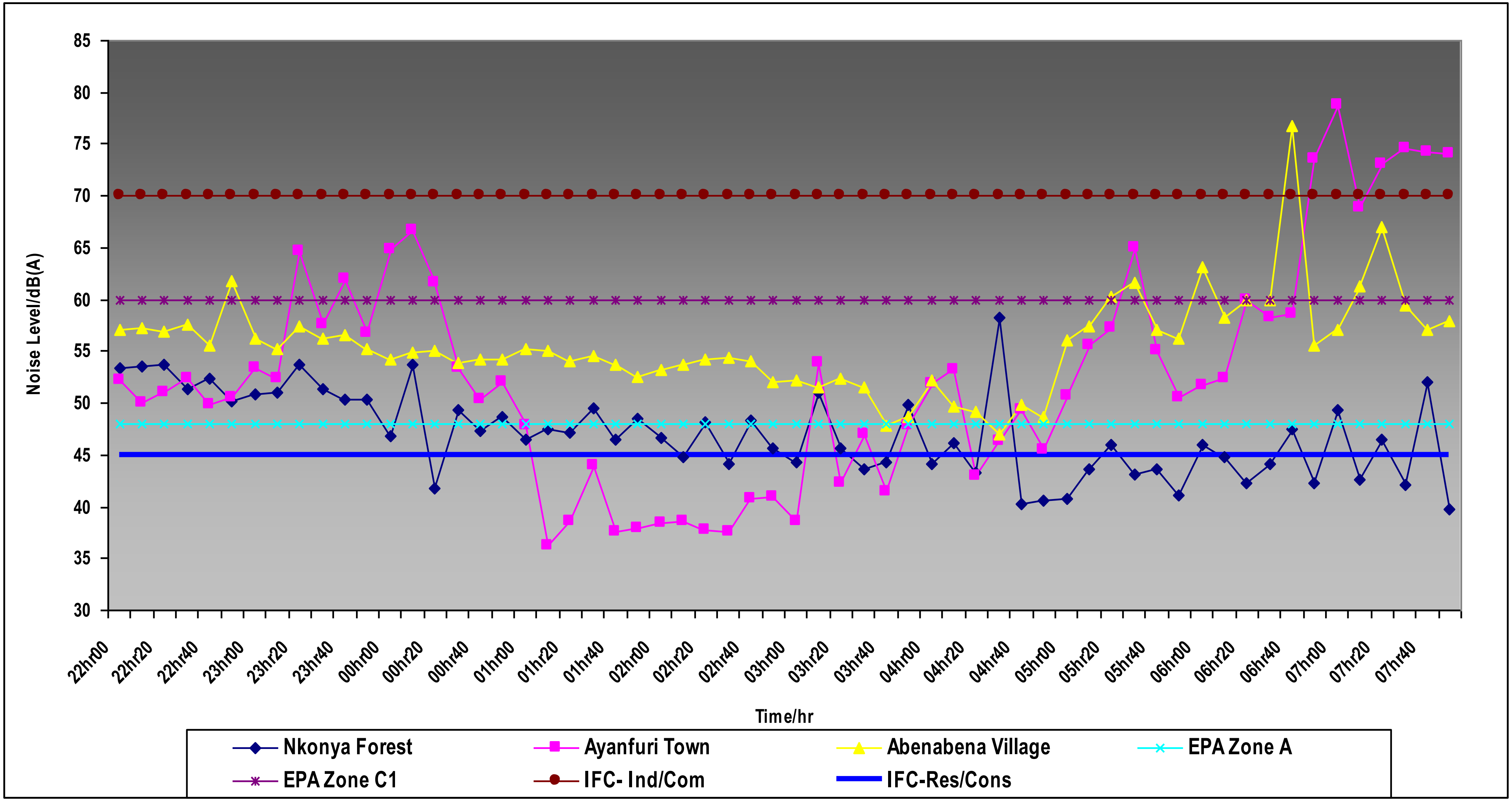
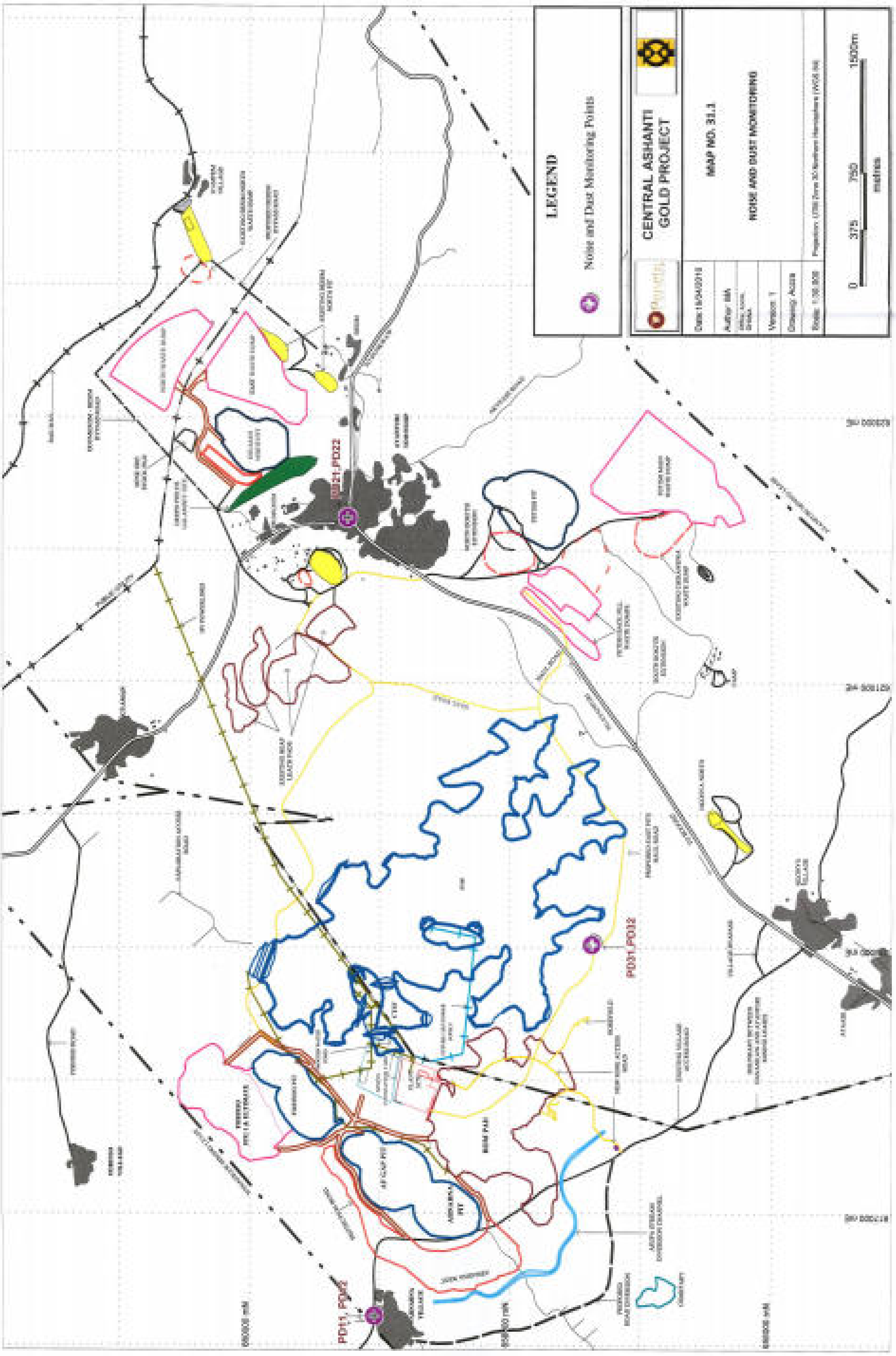


Figure 31.4: Noise Monitoring Results for Night-time

Map 31.1


LEGEND
Noise and Dust Monitoring Points
CENTRAL ASHANTI GOLD PROJECT
MAP NO. 31.1
NOISE AND DUST MONITORING
PD21-PD22
PD31-PD32
PD11-PD12

3.2 THE AQUATIC ENVIRONMENT

3.2.1 Surface Water Hydrology

3.2.1.1 The Ofin River Catchment and Project Area Tributaries

The streams on the western side of the CAGL Project area drain into the Ofin River. On the eastern side they drain to the Mansi River. The Ofin Basin has a drainage area of about 8,344km^2, while the Mansi is 133 km^2.

Two main sub catchments of the Ofin that falls within the Project area are identified as the Subin and the Fobin (Map 32.1). Some drainage characteristics are shown in table 32.1.The main tributaries of the Subin River are the Aponapon, Bowodinanwu, Asuaa, Danyami and the Nsanka streams. The main tributaries of the Fobin River are the Akesoa, Asuafu, Abnabna, Takrowa, Maninwu, Amantifuawura and the Kyiritwe streams.

The streams draining the Chirawewa pit area are principally made up of the Kyiriawewa and the Meretwe streams. The two streams form part of the Mansi Catchment of the Ankobra River System.

Table 32.1 Drainage Characteristics of Streams in the Project Area

Stream Name	Length km	Area km^2	Difference in Level, m (from source to mouth), a.m.s.l	Slope
Subin Basin		28.93	52.0	0.006
Subin stream				
Aponapon	5.45	9.46	51.0	0.009
Bowodinnanwu	3.61	3.87	43.0	0.012
Asuaa	2.88	2.47	39.0	0.014
Danyami	2.23	0.40	33.0	0.015
Fobin Basin		53.23	54.0	0.005
Akesoa	9.23	11.39	45.0	0.005
Asuafu	7.72	13.81	48.0	0.006
Abnabna	4.55	4.99	48.0	0.011
Takorowa	1.69	1.11	11.0	0.007
Maninwu	2.85	3.34	27.0	0.010
Amantifuawura	1.21	1.12	16.0	0.013
Kyiritwe	1.78	0.98	10.0	0.006
Mansi Basin		132.7	195.1	0.003
Kyiriawewa	10.1	27.60	59.0	0.006
Meretwe	10.2	37.60	49.0	0.005

3.2.1.2 The Subin Catchment

The Subin Catchment covers an area of about 28.93km^2. It originates around the Ayanfuri area and empties into the Ofin River after traversing a distance of about 9.20km with a slope of 0.006. The Subin is a perennial water source but the stream channel is not well defined in most sections. The sources have been disturbed by 'galamsey' operators. With respect to the points assessed, its widest and narrow widths are about 5.1m and 4.2m respectively.

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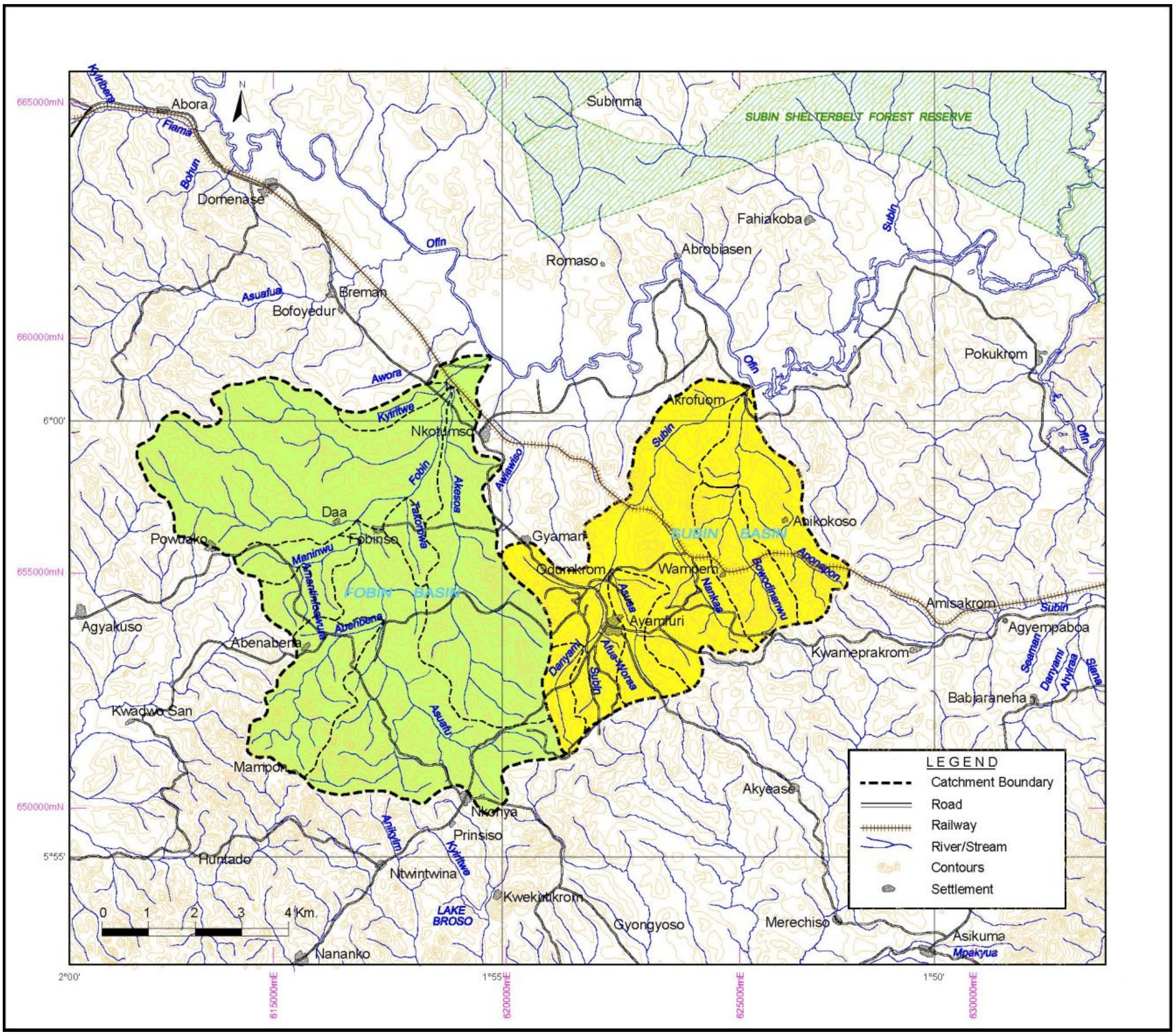
Map 32.1: Ofin River Sub-catchments and Associated Tributaries in the Project Area



It had uneven flow, sluggish at the shallow depth sections and quite swift at the deep sections. One main sub catchment of the Subin that has been disturbed as a result of the previous mining operations in the area is the Nsankaa stream, which is ponded at the upstream portion close to the road leading to Wampem. There are a lot of raffia palms in the Subin basin.

The difference in level from source to mouth of the stream is 52m a.m.s.l. The substratum of the Subin is sandy clay and contains considerable amount of decaying organic matter.

3.2.1.3 The Subin Sub-Catchments

Aponapon Sub-Catchment

The Aponapon stream has a catchment area of about 9.46km^2. It takes its source east of Wampem and travels a distance of about 5.45km before it joins the Subin at Mfantseman Settlement and has a slope of 0.009. Its widest channel is about 3.35m. The difference in level from source to mouth of stream is 51m a.m.s.l. The stream channel is not well defined and the flow was sluggish.

Bowodinanwu Sub-Catchment

The Bowodinanwu stream also a sub catchment to the Subin stream takes its source east of Wampem and it is seasonal. It has a catchment area of about 3.87km^2. It traverses a distance of about 3.61km before it joins the Aponapon around Anikokoso Settlement with a slope of 0.012. The difference in level from source to mouth of stream is 43m a.m.s.l.

Asuaa Sub-Catchment

The Asuaa stream also a sub catchment to the Subin stream drains the eastern portions of Ayanfuri. It has a catchment area of about 2.47km^2. It travels a distance of about 2.88km before it joins the main Subin River with a slope of 0.014. The difference in level from source to mouth of stream is 39m a.m.s.l. The channel width at the widest section is 1.1m whilst the narrow section is about 0.8m. The stream channel is not well defined and the bed has been disturbed by 'galamsey' operators at some sections.

Danyami Sub-Catchment

The Danyami stream also a sub catchment to the Subin stream drains the western portions of Ayanfuri. It has a catchment area of about 0.40km^2. It travels a distance of about 2.23km before it joins the main Subin River with a slope of 0.015. The difference in level from source to mouth of stream is 33m a.m.s.l. The channel width at the widest section is 1.2m whilst the narrow section is about 0.6m. The stream channel is not well defined and the bed has been disturbed by 'galamsey' operators at some sections.

3.2.1.4 The Fobin Sub-catchments

The Fobin Catchment covers an area of about 53.23km^2. It originates around the Ayanfuri area and empties into the Ofin River after traversing a distance of about 10.64km with a slope of about 0.005. The Fobin is a perennial water source but the stream channel is not well defined in most sections. The channel has been disturbed at some sections by 'galamsey' operators and an earlier large scale mining operations. With respect to the points assessed, its widest and narrow widths are about 8m and 5.2m respectively.

It had uneven and diffuse flow, sluggish at the shallow depth sections and quite swift at the deep sections. There were a lot of raffia palm and bamboo in the Fobin basin.
The difference in level from source to mouth of the stream is 54m a.m.s.l. The substratum of the Fobin is sandy clay and contains a lot of decaying organic matter.

Akesoa Sub-Catchment

The Akesoa stream is a perennial tributary to the Fobin and has a catchment area of about 11.39km$^{2.}$ It traverses a distance of about 9.23km before it joins the Fobin with a slope of 0.005. Its widest channel width is about 9.0m. The difference in level from source to mouth of stream is 45 a.m.s.l. The stream channel is not well defined at the upstream portions and the flow was sluggish.

Asuafu Sub-Catchment

The Asuafu stream is a perennial tributary to the Fobin and has a catchment area of about 13.81km$^{2.}$ It traverses a distance of about 7.72km before it joins the Fobin with a slope of 0.006. The difference in level from source to mouth of stream is 45 a.m.s.l. The stream channel is not well defined and the bed has been disturbed by 'galamsey' operators at some sections.

Abnabna Sub-Catchment

The Abnabna stream is a perennial tributary to the Fobin and has a catchment area of about 4.99km$^{2.}$ It traverses a distance of about 4.55km before it joins the Fobin with a slope of 0.011. Its widest channel width is about 1.6m. The difference in level from source to mouth of stream is 45m a.m.s.l. The stream channel is not well defined. The stream is ponded close to the Abnabna community and the area has been declared sacred.

Takorowa Sub-Catchment

The Takrowa stream is a seasonal tributary to the Fobin and has a catchment area of about 1.11km$^{2.}$ It traverses a distance of about 1.69km before it joins the Fobin with a slope of 0.007. The difference in level from source to mouth of stream is 11m a.m.s.l. The stream channel is not well defined.

Maninwu Sub-Catchment

The Maninwu stream is a seasonal tributary to the Fobin and has a catchment area of about 3.34km$^{2.}$ It traverses a distance of about 2.85km before it joins the Fobin with a slope of 0.010. The difference in level from source to mouth of stream is 27m a.m.s.l. The stream channel is not well defined.

Amatinfuawura Sub-Catchment

The Amantinfuawura stream is a seasonal tributary to the Fobin with a marshy source. It has a catchment area of about 1.12km$^{2.}$ It traverses a distance of about 1.21km before it joins the Maninwu with a slope of 0.013. The difference in level from source to mouth of stream is 16m a.m.s.l. The stream channel is not well defined.

Kyiritwe Sub-Catchment

The Kyiritwe creek is a seasonal tributary to the Fobin with a marshy source. It has a catchment area of about 0.98km^2. It traverses a distance of about 1.78km before it joins the Fobin with a slope of 0.006. The difference in level from source to mouth of stream is 10m a.m.s.l. The stream channel is not well defined

3.2.1.5 The Mansi Sub-Catchments

The Kyiriawewa stream joins the Mansi at Nsuaem No 1 after traversing a distance of about 10.1km and draining a catchment area of 27.6km^2, while the Meretwe joins the Mansi at Nsuaem No 2 after traversing a distance of about 10.2km and draining a catchment area of 37.60km^2.

3.2.1.6 Sources of Drinking Water

Many of the above sub-catchments are water sources for numerous communities. Uses include drinking water (though contaminated) household chores, bathing and house construction. A list of communities, their water sources and uses in relation some of the above subcatchments are provided in Section 38, table 38.2).

3.2.1.7 Stream Flow

The discharge levels of the two main rivers and their tributaries are assessed in relation to the catchment area of the Ofin River at Dunkwa by the Area-Ratio method. Table 32.2 shows the estimated low flow data based on the Ofin River at Dunkwa.

The gauge station on the Ofin River at Dunkwa-on-Ofin has been moved further downstream to Adwumaim. The flow data obtain for Adwumaim is provided in Appendix 3.1.1.6 – table 5) as Table A5 in the Annex, which showed that the flows recorded ranged from 57.874m^3/s to 439.900m^3/s with an average of 132.586m^3/s.

Instantaneous discharges reflecting field conditions at the time of the study were also estimated for the streams. The results are presented in table 32.3.

Table 32.2: Flow Estimates of the Streams in the CAGL Project Area

Stream Catchment	Catchment Area km^2	Mean Annual Flow,m^3/s	Minimum Observed flow, m^3/s DWF		
			Return Periods, Years		
			2	5	10
Ofin at Dunkwa	8,344.00	75.900	2.2640	0.5660	0.5240
Subin River	28.93	0.263	0.0078	0.0020	0.0020
Aponapon stream	9.46	0.086	0.0026	0.0006	0.0006
Bowodinanwu	3.87	0.035	0.0011	0.0003	0.0002
Asuaa stream	2.47	0.022	0.0007	0.0002	0.0002
Danyami stream	0.40	0.004	0.0001	-	-
Fobin River	53.23	0.484	0.0143	0.0036	0.0034
Akesoa stream	11.39	0.104	0.0031	0.0008	0.0007
Asuafu stream	13.81	0.126	0.0037	0.0009	0.0009
Abenabena stream	4.99	0.045	0.0013	0.0003	0.0003
Takorowa stream	1.11	0.010	0.0003	-	-
Maninwu stream	3.34	0.030	0.0009	0.0002	0.0002
Amantinfuawura stream	1.12	0.010	0.0003	-	-
Kyiritwe stream	0.98	0.009	0.0003	-	-
Mansi River	132.68	1.70	0.128	0.066	0.045
Mansi at Nsuaem No 2	100.30	1.29	0.097	0.050	0.034
Kyiriawewa	27.60	0.35	0.027	0.014	0.010
Meretwe	37.60	0.48	0.036	0.019	0.013
DWF means Dry Weather Flow					

Table 32.3: Instantaneous Flow Estimation for the streams in the CAGL Project Area			
Stream	**Measurement Point**	**Instantaneous Flow, m³/s**	**Remark**
Subin River	6°00'23.7"N 1°52'08.9"W	0.2462	Measurements taken close to the Mfantseman Settlement but before the confluence with Aponapon
Aponapon Stream	5°58'39.4"N 1°51'39.4"W	0.0246	Measurements at Fetching Point close to the railway line
Asuaa Stream	5°58'15.8"N 1°53'40.5"W	0.0223	Measurements taken on the Ayanfuri Wampem Road (galamsey ongoing)
Danyami stream	5°56'52.1"N 1°54'18.1"W	0.0038	Measurements taken upstream of culvert on Ayanfuri Nkonya Road (galamsey ongoing)
Fobin River	5°58'58.3"N 1°56'35.8"W	0.3235	Measurements taken at Bamboo Canopy close to the Fobinso Settlement
Akesoa stream	6°00'19.8"N 1°55'34.6"W	0.0647	Measurements taken on the culvert on the Akesoa at Nkotumso on Diaso Road
Asuafu Stream	5°57'48.8"N 1°56'21.3"W	0.1797	Measurements taken at upstream of the culvert on the Asuafu stream close to Abenabena Pit
	5°56'09.1"N 1°55'18.2"W	0.0034	Measurements downstream of culvert on the main Ayanfuri Nkonya Road. Channel had been trained.
Abenabena Stream	5°57'40.9"N 1°56'47.9"W	0.0347	Measurements taken at the Culvert close to the Abenabena Community and downstream of Sacred Groove

3.2.1.8 Calculation of Runoff Volumes

The Soil Cover Complex (SCC) method of predicting a catchment's hydrologic response to storm events is used to estimate the volume of runoff. This is based on rainfall runoff relationships, and the runoff coefficient is described in this case as the Curve Number (CN). The CN integrates the effects of soil texture and ground cover into an average runoff response parameter that represents the whole catchment. Based on field inspection carried out as well as the future operations within the Ayanfuri catchment, this is estimated to be 70 units.

The 24hr maximum rainfall is the input rainfall data for the SCC method, and following specified return periods derived from these events over a 30 year period at Dunkwa-on-Ofin are used.

The summary of calculation results are presented in tables 32.4 and 32.5.

Table 32.4: Calculation of Runoff Volumes into Subin for Different Return Periods						
Description	**Return Period**					
	2-yr	**5-yr**	**10-yr**	**20-yr**	**50-yr**	**100yr**
24hr rainfall, mm	78	101	110	121	129	144
Curve number, CN	70	70	70	70	70	70
Runoff depth, mm	20.32	33.02	38.10	48.26	53.34	66.04
Catchment area, km²	28.93	28.93	28.93	28.93	28.93	28.93
Runoff volume, x 10⁶m³	0.59	0.96	1.10	1.39	1.54	1.91

Table 32.5: Calculation of Runoff Volumes into Fobin for Different Return Periods						
Description	**Return Period**					
	2-yr	**5-yr**	**10-yr**	**20-yr**	**50-yr**	**100yr**
24hr rainfall, mm	78	101	110	121	129	144
Curve number, CN	70	70	70	70	70	70
Runoff depth, mm	20.32	33.02	38.10	48.26	53.34	66.04
Catchment area, km²	53.23	53.23	53.23	53.23	53.23	53.23

Runoff volume, $x10^6 m^3$	1.08	1.76	2.03	2.57	2.83	3.52

3.2.1.9 Estimation of peak flows

In order to understand and design water carrying structures such as channels, culverts and slope drains required for diversion of storm runoff from the proposed active work areas, it was necessary to compute peak rates of runoff in relation to the recurrence interval or return periods for specified rain events

In this case, the Rational Method is used to predict the Subin and Fobin watershed hydrologic response to storm events and to provide estimates of the peak runoff rates. The Rational Formula is given as:

$Qp = 0.278\ C\ I\ A$ (1);

where
Qp is the peak runoff rate (m^3/s)
C is the runoff coefficient
I is the design rainfall intensity (mmh^1), and
A is the catchment area (km^2)

Large storm events occur less often than small events and this can be related to the probability (Pr) of a given sized event occurring in any year to the exceedance interval or return period, T which is computed as T = 1/Pr. So that a storm that has a 5% probability of occurring in a given year has a 20 year return period (1/0.050 = 20). Also, a 100 year storm has a 1% probability of occurring each year. For this work, various return periods were chosen as follows: 5, 10, 50, and 100 year return periods.

The Kirpich Method shown in equation 1 for predicting the time of concentration, Tc was used in this study (Kirpich, 1940). This is most suitable for watersheds with natural catchments and agricultural areas.
$Tc = 0.00025(L/S^{0.5})^{0.80}$;………………………………………………….. (2) where Tc is time of concentration;

L is the length of the longest flow path to the point of interest (m); and
S is the overall catchment slope) m m^{-1}).

The Tc computed for the Subin and Fobin Rivers using the above relationship gives 3.0 hrs and 3.5 hrs respectively.

The rainfall intensity is derived from the duration equal to the Subin and Fobin stream's response time or the time of concentration computed above. Consequently, this design rainfall intensity is a function of three main parameters consisting of (1) the stream time of concentration, Tc; (2) the ecological characteristics of the watershed; and (3) the return period for which the peak runoff rate is designed. For this work, the Intensity Duration Frequency (IDF) Curve was used following from the estimated rainfall duration and return periods. The major constraints in this determination were the lack of site specific information hence curves from the closest available site i.e. Kumasi is applied, (Dankwa, 1974). Furthermore, these curves have not been updated since the middle seventies but nevertheless provide fairly reliable estimates of the rainfall intensities as these were based on long series of rainfall data.

The runoff coefficient is the watershed characteristic that contributes to the attenuation of the rainfall to produce the peak runoff rate. This is a dimensionless parameter between 0.0 and 1.0 depending on the watershed's soil infiltration rate land use and the land slopes. Soils with rapid infiltration rates such as sands have low runoff coefficients (0.0 to 0.3) while soils with slow infiltration rates such as clays have much higher runoff coefficients. There is also some influence of vegetation on runoff depending on how dense or large the vegetation is, and also the presence of deep rooted vegetation which could improve soil cover.

For the Ayanfuri area, a uniform soil type and land use as well as slopes was assumed based on the observations during the field inspections, and a single runoff coefficient of 0.4 units is therefore used.

In accordance with the above estimations, the following computations of peak runoff are given for return periods ranging from 5 years to 100 years as shown in tables 32.6, 32.7, 32.8 and 32.9.

3.2.1.10 Conclusions

The hydrological assessment has shown that:

- The streams in the Project area are mostly perennial and fall within two main catchments, the Fobin and Subin catchments. These rivers discharge into the Ofin River of the Pra River System.
- The stream/water bodies have been disturbed by activities of 'galamsey' operators in the Project area. These streams take their source from a number of swamps in the area which would be impacted by the mining operations. Some of the stream channels had already been diverted. This applies especially to galamsey activity on the Subin along the Odumkrom to Esuajah North Road, the Asuafu below the Abnabna – Fobinso haul road and the Akesoa above Nkutumso.
- The mine water requirements can be met. Enough water should however be stored during the dry season for mining operations.
- The proposed diversion of the Asuafu into the Abnabna stream will require channelling it downstream of the sacred groove close to the Abnabna village.
- The peak runoff and the runoff volumes for the various return periods from the 5yr to the 100yrs return periods in the Subin and Fobin Rivers have been determined. These ranged from110.31m^3/s for the 5yr and 187.9m^3/s for the 100yr return period for the Subin River. The corresponding values for the Fobin are 183.44m^3/s and 308.21m^3/s.
- There are wide variation in peak runoff using the time of concentration i.e., from 110m3/s (5yr) to 187.94m3/s (100yr) for the Subin River and 183.44 (5yr) to 308.21m3/s (100yr) for the Fobin River.
- This probably provides better measure of discharges to be considered in the design of water structures rather than the 24hr max events.
-

Table 32.6: Computation of Peak Storm Runoff in Subin & Fobin Streams for a Return Period of 5 yrs

Description	Tc	Value	
		Subin	Fobin
Runoff Coefficient, C	-	0.4	0.4
Length of stream to discharge point	-	9.2km	10.64km
Difference in elevation, H	-	52.0m	54.0m
Computed Time of Concentration, Tc	-	3.0hr	3.5hr
Rainfall intensity, i	Tc 24 hour max	34.29mm/hr 5.33mm/hr	30.99mm/hr 5.33mm/hr
Area of watershed	-	28.93km^2	53.23km^2
Peak runoff, Qp	Using Tc Using 24 hr max	110.31m^3/s 17.1m^3/s	183.44m^3/s 31.55m^3/s

Table 32.7: Computation of Peak Storm Runoff in Subin& Fobin Streams for Return Period of 10 yrs

Description	Tc	Value	
		Subin	Fobin
Runoff Coefficient, C	-	0.4	0.4
Length of stream to discharge point	-	9.2km	10.64km
Difference in elevation, H	-	52.0m	54.0m
Computed Time of Concentration, Tc	-	3.0hr	3.5hr
Rainfall intensity, i	Tc 24hour max	38.10mm/hr 6.35mm/hr	34.29mm/r 6.35mm/hr
Area of watershed	-	28.93km^2	53.23km^2
Peak runoff, Qp	Using Tc Using 24hr max	122.57m^3/s 20.43m^3/s	202.97m^3/s 37.59m^3/s

Table 32.8: Computation Peak Storm Runoff in the Subin & Fobin Streams for 50 yr Return Period

Description	Tc	Value	
		Subin	Fobin
Runoff Coefficient, C	-	0.4	0.4
Length of stream to discharge point	-	9.2km	10.64km
Difference in elevation, H	-	52.0m	54.0m
Computed Time of Concentration, Tc	-	3.0hr	3.5hr
Rainfall intensity, i	Tc 24 hour max	54.61mm/hr 8.76mm/hr	46.99mm/hr 8.76mm/hr
Area of watershed	-	28.93km^2	53.23km^2
Peak runoff, Qp	Using Tc Using 24 hr max	175.68m^3/s 28.18m^3/s	278.14m^3/s 51.85m^3/s

Table 32.9: Computation Peak Storm Runoff in the Subin & Fobin Streams for 100 yrs Return Period

Description	Tc	Value	
		Subin	Fobin
Runoff Coefficient, C	-	0.4	0.4
Length of stream to discharge point	-	9.2km	10.64km
Difference in elevation, H	-	52.0m	54.0m
Computed Time of Concentration, Tc	-	3.0hr	3.5hr
Rainfall intensity, i	Tc 24 hour max	mm/hr mm/hr	mm/hr mm/hr
Area of watershed	-	28.93km^2	53.23km^2
Peak runoff, Qp	Using Tc Using 24 hr max	187.94m^3/s 31.04m^3/s	308.21m^3/s 57.12m^3/s

3.2.2 HYDROGEOLOGY OF REGION AND PROJECT AREA

3.2.2.1 Introduction

The hydrogeological report represents an assessment to characterize the aquifer types (numbers, type, depth, and flow), determine the areas and rate of recharge to the aquifers identify groundwater users and assess the level of sensitivity to pollution of aquifers within and around the Project facilities.

The assessment was done using mostly drill data and logs from several exploration drill holes within the Project area and also water quality data acquired from a previous surface and ground water sampling programme.

The parameters used for the quantitative assessment included among others borehole depths, depth to water table/transition zones, and aquifer materials.

The assessment has drawn on previous studies by AngloGold Ashanti (undated but c. 2004) and by Coffey Geotechnics (2007, 2009), Kuma (2007) and internal studies undertaken by Sun Gold Limited (2007-2008).

3.2.2.2 Groundwater Occurrence

The Project area is underlain by the Birimian metasediments whose permeability is highly dependent on the secondary permeability obtained from fractures, quartz stringers, stockworks, veins and shear zones which have improved groundwater transmission and storage. The development of aquifers in these rocks is therefore dependent on the nature, length, density, thickness and the degree of interconnection of the fractures, stringers, stockworks and veins and also on the in-filling of the fractures as well as on the extent of weathering in the area.

For substantial amounts of groundwater to occur in these rocks, the fractures should be many and interconnected causing enough porosity and permeability for groundwater transmission and accumulation.

The mode of occurrence of groundwater is thus basically linked to the nature and thickness of the decomposed zones and their interconnection to rock fractures, joints, quartz-veins and pegmatites that occur in these rocks. Quartz veins and pegmatites in the area are fractured and to some extent brecciated due to brittle deformational activities which may have affected them.

3.2.2.3 Groundwater Flow Direction

In the study area, due to the heterogeneity of the aquifers and their dependence on secondary permeability, such as fractures and quartz veins among others, flow of groundwater within aquifers occurs predominantly in the fractures and other discontinuities rather than as intersticial flow. There are many barriers to continuous groundwater flow laterally as well as with depth. The rock types are varied and as such, weather to different depths. The nature and degree of weathering also varies spatially. Similarly, unfractured rocks are very common giving credence to lateral barriers to groundwater flow.

The determination of groundwater flow direction in any geologic formation is very complex and depends upon a variety of factors. The presence of geological structures such as faulting, folding and jointing constitute important controlling factors. Groundwater movement is in accordance with the hydrostatic gradients, where the difference in pressure heads between any two points is a prime motivating factor.

Coffey, 2007 assumed the direction of groundwater flow towards the Offin River to the north, based on terrain analysis (Regional topography).

To confirm this, static water levels for twenty-five (25no) inclined exploration holes from Perseus Mining limited were analysed. Geological sections with plot of static water levels were prepared for selected profiles within the concession. From the sectional maps, the difference in hydraulic heads was used to determine the flow directions. Flow is generally in the direction of low hydraulic gradient. The results showed that groundwater flow is radial within the Project area.

3.2.2.4 Determination of Recharge areas and rate of recharge

The study area is in a moist semi-deciduous forest with rainfall of between 951.2 mm to 1829 mm and it is characterized by seasonal rainfall, high evapotranspiration rate and medium surface runoff. Infiltration of rainwater and subsequent percolation into the groundwater system as base flow also depends on the aperture, density and degree of interconnection of the fractures and the permeability of the weathered rock.

Topographic highs are normally considered as areas of groundwater recharge and topographic lows as areas of groundwater discharge, especially in a terrain in which the occurrence of groundwater is controlled by the geomorphology, geology and tectonic setting.

Recharge of an unconfined aquifer occurs at the ground surface directly above the aquifer. In contrast, recharge to a confined aquifer may occur many kilometres away, typically at a higher elevation where the aquifer is no longer confined; that is, where the overlying material are permeable and allow percolating rainfall to reach the confined aquifer. Once recharged, the groundwater flow downgradient to where it is confined.

The occurrence of groundwater and the subsequent sustained withdrawal of water from an aquifer depend essentially on the amount of recharge that reaches the aquifer. This in turn is dependent, to some extent, on the soil moisture deficit, soil texture, soil structure, amount of vegetation cover, and the extent of lateral and vertical soil and aquifer parameter variation. Other critical inputs to groundwater recharge include the amount of precipitation, the extent of evapotranspiration, rock type, topography, permeability of aquifer, and surface runoff.

The rate of recharge to the aquifers in the study area will require a continuous data gathered over a period of years to be estimated. Generally, about 15% of the total precipitation ends up as groundwater, but this varies locally and regionally from 1 to 20%. Previous work carried by Jay Minerals Services Limited on the Ayanfuri concession estimated the recharge from 3 to 5% of the total annual rainfall.

3.2.2.5 Aquifer characteristics

Aquifer types

Aquifers are geologic layers that are filled with water and that can transmit enough water to supply a well under normal hydraulic gradient. Both confined and unconfined aquifers exist in the study area. Flow of groundwater occurs in three distinctly different but hydraulically interconnected aquifers namely:

Weathered rock aquifers
Fractured quartz vein aquifers
Fractured rock aquifers

Aquifers in the area are highly heterogeneous with limited areal extent. Their characteristics change rapidly due to the nature of the topography, weathering conditions, geology and the secondary structural features necessary for the development of high permeability in the rock.

3.2.2.6 Depth to Aquifer

The depth to transition zones (moderately weathered zones) from drill logs was generally considered as the depth to the aquifer in this study. The transition zones are known to be good aquifers, especially when fractures and quartz veins crosscut them. The ability of moderately weathered zones and the fractured basement rocks to bear and yield water depend on the number and size of interstices created during weathering, fracturing and the extent to which they are interconnected.

A similar assessment of groundwater in the region carried out by Water Resources Research Institute (WRRI, 1996) reported a variation in depths to which aquifers were intercepted from 6-69m with a mean of 37m for borehole logs. Coffey, 2007 on the other hand, reports the depth to aquifer from a range of 13-60m on the regional water bores.

As part of this study, drill logs of exploration holes were examined and the depth to the transition zones which are normally considered as the water bearing zones varied between 6 and 92m with a mean of 22.4m. This is indicative on both shallow and deep seated aquifers in the study area.

3.2.2.7 Yield (flow)

No yield measurements were carried out on the existing boreholes and no data was available in the study area but earlier assessment by the WRRI, 1996 recorded borehole yield in the range of 0.6-8.2m^3/hr and averaged 2.7m^3/hr.

The Coffey (2007) study on the regional boreholes in the area recorded borehole yields in the range of 0.7-10.79m^3/hr with a mean of 2.7m^3/hr.

The variations in yields may be due largely to weathering and fracturing. The borehole tapping water from relatively thick layers of unconsolidated and quartzite fragments derived from sandstones and quartzites as well as fractures in these rocks, were found to be relatively high yielding according to the WRRI report.

3.2.2.8 Static Water Level

The depth to static water levels recorded at the time of pump installation during the WRRI assessment in the region varied between 1 and 19m with a mean of 7.5m. Coffey, 2007 on the other hand, recorded static water level in the range of 1.7 to 23.3m with a mean of 9.16m.

For this study, data was obtained for groundwater levels in inclined exploration holes at the mine site. The groundwater levels were then projected to the vertical plane for analysis. The static water levels ranged from 1.7 to 26.6m with a mean of 12.62m in the inclined holes. However, it ranged from 123.534-133.883m (MSL). A summary of static water levels projected to the vertical and reduced to MSL is presented in table 32.10.

Table 32.10: Static water levels projected to the vertical and reduced to MSL							
BHID	**E -UTM**	**N – UTM**	**RL**	**Dip**	**Azm**	**SWL in inclined holes (m)**	**SWL Projected vertical and Reduced to MSL (m)**
ABDD088	617,019.13	658,286.08	134.979	-60	NW	1.762	128.423
ABRC 051	617,132.47	658,441.19	134.974	-50	NW	11.351	126.278
ABRC144	617,035.65	658,609.14	141.639	-50	SE	14.421	130.592
ABRC146	617,088.75	658,549.52	139.773	-50	SE	8.632	133.161
ABRDD155	617,011.81	658,575.34	147.173	-70	SE	17.768	130.476
ABDD091	617,113.17	658,288.32	133.757	-50	SE	1.066	132.940
ABRDD286	617,022.16	658,563.91	147.187	-70	SE	19.911	128.477
ABRDD302	616,937.25	658,539.05	148.303	-70	SE	20.117	129.399
ABRDD306	616,962.42	658,570.08	149.196	-75	SE	18.272	131.547
ABRDD308	617,099.47	658,305.55	133.6	-50	NW	12.897	123.721
ABRDD316	616,965.68	658,627.00	146.796	-70	SE	13.741	133.883
ABRDD324	617,061.17	659,310.33	154.443	-60	NW	14.162	142.178
AFRC018	617,891.18	659,646.60	142.123	-60	SE	5.929	136.989
AFRDD070	617,818.05	59,728.43	139.981	-60	SE	14.322	127.578
AFRDD071	617,991.77	659,924.91	130.438	-50	SE	9.013	123.534
AFRDD072	618,035.03	659,935.81	131.428	-50	SE	9.085	124.468
AFRDD073	618,061.28	659,905.74	131.107	-50	SE	9.818	123.586
AFRDD078	617,729.75	659,646.96	156.339	-70	SE	26.573	131.368
AFRDD080	618,004.66	659,909.38	130.615	-50	SE	4.515	127.156
AFRDD081	618,058.53	659,968.89	141.272	-50	SE	20.089	125.883
AFRDD082	617,841.96	659,701.00	139.724	-60	SE	14.264	127.371
FBDD016	617,894.63	659,702.66	141.106	-60	SE	15.512	127.672
FBDD032	617,779.97	659,680.40	131.065	-50	SE	8.134	124.834
FBDD033	618,007.77	659,965.90	130.207	-50	SE	6.628	125.130
AFRDD90	617,779.97	659,680.40	149.13	-50	SE	25.886	129.303

3.2.2.9 Aquifer Transmissivity

No pump testing data on existing boreholes was sighted during the study. Coffey 2007, recorded a transmissivity range of 1.7 to 3.7m^2/d with an average of 2.98m^2/d. The Aquifers in the study area are therefore characterised by low transmissivity, limited areal extent and low storage capacity.

3.2.2.10 Groundwater Use within the Project area

As part of the study, groundwater users within 5km radius of the Project facilities were identified. A summary of the communities, the number of boreholes, status and GPS localization of each borehole is presented in table 32.11. A total of twenty–four (24) boreholes in eleven communities were identified in 5km radius of the Project area. Out of this, one of the boreholes in Ayanfuri is earmarked for mechanization which is an on-going project; five (5) boreholes had broken down mainly due to handpump problems. The remaining boreholes were all in good condition and functioning. There is however the need to increase the number of boreholes in the area to meet the current increase in population within the communities.

Table 32.11: Groundwater Users in the CAGL Project Area					
Location (Village)	**Code**	**UTM Co-ordinates**			**Comments**
		Northern	**Eastern**	**Elevation(m)**	
Abenabena	AB01	659022	616227	143	Functioning, around entrance to town
Powuako	PK01	660806	613910	171	Functioning
Nkotimso	NKT01	663297	619479	131	Functioning, close to the market
Nkotimso	NKT02	663398	619648	130	Functioning, close to high tension
Nkotimso	NKT03	663436	619531	126	Faulty, around angloga area
Nkotimso	NKT04	663215	619582	130	Faulty, around egyumamu area
Fobinso	FB01	661329	617332	143	Functioning, within center of town
Fobinso	FB02	661422	617365	147	Functioning, around the football pitch
Ayanfuri	AYF01	659566	622332	161	Functioning, around chief's palace
Ayanfuri	AYF02	659532	622213	148	Functioning, around pentecost church
Ayanfuri	AYF03	659183	622616	149	Functioning, around church of christ
Ayanfuri	AYF04	658767	621997	153	Faulty, around D/C school
Ayanfuri	AYF05	659012	622445	154	Functioning, around zongo
Ayanfuri	AYF06	659706	622480	141	to be mechanised, on-going
Wampem	WP01	660455	624771	143	Functioning
Wampem	WP02	660445	624851	144	HDW, water is turbid
Princiso	PS01	655165	618947	165	Functioning
Ataase	AT01`	655358	618580	174	Faulty
Gyongyoso	JJ01	652915	622268	139	Functioning
Nkonya	NKY01	655588	619280	167	Faulty, c-line area
Nkonya	NKY02	655668	619042	160	Functioning, close to market
Gyaaman	G01	661159	620465	152	Functioning
Gyaaman	G02	661131	620394	162	Functioning
Gyaaman	G03	660970	620521	160	Functional, close to the main road

3.2.2.11 Dewatering of Proposed Mining Operations

Coffey Geotechnics has completed a hydrogeological assessment of the feasibility of dewatering proposed mining operations for the Perseus CAGP (May 2009). The work involved a review of available reports, and of field and laboratory test data collected by mine site personnel; a visit to the Project site; and collation and interpretation of data collected from mine site personnel during the dewatering of two existing pits (Abnabna and Fobinso North).

During the course of pit dewatering, Perseus collected records on Abnabna and Fobinso North pit dewatering including:

- Quantities pumped pit water levels and pit water quality on a weekly basis;
- Groundwater elevations in inclined exploration bores in the vicinity of the two pits;
- Daily rainfall records for Dunkwa;
- Pit survey data showing surface areas for water table elevations at 1m intervals.

In addition, data was collected on pit water levels for other pits including Fobinso South.

Trial pit dewatering was undertaken as a means of accessing the base of two pits for resource drilling purposes (the existing Abnabna and Fobinso North pits) and provided a valuable mining scale test of hydrogeological conditions at the CAGP.

Licensing approval was received to dewater the above named pits and dispose of the pumped water into natural streams that ultimately drain to the Ofin River. The approved discharge rate was $0.35m^3/s$ up to a maximum $5x10^6m^3$ per year, until December 2008.

The impact of the dewatering was monitored both through pit water balance data and also through a number of exploration boreholes acting as groundwater monitoring bores adjacent to each pit. Water balances were undertaken, taking into account dewatering rates, storage volume for different pit elevations, and contributions from rainfall and evaporation, and the groundwater leakage rate into the pits for a nominal drawdown of 15m was assessed as 700kL/d (Fobinso North) and 500kL/d (Abnabna).

The water yielding conditions in the pits are judged to be dictated by fracture systems/ jointing in the rock and are non-homogeneous and anisotropic. Nevertheless based on observations of monitoring bore performance, and the absence of data suggesting major linear hydrological features, the interconnection of such fractures/ jointing can be interpreted in terms of an overall permeability, and an overall storativity. The adopted figures based on this analysis were a permeability of k=0.1m/d and a specific yield of S_y=0.02 for the 30m below standing water level, reducing to k=0.01m/d and S_y=0.005 for greater depth.

Under "average" seasonal conditions, following removal of stored waters, then the immediate on-going dewatering yield for each individual pit is likely to range from 500kL/d to nominally 1500kL/d depending on size of pit, local ground conditions, meteorological conditions, depth and proximity to recharge boundaries. As pits expand this figure will increase, however the increase is primarily dictated by the length of pit in proximity to recharge areas. Abnabna pit is in close proximity to a significant stream system, the Asuofo. Pits at significant distances from recharge boundaries may not experience a significant increase in dewatering requirements, as the aquifer "drains" and hydraulic gradients reduce. Until operational data shows otherwise, planning should be based on groundwater inflows of up to 1500kL/d.

Extreme rainfall events falling within pit envelopes (bunded areas) will lead to much larger inflows over short periods, and therefore the sizing and placement of dewatering plant is likely to be based on a consideration of what is an acceptable length of continuous period for which access to the base of pit will not be available for mining, following a major rainfall event. The report presents an assessment of pump operating requirements. The operational costs involved in maintaining a large pump which has been sized for design-limit rainfall events to pump the comparatively low flows that would be experienced in dry season conditions, is likely to justify using a smaller pump for day to day pumping requirements, and operating the larger pump only following significant rainfall.

Some pit crest levels are close to natural drainage water levels. Adequate bunding will be required around such pits to protect them from inundation should water levels rise significantly in the natural drainage systems during an exceptional wet season. This situation will be exacerbated as pit envelopes are widened. It was noted that stream diversion works are likely to be required as the edges of the pits approach the existing water courses (in particular Abnabna).

It was noted that high rates of dewatering required to drain the currently full pits creates a risk of 'rapid drawdown' loading on pit walls reducing wall stability. Similarly, as the pits are expanded across current stream alignments, the water within the streams during periods of flow will both increase recharge to the pits and possible dewatering volumes, and also will result in higher potentiometric pressures in pit walls reducing their stability.

Dewatering below the pit floor is expected to require in pit dewatering systems because of the generally low permeabilities at depth (floor sumps and slope toe drains). However the probability does exist that significant water yielding structural discontinuities in the deeper bedrock will be encountered, and these should be intersected outside the pit and pumped to below pit floor levels to assist in draining the pit.

3.2.2.12 Removal of Groundwater Inflows

The second component is the on-going removal of groundwater inflows. Given the expected low magnitude of groundwater inflows for the sizes of these pits, and the low permeability assumed below the base of oxidation, dewatering bores located outside the pit will generally not be practical, and dewatering will need to be achieved using in-pit sumps and collector systems around the toe of pit walls. It is probable however that some significant water yielding structural discontinuities will be identified as mining proceeds. These should be targeted by boreholes drilled to intersect them outside the pit and pumped to provide a means of lowering water levels below the pit floor (the discontinuity acts as a "drain" collecting water for the bore pump to remove) and supplement the in pit dewatering.

At the start up of mining, groundwater inflows are likely to be of the order experienced during the recent trial dewatering for Abnabna and Fobinso North pits. Inflow figures have been interpolated for the remaining pits based on pit sizes.

3.2.2.13 Dewatering Requirements During Pit Expansion

The hydrogeological model developed for Ayanfuri assumes that permeabilities are very low below the base of oxidation. By implication then, deepening of the pits by itself does not lead to a significant increase in groundwater flow. Increasing the perimeter of the pit above the base of oxidation will increase groundwater flow. However the major driver for groundwater flow for these sites is likely to be the proximity to a constant source of groundwater recharge – and more specifically the length of pit adjacent a recharge zone and the separation of the pit from the recharge zone.

The pit that is most likely to experience an increase in groundwater inflow as it is developed will be Abnabna due to its close proximity to the Asuafo Stream.

3.2.3 Surface and Groundwater Water Quality

3.2.3.1 General Introduction

Information on the quality of water in surface streams and representative groundwater locations of the CAGL Project area dates from 1991 when Jay Mineral Services (JMS) undertook an Environmental Impact Assessment of the Ayanfuri Project for Cluff Resources PLC.

Information was also gathered by Ashanti Goldfields Company (AGC) during its ownership period of the Ayanfuri Project (1996 – 2004) and viewed in the document, AGC Decommissioning Plan for Ayanfuri Mine (2004). A large amount of information in that document however is a repetition from the JMS document.

In November 2006, a limited sampling of streams and boreholes was undertaken by a team from the European Union Mining Sector Support Project for Environmental Impact Assessment of Mining and Exploration Areas in Ghana.

In July 2008, Perseus Mining Limited (Perseus) commissioned SGS Laboratory Services Ghana Ltd to undertake a sampling programme of streams and boreholes in the Project area on a quarterly basis, beginning in August 2009.

3.2.3.2 Summary of JMS Surface Water Assessment

As part of baseline sampling programme in JMS collected surface water samples from a variety of river locations[1] in August 1991 and August 1992. The results of the sampling are presented in tables 32.12, 32.13 and 32.14.

Table 32.12: Jay Minerals/AGA Report: Physical Parameters - Surface Water in the Ayanfuri Concession

Location	Temp (⁰C)	Cond. (us/cm)	pH	Turb. NTU)	DO (mg/l)	SS (mg/l)	TDS (mg/l)
*River Subin -Ayanfuri	28.6	76.5	6.7	14	4.8	36	50
*River Subin -Dredge Road	26.0	73.3	7.0	51	-	49	47
*River Asuaa -Ayanfuri	23.9	51.6	6.6	9	5.3	66	32
*Sampa Pond — Nkonya	26.9	58.3	6.5	28	4.8	72	38
*Lake Broso -Broso	27.5	51.7	6.8	20	6.2	26	34
*River Boti -Nanankaw	27.4	48.8	6.2	19	2.9	74	32
*River Huafi - Huntado	25.2	78.0	6.8	6	6.3	7	51
*River Abnabna -Abnabna	23.8	66.6	6.8	38	4.8	29	43
*River Fubri -Nkotumso	24.4	60.9	7.0	43	6.0	70	40
*River Akesoa -Nkotumso	24.4	66.3	6.8	14	5.0	58	42
**Dabiaem Stream	25.7	120	6.5	41	0.00	43	7
**Danyami Stream	26.1	430	4.0	325	1.44	213	319
**Subin stream (upstream)	25.4	250	6.6	*66*	0.00	39	159
**Subin Stream (midstream)	28.1	160	6.6	86	1.60	48	224
**Subin Stream (downstream)	25.3	100	6.7	60	2.72	21	57
**Asuaa Stream	27.4	180	5.0	32	4.16	10	130
**Chirawewa (downstream)	27.0	220	5.2	18	2.40	20	238
**Chirawewa (upstream)	25.7	70	6.6	6	2.72	11	46
**Abnabna Stream	31.7	90	6.5	175	4.8	128	60
(Jay Minerals, *Table 3.8 & **3.17; ** repeated in AGA Decomm report Appendix 3-Table 1)							
* Collected on concession area August 1991; ** Collected in proposed mine site area August 1992							

[1] In earlier reports relating to the CAGL Project area, a water course may have been labeled as a river or a stream. CAGL prefers to limit the use of “river” to the Ofin, Fobin and Subin and term their tributaries as streams.

Table 32.13: JMS Mean Concentrations of Trace Metals in Surface Waters (mg/1)

Location	Hg	Cd	Pb	As	Cu	Cr	Zn	Ni	Mn	Fe
*River Subin – Ayanfuri	<0.001	<0.005	0.017	-	<0.010	<0.05	0.77	<0.05	0.26	2.77
*River Subin - Dredge Road	<0.001	<0.005	0.014	-	<0.010	<0.05	0.17	<0.05	0.10	3.16
*River Asuaa – Ayanfuri	<0.001	<0.005	0.010	-	<0.010	<0.05	0.06	<0.05	0.11	1.59
*Sampa Pond- Nkonya	<0.001	<0.005	<0.010	-	0.010	<0.05	0.10	<0.05	0.30	3.16
*Lake Broso - Broso	<0.001	<0.005	0.018	-	<0.010	<0.05	0.54	<0.05	4.54	4.08
*River Boti - Nanankaw	<0.001	<0.005	0.027	-	0.038	<0.05	1.77	<0.05	0.84	3.56
*River Huafi - Huntado	<0.001	<0.005	0.020	-	<0.010	<0.05	0.56	<0.05	0.30	1.19
*River Abnabna - Abnabna	<0.001	<0.005	0.014	-	<0.010	<0.05	0.33	<0.05	2.44	2.57
*River Fubri - Nkotumso	<0.001	<0.005	0.018	-	0.012	0.05	0.45	<0.05	0.45	2.31
*River Akesoa - Nkotumso	<0.001	<0.005	0.015	-	<0.010	0.05	0.31	<0.05	0.10	1.59
**Dabiasem Stream	<0.001	<0.005	<0.01	<0.03	<0.01	<0.05	0.29	<0.05	0.56	20.9
**Danyame Stream	<0.001	<0.005	0.05	<0.03	<0,01	<0.05	0.72	<0.05	0.88	24.4
**Subin Stream (up)	<0.001	<0.005	0.01	<0.03	<0.01	<0.05	0.20	<0.05	1.13	3.29
**Subin Stream (mid)	<0.001	<0.005	<0.01	<0.03	0.02	<0.05	0.11	<0.05	0.83	16.6
**Subin Stream (down)	<0.001	<0.005	<0.01	<0.03	0.02	<0.05	0.14	<0.05	0.18	15.9
**Esuaa Stream	<0.001	<0.005	0.02	<0.03	<0.01	<0.05	0.26	<0.05	0.60	0.87
**Chirawewa (down)	<0.001	<0.005	0.02	<0.03	<0.01	<0.05	0.31	<0.05	1.13	2.72
**Chirawewa (up)	<0.001	<0.005	<0.01	<0.03	<0.01	<0.05	0.10	<0.05	0.81	1.57
**Abnabna	<0.001	<0.005	<0.01	<0.03	<0.01	<0.05	0.10	<0.05	0.23	1.88
Natural Background	<0.001	0.005	0.005	0.02	0.005	0.05	0.03	<0.05	0.12	0.67
WHO Limits	0.001	0.005	0.050	0.05	1.000	0.05	5.00	0.01	0.10	0.30

* Collected on concession area August 1991; ** Collected in proposed mine site area August 1992

Table 32.14: JMS Mean Concentrations of Nutrients and Other Chemicals In Surface Waters mg/

LOCATION	PO,-P	N0$_3$-N	NH$_3$-N	BOD	COD	CN	CL	SO^4	TH
*River Subin - Ayanfuri	<0.01	0.07	0.011	1.92	55	<0.1	9.5	0.09	18
*River Subin - Dredge Road	0.04	0.11	<0.01	-	39	<0.1	9.0	0.09	18
*River Asuaa - Ayanfuri	0.04	0.07	0.011	2.08	23	<0.1.	8.7	0.09	12
*Sampa Pood- Nkonya	<0.01	0.18	0.11	5.14	55	<0.1	9.0	0.18	24
*Lake Broso - Broso	<0.01	0.07	0.011	3.84	33	<0.1	10.2	0.06	12
*River Boti - Nanankaw	0.04	0.11	0.011	1.44	28	<0.1	7.9	0.09	15
*River Huafi - Huntado	<0.01	0.07	0.011	1.38	20	<0.1	12.0	0.09	18
*River Abnabna – Abnabna	<0.01	0.11	0.010	1.60	61	<0.1	6.5	0.09	20
*River Fubri - Nkotumso	0.06	0.11	0.090	1.44	31	<0.1	6.0	0.12	18
*River Akesoa - Nkotumso	0.04	0.11	<0.01	1.75	24	<0.1	9.0	0.06	18
Mean Values	0.02	0.10	0.028	2.29	37	<0.1	8.8	0.10	17
**Dabiasem Stream	0.07	0.99	0.07	8.30	20.3	<0.1	20.8	5.0	34
**Danyame Stream	<0.01	0.76	0.70	5.42	103.6	<0.1	29.8	125.0	124
**Subin Stream (upstream)	0.03	0.26	0.03	7.90	61.0	<0.1.	20.8	50.0	90
**Subin Stream (midstream)	0.06	0.14	0.10	8.90	81.3	<0.1	32.7	35.0	32
**Subin Stream (downstream)	0.03	0.11	0.03	3.80	67.1	<0.1	14.9	12.0	30
**Esuaa Stream	<0.01	0.68	0.03	2.72	54.9	<0.1	19.8	45.0	60
**Chirawewa (downstream)	<0.01	0.02	0.02	2.28	18.2	<0.1	30.8	44.0	66
**Chirawewa (upstream)	0.03	0.02	0.22	1.80	77.2	<0.1	15.9	3.0	32
**Abnabna Stream	0.08	0.34	0.50	3.36	125.9	<0.1	15.9	20.0	22
Mean Values	0.04	0.37	0.19	5.00	67.7	<0.10	21.3	37.7	54
Natural Background Levels	0.02	0.02	0.23	0.1-3.0	0.5-10	<0.10	2-50	0.1-10	5-100
WHO Limits	-	-	10	-	-	0.10	250	400	500

* Collected on concession area August 1991; ** Collected in proposed mine site area August 1992

JMS stated that of nine trace metals analysed, four were not detected in any surface water samples. These were mercury (Hg), cadmium (Cd), chromium (Cr) and nickel (Ni). Copper (Cu) was detected in only 3 of the 10 samples al low concentrations. The mean values for lead (Pb) and zinc (Zn), 0.016 and 0.51 mg/l respectively, were also well below WHO limits. On the other hand, all the iron (Fe) and manganese (Mn) concentrations in surface waters were higher than the WHO limits. Iron concentrations for example ranged from 1.19 to 4.08 mg/l with a mean of 2.60 mg/l compared to the WHO limit of 0.3 mg/l for drinking water.

3.2.3.3 Summary of AGC Surface Water Monitoring (2004)

AGC presented a summary of surface water quality as presented below.

- In general pH values were within WHO guidelines for drinking water.
- In the vicinity of the mine-site, waters were slightly acidic.
- Turbidity values and suspended solids concentrations were high, above WHO limits, due to the presence of very fine organic and inorganic particulates.
- Dissolved oxygen levels were low.
- The concentration of nutrients in surface waters was generally low and within W.H.O. guideline limits, where applicable.
- Cyanide and arsenic were not detected in any water samples.
- Around the mine-site, surface waters showed significant organic contamination from both natural and anthropogenic sources.
- Iron (Fe) and manganese (Mn) concentrations were higher than WHO limits, due to a high natural concentration in soils and bedrocks.
- Surface waters were found to have bacteria contamination and were not suitable for direct human consumption.

The above summary, however, omits mention of seepage from the closed heap leach pad complex into a nearby stream and which has a high pH (11.0) and elevated levels of arsenic (2.32 and 2.16 mg/l. Elevated levels of lead in eight of the 14 sample locations are also not commented on (see Appendix 3.2.3.3).

3.2.3.4 Summary of EU-MSSP Surface Water Investigation

As a result of time constraints, only two pits, Chirawewa and Fetish, were included in the investigation along with one waste dump seepage, four streams and two points associated with the defunct heap leach pads[2]. The most important results are shown in table 32.15. The complete set of analyses is presented in Appendix 3.2.3.4.

Water in the Chirawewa water (G0415) was of Na-Cl-SO4 type with a pH of 6,78 and a TDS level of 20,5. The pit water contained low levels of trace metals. The low TDS indicates that the pit water is dominated by water with short residence time, i.e. rain water.

A small stream flows southwards out from Chirawawa waste dump. The leachate leaving the dump (G0416) was of Na-Ca-Mg-HCO3-Cl water type. The TDS level was relatively high (141 mg/l) and the level of TSS was high (74,9 mg/l) **(**Figure 32.2). The water contained a very high level of iron (33,9 mg/l) and a high level of arsenic (74,9 mg/l) (Figure 32.1).

[2] The investigation did not report UTM location figures.

Table 32.15: Selection of Results from EU-MSSP Analysis of Water Samples at the Ayanfuri Mine								
Sample ID	**Site**	**Water type**	**pH**	**TDS** mg/l	**TSS** mg/l	**Fe** mg/l	**Mn** µg/l	**As** µg/l
G0415	Chirawawa Pit	Na-Cl-SO4	6,78	20,5	0,70	0,01	11,5	3,81
G0416	Chirawawa Stream*	Na-Ca-Mg-HCO3-Cl	6,47	141	74,9	33,9	187	74,9
G0414	Fetish Pit	Na-SO4-Cl-HCO3	6,82	19,9	4,1	0,04	1,93	4,11
G0417	Subin Str. US Danyami	Ca-Na-HCO3	7,39	40,9	27,4	0,52	144	4,28
G0410	Heap Leach 4 Seepage	Na-HCO3-SO4	9,83	544	16,0	0,66	2,33	3710
G0411	Stream N of Heap Leach	Ca-Na-HCO3	7,52	225	27,2	0,40	58,4	45,7
G0412	Subin Stream DS Asuaa	Ca-Na-HCO3-Cl	7,53	82,2	454	0,14	16,0	9,65
G0419	Akesoa Str. at Nkotonsus	Ca-Mg-Na-HCO3	6,40	99,3	12,9	2,13	1260	3,43

The Fetish pit was sampled at its southern end. The pit water (G0414) was of Na-SO4-Cl-HCO3 type with a pH of 6,82 and had a low TDS level (19,9 mg/l). The water contained generally low levels of metals.

Since the whole Fetish pit and waste dump area drains to the Subin stream, the stream was sampled before the confluence with the Danyami stream. However, there was no actual flow at the time of the sampling, only stagnant water. The stream water (G0414) was of Ca-Na-HCO3 type with a pH of 7,39 and a TDS level of 40,9 mg/l. The TSS level in the water was relatively high (Figure 32.2). Except for an elevated level of iron the general level of metals was low.

From the north front of the rehabilitated Heap Leach Pad 4 there was seepage flowing out into a marshy area. Below the marsh land the seepage is monitored by the mining company AGA. The seepage water (G0410) sampled by the MSSP-team was of Na-HCO3-SO4 type with a high pH (9,83) and a high level of TDS (544 mg/l). The water contained a very high level of arsenic, 3710 µg/l, i.e. 11 times above the US/EPA Freshwater Acute Criteria (Figure 32.3). The levels of chromium (88,7 µg/l), molybdenum (285 µg/l) and selenium (28,6 µg/l) were also high. Chromium was almost 2 times, molybdenum was 4 times and selenium was almost 3 times above the WHO Drinking Water Guidelines.

Photo 32.1

Downstream from the discharge from the heap leach a stream flows down to Odumkrom and the Subin stream. The stream was sampled along the road, just north of the heap leach area, but unfortunately the water seemed stagnant (photo 32.1). The water (G0411) was of Ca-Na-HCO3 type with a pH of 7,52 and with a high TDS level (225 mg/l). The level of suspended solids was relatively high (TSS 27,2 mg/l) (Figure 32.1) and the level of arsenic was high (45,7 µg/l). The arsenic level was 4,5 times above the WHO Drinking Water Guidelines (Figure 32.1). This sample point subsequently became the SGS Laboratory Services sample point PA 20.

Part of the run-off from the old Ayanfuri mine area drains into the Subin stream, which joins the Ofin river approximately 6 km from Ayamfuri town. The Subin was sampled 2 km down-stream from Ayanfuri village town and after the confluence with the Asuaa stream, which drains the Esuajah South pit and waste dump. The stream was very turbid because of intensive galamsey activity especially in the Asuaa stream. The turbidity was 809 NTU and the level of total suspended solids was very high at 454 mg/l. The water (G0412) was of Ca-Na-HCO3-Cl type with a pH of 7,53 and a TDS level of 82,2 mg/l. The level of trace metals was low, with exception for arsenic (9,65 µg/l), which had a level just below the WHO Drinking Water Guidelines. The elevated arsenic level was attributed to drainage from the heap leach pads area (Figure 32.1).

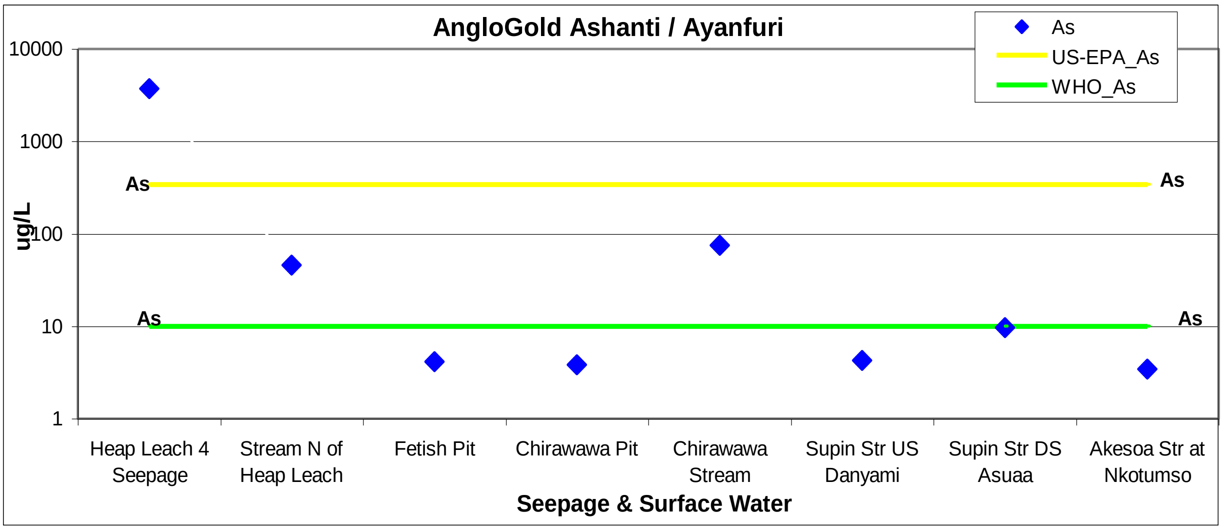


Figure 32.1: Concentrations of Total Arsenic at Sampled Locations in CAGL Project Area

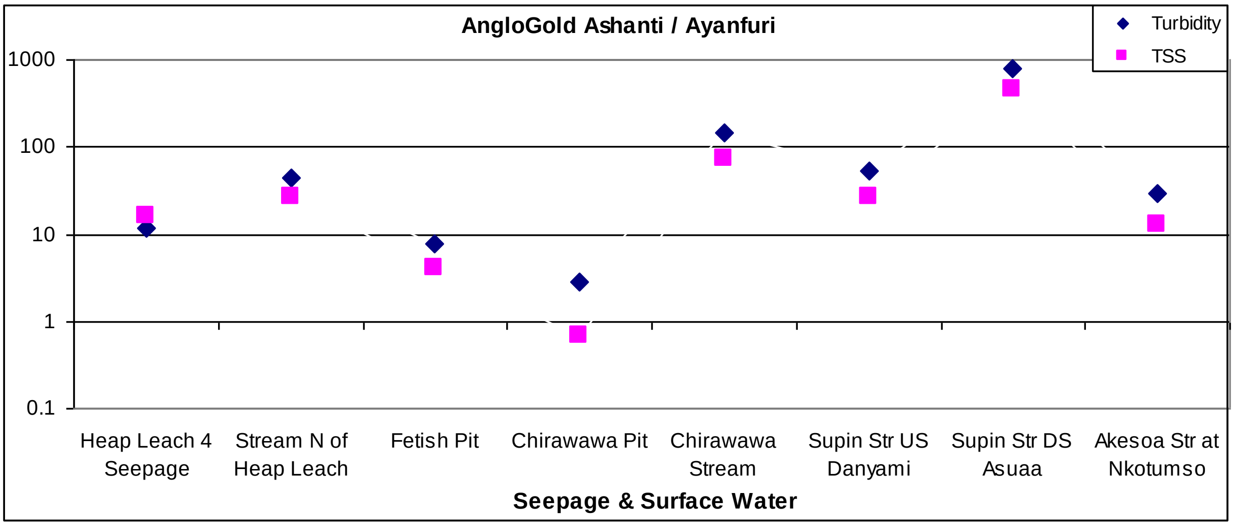


Figure 32.2: Turbidity and Total Suspended Solids at Sampled Locations in CAGL Project Area

3.2.3.5 Summary of SGS Laboratories Surface Water Programme

The SGS sampling programme for surface waters was initiated in August 2008. The sampling locations for the three field sampling programmes are listed in table 32.16 and shown in Map 32.2. The various sampling locations were selected to obtain baseline information on water quality relating to previous large-scale mining activity and locations not influenced by such activities but that are influenced by day-to-day activities of communities in the Project area.

Table 32.16: Surface Water Sampling Locations in the CAGL Project Area					
Location ID	Description	Aug 2008	Dec 2008	April 2009	July 2009
PA3	Akesuoa River downstream of Nkutumso Village	√	√	√	-
PA4	Akesuoa River upstream of Nkutumso Village	√	√	√	√
PA7	Subin River downstream of Odumkrom Village	√	√	√	√
PA11	Asuafu River downstream of Nkonya Village	√	√	√	√
PA13	Drainage immediately downstream of Abenabena	√	√	√	√
PA15	Subin River at the railway crossing	√	√	√	√
PA16	Swamp area downstream of Chirawewa pit complex	√	√	-	√
PA17	Downstream Chirawewa on road to Dabiesem		√	-	√
PA19	Asuaa downstream Ayanfuri at culvert on N. Esuajah haul road		√	√	√
PA20	Culvert on Sefwi-Bekai road nr Odumkrom (EU sample point)		√	√	√
PA21	Pond on Fobinso haul road below HLP		√	√	√
PA23	Pond below Chirawewa waste dump		√	-	√
PA24 (As1)	Stream north of HLP nr Gyaaman but above HLP drainage		√	-	√
PA 25 (As2)	Drainage from swamp area to stream north of HLP		√	-	√
PA27 (new PA3	Sample relocated better reflect drainage from Proposed TSF area			√	√

Overview of August and December 2008 Results

SGS provided an overview of the results of the sampling periods August and December 2008 in its report for the December sampling programme. SGS analysis results for August and December 2008 and April 2009 are provided in Appendix 3.2.3.6. Table 32.16 present results of field parameters, heavy metals and physico-chemical parameters analysed for the August sampling programme.

pH and Conductivity

The pH of water samples was slightly acidic to neutral. It ranged from 6.1 (PA16 - downstream of Chirawewa) to 7.8 (PA100 – pond on Fobinso haul road below Heap Leach). All samples had pH within the recommended range for drinking water set by the WHO. There is no indication of a water quality problem regarding pH at the sampled locations.

The highest conductivity was 220.6 µS/cm recorded at PA 13 (drainage immediately downstream of Abnabna) and the lowest record was 40.2 µS/cm, at PA 23 (Chirawewa pond below waste dump). For locations that had previous results, the conductivity increased at four locations. The increased was significant at PA11 and PA4. It is possible that some artisanal mining activities upstream of the Abnabna village are responsible for the release of salts that have influenced the levels of conductivity. There are no available guideline values by the IFC/WB and WHO for comparison.

Physico-chemical parameters

Nitrate levels at all sampling locations were below guideline value (50 ppm) of IFC/WB and the WHO, except PA20 (76.4 ppm), which exceeded the guideline. It is possible that farmers upstream or along the banks apply nitrogen fertilizer that has contributed to nitrate in water at that location.

Sulphate levels at all locations were below the WHO guideline set at 250 ppm. The highest level recorded was at PA20 (135.9 ppm). Sulphate in water can result from decaying plant and animal matter and ammonium fertilizers containing sulphates. Given that PA20 also recorded the highest nitrate level, it is possible that the source of sulphate is also from fertilizer application on farms within the stream's catchment.

Total Suspended Solids (TSS) at four locations had results exceeding the IFC/WB guideline value set at 50 ppm. The order was as follows: PA15 (720.7 mg/l) > PA19 (675.2 mg/l) > PA11 (142.9 mg/l) > PA4 (57.4 mg/l). Location PA 15 recorded the highest TSS in the previous sampling, though current results showed a decline. Artisanal mining activities discharge waste water from their gold processing activities, which could be responsible for the high TSS at PA15.

The highest TDS recorded was at PA20 (640 mg/l) and the lowest (28mg/l) was recorded at PA23. However, all levels recorded were well below the WHO guideline.

Heavy Metals

Results of heavy metals analysed are shown in table 32.17. These results are compared with either the WHO or IFC/WB guideline values. Where both guidelines are available the stringent of the two is used in the discussion.

Arsenic (As) and Iron (Fe) had respectively 60 % and 100% of samples analysed exceeding WHO guideline values. The highest As level recorded was at PA20 (0.43 ppm). PA100 and PA3 had levels below detection limits set by the laboratory. The order for As was as follows: PA20 > PA15 > PA21 > PA19 > AS2 > PA16 > PA11 > PA23.

It is possible that leachate from abandoned mine waste heap (heap leach pads) close to Odumkrom or artisanal mining activities further upstream are responsible for the high As record at PA20. Traditional ore processing occurs upstream of PA15 and could be responsible for the As level recorded. Illegal artisanal mining activities are responsible for the ponds created along the Fobinso haul roads, which also collect rainwater. It is possible that the activities of the miners are responsible for As levels recorded at PA12. The reasons above could also be responsible for levels of As recorded at other sampling locations.

The highest Fe level was recorded at PA15 (70.1 ppm) and the lowest was at PA100 (0.4 ppm). The order was as follows: PA15 > PA19 > PA11 > PA 16 > PA4 > PA13 > PA7 > PA3 > PA17 > PA20 > PA23 > PA21.

Copper (Cu) and Zinc (Zn) levels in all water samples tested had results lower than the WHO guideline value. These levels could possibly be attributed to natural load. One location PA20 recorded Chromium (Cr) level higher than the WHO set limit. Manganese (Mn) levels at two locations, PA3 and PA13 exceeded the WHO set value of 0.5 ppm.

Sampling Results April 2009

The number of surface water sampling locations in April 2009 was limited by lack of flow in several of the previously sampled locations. The data are contained SGS analysis report provided is presented in Appendix 3.2.3.6.

The range of parameter values was broadly similar to those recorded in the first two sampling periods. pH ranged from 5.9 to 6.7 The highest conductivity was 58.0 μS/cm recorded at PA20 and the lowest record was 7.1 μS/cm at PA4. TDS ranged from 43 (PA19) to 380 (PA20) mg/l, TSS from 6.7 (PA27) to 943 (PA19) mg/l.

Iron ranged from 0.22 (PA21) to 92.4 9 (PA19) mg/l, manganese from <0.05 to 0.83 (PA3) mg/l, copper and zinc were all <0.05 mg/l and mostly < 0.02 mg/l. Chromium was < 0.03 mg/l for all samples, cadmium <0.02 mg/l for all samples. Arsenic ranged in value from <0.002 to 0.68 (PA 21) mg/l.

Table 32.17: SGS Surface Water Analyses for December 2008

Location	Location ID	pH	Conductivity	TDS ppm	TSS ppm	Apparent Colour	True Colour	Turbidity NTU	COD ppm	BOD ppm	DO ppm	Alkalinity mg CaC03/L	Hardness ppm
Daa Hamlet	PA2	5.9	5.6	45.0	26.8	15	5	70	<25	<5	4.0	15.6	14.7
Akesuoa	PA3	6.5	9.0	67.0	9.1	10	5	12	29	<5	4.1	32.3	25.3
Akesuoa	PA4	6.1	10.0	74.0	13.4	10	5	13	32	5	3.7	36.3	30.2
Subin River	PA7	6.4	17.7	111	8.8	5	<5	18	26	<5	4.3	65.0	54.5
Asuafu River	PA11	5.8	5.3	70.0	192	50	10	160	<25	<5	4.0	11.1	11.5
Drainage	PA13	6.3	8.3	236	424	150	15	850	55	15	4.2	24.7	23.2
Subin River	PA15	6.6	11.5	638	1945	400	20	1000	50	12	4.1	39.0	32.4

Table 32.17: continued

Location	Location ID	Na ppm	K ppm	Sulphate ppm	Cl ppm	Nitrate ppm	Nitrite ppm	Phosphate ppm	Ca ppm	Mg ppm
Daa Hamlet upstream of Fobinso Village	PA2	4.1	0.9	1.0	4.5	0.15	<0.05	<0.02	2.7	1.9
Akesuoa River downstream of Nkutumso Village	PA3	5.3	0.8	<1	4.6	0.14	<0.05	<0.02	4.8	3.2
Akesuoa River upstream of Nkutumso Village	PA4	5.6	0.6	<1	5.0	0.21	<0.05	<0.02	5.7	3.9
Subin River downstream of Odumkrom Village	PA7	7.2	4.7	<1	10.0	0.12	<0.05	<0.02	14.5	4.4
Asuafu River downstream of Nkonya Village	PA11	3.8	2.0	1.6	7.7	0.07	<0.05	<0.02	2.4	1.3
Drainage immediately downstream of Abenabena	PA13	3.9	2.8	6.6	8.9	1.09	<0.05	<0.02	4.1	3.2
Subin River at the railway crossing	PA15	3.4	5.9	26.7	16.7	1.05	0.10	0.25	8.3	2.8

Table 32.17: continued

Location	Location ID	As ppm (Total)	Se ppm (Total)	Hg ppm (Total)	Fe ppm (Total)	Mn ppm (Total)	Cu ppm (Total)	Zn ppm Total)
Daa Hamlet upstream of Fobinso Village	PA2	0.015	<0.003	<0.002	4.39	<0.05	<0.02	0.03
Akesuoa River downstream of Nkutumso Village	PA3	0.003	<0.003	<0.002	2.57	<0.05	<0.02	0.04
Akesuoa River upstream of Nkutumso Village	PA4	0.004	<0.003	<0.002	2.88	<0.05	<0.02	0.03
Subin River downstream of Odumkrom Village	PA7	0.015	<0.003	<0.002	3.52	<0.05	<0.02	0.07
Asuafu River downstream of Nkonya Village	PA11	0.062	<0.003	<0.002	14.8	<0.05	<0.02	0.07
Drainage immediately downstream of Abenabena	PA13	0.021	<0.003	<0.002	38.9	<0.05	0.03	0.08
Subin River at the railway crossing	PA15	0.530	<0.003	0.006	127	<0.05	0.06	0.04

Table 32.17: continued

Location	Location ID	Ag ppm (Total)	Al ppm (Total)	Cd ppm (Total)	Co ppm Total)	Cr ppm Total)	Mo ppm (Total)	Ni ppm (Total)	Pb ppm (Total)
Daa Hamlet upstream of Fobinso Village	PA2	<0.02	0.9	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Akesuoa River downstream of Nkutumso Village	PA3	<0.02	<0.2	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Akesuoa River upstream of Nkutumso Village	PA4	<0.02	<0.2	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Subin River downstream of Odumkrom Village	PA7	<0.02	<0.2	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Asuafu River downstream of Nkonya Village	PA11	<0.02	1.1	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Drainage immediately downstream of Abenabena	PA13	<0.02	14.1	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Subin River at the railway crossing	PA15	<0.02	36.8	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02

3.2.3.7 Arsenic in Surface Waters

The results of the EU-MSSP site visit in 2006 prompted an emphasis on evaluating the extent of distribution of arsenic contamination in streams in the Project area. This emphasis was incorporated into the SGS sampling programme. A specific summary of the arsenic concentrations at various locations is presented in table 32.18.

Table 32.18: Arsenic in Surface Waters (mg/l)

Sample Point ID	Sample Location	August 2008 1st sampling	December 2008 2nd sampling	April 2009 3rd sampling	July 2009 4th sampling
PA2	Daa hamlet upstream of Fobinso Village	0.015	-	-	-
PA3	Akesuoa River downstream of Nkutumso Village	0.003	<0.002	0.008	-
PA4	Akesuoa River upstream of Nkutumso Village	0.004	0.005	0.006	0.004
PA7	Danyani stream downstream Ayanfuri at NE haul road	0.015	0.010	0.044	0.014
PA11	Asuafu River on highway before Nkonya Village	0.062	0.024	(1)	0.022
PA13	Drainage immediately downstream of Abenabena Village	0.021	0.005	0.020	0.048
PA15	Subin River at the railway crossing	0.53	0.130	0.11	0.048
PA16	Swamp area downstream of Chirawewa pit complex	-	0.030	-	0.046
PA17	Downstream Chirawewa on road to Dabiesem	-	0.004	-	0.008
PA19	Asuaa downstream Ayanfuri at culvert on N. Esuajah haul road	-	0.086	0.34	0.038
PA20	Culvert on Sefwi-Bekai road nr Odumkrom (EU sample point)	-	0.430	0.48	0.260
PA21	Pond on Fobinso haul road below HLP	-	0.098	0.68 (3)	0.280
PA23	Pond below Chirawewa waste dump	-	0.016	(2)	<0.002
PA24[1]	Stream north of HLP nr Gyaaman but above HLP drainage	-	0.002(4)	dry	0.008
PA 25[1]	Drainage from swamp area to stream north of HLP	-	0.044(4)	dry	0.110
PA27	Sample relocated from PA3 to better reflect drainage from TSF area	-	-	0.010	0.012

[1] Formerly sample points As1 and As2 respectively
(1) Dry stream as time of sampling
(2) No access, polluted by galamsey operation
(3) Sample from centre of pond, previous from edge
(4) Indicates HLP as source of contamination

3.2.3.8 Summary of JMS Groundwater Assessment

A summary of the ground water quality assessment in 1991 is provided below.

The ground waters were slightly acidic with a mean pH value of 6.0 (Table 32.19). The pH of the borehole 49/D/26-1 at Nanankaw and the drill hole at Chirawewa fell outside the WHO recommended range. This should not be a cause for great concern however since one of the main objectives in controlling pH in water supplies is to minimise corrosion and incrustation in distribution systems. In the absence of such a distribution system the acceptable pH range may be broader. Moreover the drill hole waters are normally not used for drinking purposes.

Table 32.19: Summary of JMS Groundwater Assessment (ppm)

Location	Hg	Cd	Pb	Cu	Cr	Zn	Ni	Mn	Fe
Nanankaw 49/D/26-1	<0.001	<0.005	<0.01	<0.01	<0.05	0.031	<0.05	0.160	4.21
Nanankaw 49/D/26-2	<0.001	<0.005	<0.01	0.010	<0.05	0.048	<0.05	0.160	4.81
Nanankaw 49/D/26-3	<0.001	<0.005	0.023	<0.01	<0.05	0.010	<0.05	1.200	2.64
Abnabna 49/A/57-1	<0.001	<0.005	0.0 18	<0.01	<0.05	0.260	<0.05	0.360	2.7
Cbirawewa Drill Hole	<0.001	<0.005	<0.01	0.024	<0.05	0.029	<0.05	0.280	0.53
Mean Values	<0.001	<0.005	0.011	<0.01	0.050	0.280	<0.05	0.430	2.98
WHO Limits	0.001	<0.005	0.050	1.00	0.050	5.000	-	0.100	0.30

With the exception of the drill hole, turbidity values were low to moderate although higher than the WHO limit of 5 NTU. High levels of turbidity can stimulate the growth of bacteria. The drill hole also had very high concentrations of suspended solids.

On the average, electrical conductivity values in ground waters were 3 to 4 times higher than for surface waters, a factor arising from dissolution of solutes from aquifer materials. The low DO values, 0.48 to 2.4 mg/l are also normal for ground waters whose depths oxygen hardly penetrates. Like the surface waters, the ground waters were also warm with a mean temperature value of 26.5°C.

The pattern of trace metal occurrence in groundwairrs was the same as for surface waters. While mercury, cadmium, chromium and nickel were undetected, copper was detected in only 2 out of 5 samples and lead and zinc levels were below their corresponding WHO limits (Table 32.19).

The second baseline assessment took groundwater samples from a borehole at Abnabna and from a borehole (labelled BH5) at Esuajah South and analysed for arsenic only. Both boreholes returned arsenic values <0.03.

3.2.3.9 AGC Groundwater Quality Assessment

Information on additional groundwater quality in the AGC report is limited to one village borehole (Table 32.20) and water sampled from several of the open pits. For the latter, it is not wholly possible to determine to what extent the water in the pits is actual groundwater and how much is rainfall.

3.2.3.10 Results of EU-MSSP Groundwater Investigation

Two boreholes were sampled in the Ayanfuri area. The borehole in the northern part of the town, outside the Pentecoast church, was sampled. The groundwater (G0413) was of Na-Mg-Cl-NO3 type with a pH of 5,37 and a TDS level of 86 mg/l. The water contained a high level of nitrate (37,2 mg/l), which makes the water less suitable for human consumption. The sodium, chloride and nitrate indicate an impact from domestically polluted surface water. The level of trace metals in the groundwater was low (Table 32.21 and Appendix 3.2.3.4).

The second borehole sampled was at Gyaaman village, 3 km northwest of Ayamfuri town. It was well protected from surface infiltration, which is proven by the good groundwater quality. The water (G0418) was of Ca-Na-Mg-HCO3 type with a pH of 6,54 and a TDS level of 189 mg/l. The iron level was slightly elevated (0,91 mg/l) and the concentration of trace metals was generally low (Table 32.21 and Appendix 3.2.3.4).

Table 32.20: AGC Groundwater Quality Assessment							
Location	**pH**	**Cond (µS/cm)**	**Turbidity NTU**	**TDS mg/l**	**TSS mg/l**	**DO mg/l**	**TH**
Gyaman Village BH-1	8.1	438	180	170	175	5.7	54
Gyaman Village BH-2	6.4	294	5	98	4	6.3	91
WHO Limits	6.5						500

Table 32.20 continued								
Location	**Pb mg/l**	**Cu mg/l**	**As mg/l-**	**Fe mg/l**	**CN**	**NO3-N mg/l**	**S04 mg/l**	**Cl mg/l**
Gyaman Village BH-1	0.01	<0.01	<0.01	0.07	<0.01	4.26	35.5	12.57
Gyaman Village BH-2	<0.01	<0.01	<0.01	0.20	<0.01	0.09	1.76	2.84
WHO Limits						10	250	250
Average values for June – October 2003								

Table 32.20 continued						
Station name	**Unit**	**Esuajah North Pit**	**Esuajah South Pit**	**Chirawewa Pit**	**Fetish South Pit**	**South Bokit West Ext. Pit**
Station Code		S5	S6	S9	S10	S14
pH		6,8	8,2	6.6	6.8	6.0
Conductivity	uS/cm	63	399	70	46	35
DO		5,9	5,9	5.2	6.1	5.4
Turbidity	NTU	1561	20	21	182	93
TDS		24,8	149	146	175	
TSS	mg/l	712	17			
BOD	mgO/l	0,37	5,75	0.40	4.26	
Cl	mg/l	3.72	10.30	6.02	3.12	3.83
S	mg/l	4.16	18.0	6.74	4.88	2.84
Fe	mg/l	0.06	0.06	0.05	0.02	0.04
As	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Pb	mg/l	0.02	0.20	0.07	0.01	0.06
Cyanide Total	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Average values for June – October 2003						

Table 32.21: Water types and major pollutants of groundwater from the Ayamfuri mine area								
Sample ID	**Site**	**Water type**	**pH**	**TDS** mg/l	**NO3** mg/l	**Fe** mg/l	**Mn** µg/l	**As** µg/l
G0413	Ayamfuri Town BH N	Na-Mg-Cl-NO3	5,37	86,0	37,2	0,021	147	0,35
G0418	Gyaman Village BH	Ca-Na-Mg-HCO3	6,54	189	4,5	0,91	05	0,24

3.2.3.11 Results of SGS Groundwater (Village Wells) Investigation

In August 2009, borehole wells were sampled in five villages in the Project area. The results are collated in table 32.22. A second sampling took place April 2009 (Appendix 3.2.3.11) at four of the five villages (the well at Fobinso was not working due to a broken pump).

Apart from pH and iron values in several of the wells, borehole water in the villages is of reasonable quality by rural standards and shows no evidence that the wells are chemically polluted.

Table 32.22: Results of Analysis of Boreholes (Wells) at Five Villages in the Project Area

Location	Location ID	pH	Conductivity	TDS ppm	TSS ppm	Apparent Colour	True Colour	Turbidity NTU	COD ppm	BOD ppm	DO ppm	Alkalinity mg CaC03/L	Hardness ppm
Abnabna	PA12	**6.3**	26.5	196	7.4	5	<5	20	<25	<5	4.4	123.7	75.2
Ayanfuri	PA6	**5.1**	9.3	55.0	2.5	<5	<5	0.5	<25	<5	4.3	9.1	14.6
Gyaaman	PA8	**5.3**	19.9	110	8.7	<5	<5	0.6	<25	<5	4.1	14.6	30.0
Fobinso	PA9	**5.3**	12.2	81.0	7.5	<5	<5	0.8	<25	<5	4.2	24.6	21.4
Nkutumso	PA5	**6.0**	22.0	161	<1	<5	<5	2.3	<25	<5	4.2	74.7	56.7

Location	Location ID	Na ppm	K ppm	Sulphate ppm	Cl ppm	Nitrate ppm	Nitrite ppm	Phosphate ppm	Ca ppm	Mg ppm
Abnabna	PA12	21.0	0.7	1.8	7.9	<0.06	<0.05	<0.02	16.7	8.1
Ayanfuri	PA6	7.8	0.4	<1	14.3	6.40	<0.05	<0.02	1.9	2.4
Gyaaman	PA8	20.0	1.8	1.6	26.7	33.5	<0.05	<0.02	2.2	6.0
Fobinso	PA9	8.7	0.4	1.0	12.3	9.18	<0.05	<0.02	3.2	3.2
Kutumso	PA5	18.0	0.7	7.5	11.7	<0.06	<0.05	<0.02	8.9	8.4

Location	Location ID	As ppm (Total)	Se ppm (Total)	Hg ppm (Total)	Fe ppm (Total)	Mn ppm (Total)	Cu ppm (Total)	Zn ppm Total)	Ag ppm (Total)
Abnabna	PA12	<0.002	<0.003	<0.002	4.60	0.05	<0.02	0.08	<0.02
Ayanfuri	PA6	<0.002	<0.003	<0.002	<0.05	<0.05	<0.02	0.07	<0.02
Gyaaman	PA8	<0.002	<0.003	<0.002	0.55	0.05	<0.02	0.05	<0.02
Fobinso	PA9	<0.002	<0.003	<0.002	<0.05	<0.05	<0.02	0.18	<0.02
Nkutumso	PA5	<0.002	<0.003	<0.002	0.54	0.06	<0.02	0.09	<0.02

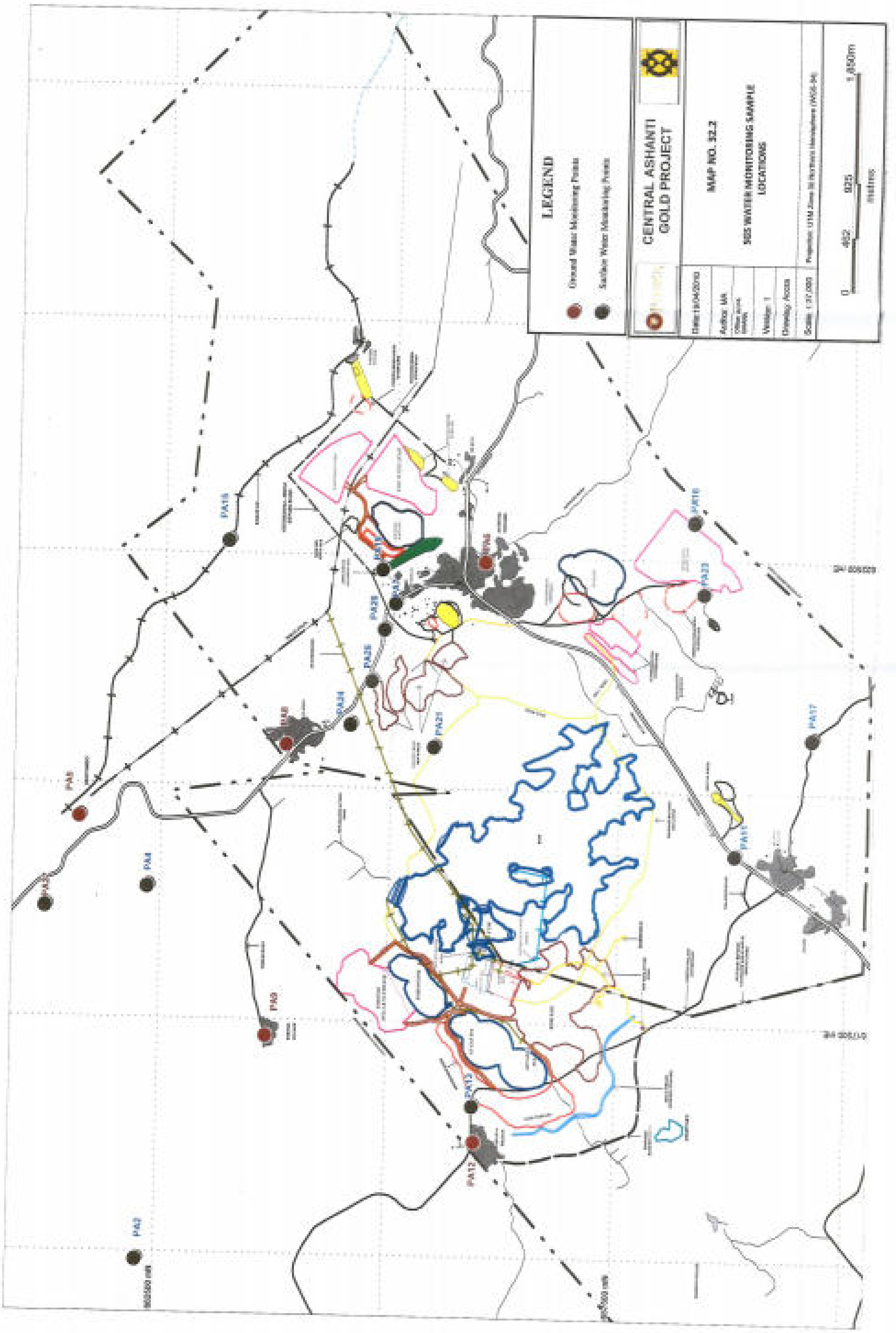
Location	Location ID	Al ppm (Total)	Cd ppm (Total)	Co ppm Total)	Cr ppm Total)	Mo ppm (Total)	Ni ppm (Total)	Pb ppm (Total)
Abnabna	PA12	<0.2	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Ayanfuri	PA6	<0.2	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Gyaaman	PA8	0.3	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Fobinso	PA9	<0.2	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02
Nkutumso	PA5	<0.2	<0.02	<0.03	<0.03	<0.2	<0.05	<0.02

3.2.3.12 Results of SGS Pit Water Sampling

SGS sampled water in four open pits in April 2009 as part of the CAGL groundwater programme. Samples were taken from within the first 25 cm of depth in the centre of the pits using a small boat. The water in the pits was considered primarily groundwater with some possible contribution from rainfall and surface runoff from the pit walls. The results are presented in table 32.23 and Appendix 3.2.3.11.

Table 32.23: Results of SGS Pit Water Sampling				
Sample Number	**PA60**	**PA61**	**PA62**	**PA63**
Description	**Fetish**	**Fobinso N**	**Fobinso S**	**Abnabna**
Physical Parameters				
pH	8,6	7,1	3,8	7,5
Apparent Colour	<5	<5	5	<5
True Colour	<5	<5	<5	<5
Turbidity	3,1	43,4	36,8	6,9
Total Dissolved Solids	42	108	40	194
Total Suspended Solids	<1	25,7	<1	4,9
Conductivity	5,9	15,9	5,7	27,6
Dissolved Oxygen	4	4	3,9	4
Nutrients and Other Chemicals				
Total Hardness	22	41,2	3,8	104
Alkalinity	21,9	56	<0.5	123,6
Calcium (Ca++)	7	11	1	29
Magnesium (Mg++)	1,1	3,3	<0.5	7,7
Sodium (Na)	4,2	13	3,9	17
Potassium (K)	1,2	0,8	0,8	0,9
Chloride	3,1	5,3	4,2	6,9
Nitrate	1,33	2,22	6,15	0,31
Phosphate	<0.02	<0.02	<0.02	0,02
Sulphate	2,3	11,2	3,7	7,7
Silica	-	-	-	-
Additional Chemical Tests				
Biochemical Oxygen Demand	<5	<5	<5	<5
Chemical Oxygen Demand	<25	<25	<25	<25
Trace Metals (Total)				
Iron as Fe (Total)	0,06	0,63	<0.91	0,14
Manganese as Mn (Total)	<0.05	<0.05	<0.05	<0.05
Copper as Cu (Total)	<0.02	<0.02	<0.02	<0.02
Zinc as Zn (Total)	<0.02	<0.02	<0.02	<0.02
Lead as Pb (Total)	<0.02	<0.02	<0.02	<0.02
Chromium as Cr (Total)	<0.03	<0.03	<0.03	<0.03
Nickel as Ni (Total)	<0.05	<0.05	<0.05	<0.05
Arsenic as As (Total)	0,008	0,034	0,016	0,06
Cadmium as Cd (Total)	<0.02	<0.02	<0.02	<0.02
Aluminium as Al (Total)	<0.2	<0.2	0,2	<0.2
Antimony as Sb (Total)	<0.2	<0.2	<0.2	<0.2
Molybdenum as Mo (Total)	<0.2	<0.2	<0.2	<0.2

Map 32.2


LEGEND
Ground Water Monitoring Points
Surface Water Monitoring Points
CENTRAL ASHANTI GOLD PROJECT
MAP NO. 32.2
SGS WATER MONITORING SAMPLE LOCATIONS
0
462
925
1,850m
metres

3.2.4 The Aquatic Ecology of the Project Area

3.2.4.1 Introduction

This section presents baseline information on the aquatic ecology of selected rivers within the concession of the proposed Central Ashanti Gold Project (CAGP). The survey focused on algae, macroinvertebrates and the fishes of River Akesoa and River Subin, the principal rivers draining the proposed Project area.

The objectives of the baseline survey were:

- Conduct a baseline survey of River Subin and River Akesoa in the CAGP concession with emphasis on the algae (Phytoplankton), macroinvertebrates and fishes.
- Assess the conservation status of the aquatic species in the CAGP concession.
- Assess the water quality of the rivers based on the algae and macroinvertebrates.
- Outline appropriate management measures for the mitigation of possible impacts of the Project on the aquatic environment.

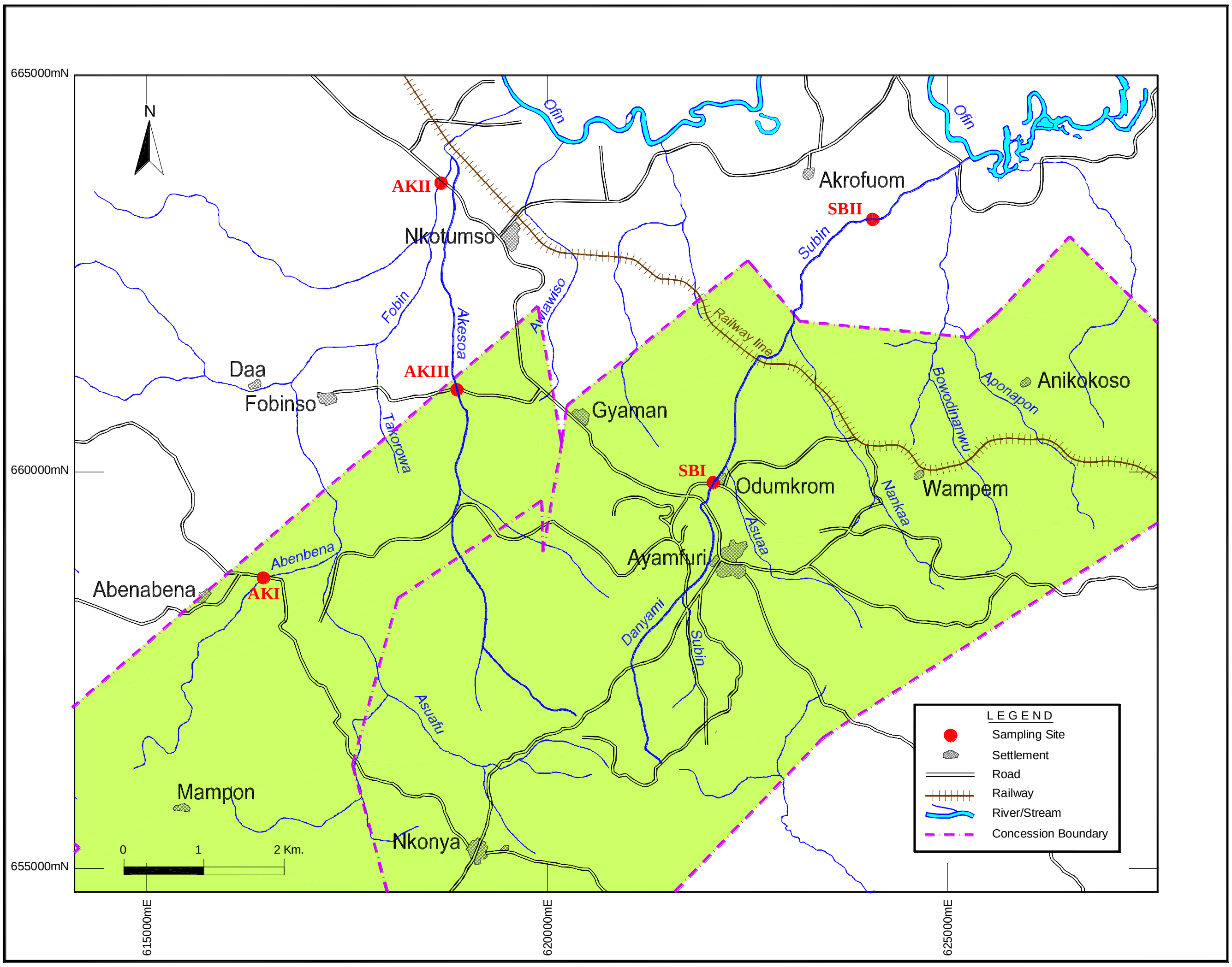
3.2.4.2 Description of the Data Collection Sites

Macroinvertebrate, algae (phytoplankton) and fish samples were collected from five locations on River Akesoa and River Subin. --The locations of the sites are presented in Map 32.3.

River Akesoa at Abnabna (AKI)

Photo 32.2

The sample site is located at the outskirts of Abnabna Village (Photo 32.2). The GPS location of the site is N5° 57' 32.7" W 1° 56' 49.2". The river flows from a fetish groove and crosses the road by a road bridge on to a flood plain dominated by sedges. This reach of the stream served as the upstream study site of River Akesoa. It was narrow upstream of the bridge and had a moderate flow. The river is about 1m wide and about 0.30m deep. The bottom is mainly mud and silt. The greater part of the river downstream of the road bridge is exposed to full sunlight because most of the indigenous tree cover had been felled. The reach upstream of the road bridge and adjoining the fetish groove, however, had a good tree cover that provided some shade. The water was turbid 275 NTU. Other chemical characteristics of the water were pH 6.31, conductivity; 103µS/cm, total dissolved solids 147mg/l and dissolved oxygen measured 2.20mg/l. The habitat score was estimated as 54/120.



Map 32.3: Location of the Aquatic Ecology Sampling Points

River Akesoa at Nkutumso (AKII)

Photo 32.3

The sampling site was located upstream of the Ayanfuri – Nkutumso road bridge (Photo 32.3). The GPS location of the site is N6° 0’ 12.2” W 1° 55’ 38.0”. The river had a mean width of 5m and a depth of

0.75m. The river had a gentle flow and the bottom was a mixture of mud and gravel. The canopy was discontinuous with portions of the river exposed, whereas the sheltered portions allowed sunlight to filter through. The water was turbid 248 NTU, low in conductivity (61.7 µS/cm) and dissolved solids (TDS, 33.9 mg/l) but well oxygenated (DO 3.50mg/l) and a pH of 5.4. The site served as the downstream reach of the stream. The habitat score was estimated as 52/120.

River Akesoa at Fobinso (AKIII)

Photo 32.4

The site is located at the road bridge on the Gyaaman to Daa road (Photo 32.4). The GPS location is N5° 58' 51.4" W 1° 56' 6.0". The river was about 4m wide with a moderate flow. The bottom was made up of gravel with patches of mud in places. The water was well oxygenated (4.0mg/l). The water was turbid (75.2 NTU) low in conductivity (68.8 µS/cm) low TDS (37.8mg/l) and a pH of 6.4. The canopy was intact and very little sunlight penetrated the through to the surface of the water. The habitat score was estimated to be 73/120.

River Subin at Ayanfuri (SBI)

Photo 32.5

The site is located on the outskirts of Ayanfuri on the Ayanfuri to Nkutumso road (Photo 32.5). The GPS location is N 5° 58' 10.9" W 1° 53' 50.0". The site served as the upstream reach of the river. Samples were collected from the upstream side of the road bridge. The water was turbid (96.2 NTU), moderate in conductivity (115 µS/cm) and well oxygenated (2.9mg/l) and a moderate flow. The bottom was gravely and the water was partly covered by the gallery forest. The river is shallow (0.30m deep) and about 1 ½ m wide and had a pH of 6.68. The site represented the upstream reaches of River Subin.

River Subin at Akrofuom (SBII)

Photo 32.6

The site is located to the east of Akrofuom Village (32.6). The GPS location is N5° 59' 57.8" " W 1° 52' 48.0". The location served as the downstream site of the river before it entered the Offin River. The water was turbid (181NTU) with pH close to neutral (pH 6.99) low TDS (59.4 mg/l) and conductivity (108 µS/cm). The bottom was made of gravel and pebbles and the gallery forest shaded the river. All the rivers were turbid because it had rained two days before the survey.

The results of the water analyses for the five sites are summarised in table 32.24.

Table 32.24: Water Analysis of Five Survey Locations for Aquatic Ecology

Parameter Location	pH	DO mg/l	Conductivity uS/cm	Turbidity (NTU)	TDS mg/l	Width m. m	Depth. m
AKI	6.31	2.20	103	275	147	1	0.30
AKII	5.4	3.50	61.7	248	33.9	0.5	0.75
AKIII	6.4	4.0	68.8	75.2	37.8	4	-
SBI	6.68	2.9	115	-	96.2	1.5	0.3
SBII	6.99	-	108	181	59.4	-	-

A summary of the assessment of the physical riparian habitat of the sample collection sites is presented in table 32.25. The most impacted site (i.e. the site with the lowest habitat score) was Nkutumso, (AKII, 54/120) and that with the least anthropogenic impact was Akrofuom, (SBII, 88/120).

3.2.4.3 Methods of Study

The survey followed, broadly, the protocols described by Barbour *et al.* (1999) for bioassessment of wadeable streams and rivers in this study. The details of the methods followed are:

Algae (Phytoplankton)

A one litre sampling wide-mouth bottle was used to collect water sample from the sites. A few drops of 4% formalin were added to each of the samples immediately in the field, and the sample kept in a cold box for examination in the laboratory. In the laboratory, samples were shaken vigorously and a 25ml counting chamber was filled with an aliquot of the sample. A drop of liquid soapy detergent was added to the sample to facilitate sedimentation of the plankton and the aliquot left to stand for four hours. Samples were then examined under a Leitz inverted microscope and the types of algae present as well as their numbers counted with the aid of available taxonomic keys (Needham and Needham, 1969; APHA, 1998). Three replicate aliquots for each sample was so examined and the mean numbers for the sample extrapolated to numbers per litre by multiplying the numbers by a factor of 40. The percentage composition of the major phyla present in the samples was estimated. Based on the composition of the algal species present at the various sites, an assessment of the water quality was made.

Table 3.2.4.3: Assessment of the Physical Habitat of Sampling Sites

River	**Akesoa AKI**	**Akesoa AKII**	**Akesoa AKIII**	**Subin SBI**	**Subin SBII**
Location	**Abnabna**	**Nkutumso**	**Fobinso**	**Ayanfuri**	**Akrofuom**
Geographical Coordinates	N5º57' 32.7" W1º 56' 49.2"	N 6º 0' 12.2" W 1º 55' 38.0"	N5º 58' 51.4" W 1º 56' 6.0"	N5º 58' 10.9" W1º 53' 50.0"	N5º 59'57.8" W1º 52' 49.0"
Mean Width (m)	1.50	6.00	4.00	1.50	7.00
Mean depth (m)	0.30	0.75	0.70	0.30	0.70
Bottom substrate	Substrate dominated by mud and silt. **4**	Substrate dominated by mud; gravel <10%. **4**	Substrate a mixture of mud and gravel; gravel forms about 30% of bottom. **7**	Substrate dominated by mud and gravel; gravel 40-50% of bottom. **12**	Substrate dominated by gravel; gravel > 60% of bottom. **18**
Habitat Complexity	Monotonous , dominated by sedges **4**	Habitat dominated by gravel. No aquatic weeds present. **12**	Structural types and sizes of materials suboptimal. No aquatic weeds present. Some limited snags present. **17**	Marginal, with no undercut banks; other structural components like snags and aquatic weeds very limited. **12**	Structural types and sizes of materials suboptimal. No aquatic weeds present. Some limited snags present. **14**
Pool quality	Pools absent. **4**	Pools absent **5**	Few deep pools present **9**	Pools absent **4**	Pools absent **5**
Bank stability	Very little bank failure. **17**	Few previous bank failure that had healed over **13**	Few previous bank failure that had healed over **14**	Few previous bank failure upstream side of bridge that had healed over **14**	Few previous bank failure upstream side of bridge that had healed over **15**
Bank protection	About 60% of stream banks covered with vegetation. Bank material soft. **13**	About 75% of stream banks covered with vegetation. Bank material laterite. **14**	About 80% of stream banks covered with vegetation. Bank material mixture of laterite and humus. **16**	About 90% of stream banks covered with vegetation. Bank material clay overlying laterite **14**	About 90% of stream banks covered with vegetation. Bank material mixture of stones and humus. **18**
Canopy	Discontinuous canopy with areas exposed fully to sun. **12**	Discontinuous canopy. Sun filtering through to stream **13**	Canopy dense. Filtered light to water surface minimal. **10**	Water surface exposed to sun through the day. **4**	Canopy made of trees of different heights. Provide shade and filtered light to water surface. **18**
Total habitat score	**54/120**	**52/120**	**73/120**	**60/120**	**88/120**

Benthic Macroinvertebrates

A D-frame pond net (sweep net of mesh size 350µm) was used to collect samples from the selected reaches of the rivers. The sites also coincided with the sites where the algae (phytoplankton) and fish samples were collected. Between twenty and thirty meters of each reach was sampled for a maximum of thirty minutes; and sampling covered all habitats within the reach. Each pond net full of bottom material was considered as a replicate sample. Samples were preserved in 4% formalin and brought into the laboratory for further processing. A maximum of five replicate samples were collected from each reach.

Samples were examined under a dissecting microscope, in the laboratory, and all macroinvertebrates sorted out. The individuals were identified as far as possible with the aid of available taxonomic keys (Dejoux *et al.,* 1982; Brown and Kristensen, 1998). The data obtained was used to estimate the following parameters:

- The relative number of the different taxa present in each reach.
- Shannon-Weiner Diversity index for the biocenosis from each reach. The index was estimated as:

$$H' = \sum_{i=1}^{s} [(n_i / n) \log_e (n_i / n)]$$ **(Ludwig and Reynolds, 1988)**

- The food guilds represented by benthos from each reach and,
- EPT index which is a measure of the quality of the water at the sites (Barbour *et al.,* 1999; Mackie, 2004).

Fish Population Assessment

A battery of gill nets was deployed in the reaches selected for the study. The nets were multifilament meshed with mesh sizes of 12.5, 15.0, 17.5 and 20.0mm. Each net measured 6.0m by 1m in area. Fish nets were set in the evening and harvested the following morning. -All fish caught in two consecutive nights' fishing constituted the species present at the reach. The species list was supplemented by information provided by the inhabitants in the community. Each individual species of fish caught was identified to species level by consulting available taxonomic keys (Dankwa *et al*., 1999; Paugy *et al.* 1990), measured and weighed and the data obtained to estimate the following:

1. Catch per Unit Effort (CPUE) (a measure of fish productivity (Lévêque *et al.,* 1988)

   CPUE=N x100/lx2xnxd or Wx100/lx2xnxd

   Where

   N= number of fish caught by net

   W= weight of fish caught by net

   l = length of gill net

   d= depth of immersion of net (i.e. mean depth of reach of river fished)

   n= number of nights fished

2. Coefficient of Condition of fish species K

   $$K = \frac{Wx10^5}{L^3}$$ (Lévêque *et al*., 1980; Williams, 2000)

   Where W = weight of fish (g)

   L = standard length of fish

3.2.4.4 Results and Discussion

Algae (Phytoplankton)

Fifteen species of algae were collected from rivers in the Central Ashanti Gold Project (CAGP) area at Ayanfuri. River Akesoa and River Subin had 12 and 9 species of algae respectively whereas nine species were common to both rivers. Filamentous algae (macro-algae) were scarce at all the sampling sites.

The species of algae that were found are:

A.	**B.**	**C**
Chlorophyta (Green algae)	**Bacilliarophyta (**Diatoms)	**Cyanophyta** (Blue-green algae)
Chlorella sp	*Navicula sp*	*Coelosphaerium sp*
Chlamydomonas sp	*Rivularia sp*	*Cylinderospermopsis sp*
Euglena sp	*Synedra sp*	*Planktorix sp*
Phacus sp	*Pinnularia sp*	
Oocystis sp		
Volvox sp		
Trachelmonas sp		
Closterium sp		

The diversity of the algal communities present in the CAGP concession area is presented as figure 32.3. Shannon-Weiner diversity (H') was 1.84, 1.98, 1.61, 1.87 and 1.28 at Abnabna (AKI), Nkutumso (AKII), Fobinso (AKIII), Ayanfuri (SBI) and Akrofuom (SBII) respectively. Thus, the highest algal diversity occurred at Nkutumso and the lowest at Akrofuom. Details of the distribution of algal species and their abundances across the CAGP concession area are presented in Appendix 3.2.4.4.

The relative abundance of the components of the algal communities at the various sites is presented as figure 32.4. The Chlorophyta dominated the plankton communities at all sites.

The trend of dominance was AKIII>SBII>AKII>AKI>SBI. In the case of the Bacilliarophyta the trend was AKI>AKII>SBII>AKIII>SBI; whereas it was SBI>AKII>AKI when the Cyanophyta was considered. No Cyanophyta occurred at Fobinso (AKIII) and Akrofuom (SBII); and where the Cyanophyta population was high the Bacilliarophyta was reduced in size. Nutrient-enriched waters are usually dominated by Cyanophyta. Thus, when one considered the algal communities at the various sites one can say that Fobinso (AKIII) and Akrofuom (SBII) were the least impacted by humans as no Cyanophyta were found in the waters at these sites. However, Ayanfuri (SBI) which had a large Cyanophyta population, indicated that the site was receiving nutrients inputs Therefore, the site at Ayanfuri, on River Subin (SBI), should be noted as a possible point of pollution of River Subin.

3.2.4.5 Benthic Macroinvertebrate Fauna

Ninety macroinvertebrate taxa were collected from the five sampling sites on River Akesoa and Subin in the CAGP area. The occurring taxa and their abundances at the various sites are presented as Appendix 3.2.4.5. The number of aquatic macroinvertebrate species as well as estimates of faunal diversity at the various sites is presented as Figure 32.5.

The highest number of macroinvertebrate species, 51 was collected from River Akesoa at Abenabena (AKI) whereas the lowest, 23, was from River Akesoa at Nkutumso (AKII). Similarly, diversity of macroinvertebrates, H', was 2.10, 1.57, 2.97, 2.15 and 2.95 at Abenabena(AKI), Nkutumso (AKII), Fobinso (AKIII), Ayanfuri (SBI) and Akrofuom (SBII) respectively. Thus, the highest macroinvertebrate diversity in the CAGP area occurred in River Akesoa at Fobinso and the lowest in River Akesoa at Nkutumso.

Figure 32.3: Diversity of Algae at Various Sites in the CAGP Concession Area

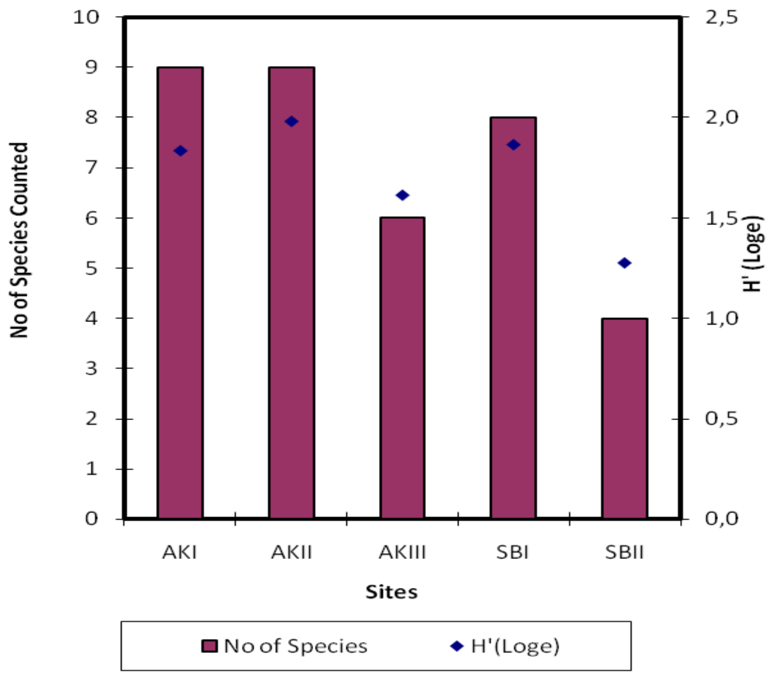


Fig. 4.1: Diversity of Algae at Various Sites in the CAGP Concession Area

Figure 32.4: Relative abundance of Chlorophyta Bacilliarophyta and Cyanophyta in River Akesoa and River Subin in CAGP area

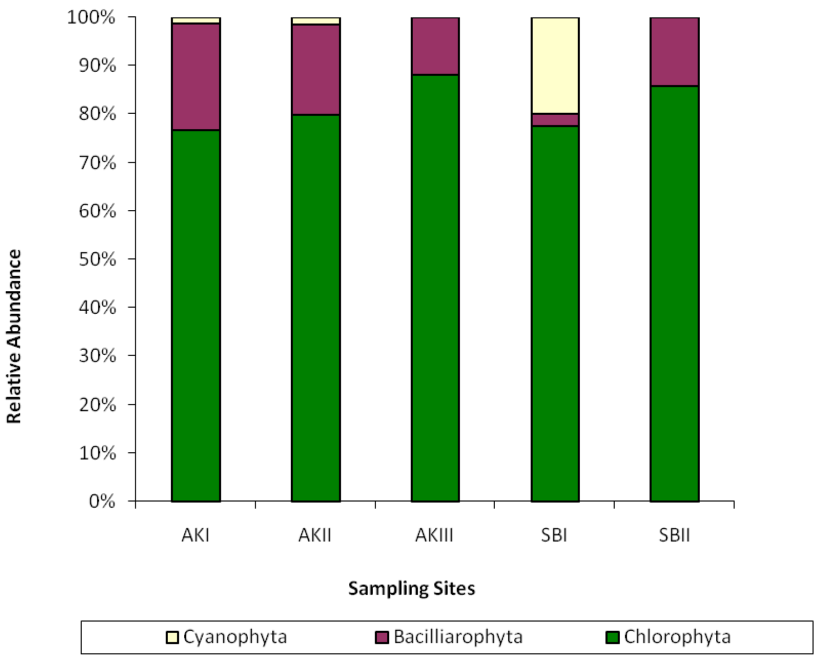
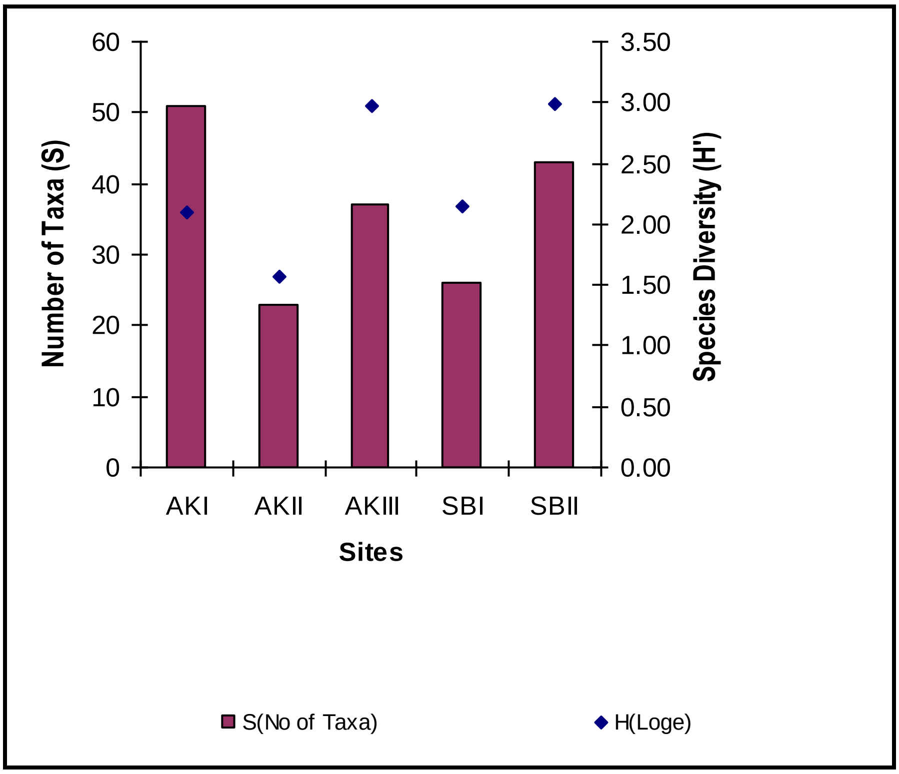


Fig. 4.2: Relative Abundance of Chlorophyta Bacilliarophyta and Cyanophyta in River Akesua and River Subin in CAGP Concession Area.

Figure 32.5: Number of Taxa (Species) and Diversity (H') of Macroinvertebrates in Rivers in CAGP Project area



3.2.4.6 Assessment of water quality based on EPT index

The Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa present at Abnabna (AKI), Nkutumso (AKII), Fobinso (AKIII), Ayanfuri (SBI) and Akrofuom (SBII) are 3,3,6,4 and 12 respectively (Appendix 3.2.4.5).The EPT are macroinvertebrate groups that are sensitive to pollutants in water. Generally, the presence of these taxa in a reach is an indication that the water is of good quality. In addition, the greater the variety of EPT taxa presents, the better the quality of the water (See Mackie, 2004 below). This method of assessing the quality of water is useful where a biotic index has not been developed for use in a country such as Ghana. Based on the classification provided by Mackie, it is apparent that the quality of water at the reaches studied ranged from moderately impacted at Abnabna, Nkutumso and Ayanfuri to non-impacted at Akrofuom.

EPT Value*	Water Quality Assessment
>10	Non-impacted
6-9	Slightly impacted
3-5	moderately impacted
0-2	severely impacted

3.2.4.7 Macroinvertebrate Communities as Revealed by Functional Feeding Groups

The functional feeding groups that were present in the macroinvertebrate communities collected from the various sites are presented as Figure 32.6.

The 'Gathering Collectors' in River Akesoa constituted 81%, 95% and 52% of the macroinvertebrates at Abnabna (AKI), Nkutumso (AKII) and Fobinso (AKIII) respectively. In the Subin, however, whereas the

'Gathering Collectors' dominated the site at Ayanfuri (SBI, 62%), the Predators and 'Gathering Collectors' were co-dominant

3.2.4.8 Fishery Resources

Experimental fishing in rivers in the CAGP area resulted in the capture of fish from only River Subin at Akrofuom. Four species, *Brienomyrus brachyistius, Barbus trispilos, Mastacembelus nigromarginatus and Parachanna obscura* were captured from River Subin. In addition to these species the villagers indicated that *Clarias* (senegalensis?), *Brycinus nurse* and *Mormyrus spp,* occurred in the river. Thus it may be said that seven gill-fish species are regular residents of River Subin at Akrofuom. The shell fishes encountered were *Macrobrachium sp* and *Potadoma* sp. However, none of the fish species encountered in River Subin is on the Red List of the International Union for the Conservation of nature (IUCN).

3.2.4.9 Fish Production (CPUE)

Fish production was generally low. It ranged from no catch at Nkutumso to a total of 1268.48g from River Subin at Akrofuom (From all mesh sizes). Thus, the mean catch (CPUE) was 167.11g/100m^2/night (Table 32.26). The table also showed that only small and medium sized fish was captured from River Subin.

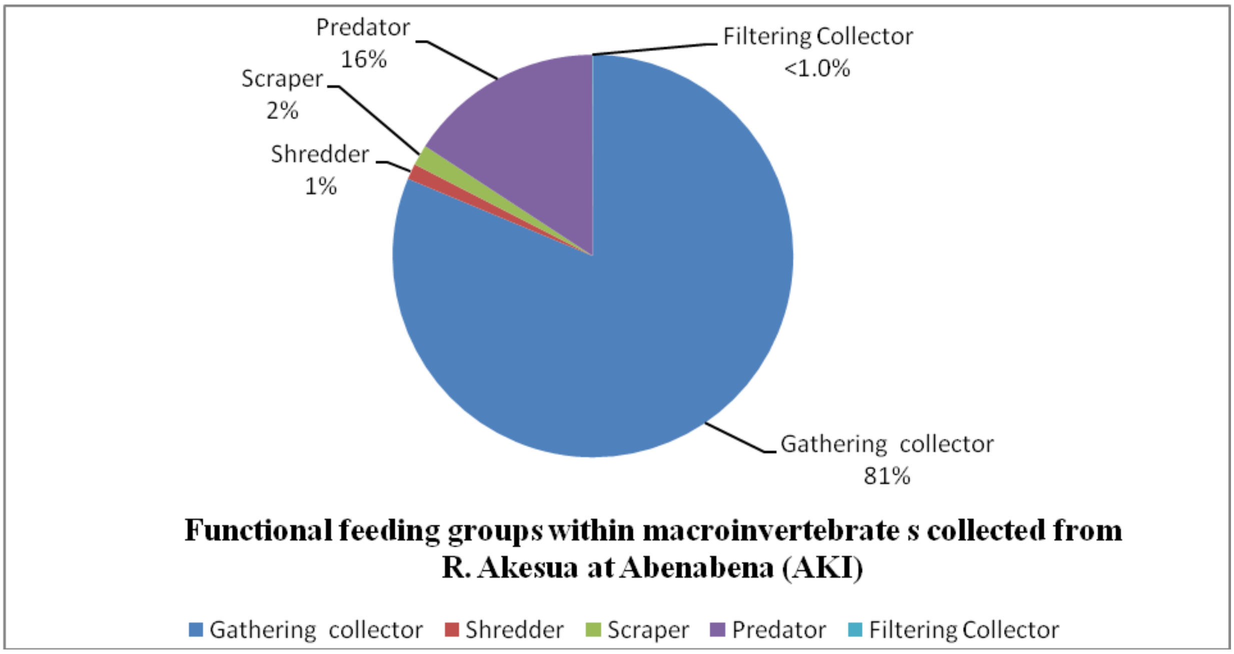
Table 32.26: CPUE of Fish (N/100m^2 / Wt(g) Caught from the CAGP Project area

Species	Subin at Akrofuom				Akesoa at Nkutumso			
	Mesh Size				*Mesh Size*			
	12.5mm	15.0m	17.5mm	20.0mm	12.5m	15.0mm	17.5mm	20.0mm
	N Wt(g)	N Wt(g)	N Wt(g)	N Wt(g)	N Wt(g)	N Wt(g)	N Wt(g)	N Wt(g)
Brienomyrus brachyistius	2 11.4	1 13.3	0 0	0 0	0 0	0 0	0 0	0 0
Barbus trispilos	2 8. 6	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Mastacembelus) nigromarginatus	0 0	0 0	1 17.6	0 0	0 0	0 0	0 0	0 0
Parachanna obscura	0 0			1 102.2	0 0	0 0	0 0	0 0
Total	4 20.0	1 13.3	1 17.6	1 102.2				
CPUE (per 100m^2 per night)	**23.81 119.05**	**5.95 79.17**	**5.95 461.90**	**5.95 608.33**	-	-	-	-
Mean CPUE	**10.42 167.11**				-	-	-	-

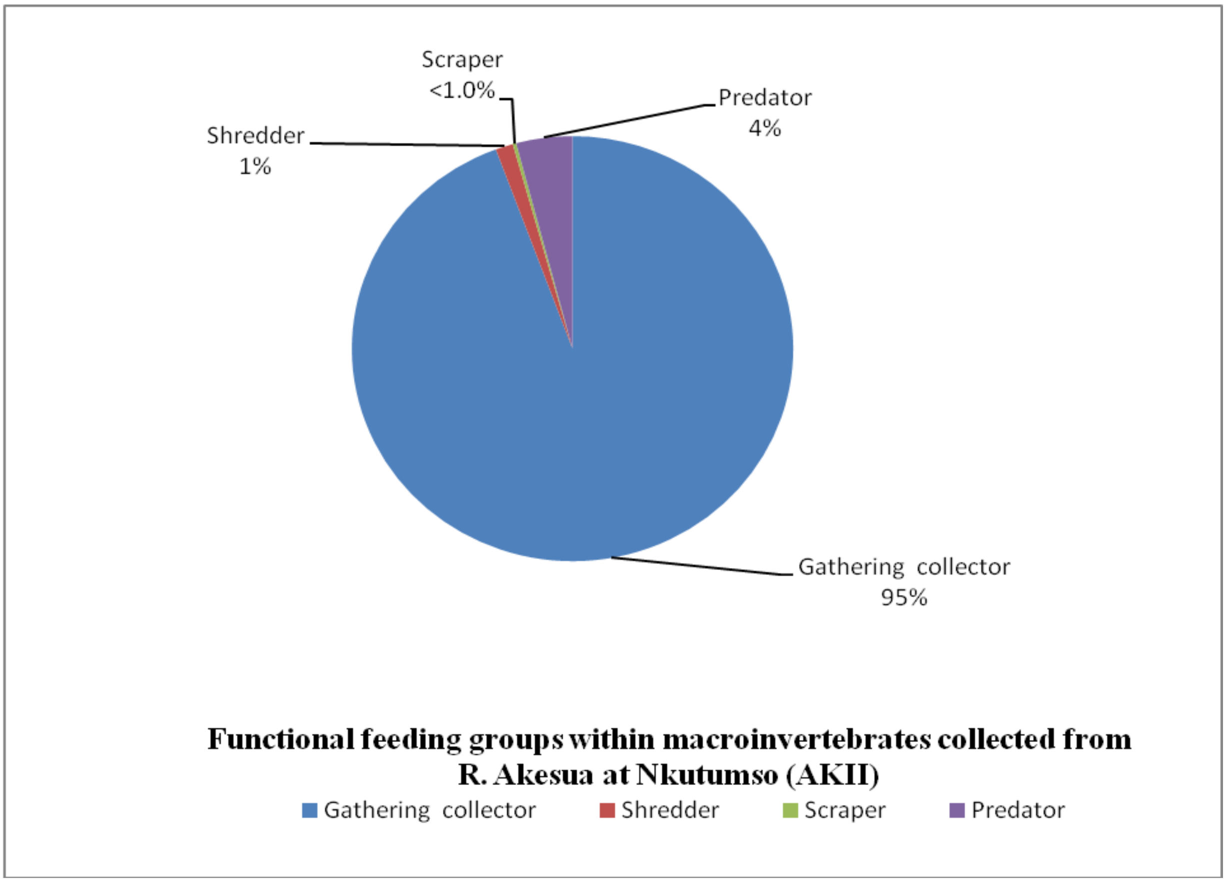
3.2.4.10 Condition of Fish (K)

The coefficient of condition (K) of the four species captured from River Subin at Akrofuom was 1.22, 2.04, 0.22 and 1.38 for *Brienomyrus brachyistius, Barbus trispilos, Mastacembelus (Aethiomastacembelus) nigromarginatus* and *Parachanna obscura* respectively. Coefficient of condition is an indicator of the general well being of a fish in its habitat. Also, it is specific to a species in the same river. Thus, *K* is a useful tool for monitoring effects of chronic of incipient pollution from the environment on fishes in a particular habitat.

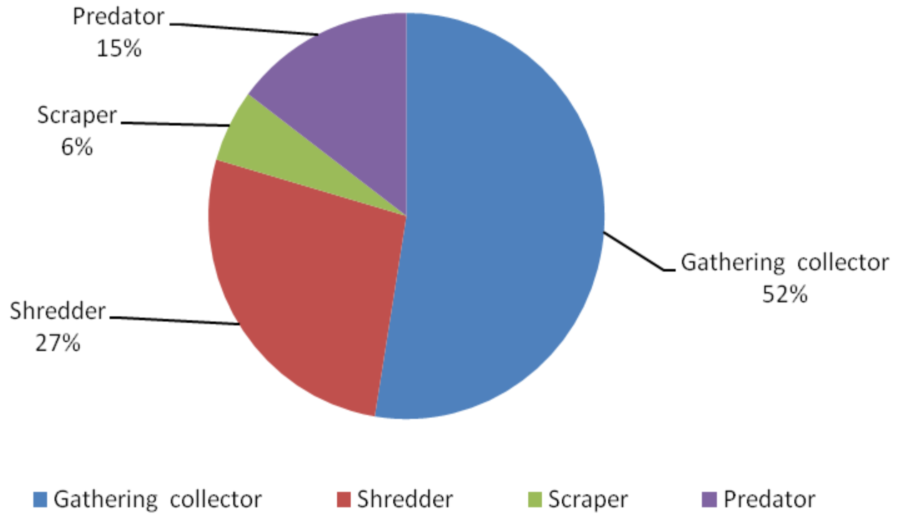
Figures 32.6(a-e): Functional feeding groups within macroinvertebrate community at various sites



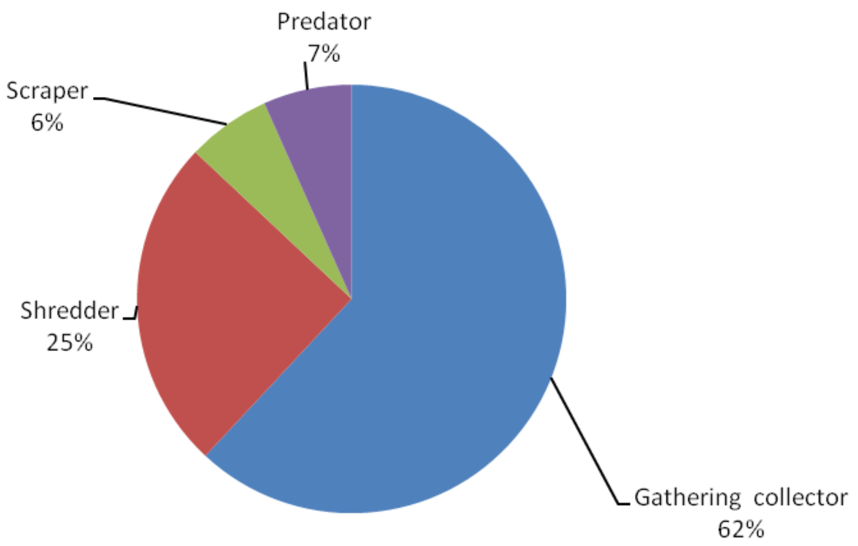
Functional feeding groups within macroinvertebrate s collected from R. Akesua at Abenabena (AKI)



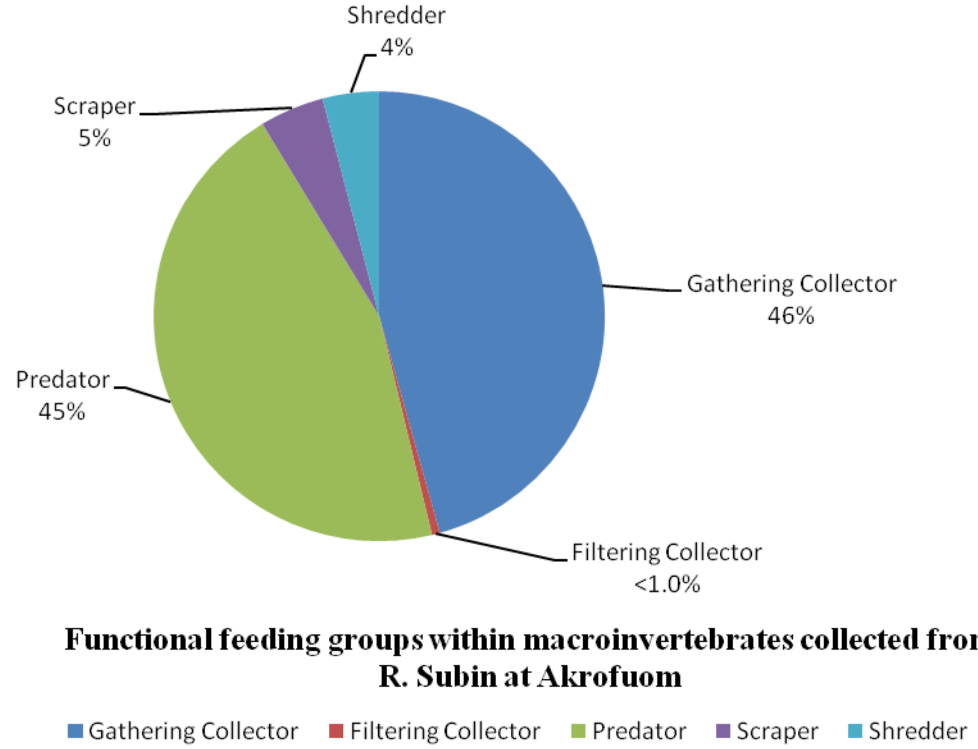
Functional feeding groups within macroinvertebrates collected from R. Akesua at Nkutumso (AKII)



Functional feeding groups within macroinvertebrate community collected from R. Akesua at Fobinso (AKIII)



Functional feeding groups within macroinvertebrates collected from River Subun at Ayanfuri (SBI)



Functional feeding groups within macroinvertebrates collected from R. Subin at Akrofuom

3.3 FLORA OF THE PROJECT AREA

3.3.1 Introduction

The Central Ashanti Gold Project (CAGP) area falls within the Offin River basin of the Pra River system. This area lies within the tropical rain forest zone of the country and the vegetation has been classified by Hall and Swaine (1981) as a Moist Semi-Deciduous forest of the Northwest sub-type. The CAGP area was an active mining site between 1994 and 2001, thus the current vegetation in the area has been severely disturbed and bears very little structural resemblance, if any, to the original primary forest classified by Taylor (1952) as belonging to the Celtis-Triplochiton Association.

Although commercial mining has been a major destructive force of the forest vegetation, agriculture, particularly food and cash crop farming, has and continues to be another major land use system in the area. Food crops such as plantain and cassava and cash crops, mainly cocoa and oil palm are prevalent in the area. At present, there is no evidence of commercial logging activities but it may be assumed that parts of the CAGP must have been logged sometime in the past. This assumption is based on the type of left-over primary forest tree species identified in the area. However, logging with chainsaws by the local people is still evident in the area.

3.3.2 Objectives and Methodology

3.3.2.1 Objectives

The general objective of the study was to assess the structural status of the vegetation of the proposed CAGP area and to ascertain the ecological and/or conservation significance of the flora. Specific objectives include the following:

- Determination of richness and % frequency of the species
- Determination of % frequency of the left-over tree species
- Identification and documentation of any endangered species using the star ratings of Hawthorne and Abu-Juam (1995)
- Assess the ecological/conservation significance of species and habitats in the area.

3.3.3 Methodology

3.3.3.1 Site Selection

All the three levels of ecological survey were employed in this study to select representative sites for detailed sampling. This was necessitated by the fact that the CAGP area had previously been mined and in some areas mining pits had been backfilled and re-vegetated whereas other pits were still open. Similarly, heap leach pads had been reclaimed in the area.

The reconnaissance survey revealed that the vegetation heterogeneity in the CAGP area was very high. This was not unusual considering the variety of anthropogenic factors that have or are still affecting the vegetation of the area. Actual site location in the field was accomplished during the preliminary survey with a site map and GPS data (Table 33.1). However, site selection for sampling during the intensive survey was based on the following criteria:

- Accessibility

- Wide coverage of entire CAGP area
- Visual assessment of vegetation and habitat type

Table 33.1: Location of Selected Sites for Transects with GPS Coordinates

Transect No.	CAGP Area	North	East	Comments
1	Fetish-camp road	656967	621401	Close to camp
2	TSF	659627	619372	Non-swampy area
3	Abnabna	658313	618236	Pant site
4	Nkonya	657300	619105	Potential haul road
5	Abnabna	658002	618326	Plant site
6	TSF	659580	618679	Swampy area
7	North Esuajah	659822	622869	Re-vegetated site

3.3.3.2 Flora Sampling

Map 33.1 shows the seven sites selected in the CAGP area for intensive sampling. At each site, a 100-m long transect was laid and five 3x3 m quadrats were located at 20-m intervals along each transect. These quadrats were used to determine species richness and % frequency of the species comprising the undergrowth. In addition to the quadrat sampling, all trees estimated to be over 20 m in height within eyes' view along each transect were also identified and recorded with the assistance of the local people.

The classification and nomenclature of species were based on Hutchinson and Dalziel (1956), Irvine (1961), Hawthorne (1990) and Bosch *et al.* (2002). Samples of species that could not be identified in the field were later identified in the herbarium of the University of Cape Coast.

3.3.4 Data Collection and Analysis

3.3.4.1 General Aspects of the Vegetation

There were no forests of any significance in the CAGP area, although at Abnabna, around the area designated as Plant Site the vegetation can be described as secondary forest with remnants of primary forest tree species. Table 3.8 clearly shows that transects 3 and 5 are by far richer in left-over trees than the rest of the transects. At any rate, it is not surprising that there are no forests of any significance in the CAGP area considering the fact that the area has been subjected to commercial surface mining in the past. Thus, the area is comprised of a mosaic of vegetation that on the surface looks deceptively homogeneous but a closer study reveals complex heterogeneous secondary vegetation composed of mosaics of variable temporal and spatial dimensions. The complexity has been added to by the re-vegetation of waste dumps, heap leach pads and backfilled pits mainly with exotic species.

The vegetation types identified in the CAGP area include secondary forests, secondary thickets and swamp vegetation. In some of the backfilled pit areas forb re-growth was prevalent and no trees were found in such areas. Species in such areas include ordinary weeds, grasses and ferns such as *Chromolaena odorata*, *Centrosema pubescens*, *Brachiaria deflexa*, *Sporobolus pyramidalis*, *Nephrolepis biserrata* and *Gleichenia linearis*.

The remarkable observation of the survey was the uniformity of the species composition of the undergrowth regardless of whether a thicket or a forest was sampled. However, there was a wide variation in species richness of the undergrowth along the different transects (Tables 33.2 to 33.5). For instance, 28 species belonging to 19 Families were identified along Transect 1 (Table 33.2) whereas only 11 species were distributed among 7 Families along Transect 4 (Table 3.4). In general, however, species richness of the undergrowth is generally poor compared to similar vegetation types elsewhere within the same geographical area.

3.3.4.2 Secondary Thicket/Forest

Five transects (T_1 – T_5) were laid in areas where the vegetation may be described as secondary thicket (T_1, T_2 and T_4) or secondary forest (T_3 and T_5). The former has more young trees than the latter and light penetration is higher. As a result, more herbaceous species and weeds, such as *Chromolaena odorata and Mallotus oppositifolius* (Tables 3.1 and 3.2), are quite prevalent and in fairly high frequencies. The secondary forest, on the other hand, has more left-over primary tree species mixed with older secondary species such as *Musanga cecropioides and Macaranga barteri*. Some of the primary species are economic trees and include *Pipterdeniastrum africana*, *Tieghemella heckelii*, *Triplochiton scleroxylon* and *Milicia excelsa* (Table 3.8). It is also interesting to note that, if Transects 6 and 7 are excluded from the determination of % frequency of the primary species, some of them have rather high frequencies, e.g. *Terminalia superba, T. ivorensis* and *Glyphaea brevis* (Table 3.8).

3.3.4.3 Swamp Vegetation

Transect 6 was located in the swampy area of the TSF. The species comprising the undergrowth of this vegetation were not very different from those of Transects 1–5 except that some of the species identified were exclusive to this transect, especially the grasses including *Coix lachrymal-jobi* and *Flagellaria guineensis* (Table 3.6). However, only a few trees were identified in the area and they include *Oxytenanthera abyssinica, Raphia hookeri* and *Anthcleista nobilis* in waterlogged areas and typical secondary species, such as *Macaranga bateri* and *Musanga cecropioides*, on higher ground.

3.3.4.4 Special Vegetation

Transect 7 depicts vegetation that mainly consists of exotic species, including *Senna siamea, Leucaenia glauca* and *Gmelina arborea*. These species have been purposely used to reclaim degraded areas resulting from previous mining activities. This transect stretched across a tailings dump area and an adjacent backfilled pit. The species used for the reclamation were mainly exotics, which are known to be fast-growing (Table 3.7). Although these exotics have formed canopies, only one seedling of the primary tree species, *Terminalia ivorensis*, was identified among the undergrowth. It may then be concluded that this special vegetation cannot develop to become a moist semi-deciduous rain forest, which is desirable. In view of this, it is suggested that future reclamation programmes should include indigenous tree species of the area to allow the area to develop into what it used to be as much as possible before the degradation occurred.

3.3.4.5 Significance of Left-Over Trees

The transect survey (excluding Transects 6 and 7) identified 27 species distributed among 17 families. The species richness is rather on the low side compared to previous studies in the same geographical area. The species composition, though, is typical for a moist semi-deciduous forest. The high frequencies of species like *Musanga cecropioides* and *Macaranga bateri* along the transects reinforce the observation that the vegetation in most of the study area is secondary in nature. Apparently, the few primary species remaining in the area were associated with cocoa plantations that required a certain amount of canopy cover when they were being cultivated.

From the foregoing it is clear that there is no true primary forest in the study area but some of the left-over trees with fairly large diameters and high frequencies, such as *Terminalia ivorensis, T. superba* *and Albizia zygia,* are of economic importance and therefore the local people should be allowed to exploit these before any mining activity resumes in the area.

3.3.5 Conclusion

The vegetation of the CAGP area has been degraded to a very large extent through past mining, logging and farming activities and therefore bears very little semblance to the original primary forest characteristic of the area. In a few areas, isolated pockets of secondary forests with left-over trees of the original primary forest were identified. The floral studies of a couple of these areas (Transects 3 and 5) did not identify any black star species. Similarly, there were no species of ecological or conservation significance. However, care should be taken to conserve some of the swamp vegetation habitats that which abound in the area.

Table 33.2: Species Composition and Frequency of Transect 1 (Q_1 – Q_5)

Family	Species	Q_1	Q_2	Q_3	Q_4	Q_5	% Frequency
ANNONACEAE	*Uvaria chamae*	x	-	-	-	-	20
APOCYNACEAE	*Landolphia owariensis*	x	-	-	-	-	20
	Picralima nitida	x	-	-	-	x	40
	Rauvolfia vomitora	x	x	x	-	-	60
ASCLEPIADACEAE	*Gongronema latifolia*	-	-	-	-	x	20
	Secamone afzelii	-	-	-	-	x	20
ASTERACEAE	*Chromolaena odorata*	x	x	x	x	x	100
BROMELIACAEAE	*Ananas comosus*	x	-	-	-	-	20
CAESALPINACEAE	*Griffonia simplicifolia*	x	x	x	x	x	100
CECROPIACEAE	*Myrianthus arboreus*	-	-	-	x	x	40
CONVOLVULACEAE	*Ipomoea mauritiana*	-	x	-	-	-	20
COSTACEAE	*Costus afer*	-	x	-	-	-	20
CUCURBITACEAE	*Momordica charantia*	-	x	-	-	-	20
EUPHORBIACEAE	*Alchornia cordifolia*	x	x	x	-	-	60
	Mallotus oppositifolius	-	-	x	-	x	40
	Manihot esculenta	-	-	x	-	-	20
MELASTOMATACEAE	*Dissotis rotundifolia*	-	-	x	-	-	20
MORACEAE	*Antiaris africana*	-	-	-	x	x	40
PALMACEAE	*Elaeis guineensis*	-	-	-	x	x	40
PAPILIONACEAE	*Baphia nitida*	x	-	x	x	x	80
	Centrosema pubescens	-	x	-	-	-	20
	Millettia zechiana	x	-	-	-	-	20
PASSIFLORACEAE	*Adenia lobata*	x	-	-	-	-	20
POACEAE	*Axonopus compressus*	x	-	x	x	-	60
	Digitaria longiflora	-	x	-	-	-	20
	Scleria deflexa	-	-	x	x	-	40
	Setaria barbata	x	-	x	x	-	60
SCHIZAEACEAE	*Lygodium macrophyllum*	x	-	x	x	-	60
SOLANACEAE	*Solanum torvum*	-	x	-	-	-	20
VERBENACEAE	*Stachytarpheta cayennensis*	-	-	-	x	x	40
Total 19	*Total 28*						

Table 33.3: Species Composition and Frequency of Transect 2 (Q_6 – Q_{10})

Family	Species	Q_6	Q_7	Q_8	Q_9	Q_{10}	%Frequency
APOCYNACEAE	*Picralima nitida*	x	x	-	-	-	40
	Rauvolfia vomitora	x	x	-	x	-	60
	Voacanga Africana	-	-	x	-	x	40
ASCLEPIADACEAE	*Secamone afzelii*	-	x	-	-	-	20
ASTERACEAE	*Chromolaena odorata*	-	x	x	x	x	80
BALANITACEAE	*Balanites aegyptica*	-	-	-	-	x	20
CAESALPINACEAE	*Griffonia simplicifolia*	x	-	-	x	x	60
COSTACEAE	*Costus afer*	x	-	-	-	-	20
EUPHORBIACEAE	*Alchornia cordifolia*	x	-	-	-	-	20
	Mallotus oppositifolius	x	x	-	-	-	40
	Manihot esculenta	-	-	-	-	x	20
MELASTOMATACEAE	*Dissotis rotundifolia*	-	x	-	x	-	40
MORACEAE	*Antiaris africana*	-	x	-	x	x	60
NEPHROLEPIDACEAE	*Nephrolepis biserrata*	x	x	-	x	x	80
PALMACEAE	*Elaeis guineensis*	x	-	x	x	x	80
PAPILIONACEAE	*Baphia nitida*	x	x	x	x	-	80
	Desmodium adscendens	-	-	x	x	-	40
	Millettia zechiana	-	-	-	-	x	20
POACEAE	*Brachiaria deflexa*	-	x	-	-	-	20
	Scleria deflexa	x	x	x	-	-	60
	Setaria barbata	-	-	x	-	-	20
SAPINDACEAE	*Paullinia pinnata*	-	-	x	x	x	60
STERCULIACEAE	*Theobroma cacao*	x	x	x	x	x	100
VERBENACEAE	*Stachytarpheta cayennensis*	-	x	x	-	-	40
Total 16	Total 24						

Table 33.4: Species Composition and Frequency of Transect 3 (Q_{11} – Q_{15})

Family	Species	Q_{11}	Q_{12}	Q_{13}	Q_{14}	Q_{15}	% Frequency
APOCYNACEAE	*Picralima nitida*	-	-	-	-	x	20
	Rauvolfia vomitora	x	x	-	-	x	60
	Voacanga africana	-	x	x	-	-	40
ASTERACEAE	*Chromolaena odorata*	-	-	-	-	x	20
CAESALPINACEAE	*Dialium guineense*	-	-	x	-	-	20
	Griffonia simplicifolia	-	-	-	-	x	20
CECROPIACEAE	*Myrianthus arboreus*	-	-	-	x	-	20
EUPHORBIACEAE	*Alchornia cordifolia*	-	-	-	-	x	20
	Mallotus oppositifolius	-	-	-	x	-	20
MORACEAE	*Antiaris africana*	-	x	-	-	-	20
PALMACEAE	*Elaeis guineensis*	x	x	-	-	-	40
PAPILIONACEAE	*Abrus precatorius*	x	-	-	-	-	20
	Baphia nitida	x	x	x	-	x	80
	Desmodium adscendens	-	x	x	-	-	40
	Millettia zechiana	-	-	x	x	-	40
POACEAE	*Setaria deflexa*	x	-	x	-	x	60
SAPINDACEAE	*Paullinia pinnata*	x	-	-	-	-	20
SCHIZAEACEAE	*Lygodium macrophyllum*	-	-	-	-	x	20
STERCULIACEAE	*Theobroma cacao*	-	x	-	-	-	20
Total 12	*Total 19*						

Table 33.5: Species Composition and Frequency of Transect 4 (Q_{16} – Q_{20})							
Family	**Species**	**Q_{16}**	**Q_{17}**	**Q_{18}**	**Q_{19}**	**Q_{20}**	**% Frequency**
APOCYNACEAE	*Rauvolfia vomitora*	x	-	-	x	-	40
	Voacanga africana	-	x	-	x	-	40
CAESALPINACEAE	*Griffonia simplicifolia*	x	x	x	x	x	100
EUPHORBIACEAE	*Alchornia cordifolia*	-	-	-	-	x	20
	Bridelia ferruginea	x	x	-	x	-	60
	Mallotus oppositifolius	-	-	-	x	-	20
MORACEAE	*Antiaris Africana*	x	x	-	x	-	60
PALMACEAE	*Elaeis guineensis*	x	-	-	x	-	40
PAPILIONACEAE	*Baphia nitida*	x	x	x	x	x	100
RUBIACEAE	*Craterispermum caudatum*	-	-	x	-	-	20
	Mussaenda elegans	-	-	-	-	x	20
Total 7	*Total 11*						

Table 33.6: Species Composition and Frequency of Transect 5 (Q_{21} - Q_{25})							
Family	**Species**	**Q_{21}**	**Q_{22}**	**Q_{23}**	**Q_{24}**	**Q_{25}**	**% Frequency**
APOCYNACEAE	*Picralima nitida*	x	-	-	-	-	20
	Voacanga africana	x	-	-	-	-	20
ASCLEPIADACEAE	*Gongronema latifolia*	x	-	-	-	-	20
	Secamone afzelii	x	x	-	x	-	60
	Pergularia daemia	-	-	x	-	-	20
ASTERACEAE	*Chromolaena odorata*	x	x	x	x	-	80
	Synedrella nodiflora	-	-	x	-	x	40
CAESALPINACEAE	*Griffonia simplicifolia*	x	x	x	x	x	100
CUCURBITACEAE	*Momordica charantia*	-	-	x	-	-	20
EUPHORBIACEAE	*Mallotus oppositifolius*	x	x	-	-	-	40
	Manihot esculenta	x	-	-	-	-	20
MENISPERMACEAE	*Triclisia subcordata*	x	-	x	-	-	40
MORACEAE	*Antiaris africana*	-	x	-	-	x	40
NEPHROLEPIDACEAE	*Nephrolepis biserrata*	-	x	-	-	-	20
PALMACEAE	*Elaeis guineensis*	-	x	-	-	-	20
PAPILIONACEAE	*Baphia nitida*	x	x	x	x	x	100
	Desmodium scoparius	-	-	-	x	-	20
	Millettia zechiana	x	-	-	-	-	20
PASSIFLORACEAE	*Adenia lobata*	-	-	-	x	-	20
POACEAE	*Setaria barbata*	x	x	-	-	-	40
STERCULIACEAE	*Theobroma cacao*	-	-	x	x	-	40
TILIACEAE	*Christiana Africana*	-	-	x	-	-	20
VEABENACEAE	*Stachytarpheta cayennensis*	-	-	-	-	x	20
Total 16	*Total 23*						

Table 33.7: Species Composition and Frequency 0f Transect 6 (Q_{26} – Q_{30})							
Family	**Species**	**Q_{26}**	**Q_{27}**	**Q_{28}**	**Q_{29}**	**Q_{30}**	**% Frequency**
APOCYNACEAE	*Rauvolfia vomitora*	-	-	-	-	x	20
ASTERACEAE	*Chromolaena odorata*	-	-	x	x	x	60
BALANITACEAE	*Balanites aegyptica*	-	-	-	-	x	20
COMMELINACEAE	*Commelina bengalensis*	-	-	x	x	x	60
COSTACEAE	*Costus afer*	x	-	-	-	x	40
EUPHORBIACEAE	*Alchornia cordifolia*	-	-	x	x	-	40
	Phyllanthus amarus	-	-	x	x	x	60
MELASTOMATACEAE	*Dissotis rotundifolia*	x	-	x	x	x	80
NEPHROLEPIDACEAE	*Nephrolepis biserrata*	x	x	x	x	x	100
PALMACEAE	*Elaeis guineensis*	x	-	x	-	-	40
PAPILIONACAEAE	*Desmodium scoparius*	-	-	-	x	x	40
	Millettia zechiana	-	-	x	-	x	40
PASSIFLORACEAE	*Adenia lobata*	-	-	x	-	x	40
POACEAE	*Brachiria deflexa*	-	x	-	x	x	60
	Coix lachryma-jobi	-	-	x	x	x	60
	Flagellaria guineensis	-	x	-	x	-	40
RUBIACEAE	*Craterispermum caudatum*	-	-	x	-	-	20
	Mussaenda elegans	-	-	-	-	x	20
	Rothmania longiflora	-	-	x	-	-	20
SCHIZAEACEAE	*Lygodium macrophyllum*	-	x	-	-	x	40
TILIACEAE	*Christiana africana*	-	-	-	x	-	20
URTICACEAE	*Fleurya aestuans*	-	-	-	x	-	20
VERBENACEAE	*Stachytarpheta cayennensis*	-	-	-	-	x	20
Total 17	*Total 23*						

Table 33.8: Species Composition and Frequency of Transect 7 (Q_{30} – Q_{35})							
Family	**Species**	**Q_{31}**	**Q_{32}**	**Q_{33}**	**Q_{34}**	**Q_{35}**	**% Frequency**
ACANTHACEAE	*Asystasia gangetica*	x	-	x	-	-	40
APOCYNACEAE	*Funtumia elestica*	-	-	x	-	-	20
ASCLEPIADACEAE	*Pergularia daemia*	-	x	-	-	-	20
ASTERACEAE	*Chromolaena odorata*	x	x	x	x	x	100
CAESALPINACEAE	*Acacia* sp.	-	-	x	-	-	20
EUPHORBIACEAE	*Alchornia cordifolia*	x	-	-	x	x	60
GLEICHENIACEAE	*Gleichenia linearis*	x	-	-	-	-	20
LYCOPODIACEAE	*Lycopodium microphyllum*	-	x	-	-	x	40
MELASTOMATACEAE	*Dissotis rotundifolia*	-	-	-	-	x	20
MIMOSACEAE	*Mimosa pudica*	x	x	x	x	-	80
NEPHROLEPIDACEAE	*Nephrolepis biserrata*	-	x	-	-	-	20
PALMACEAE	*Elaeis guineensis*	-	x	-	-	-	20
PAPILIONACEAE	*Calapogonium mucunoides*	-	x	-	-	-	20
	Centrosema pubescens	x	x	x	x	x	100
	Desmodium adscendens	-	x	-	-	-	20
	Gliricidia sepium	-	-	-	-	x	20
PASSIFLORACEAE	*Adenia lobata*	-	x	-	-	-	20
POACEAE	*Axenopus compressus*	x	x	x	x	x	100
	Brachiaria deflexa	x	-	x	x	x	80
	Flagellaria guineensis	-	-	-	x	x	40
	Panicum maximum	x	-	-	-	-	20
	Sporobolus pyramidalis	x	-	-	-	-	20
	Vetiveria nigritana	-	x	-	-	-	20
STERCULIACEAE	*Terminalia ivorensis*	-	-	x	-	-	20
VERBENACEAE	*Stachytarpheta cayennensis*	-	-	-	x	-	20
Total 17	*Total 18*						

Table 33.9: Frequency of Left-Over Tree Species along Transects 1-5							
Family	**Species**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**% Frequency**
ANNONACEAE	*Cleistopholis patens*	-	-	-	-	x	20
APOCYNACEAE	*Alstonia boonei*	x	x	x	x	-	80
	Funtumia elastica	x	x	x	x	x	100
	Rauvolfia vomitora	x	x	x	x	x	100
BOMBACACEAE	*Ceiba pentandra*	x	x	x	-	x	80
CAESALPINACEAE	*Daniellia ogea*	-	-	x	x	x	60
COMBRETACEAE	*Terminalia ivorensis*	x	x	x	-	x	80
	Terminalia superba	x	-	x	x	x	80
EUPHORBIACEAE	*Bridelia ferruginea*	x	x	x	x	-	80
	Macaranga bateri	x	x	x	x	-	80
	Margaritaria discoidea	x	-	x	-	x	60
LECYTHIDACEAE	*Petersianthus macrocarpus*	-	-	x	-	x	40
LOGANIACEAE	*Anthocleista nobilis*	-	x	x	-	-	40
MELIACEAE	*Carapa procera*	-	-	x	x	-	40
	Trichilia monadelphia	-	-	-	x	-	20
MIMOSACEAE	*Albizia zygia*	x	-	x	x	x	80
	Piptadeniastrum africana	-	-	x	-	x	40
MORACEAE	*Antiaris toxicaria*	-	-	x	-	-	20
	Ficus capensis	-	-	-	-	x	20
	Ficus exasperata	-	-	x	-	-	20
	Musanga cecropioides	x	x	x	x	x	100
MYRISTICACEAE	*Pycnanthus angolensis*	-	x	x	x	-	60
PALMACEAE	*Raphia hookeri*	-	x	-	-	-	20
RUTACEAE	*Zanthoxylum gilletii*	-	-	x	-	x	40
SAPOTACEAE	*Tieghemella heckelii*	x	-	x	x	-	60
STERCULIACEAE	*Triplochiton scleroxylon*	x	-	x	-	x	60
TILIACEAE[	*Glyphaea brevis*	x	x	x	-	x	80
Total 17	*Total 27*						

3.4 THE FAUNA OF THE PROJECT AREA

3.4.1 Introduction

This section presents a description of a field survey undertaken as part of the environmental baseline to characterise the terrestrial fauna of the Central Ashanti Gold Project (CAGP) Area. The survey included both quantitative and qualitative assessments of faunal species through non-destructive trapping of small mammals (live trapping), birds (mist netting) and bats (mist netting) as well as an assessment of the presence of larger mammals through examination of trails and spoor and discussions with local hunters and chop bar owners. This fauna survey was completed in April 2009. In addition, brief reference is made to an earlier fauna survey made in 2003 by Jay Minerals Services (JMS) for Cluff Resources EIS of its Ayanfuri Project.

3.4.2 Cluff Resources EIS Fauna Description 1993

In 1993, JMS undertook a desk study seeking published and unpublished reports that would characterise the fauna of the Ayanfuri region. No fieldwork was undertaken. The study found no records of any faunal surveys conducted in the Ayanfuri project area. Sources of information were limited to those pertaining to the Nini-Suhien National Park (NP), Ankasa Game Production Reserve (GPR) and the Bia NP and GPR are located to the south west and North-West respectively of the study area and which are wildlife conservations areas. The faunal composition of these reserves was taken with a fair amount of accuracy to represent what the situation must have been before human activities such as farming, settlement and hunting modified the fauna composition.

The study pointed out, however, that the then "concession area is fairly densely populated with quite a number of small villages and hamlets and a major settlement at Ayanfuri. With this high human population density, there is a lot of demand for land for farming and other purposes. The destruction of the forest environment for farms has the most serious effect on wildlife (Jamieson et. al. 1971). Other forms of land use which affect the environment include hunting, which is quite prevalent in the area and human settlement expansion". Nonetheless, the study concluded that "the surrounding area away from populated areas probably contains an interesting assemblage of wild mammals, reptile and avifauna among which are some protected species".

3.4.3 Terrestrial Fauna Survey March 2009

3.4.3.1 Introduction

The survey was undertaken over two periods each covering 5 days and covered the following taxa of animals: Avifauna (birds), large mammals, small mammals (including bats), and herpetofauna (amphibian and reptiles). The survey involved six study sites (Map 33.1).

3.4.3.2 Description of Survey Sites

The six study sites were as follows:

Site I

This site is situated near the old Abnabna pit (UTM: 0617012mN, 0650270mE). The old pit was half filled with water. The vegetation was mainly secondary regrowth comprising mainly of *Gleichenia linearis, Setaria sp* and *Alchornea cordifolia* plants in a marshy environment near a tributary of River Asuafu. The site also abounds with tall bamboo trees and "Galamse*y"* pits.

Site II

This site is located near the Fobinso North pit (UTM: 0617933mN, 0659451mE). The vegetation is of secondary growth of about 6-8 years old dominated by *Alchornea cordifolia.* There were few abandoned farms and a cocoa plantation nearby. The abandoned pit was full of water.

Site III

The site is near the Fetish pit (UTM: 0621929mN, 0657844mE). This site is an old pit that was reclaimed and re-vegetated with *Pachira insignis* an exotic plant species about 6-7 years old. The plantation was virtually a monoculture of *Pachira insignis* with no local plant species.

Site IV

This site is within the proposed tailings field (UTM: 0618812mN, 0659755mE). It is comprised largely of swampy areas interspersed with seemingly abandoned farmland on higher ground. The area is dominated by *Gleichenia linearis, Setaria sp, Alchornea cordifolia Pachira insignis* and *Roetbollia exalta* plant species. The hilly area is characterised by secondary re-growth of about 8-10 years old.

Site V

This site is within the proposed plant site area (UTM: 0618297mN, 0658204mE. This is the only area in the whole concession that harbours some representative forest plant species. The undergrowth of tall plant was very scanty with trees reaching about 50-60m high. There is also a cocoa plantation in this study site.

Site VI

This site is located within the Chirawewa pit complex (UTM: 0618310mN, 0658190mE). It is a reclaimed area re-vegetated with *Pachira insignis, Erythrophyllum guinneense* and other local plant species including *Alchornea cordifolia*. The area was noted to be a major galamsey zone and so highly degraded/

3.4.3.3 Survey Methodology

Larger mammals

Information on large mammals was obtained by direct observation and examination of spoor along trails and transect in various parts of the study area. The information was gathered during the day and at dusk and dawn. Additional information was obtained by interviewing hunters, bushmeat sellers and chop bar operators within the fringe communities (including Abnabna, Ayanfuri etc.) of the concession. Pictures in field guides (Happold, 1990, Booth, 1966, Meester and Seester, 1971) were shown to the local people to help in the identification of the mammals; it also gave the opportunity for others to corroborate or challenge the authenticity of the information given.

Rodents and other small mammals

In each of the six study sites 20 Sherman's (entrance size 9cm × 7cm) and Longworth's (entrance size 6cm × 5.3cm) live traps were alternately placed along 400 meter transects through representative habitat types at 10 meter intervals. Depending on the site, transects were passed through primary forest, secondary growths, abandoned farms and crop farms. All traps were pre-baited for one night followed by two nights trapping with bait made from maize (corn) powder and groundnut (peanut) paste. Traps were set in the evening (16:30 to 18:00 hrs UT) and inspected early in the morning (06:30 to 07:30 hrs UT). All captured animals were put in a large transparent polythene bag, identified, sexed and released.

Bats

Bat surveys were conducted during the night in each study site using one 12m mist net (height 2.6m with 4 shelves) per night. The net was erected across trails, adjacent to streams and edges of forests within the study site. The net was opened in the evenings (1800 to 1830 hrs UT) and collapsed early in the morning (0630 to 0730 hrs UT) after inspection. Captured bats were carefully removed from the net, identified, forearm length measured, sexed, reproductive condition noted, weighed and released. Bats caught during the first night of trapping were marked with a small amount of white cellulose paint on the inside of the wing patagum before release to avoid multiple counting (this method has been successfully used by the researcher on bats and Agama lizards).

Herpetofauna

Reptiles and amphibian surveys involved casual observations and refuge examination (i.e. searching under rocks, logs, in rotten tree stumps, in leaf litter, old termite mounds and rodent burrows). Some information was also obtained from the local people through interviews.

Avifauna

A bird survey was conducted using point counts and mist-netting. Direct observations including visual as well as vocal records were made to determine bird species occurrence. With the mist-netting, two standard 12m mist nets (height 2.6m with 4 shelves) were erected in each of the six study sites for one day (0600 to 1800 hrs UT). The nets were inspected every 30 minutes and all birds caught identified, recorded and released. Some information was also obtained from the local people.

Identification

Rosevear (1965 & 1969), Meester and Setzer (1971) and Happold and Happold (1990) were used for small mammal identification. Small mammal field handling techniques used were as outlined in Wilson et al. (1971). Nomenclature follows Wilson and Reeder (1993). For bird identification Serle et al (1982), Brown et al (1982), Urban et al (1986), Fry et al (1988) and Keith et al (1992) were used. For the herpetofauna the main references were Hughes (1988) and Schiotz (1967).

3.4.3.4 Results of the Surveys

Larger mammals

The number of large mammals recorded in the study area during the six surveys is twenty-eight (28) (Table 34.1). Out of the 28 species recorded twenty species were either sighted or their spoors scene or carcasses seen with hunters or chop bar operators. The presence of the other eight species was based mainly on interviews with hunters and other local inhabitants. Of the former 21 species, presence of three species in the study area was based on carcasses seen, information on thirteen on the remaining eighteen species obtained from spoors or sighting/hearings. Calls of the tree hyrax and footprints and feeding activities of the bush buck (*Tragilphus scriptus*) were noted.

Three of the mammals recorded in the study area are listed in the IUCN List of Threatened Species. These are the Diana monkey which is listed as 'vulnerable', and the bay duiker and Royal duiker that are listed as 'insufficiently known'. Six species (sport nosed monkey, black and white colobus, bush baby, Bossman's potto, white bellied pangolin, Pel's flying squirrels are listed in CITES (Convention on International Trade in Endangered Species). Seventeen of the species enjoyed full protection (Schedule 1) and eleven enjoyed partial protection (Schedule 2) in Ghana (Ghana Wildlife Conservation Regulations, 1995).

Assessment of relative abundance of each species is also shown in table 34.1. The various categories of abundance were determined as follows:

- **Quite common (++):** reported to be present by > 25% but <50% of interviewees and/or comprising <25% of animals seen dead or alive.
- **Fairly Common (+):** reported to have been seen by >10% but <25% of interviewees within the past one year.
- **Rare:** reported to have been seen by <10% of interviewees within the past one year.

Table 34.1: Large mammals recorded in the mining concession

Scientific Name	Common Name	Ghana Regs	A	B	C	D	Relative Abundance
Order Artiodactyla							
Cephalophus dorsalis	Bay duiker					X	++
Cehpalophus maxwell	Maxwell's duiker,		X		X	X	Rare
C. niger	Black duiker						Rare
Potamochoerus porcus	Red river hog			X		X	Rare
Neotragus pygmaeus	Royal duiker					X	Rare
Tragelapus scriptus	Bush buck		X				+
Order Primate							
Galagoides demidovi	Bush baby,		X			X	++
Galago senegalenses	Bosman's potto,		X			X	+
Cercopithecus petaurista	Spot-nosed monkey					X	Rare
Cercopthecus Diana	Diana monkey,					X	Rare
Order Pholidota							
Manis longicaudatus	Long tailed pangolin,	S1				X	+
Manis triscuspis	White tailed pangolin		X		X	X	+
Order Canivora							
Genetta maculate	Forest genet,	S1	X			X	+
Nandinia binotata	Palm civet,	S1				X	+
Atilax paludinosus	Marsh mongoose	S2	X			X	++
Vivera civetta	African civet	S1	X			X	+
Herpestes sanguinus	Dwarf mongoose	S2	X			X	++
Mungos gambianus	Gambian mongoose	S2	X			X	+
Order Hyracoidae							
Dendrohyrax arboreus	Tree hyrax	S1	X			X	+
Order Rodentia							
Anomalurops beecrofti	Beecroft's flying squirrel,	S1				X	+
Anomalurus durbianus	Derby flying squirrel	S1	X			X	+
Anomalurus pelli	Pel's flying squirrel	S1	X		X	X	+
Idiurus sp.	Red side- Striped squirrel	S1	X			X	+
Atherurus Africana	Brush-tailed porcupine	S1		X	X	X	Rare
Protoxerus strageri	Giant forest squirrel,		X			X	+
Euxerus erythropus	Ground squirrel		X			X	++
Tryonomys swinerianus	Grasscutter		X	X			++
Cricetomys gambianus	Giant rat		X			X	++

X=; **S1** = 1st schedule of Ghana Wildlife Conservation Regulations, **S2** = 2nd schedule of Ghana Wildlife Conservation Regulation; A: observed alive during survey; **B:** Tracks, faeces, and other spoors seen; **C:** carcasses seen in chop bars, with hunters and sellers; **D:** Reported to occur in interviews *****Relative Abundance ranges from Quite common (**++**) to **rare**)

Small terrestrial mammals

The catch was very poor for small terrestrial mammals. Only one individual *Proamys tullbergi* was caught during the six nights trapping at the six study sites (Table 34.2). The effort thus produced a catch rate of $8.0x10^{-3}$ rats per trap night. In Ghana terrestrial mammals are known to thrive better in disturbed habitats (Yeboah, 2004) but this seems to be true when the area is cultivated with crops that could be useful to the animals. Apparently when the earlier miners vacated the concession the farmers did not take advantage of the area.

Table 34.2: Small Terrestrial Mammals Recorded at the Six Study Locations

		Sites Identification						
Scientific Name	**Common Name**	**I**	**II**	**III**	**IV**	**V**	**VI**	**Total**
Proamys tullbergi		**0**	**0**	**0**	**0**	**0**	**1**	**1**

Bats

The presence of bats in the area was fairly good although only two species of Ghana's megachiropteran bats were caught. These were Epomops (*Epomops franqueti*) and Epomorphorus *(Epomorphorus gambianus)* (Table 34.3).

For uniformity and need for standardization of numbers, all bats caught in each study site were converted to numbers per mist net nights (no./mnn) which is defined as number caught per 100m mist net per night and is estimated as follows:

$$\frac{\text{Total numbers caught}}{\text{Number of nights}} \quad X \quad \frac{100}{\text{Total net length}}$$

Epomops franqueti was caught at a rate of 3.5mnn and *Epomorphorus gambianus at* 6.0mnn indicating that there were more Epomorphorus than Epomops in the area. Most of the catches were made at site 5, the proposed plant site, which had not been disturbed by previous mining activities. It is covered by good cocoa farm of about 18-20 years old interspersed with remnant secondary forest.

Table 34.3: Bat Species and Numbers Caught in the Study Area

		SITES						
Scientific Name	**Common Name**	**I**	**II**	**III**	**IV**	**V**	**VI**	**Total**
Megachiroptera								
Epomorphorus gambianus	*Epomorphorus*	**2**	**0**	**5**	**9**	**11**	**0**	**27(6.0)**
Epomops franqueti	*Epomops*	**1**	**0**	**3**	**5**	**7**	**0**	**16(3.5)**
Figures in brackets are numbers per 100m mist net night (N/mnn))								

Herpetofauna

The herpetofauna (amphibian and reptiles) recorded in the study area are shown in table 3.4.4. The number of species recorded in the six surveys was seven reptiles and three amphibia. While all the amphibian were seen in the field two of species of reptiles (Gaboon viper and Chameleon) were not seen but reported to be present by local inhabitants. One of the reptilian species (Chameleon) is listed in CITES Appendix II. The commonest venomous snakes recorded in the area were green mamba and black cobra.
Afrixalus dorsalis is widely distributed and common in bush land localities in the West African forest belt and in forest outliers in the humid savanna.

Table 34.4: The Herpetofauna Recorded in or Around the Study Sites		
Scientific Name	**Common Name**	**Conservation Importance**
REPTILES		
Dendroaspis viridis	Green mamba	
Bitis gabonicus	Gaboon viper*	
A. sylvanus	Forest agama	
Mabuya affinis	Common skink	
M. bladingi	Yellow-flanked skink	
M. perotitti	Orange-flanked skink	
Chameleo gracilis	Chameleon*	CITES II
AMPHIBIA		
Bufo regularis	Common toad	
Rana galamensis	Common frog	
Afrixalus dorsalis	Striped spiny reed frog	
***Species reported to occur in the area by local inhabitants**		

Avifauna

A total of 73 species of birds belonging to 26 families were caught during the surveys (Table 34.5). Out of this number, 25 species were caught in mist nets. One dry season or savanna migrant (white-throated bee eater, (*Merops albicollis*) was recorded. In addition to this, three of the species are "Biome Restricted" (ie. Restricted to the Guinea-Congo Forest Biome) and are therefore of global conservation concern. These are the speckled tinker bird (*Pogoniulus scolopaceus*), pied hornbill (*Tockus fasciatus semifasciatus*) and the black-throated coucal (*Centropus leucogaster*).

3.4.4 DISCUSSION

The fauna of the concession is generally very poor due to past farming, hunting, logging, mining (large and small-scale) disturbances and current activities from mining exploration, chain saw operators and local hunting. The survey did not record any species animal of special conservation concern that could that may preclude mining activities in the study area.

In the case of large mammals the damage to the area principally resulted from noisy mining equipment and later chain saw operators that have driven animals like monkeys away. Animals that depend on green vegetation such as Maxwell's duiker are still present as discovered in the study.

Apart from birds, the fauna of the Central Ashanti Gold concession area is generally very poor. In all except the 6th study site no small terrestrial mammals were caught. The low catch of these animals may be attributed to the large scale of disturbance to the environment caused by the previous mining company in the immediate past.

Apart from the physical disturbance to the environment no farming was allowed in the area. The re-vegetation of the area has not been attractive enough to enable re-colonization by most fauna. No food crops are available for such animals to feed on. The vegetation at the moment, although some may be useful to the animals, most have not yet reach fruiting or seeding stages to serve as food for the animals.

Concerning the few bats that were recorded in the concession it is interesting to note that they were caught in areas where there were tall trees like bamboos and the exotic plant species *Pachira insignis.* At the time of visit the exotic plant was not fruiting so whether it is capable of supporting a wide range of animals cannot be ascertained. Although these exotic species provided cover for the bare soil and shelter for some bats it is suggested that mixed tree species plantation of native flora encouraged in such reclamation exercises to bring about greater diversity of fauna since native fauna will best associate with native flora.

Table 34.5: Bird Species Recorded in the Project Area

Scientific Name	Common Name	SITES						
Family Musophagidae		**I**	**II**	**III**	**IV**	**V**	**VI**	**BR**
Crinifer piscator	Western grey plantain eater	x				x		
Tauraco persa	Green Crested Turaco					x		
Family Phasianidae								
Francolinus ahantensis	Ahata francolin	x	x		x			
Family Capitonidae								
Pogoniulus scolopaceous	Speckled tinker bird	x	x			x		+
*Lybius vieilloti**	Vieillot's barbet		x					
*Gymnobucco calvus**	Naked-faced barbet	x	x	x		x		
*Pogoniulus chrysoconus**	Yellow-fronted tinker bird	x	x	x		x		
Trachiphonis purpulatus	Yellow-billed barbet	x	x				x	
*P. bilineatus**	Yellow-rumped tinker bird	x						
P. atroflavus	Red-rumped tinker bird	x	x	x		x		
Family Cuculidae								
Centropus leucogaster	Black-throated coucal	x	x			x		+
Chrysococcyx klass	Klass cuockoo	x	x			x		
C. cupreus	Emerald cuckoo	x				x		
C. senegalensis	Senegal coucal	x	x		x	x		
Chrysococcyx caprius	Didric cuckoo	x	x					
Family Falconidae								
Falco naumanni	Lesser falcon					x	x	
Family Pycnonotidae								
*Andropadus virens**	Little greenbul	x	x	x		x		
B. canicapilla	Grey-headed bristle-bill					x		
*Pyconotus barbatus**	Common garden bulbul	x	x	x	x	x	x	
*Andropadus gracilirostris**	Slender-billed greenbul		x			x		
*A. curvirostris**	Cameroun somber greenbul	x	x					
A. latirostris	Yellow-whisked greenbul	x	x	x	x	x		
Thescarocechla leucopleurus	Swamp palm greenbul					x		
*Baeonogon indicator**	Honey guide bulbul		x					
Family Corvudae								
Corvus albus	Pied crow	x	x	x	x	x	x	
Family Bucerotidae								
*Tockus faciatus**	African pied hornbill	x	x	x	x	x	x	+
Family Apodidae								
Apus afinis	Little African Swift	x						
Family Ploceidae								
*P. nigerimus castaneofuscus**	Vieillot's black weaver	x	x					
*P cuculatus**	Village weaver	x	x	x	x	x	x	
P. nigricollis	Black-necked weaver				x			
*Vidua macrura**	Pin tailed whydah	x	x	x	x	x		
Family Estridadae								
*Niger canicapilla**	Grey-crowned negro-finch	x		x		x	x	
*Lochura cuculata**	Bronze manikin	x	x		x	x		
L. frugilloides	Magpie manikin	x			x	x		
Family Nectarinidae								
*N. olivacea**	Olive sunbird	x				x	x	
N. supperba	Superb sunbird	x						
Cinnyris cupreus	Copper sunbird		x					
N. senegalenses	Scarlet-breasted sunbird	x	x				x	

*N. adelberii***	Buff-throated sunbird					x		
Hedydipna collaris	Collared sunbird					x		
Family Acipitridae								
Polyboroides rasians	African Harrier hawk	x						
Milvus nigrans	Black kite	x	x	x	x	x	x	
Nephon monachus	Hooded vulture	x	x					
Haliaeetus vocifer	African fish eagle		x					
Gypohierax angolensis	Palm nut Vulture		x					
Family Acedinidae								
*H. senegalensis**	Woodland kingfisher	x	x		x	x	x	
*Ceyx picta**	Pygmy kingfisher	x	x		x	x		
*Alcedo cristata**	Malachite kingfisher		x					
Family Sylviidae								
Camaroptera brachura	Grey-backed camaroptera	x				x	x	
C. superciliarus	Yellow-browned camaroptera					x		
Hylia prasina	Green hylia	x	x			x		
Family Oreolidae								
Oriolus brachyrhynchus	Western Black-headed oriole	x				x		
Family Columbidae								
Teron australis	Green fruit pigeon	x						
T. tympanistra	Tambourine dove						x	
T. brechmeri	Blue-headed wood dove		x					
Streptopedia semitorquata	Red-eyed dove	x	x			x		
S. decipiens	Mourning dove					x		
Family Didruridae								
*Dicrurus modestus**	Velvet-mantled drongo	x	x				x	
Family Hirundinidae								
Hirundo nogrita	White-throated blue swallow	x						
*Hirundo rustica**	Barn's swallow	x	x				x	
Hirundo abyssinica	Lesser-stripped swallow	x	x					
Delichon urbica	Common house martin	x	x					
Family Adeidae								
Egretta alba	Great egret	x	x					
Egretta intermedia	Intermediate egret	x	x					
Egretta gularis	Western Reef Egret		x					
Bubulcus ibis	Cattle egret	x	x					
Family Struthionidae								
Family sturnidae								
Lamprothornis spledidus	Splendid glossy starling		x					
Family Jacanidae								
Actophilornus africana	African Jacana	x	x					
Family Rallidae								
Amaurornis flavirostris	Black crake	x	x					
Family Scolopacidae								
Calidris fuscicollis	White-Rumped sandpiper	x	x					
Family Meropidae								
*Merops pusillus**	Little Bee-eater	x	x		x	x		
*Merops albicollis**	White-throated Bee-eater	x	x	x	x			
X Bird encountered in the sites; *Birds caught in the mist nets; + Biome restricted species (BR=Biome Restricted Species)								

The presence of *Afrixalus dorsalis*, a very sensitive species to pollution in the concession is an indication that the study area did not face serious water pollution in the past. It is hoped that conditions will be further maintained to avoid the disappearance of these species from the area.

As stated earlier the avifauna, especially water birds was quite good. However it is important to think about where all these birds will go or what happens to them after mining in the concession resumes. Most of the birds use the water that filled uncovered old pits and their surroundings for wetland resources. We were informed that the Fetish pits will not be re-mined. If that is true then it is likely most birds in the area will move to this side in addition to Subriku dam area in Ayanfuri German about 3-4km from the concession. We hope management will stick to that laudable idea. Thus although some biome restricted bird species and birds of local conservation interest were found in the study area, other similar habitats exist immediately out site the concession for their survival.

3.4.5 REFERENCES

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3.5 SOILS OF THE PROJECT AREA

3.5.1 Introduction

This section presents the findings of a survey of the soils of the proposed CAGL Project area and its immediate surrounds. The objectives were to map the soil resources of the area, describe and evaluate them for rain fed agricultural production, for the suitability of the soils to be used for reclamation and to map out the various vegetation and land use units within the Project area.

3.5.2 Objectives

The objectives were to map the soil resources of the area, describe and evaluate them for rainfed agricultural production and the suitability of the soil materials for reclamation and to map out the various vegetation and land use units within the concession.

3.5.3 Methodology

A detailed soil survey was employed to identify and describe the soils at the series level. Soil identification was recorded with the aid of GPS at 40 m interval on existing cut lines (traverses), roads and foot paths. The soil series identified followed the same trend, i.e. well drained soils of *Bekwai series* on summit to upper slope sites and *Nzima series* on upper to middle slope sites, moderately well drained *Kokofu series* on lower slope sites and poorly drained *Kakum, Oda, Temang series* in the valley bottoms.

Three profile pits representing the dominant soils i.e. *Bekwai, Nzima and Kokofu series* were dug and described according to FAO 2006 guidelines for soil description (Appendix 3.5.6).

The GPS points were plotted and overlaid on a geo-referenced (hypso) contour and hydro layers of the area which served as the base map. The boundaries between the soil units were drawn by interpolation taking the hypso and hydro layers into account. The valley bottom soils were mapped together as one complex unit due to their spatial occurrence in the valleys.

3.5.4 Geology

The area is underlain by Lower Birrimian Formation which consists mostly of phyllite, greywackes and schists. These were laid down in early geological times and consist mainly of clay deposits which have subsequently been hardened and altered. A cross section of the hills along the roads reveals the presence of an uneven distribution of quartz veins injected into the phyllites which break up on weathering to give rise to stones and gravel.

3.5.5 Topography

The topography of the area varies from gently undulating to hilly. There are moderately high-elevated lands with lowlands and valleys lying between them. The highlands are plateau, trending in different directions, with flat tops and amorphous shapes.

There are rivers and streams draining through the valleys; those that streams. Those that drain northwards are tributaries of the Ofin River. Those that flow southeast eventually enter the Ankobra River.

3.5.6 Soil Resources

The soils belong to the Bekwai-Nzima/Oda compound association. On a typical toposequence, *Bekwai series* occupies the summit and upper slope sites followed by Nzima *series* on the upper to middle slopes, whiles Kokofu *series* follows on the middle to lower slope sites. The narrow valley bottoms are occupied by alluvial soils of *Oda, Kakum* and *Temang series*. Both *Bekwai and Nzima series* are developed in-situ whereas *Kokofu series* is a colluvial material from slope wash.

On the summit and upper slope sites the soils are deeply weathered, with strong brown to yellowish brown top soil grading into dark red to red for *Bekwai series* and yellowish brown to yellowish red for *Nzima series* in the sub soil. They are well drained with few angular quartz gravel and common manganese dioxide concretions below the top soil. The colluvial middle to lower slope soils are also very deep, imperfectly drained, yellowish brown top soil over strong brown to brownish yellow sub soil free from gravel and concretions.

The valley bottom soils are deep, grey to yellowish brown, mottled, imperfectly to poorly drained with varying texture from sandy loam to sandy clay loam.

3.5.7 Short Description of Soil Series

A short description of the various soils series is presented below. A detailed description based on the FAO classification is presented in Appendix 3.5.7. The distribution of the various soil series in the Project area is shown in Map 35.1. The classification and assessment of the agricultural and other use capabilities is described in Section 3.6.

Bekwai series (Ferric Acrisol)

These are soils occupying the summit and upper slope sites of the hills of the area. They are deep (over 150 cm), well drained, strong brown grading to yellowish red and finally dark red to red colour, concretionary and gravely, loam to clay in texture. They have well developed sub angular blocky structure and illuvial clay accumulation in the sub soils. They are acidic in reaction throughout their profiles.

Their profiles have thin topsoil of up to 9 cm thick with dark brown or strong brown colour, loam to clay loam textures, weak fine crumb structure and a moderately acid reaction. The top soils are usually separated from the sub soils by a thin transitional horizon. The sub soils are thick, strong brown to yellowish red colour, clay texture, moderate fine to strong medium sub angular blocky structure, gravely and concretionary, acidic in reaction and with illuvial clay accumulation (Argic B horizons). At the base of the profiles are bright reddish-yellow to dark red silty clay loam horizons with fragments of decomposed parent rock overlying soft saprolite.

Nzima Series (Ferric Acrisol)

These soils are developed on upper and middle slope sites and sometimes on low summits. They are deeply weathered, well to moderately well drained, dark yellowish-brown to reddish yellow in colour, concretionary and gravely, loam to clay in texture with well developed sub angular blocky structure and illuvial clay accumulated in the sub soils. These soils are acidic throughout their profiles.

The top soils are of thickness up to 10cm, dark yellowish brown in colour, sandy loam to clay loam in texture, weak fine to medium crumbs, with slightly acid reaction. The thick sub soils are yellowish-brown to strong brown in colour, clay loam to clay textures, weak fine to strong coarse sub angular blocky structure, gravely and concretionary, strongly acid in reaction with illuvial clay accumulation.

Kokofu Series (Haplic Acrisol)

The soils are developed on middle to lower slope sites usually below *Nzima series*. They develop over colluvial materials from upslope wash. They are very deep (over 200cm), moderately well to imperfectly drained, non-concretionary, brown to brownish-yellow in colour with loam to clay textures, weak fine to strong coarse sub angular blocky structures and acidic in reaction.

A typical profile consists of up to 8cm of dark yellowish brown, friable, weak fine crumbs, loam topsoil. This is underlain by up to 6cm of thick yellowish brown, loamy transitional horizon. The subsoil is over 160cm thick, yellowish-brown to brownish-yellow, clay with moderate medium to strong coarse sub angular blocky structure and acidic in reaction.

Kakum series (Dystric Cambisol)

These are soils developed from colluvial sediments within depressions and wide valleys. They are young soils with little profile development but are very deep, imperfectly drained and may be flooded during prolonged wet seasons. The soils have silty clay to sandy clay loam textures and are acidic in reaction. There are frequent quartz gravels within the sub soils.

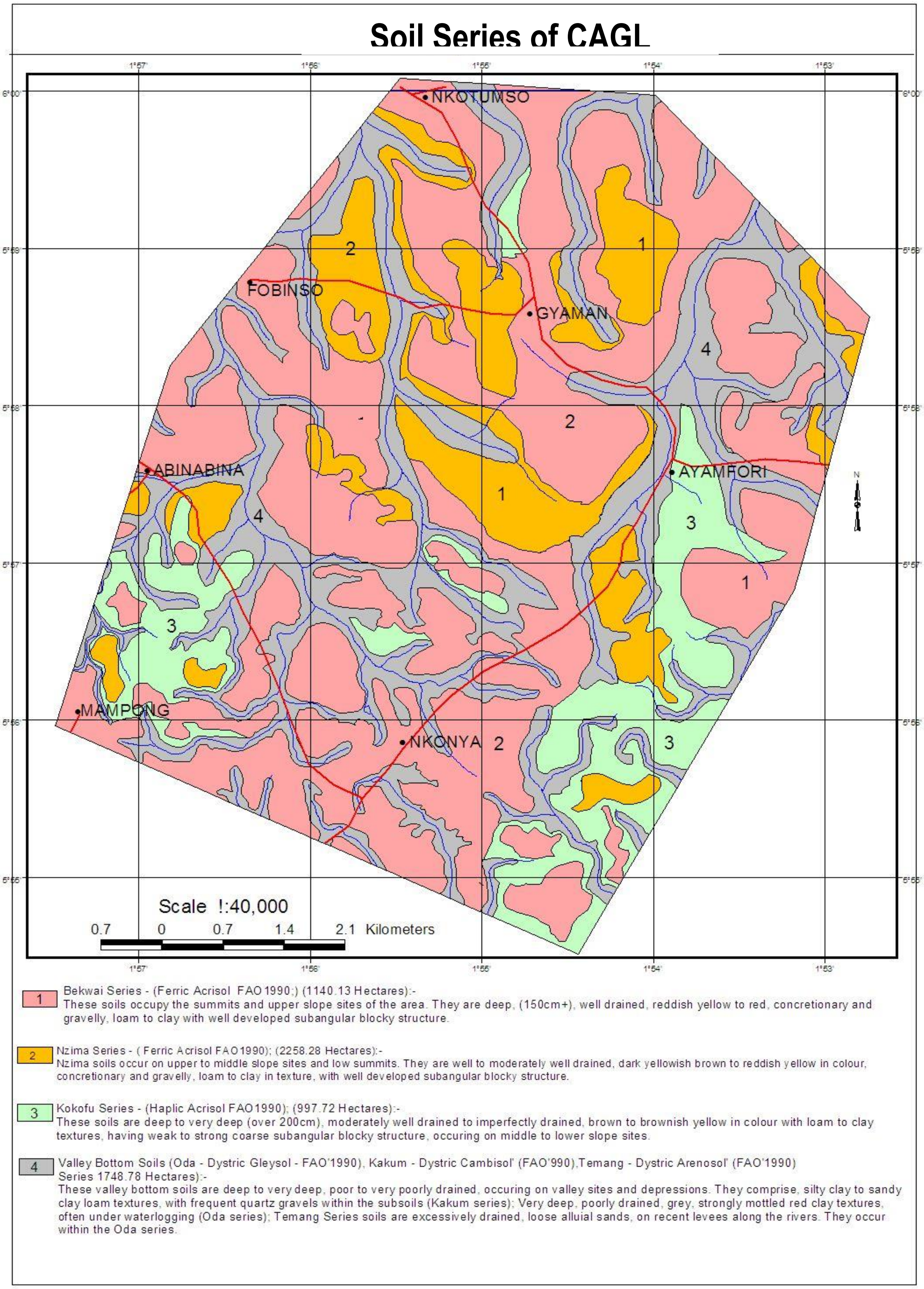
They have thick humus-rich top soils with dark brown colour, friable weak medium crumb structure and sandy loam to clay loam textures. The thick sub soils are yellowish-brown to reddish-yellow in colour with distinct mottles, weak medium sub angular blocky, with frequent quartz gravels and sandy clay loam to silty clay textures.

Oda series (Dystric Gleysol)

These are heavy-textured soils developed from alluvial deposits along streams and rivers. The soils are poorly drained, greyish in colour, strongly mottled with clay loam to clay textures. They become waterlogged or saturated for most pails of the year. These soils have an AC horizon. The subs soils are deep, structureless, with occasional quartz gravel, grey in colour with distinct mottles. The water table is close to the soil surface.

Temang series (Gleyic Arenosol)

These soils are very porous, loose and excessively drained alluvial sands found on recent levees of the streams. They are limited in extent, occurring within Oda *series*. The top soils, which show little development, are dark brown with sandy loam to loamy sand textures and weak fine crumb structure. The sub soils are grey, mottled, with fine sand texture throughout the profile.



Map 35.1: Distribution of Soil Series in CAGL Project Area

3.6 THE LAND USE OF THE PROJECT AREA

3.6.1 Introduction

This chapter describes the land use survey of the Project area. It was undertaken in conjunction with the described soil series survey.

3.6.2 Objective of the Survey

The objective if the survey was a land use/cover assessment describing the various vegetation units and their distribution. This information will be used for 1) an assessment of the potential impact of project development and operations on land use and 2) assist in the development of sustainable land use systems for local communities during and after operations.

3.6.3 Survey Methodology

Field work was undertaken in April 2009 following first rains of the year. Fieldwork was preceded by the desktop activities that provided information for the field activities. The satellite data was enhanced to identify existing land-use/cover types in the area. A digital copy of the 1990 topographical map, at the scale of 1: 50000, of Ghana was procured. A Digital Elevation Model (DEM) was derived from 50ft interval contours to represent the topography of the area. Coordinates of specific locations and features were identified and entered in a Garmin GPS receiver, and used to direct navigation to these locations for close observation in the field.

Transects, tracks, paths and roads were used to access these features and locations of land-based activities. These were photographed, geo-located, and descriptively annotated. Plant species of economic and ecological importance, as well as indicators of specific vegetation-dominated cover types were identified. All the settlements were visited. The names of identified water bodies were enquired from the natives of the settlements. There were limited interactions with some natives encountered in the field.

3.6.4 Classification of Land Use/Land Cover Types

The generation of the scheme was based on the spectral information of the satellite data, and the ground truth information. There was a stepwise process of defining the classes, i.e., several classes were initially generated, but closely related ones were subsequently merged. The classification was also based on the purpose of the information output and the scale of information generation. Many of the main land-use/cover categories were classified to two levels. The natures of most of the land-use/cover types in the area were fully ascertained. These included:

1. *Forest types*- both naturally regenerated secondary forest and cultivated tree plantations;
2. *Cash crop plantation*- including predominantly cocoa, oil palm, citrus and to a limited extent rubber.
3. *Mixed annual cropping* – mostly cassava, plantain, maize.
4. *Settlements* - (including hamlets).
5. Some sites of active *galamsey* operations *etc.*
6. *Mining (formal and informal)*

The classification scheme for land use and land cover is presented in table 36.1. Effort was made to differentiate, especially, closely related forms of the same land-use/cover types to ensure the design of an effective classification scheme. Information on land cover types were collected in the form of photographs and textual descriptions. Location information was secured. The extent of physical disturbance by land uses such as farming and mining were observed.

Table 36.1: Classification Scheme for Land Use and Land Cover	
A	**Forest**
	Closed forest (CF) (canopy>60%)
	Moderate to opened forest/tree crops (MOFC) (Less than 60%, greater than 35%)
B	**Thicket/Tree crops (TT)**
C	**Tree/Palm plantation**
D	**Cultivated/Arable Lands**
	Fallows with isolated/treeless fallow
	Current cultivation (CC)
E	**Exposed/Degraded land (ED)**
F	Water Bodies (WB)
	Rivers and Streams
	Mine Pits/Ponds
G	**Settlements**
	Towns/Hamlet
H	**Roads**
	Second class Roads
	Third class Roads
	Tracks

3.6.5 Forest vegetation cover

3.6.5.1 Closed Forest (CF) (canopy>60%)

These are secondary deciduous forest formations with canopy cover greater than sixty percent (60%). These essentially are not cultivated and do not occur on an extensive scale: they may have some disturbances in limited locations, but these were not considered in the classification. They are restricted to inaccessible areas such as steep slopes, higher elevations and riverine areas (Photo 3.6.1).

Photo 3.6.1

3.6.5.2 Opened forest-Cocoa (MOFC) (Less than 60%, greater than 30%)

These are secondly forest formations with moderate to more opened fragmentations. Depending on the extent of disturbances, the canopy cover could range from 30-60%, and may have some amount of cocoa farms.

3.6.5.3 Thicket/Cocoa (TC)

Thickets are matured fallows with young trees, some of which are about 15-20 m high with climbers and thorny bushes, which have very dense undergrowth, rendering them virtually impenetrable (Photo 3.6.2). Relics of cocoa trees are indications of abandoned or unkempt cocoa farms. That explains their inclusion in the same class.

Photo 3.6.2

3.6.5.4 Tree/Palm Plantation (T/PP)

Tree plantations are scattered in the area, specifically planted to rehabilitate the degraded lands by previous mining activities (Photo 3.6.3). Most of these have been successfully regenerated into matured trees.

Photo 3.6.3

3.6.5.5 Cultivated/Arable Lands (CAL)

These are farm lands which are either under current cultivation or fallow fields, not up to the maturity of thickets. These may be long fallows/bushes, matured mixed annual crops, or currently cultivated lands. The actively cropped areas may have annual crops, usually cassava and plantain. The fallows may be of different height and density dependent on age. These are three classes under this category.

3.6.5.6 Current Cultivation (CC)

These are currently cleared cultivated farmed lands awaiting planting (Photo 3.6.4).

Photo 3.6.4

3.6.5.7 Bush Fallow fields/Annual Crops (BFAC)

These are fields left unattended with relics of previous planted crops (Photo 3.6.5).

Photo 3.6.5

3.6.5.8 Exposed/Degraded land (ED)

These are essentially areas that have been previously mined and denuded of vegetation (Photo 3.6.6). They are mostly associated with mined pits or tailings and *galamsey* operations.

Photo 3.6.6

3.6.5.9 Water Bodies (WB)

A number of water bodies occur within the Project area primarily as a result of past mining activities. (Photo 3.6.7).

Photo 3.6.7

3.6.5.10 Settlements Villages and Hamlets

These are built-up areas for human habitation (Photo 3.6.8).

Photo 3.6.8

The overall distribution of the various land classification types is presented in Map 36.1.

3.6.6 LAND SUITABILITY EVALUATION

The land suitability evaluation method applied in this report is the approach of the FAO framework for land evaluation (1976), using the guidelines of Sys et al, (1993).

The following suitability classes were used:

S1: Highly suitable (No constraints on land and climate, therefore expected yield is 80-100% of maximum attainable yield),

S2: Suitable (Some level of constraints either due to climatic or land quality. Expected yield is put at 60-80% of maximum attainable yield).

S3: Moderately suitable (Severe constrain due to either or both land quality and climate factors. Expected yield is about 40-60% of maximum attainable yield).

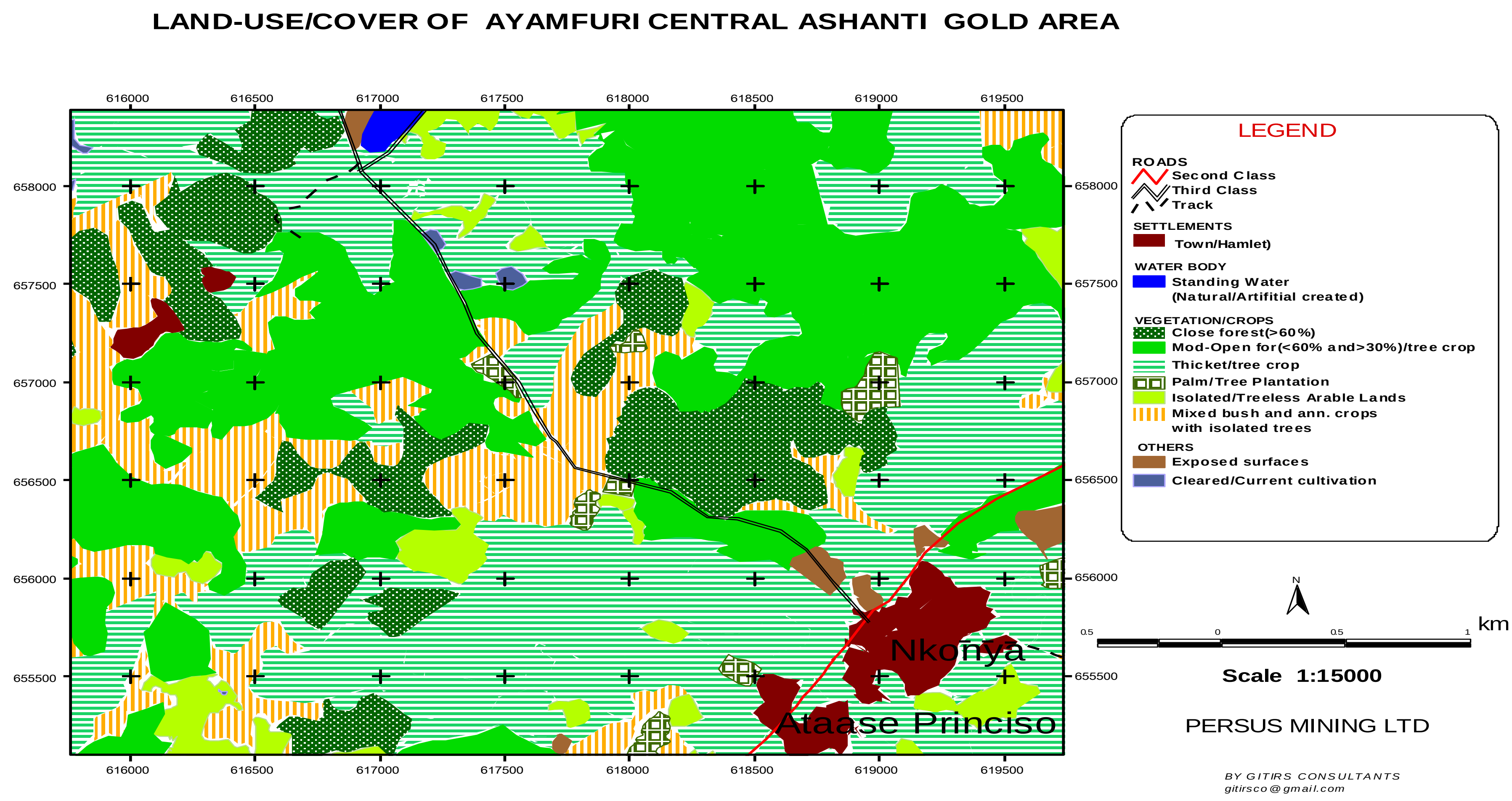
N1: Actually unsuitable but potentially suitable (Very severe constraints due to both climate and land quality which can be corrected to some extent. Expected yield is between 20-40% of maximum attainable yield).

N2: Permanently Not suitable (Very severe constraints which cannot be corrected).

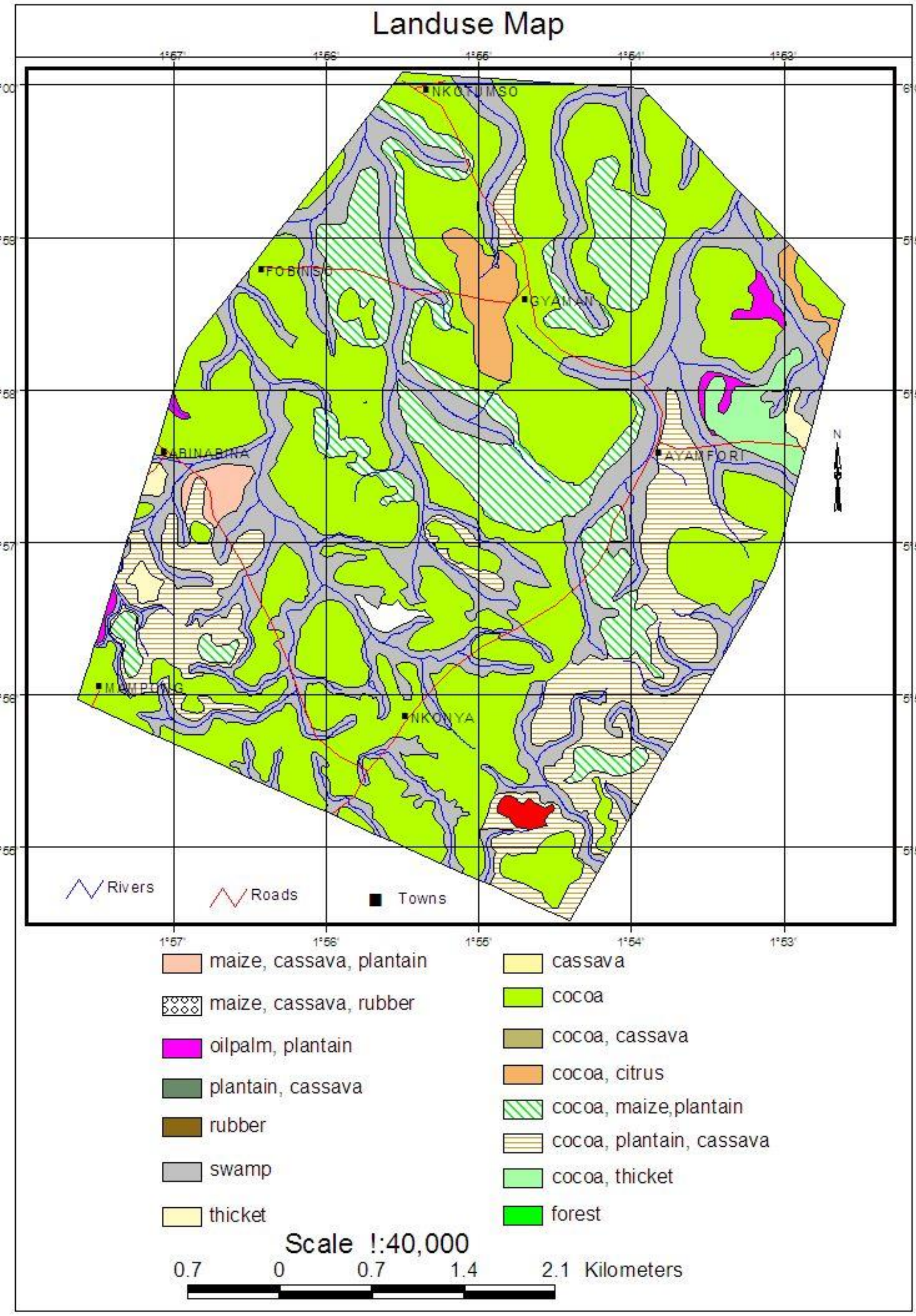
The suitability sub classes which define the types of limitation or improvement measures are as follows:

c:	climate.	n:	salinity/alkalinity.
t:	topography.	f:	fertility.
w:	wetness.	s:	physical.

Land suitability evaluation was performed for some selected crops (cocoa, oil palm, citrus, maize, plantain, cassava, rice, sugarcane, eggplant and okra) grown in the area. The crop growth and production requirements were 'matched' against soil and landscape characteristics of the area. A map showing the distribution of agricultural land use capability is presented below (Map 36.2). A detailed analysis of agricultural land use capability according to the soil series capability is presented in Tables 2a–2f).



Map 36.1: Land Use – Land Cover in the CAGL Project Area



Map 36.2: Agricultural Land Use Capability in the CAGL Project Area

Table 36.2a: Soil suitability assessment matrix (cocoa)

Soil series	Slope	Wetness		Depth	Particle size		Soil fertility			
		Drainage	Flooding		Texture	Gravel	pH	Org. carbon	CEC	Suit. rating
Bekawi	S1	S1	S1	S1	S1	S1	S2	S1	S2	S2f
Nzima	S1	S1	S1	S1	S1	S1	S2	S1	S2	S2f
Kokofu	S1	S1	S1	S1	S1	S1	S2	S1	S2	S2f
Oda/ Kakum/Temang	S1	S2/N1	N1	S1	S1/S3	S1	S2	S2	S2	N1wf

Table 36.2b: Soil suitability assessment matrix (oil palm)

Soil series	Slope	Wetness		Depth	Particle size		Soil fertility			
		Drainage	Flooding		Texture	Gravel	pH	Org. carbon	CEC	Suit rating
Bekawi	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nzima	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Kokofu	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Oda/ Kakum/Temang	S1	S3	N1	S1	S1/S3	S1	S1	S2	S1	N1wtf

Table 36.2c: Soil suitability assessment matrix (citrus)

Soil series	Slope	Wetness		Depth	Particle size		Soil fertility			
		Drainage	Flooding		Texture	Gravel	pH	Org. carbon	CEC	Suit. rating
Bekawi	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nzima	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Kokofu	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Oda/ Kakum/Temang	S1	N1	N1	S1	S1/S3	S1	S2	S2	S3	N1wtf

Table 36.2d: Soil suitability assessment matrix (maize, cassava, plantain)

Soil series	Slope	Wetness		Depth	Particle size		Soil fertility			
		Drainage	Flooding		Texture	Gravel	pH	Org. carbon	CEC	Suit. Ratin g
Bekawi	S1	S1	S1	S1	S1	S1	S2	S1	S2	S2f
Nzima	S1	S1	S1	S1	S1	S1	S2	S1	S2	S2f
Kokofu	S1	S1	S1	S1	S1	S1	S2	S1	S2	S2f
Oda/ Kakum/Temang	S1	S3	N1	S1	S1/S3	S1	S2	S2	S2	N1wtf

Table 36.2e: Soil suitability assessment matrix (vegetables - garden eggs, okra)

Soil series	Slope	Wetness		Depth	Particle size		Soil fertility			
		Drainage	Flooding		Texture	Gravel	pH	Org. carbon	CEC	Suit. Ratin g
Bekawi	S2	S1	S1	S1	S1	S1	S2	S1	S2	S2f
Nzima	S2	S1	S1	S1	S1	S1	S2	S1	S2	S2f
Kokofu	S2	S1	S1	S1	S1	S1	S2	S1	S2	S2f
Oda/ Kakum/Temang	S1	S1	S3	S1	S1/S3	S1	S2	S2	S2	S2/S3 tf

Table 36.2f: Soil suitability assessment matrix (rice, sugarcane)

Soil series	Slope	Wetness		Depth	Particle size		Soil fertility			
		Drainage	Flooding		Texture	Gravel	pH	Org. carbon	CEC	Suit. Class
Bekawi	S2	N1	N1	S1	S1	S1	S2	S1	S2	N1swf
Nzima	S2	N1	N1	S1	S1	S1	S2	S1	S2	N1swf
Kokofu	S1	S1	S2	S1	S1	S1	S2	S1	S2	S2wf
Oda/ Kakum/Temang	S1	S1	S3	S1	S1/S3	S1	S2	S2	S2	S3wtf

3.7 SOCIOECONOMIC SURVEY OF ADMINISTRATIVE DISTRICTS

3.7.1 Format of the Socio-economic Survey

This section provides a socio-economic baseline survey of the Project area which is located partly in the Wassa Amenfi East District of the Western Region of Ghana and partly in the Upper Denkyira District[1] of the Central Region of Ghana. A detailed socio-economic survey of the two Administrative Districts and the immediate area around the proposed development was undertaken. Information on such topics as political administration, revenue sources, local economy and development, industry, banking services, health, education, water and sanitation among others is presented[2].

3.7.2 Wassa Amenfi East District

3.7.2.1 *General*

The Wassa Amenfi East District (WAED) is one of the 28 newly created Districts. Carved out of the former Wassa Amenfi District Assembly, the District was established by a legislative instrument, L I 1788 and was inaugurated on 27 August 2004. It has Wassa Akropong as its District capital (Map 37.1). Typical of most of the newly created Districts WAED is predominantly rural, with only eight percent (8%) of the population living in urban areas. Indeed the Ministry of Local Government and Rural Development has classified the Wassa Amenfi East District as one of the most depressed and disadvantaged Districts in Ghana

The District is located in the middle part of the Western Region of Ghana. It lies between latitudes 5, 30` N, 6, 15` N, longitudes 1, 45` W, and 2, 11` W. It has an estimated total land area of about 16000 square kilometers; about 8% of the size of the region. It is bounded to the west by Wassa Amenfi West; to the East by Mpohor Wassa East, to the North by Upper and Lower Denkyira and to the south by Wassa West District.

3.7.2.2 *Governance within the District*

The District Chief Executive (DCE) is the most senior Government official within the District. The DCE is appointed by the President of the Republic of Ghana, and approved by two thirds of the members of the District Assembly present and by voting. The local civil service is headed by the District Co-ordinating Director (DCD). The District Assembly comprises 15 appointed and 30 elected members.

3.7.2.3 *Political*

The Assembly is the highest political administrative authority within the District and its mandate is to provide prudent management of the District and oversee the overall development of the District. The Assembly has one (1) Town Council and six (6) Area Councils, one hundred and fifteen (115) Unit Committees and one political constituency (the Amenfi East Constituency).

The Member of Parliament in the District is an ex-officio member. A Presiding Member elected from among their rank, chairs the Assembly.

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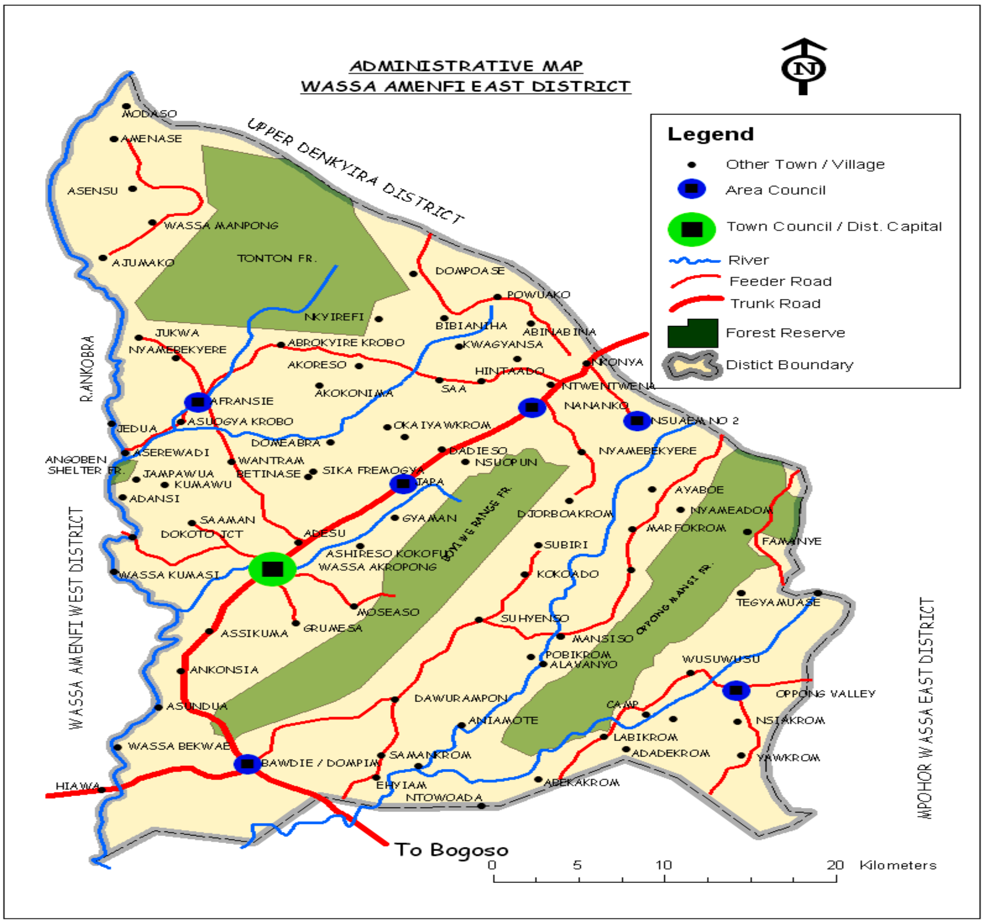
[1] See footnote on page 3.97

[2] Information for this chapter was obtained through direct interviews and document supply from the District Planning Officer, District Agriculture Officer and Disrict Education Officer, Upper Denkyira District – District Chief Executive, Upper Denkyira West District – The Medical Officer, Ayanfuri Health Centre – District Planning Officer and District Health Director, Wassa Amenfi East District.



Map 37.1: Administrative Map of the Wassa Amenfie East District

To ensure effective administration of the Assembly, the DCE is supported by a secretariat or central administration, which is headed by a DCD who reports to the DCE and is in-charge of the day-to-day administration of the Assembly. The secretariat provides advisory services to the Executive Committee of the Assembly in the areas of planning, programming and budgeting functions. Other units of the Assembly are the District Planning and Co-coordinating Unit and five Sub-committees namely the Finance and Administration, Justice and Security, Works, Development Planning, Social Service and Agric/Environment. These sub-committees submit recommendations to the Executive Committee which is forwarded to the District Assembly.

3.7.2.4 *Traditional Authorities*

Although chiefs do not have political authority, the relevance and institutional capacity of the traditional authorities in governance especially at the sub national level should not be under estimated. The Paramount Chief at Wassa Akropong is Nana Kwame Bassanyin III who exerts control over the sub-chiefs. In the rural areas the contribution of chiefs to socio economic development is very pronounced.

The Chiefs virtually lead their people in their socio-economic development efforts. The usual practise is that in villages local chiefs and their elders settle disputes and deal with minor offences.
The role of the chiefs, among others, includes the following:

- Custodian of stool lands;
- Leadership and direction of subjects;
- Keeping of traditional heritage;
- Mobilization of population for development efforts and;
- Local arbitration and settlement of disputes.

3.7.2.5 ***Law Enforcement***

Even at the District Level, law enforcement and policing fall within the realm of the central government. There is a Circuit Court at Wassa Akropong which is the highest court of adjudication in the District. There is also Police Station at Wassa Akropong headed by a Chief Inspector, and a police post at Bawdie.

3.7.2.6 ***Sources of District Revenue***

There two main sources of revenue for the District which are the District Common Fund and Internally Generated Fund. The District Common Fund is an allotment given to the District via the Central Government. The Internally Generated Fund is accrued from the utilisation of natural resources and activities undertaken in the District. These funds are limited and the sources of these include the following:

- Property rates and receipts from socio-economic activities,
- Stool lands and development levies,
- Fees and fines
- Licences for businesses,
- Rent
- Interest on investment
- Grants in Aid
- Other miscellaneous sources

3.7.2.7 ***Expenditure***

The main areas of expenditure are wages, travelling and transport, general expenditure (e.g. office stationery, office expenses) maintenance and repairs, and miscellaneous. The capital expenditure includes common fund projects, assembly projects and on-going projects.

3.7.2.8 ***Population size and Growth***

The District has an estimated total population of about 115,092 (i.e. 41% of the total population of the former Wassa Amenfi District) and a growth rate of 2.9% according to the 2000 population census figures.

3.7.2.9 ***Age-Sex Structure***

The population of the District is very youthful (under 15), accounting for about 42% of the total population (Table 37.1).

Table 37.1: Age – Sex Structure in the Wassa Amenfi District						
Age	**Male**		**Female**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**
0 – 9	8,887	8%	7,438	7%	16,325	15%
10 – 19	14,442	13%	11,687	10%	26,129	23%
20 – 44	25,551	23%	19,127	17%	44,678	40%
45 – 64	9,998	9%	8,502	8%	18,500	17%
65+	3,334	3%	2,126	2%	5,460	5%
TOTAL	**62,212**	**56%**	**48,880**	**44%**	**111,092**	**100%**
Source: Field survey, 2005, District Office, Wassa Akropong						

3.7.2.10 *Ethnic Composition of the Population*

The District's population is predominantly Wassas with inheritance through the female line. Positions of traditional authority are almost exclusively male. Most of the Country's major ethnic groups (Ashantis, Akuapems, Krobos, Kusasis, Ewes, Fantis) are also represented in the District.

3.7.2.11 *Religious Composition of the District*

The majority of the District's inhabitants are Christians and Muslims. However in parallel with the mainstream religions, traditional religion or fetishism is still commonplace within the District. Even at the national functions, a Christian and Islamic prayer is normally observed and then the traditionalist follows with their "labation". It is common to have a traditionalist that is a Catholic or Methodist or even a Muslim. Traditionalistic practises are seen especially by rural communities as a part and parcel of culture and members of these communities would hardly if ever compromise to do otherwise.

3.7.2.12 *Local Economy*

Agriculture is the mainstay of the District Economy. Wassa Amenfi East District lies within the wettest part of the country. It has a bi-modal pattern of rainfall being from March to July, and the second commences in September and ends in early December. The average annual rainfall ranges between 140mm to 173mm. It has a mean annual temperature of 29ºC in the hottest month (March) and 24ºC in the coolest month (August).

There are two main agricultural soil groups identified in the District, these are forest ochrosol-oxysols found in the northern parts, and oxysols in the southern parts.

3.7.2.13 *Farming Methods*

Mechanized farming is rarely practised. The common farm practices are the traditional slash and burn. Indigenous methods like bush fallowing and shifting cultivation are common.

The total number of farmers in the District is about 25,000[3]. There is however only 13 agricultural extension officers assigned to the District. This gives a ratio of one extension officer to 1,666 farmers, well beyond the national ratio of 1:400. Subsequently farmers have very little access to information on new technologies to improve seeds, benefits of forming co-operative, and proper-use of agro-chemicals to increase yields.

[3] **"**Wassa Amenfi East District Medium Term Development Plan 2006-2009" page 11.

3.7.2.14 *Crops Grown in the District*

The soil types that exist in the District support the cultivation of tree crops such as coffee, oil palm, rubber, cola and cocoa. The cash crops mainly cultivated in the District include cocoa, coffee, oil palm, plantain, and cassava. Major food crops include plantain, cassava, cocoyam, maize, rice, garden eggs, tomatoes and pepper.

3.7.2.15 *Livestock in the District*

There is very limited activity on cattle rearing. Most households keep goats, sheep, and fowls in their backyards. There are, however, a number of piggeries in the District and most of them with reasonably adequate shelters as well as appropriate feeding methods. Free-range piggeries, though few, also exist in the District.

3.7.2.16 *Employment*

Of the total labour force in the District; agriculture employs about 80% of the active labour force.

Agricultural in the District is mostly subsistent. Crops are grown to feed the family and the remaining sold.

About 70% of the farmers depend on family members to help them in the farms. The rest use hired labour and the 'Noboa' system to help them in their farms.

3.7.2.17 *Non Traditional Commodities*

Non traditional commodities are not well patronised in this District. There is very limited activity on cattle rearing, bee keeping, snail keeping, mushroom farming and grass cutter rearing.

3.7.2.18 *Forest Reserves*

The District has four forest reserves, covering a total of 400 square kilometres. Out of these, the Asankrangwa Forest District manages two, whilst the remaining two are managed by Dunkwa Forest District (Table 37.2).

Table 37.2: Forest Reserves in the Wassa Amenfi District

Forest Reserve	Forest District	Location/Area	Forest Size km^2	Hectares
1.Opong Mansi	Dunkwa	Twepiase/Asikuma	117	11,700
2.Bowiye Range	Dunkwa	Moseaso	120	12,000
3. Tonton	ASankrangwa	Wassa Mampong	146	14,600
4. Small part of Angoben Shelter	Asankran	Aserewadi	-	
Total			**383**	**38,300**

Source: District office, Forest Service Division, Asankrangwa

3.7.2.19 *Industry*

The industrial sector is the smallest sector and it employs only about 6% of the active labour force. These include indigenous small-scale wood processing plants, oil palm processing, cassava processing, local gin distilling, soap making, carpentry and activities of other artisans.

Almost all manufacturing and processing industries employ labour intensive techniques for production and operate on a small scale. The employees are primarily apprentices. Entrepreneurs that set up their own industries depend largely on personal savings and/or assistance from close relatives. This makes start up capital very low. Only a few have or may ever have access to bank loans.

3.7.2.20 *Transport*

The chief means of transportation is road. Rail plays almost no part in District transport activities.

3.7.2.21 *Road Network*

The WAED has about a 400 km stretch of trunk roads which span between Bawdie and Hiawa on one hand and between Bawdie and Nkonya on the other. The District has 471 km stretch of feeder roads. This constitutes 217 km engineered roads, 42 km of partially engineered roads, and 212 km of non-engineered roads. Out of the total, only a 113 km stretch of the engineered roads is gravelled, therefore in good shape and motorable all year round. The rest are in a very deplorable condition making it difficult to use.

The District is characterised by a very poor road network. This adversely affects movement of goods and people, and the delivery of services. Consequently, many residents find it difficult to travel outside their immediate community. The poor road network prevents easy and timely access to markets for farm produce and is a major disincentive to farmers who may be forced to produce far below their potential level of crop production.

3.7.2.22 *Railways*

The stretch of railway in the District is rather short, stretching from Hiagon through Oppong Valley to Adade-krom. This is only about 30 km and thus makes rail transport use unpopular to most inhabitants of the District.

3.7.2.23 *Energy*

In addition to the District capital, many communities have access to electricity[4]. A lot more though, still remain to be connected to the National Grid.

3.7.2.24 *Telecommunications*

The Telecommunication System in the District is rather quite primitive. Presently, there is no Ghana Telecom fixed line service in the District. A few communication centres use the radiophone system while Scancom (MTN) and Ghana Telecom (Vodafone) operate cellular network services. With the exception of the District capital and a few major towns, which have access to radiophones and cellular network services, the rest of the District is without telephone facilities. There is no internet service in the entire District.

3.7.2.25 *Postal services*

There is a Post Office at Wassa Akropong. The postal office offers services in the form of sale of stamps and also EMS. Mails are usually dispatched to Dunkwa or Takoradi. There are about 100 mail boxes available in Wassa Akropong.

[4] District Administration makes this statement but does not provide any data in its report "Wassa Amenfi East District Medium Term Development Plan 2006-2009"

3.7.2.26 ***Financial Services***

There is one rural bank at Wassa Akropong, the Amenfiman Rural Bank. Also existing is Central Financial Consult and Noble Character that are financial institutions that offer Savings and Loans services. There is no Social Security and National Insurance Trust (SSNIT) in the District, patronisers access this facility via the SSNIT office located in Dunkwa-on-Ofin in the Upper Denkyira East District.

3.7.2.27 ***Tourism***

The tourism sub sector of the District economy is at its most rudimentary stage of development. There are a number of known eco-tourist sites, (e.g. Nkonya) in the District but these need to be developed to harness its full potential. The District is known to have a cherished heritage rich in oral and material history. There is the need to establish a District Centre of Culture to give it the needed boost in terms of publicity, marketing and development.

The hospitality industry is also not developed. The few hotels and guest houses that operate in the District are of very low standard. Restaurants and chop bars are no exception.

3.7.2.28 ***Education***

The District has 314 educational institutions, comprised of 124 Nurseries/Kindergarten, 127 Primary, 61 Junior High Schools/Junior High Schools, 1 Senior High School and 1 Vocational School (Table 37.3). A second Vocational School at Wassa Akropong is not currently functioning.

Table 37.3: Number of Schools (Private/Public) in the Wassa Amenfi District

Category	Public	Private	Total
Nursery/KG	94	30	124
Primary	99	28	127
JSS	43	18	61
SSS	1	0	1
Vocational	1	0	1
TOTAL	**238**	**76**	**314**

Source: GES, WASSA AKROPONG, 2005

Enrolment

Enrolment in the various grades of schools is presented in Table 37.4.

Table 37.4: Enrolments by Gender(Public/Private) in the Wassa Amenfi District

Gender	Pre-School		Primary		JSS		SSS	
	No.	%	No.	%	No.	%	No.	%
Boys	3773	48.9	9880	53.32	2915	57.05	398	53.64
Girls	3938	51.1	8653	46.68	2195	42.95	344	46.36
Total	**7711**	**100**	**18533**	**100**	**5110**	**100**	**742**	**100**

Source : GES, WASSA AKROPONG, 2005

School Staffing Situation

There are a total of 803 teachers in the Wassa Amenfi East District, of which 224 are trained and 579 who are not trained (Table 37.5).

Table 37.5: Number of Trained/Untrained Teachers in the Wassa Amenfi District					
Level	**Trained**	**Untrained**	**Total**	**Percentage**	
				Trained	**Untrained**
Pre-School	3	184	187	1.61%	98.39%
Primary	110	292	402	27.61%	72.64%
JSS	111	103	214	51.87%	48.13%
Total	**224**	**579**	**803**	**27.01%**	**72.99%**
Source : GES, WASSA AKROPONG, 2005					

Teacher – Pupils Ratio

Table 37.6 gives the teacher- pupils ratio for basic education in the District. In the primary schools the ratio is lower than the national ratio, but lower than the national ratio at JSS.

Table 37.6: Teacher - Pupil Ratio in the Wassa Amenfi District		
Level	**Teacher – Pupil Ratio**	
	District	National
Primary	1:46	1:45
JSS	1:23	1:35
Source: GES, WASSA AKROPONG, 2005		

3.7.2.29 ***Health***

The District is divided into twelve (12) health Sub-Districts or health regions. Each Sub-District or Health Region has communities it is assigned to oversee. The table 37.7 below indicates the Sub-District or Health Regions along with the number of communities it oversees.

Table 37.7 List of Health Sub Districts/Health Regions with Communities		
No.	**Sub District/Health Region**	**Number of Communities**
1	Wassa Akropong	92
2	Oppong Valley	24
3	Afransie	18
4	Pewuako	15
5	Wassa Mampong	15
6	Jukwa Hemang/Mpatasie	20
7	Dawurampong	18
8	Wassa Saa	22
9	Bawdie	20
10	Nsuaem	15
11	Sushyensu	10
12	Dokoto Junction	18
Source: Wassa Akropong Government Hospital, 2005		

The table represents the Sub Districts per catchment community. These Sub Districts are very significant for efficient health delivery systems. However health delivery is seriously hampered for various reasons. These include, high patient to doctor ratio, inaccessibility to health post or hospital, poor road network, or lack of funds to offset medical expenses. Health facilities in Nsuaem, Suhyensu and Dokoto Junction are not yet available.

3.7.2.30 *Distribution of Health Institutions*

Hospitals

There is one government hospital located at Wassa Akropong headed by a District Health Director. hospital lacks basic facilities such as an X-tray facility, a cold room for storage of vaccines, an adequate Blood Bank and Maternity Unit (which is currently shared with the male unit).

Health Stations

There six health centres, in the District, distributed in the following localities; Oppong Valley, Pewuako, Wassa Mapong, Jukwa Hemang, Dawurampong, and Wassa Saa. There are two private clinics situated at Afransie and Bawdie (Table 37.8).

Table 37.8: Health Centres in the Wassa Amenfi East District

Location	Health Centre/Post	GHS/MOH	Quasi/Gov't	CHAG/Mission	Private
Oppong Valley	1	1	-	-	-
Pewuako	1	1	-	-	-
Wassa Mampong	1	1	-	-	-
Jukwa Hemang	1	1	-	-	-
Dawurampong	1	1	-	1	-
Wassa Saa	1	1	-	-	-
District Total	**6**	**6**	**-**	**1**	**-**

3.7.2.31 *Mortality Rate in the District*

On the top ten list of diseases that cause death in the District, anaemia ranks number one with 38 deaths in 2004. Malaria ranks number two with 20 deaths and hypovolemic shock ranks number ten with 4 deaths.

3.7.2.32 *Common Diseases in the District*

Malaria is the second cause of death but number one in terms of reported cases at the Wassa Akropong hospital which is approximately 54%. This is an indication that malaria continues to be a threat to life in the District. The implication is that sanitation in the District should be improved to reduce the incidence of malaria and other communicable diseases. The use of Insecticide Treated Nets (ITNS) needs to be encouraged and be readily made available.

3.7.2.33 *HIV/AIDS*

HIV/AIDS is recorded in the District. Of 407 people tested in 2004 111 were positive, in January 2005 nine of 39 persons tested positive and in 2008 22 of 108 were infected. Education on this virus is being intensified in the District as presented in Table 37.9.

Table 37.9: Top Ten Common Diseases in the Wassa Amenfi District		
Disease	**No. of Reported Cases**	**No. of Deaths**
Malaria	3276	20
Acute Respiratory Infection	923	15
Gynaecological Disorders	356	-
Diarrhoea	238	-
Pregnancy related Complications	472	-
Cardiac Diseases	110	11
Typhoid	133	2
Anaemia	237	38
Skin Disease	299	-
Source: Wassa Akropong Gov't Hospital, 2005		

3.7.2.34 ***Water***

The sources of water in the District are:

- Boreholes
- Piped born water
- Hand dug wells
- Rivers
- Streams
- Dugouts

In the District capital the water distribution systems depend on mechanised boreholes. Interaction with community members proved that the pipes flow only from 6am to 8am each day.

Most of the inhabitants depend on pit latrines. Only a few use water closets facilities.

3.7.3 Upper Denkyira District[5]

3.7.3.1 ***General***

The Upper Denkyira District is one of the thirteen Administrative Districts of the Central Region. It lies within latitudes 5º. 30' and 6º. 02' north of the equator and longitudes 1º W and 2º W of the Greenwich Meridian. It shares common boundaries with Bibiani - Anhwiaso Bekwai and Amansie West Districts on the north, Wassa Amenfi West and Wassa Amenfi East Districts on the northwest and west respectively, Twifo-Hemang-Lower Denkyira and Assin North Districts on the south, Obuasi Municipal on the southeast and Amansie Central on the northeast. The Upper Denkyira District covers a total land area of 1700 square kilometers, which is about 17% of total land area of the Central Region.

3.7.3.2 ***Governance within the District***

Upper Denkyira District Assembly is composed of fifty-seven (57) members. These members are made of the District Chief Executive, two Members of Parliament, thirty six (36) elected members and eighteen (18) Government appointees. The legislative and deliberative functions are presided over by the Presiding Member elected from among its membership while the District chief Executive being the

[5] Upper Denkyira West district with its capital **Diaso** was created in February 2008. The CAGL Project area is now partly located in this new District. The task of collecting relevant data concerning its location and size, administration; topography and drainage; climate and vegetation; geology and soil; social infrastructure and economy is in progress.

President's representative is the political and administrative head of the District. The latter is the chairman of the District Security Committee and the host of other statutory committees including the Executive committee of the Assembly. Among the District Assembly legislative, deliberative and executive functions include, being responsible for the overall development of the District and preparation of development and a composite budget related to the approved plans, maintaining security and public safety and protecting vulnerable groups particularly women and children.

3.7.3.3 ***Law Enforcement***

The District has a District Magistrate Court situated in the District Capital – Dunkwa. The Court maintains law and order in the area. Civil and criminal cases are dealt with by the court, but cases that are related to complex chieftaincy litigations and arbitration are referred to the Denkyira Traditional Council. Also present in the District is the Commission for Human Rights and Administration Justice (CHRAJ) that are assigned domestic cases.

3.7.3.4 ***Rural - Urban Split and Spatial Distribution***

The Upper Denkyira District is mainly rural. Results of the Yr 2000 Population and Housing Census showed that the District has only one urban settlement, Dunkwa-On-Offin, with a population of 26,275. This means that the proportion of the urban population is only 23.2%. In reverse this shows that as much as 76.8% of the population lives in rural areas (settlements with less than 5000 inhabitants). Table 37.10 shows the populations of 20 largest settlements in the District. The rural nature of the District implies that poverty reduction interventions in the District have to focus on rural development strategies, especially the promotion of agriculture, agro-processing, marketing, feeder road improvements, the provision of basic social and economic infrastructure as well as group and community empowerment.

Table 37.10: Populations of Major Settlements in the Upper Denkyira District

Town	Year		
	1970	**1984**	**2000**
Dunkwa-On-Offin	15437	16,905	26,275
Ayanfuri	-	2,452	3,935
Diaso	1,813	2,232	3420
Kyekyewere	1,712	2013	2932
Mfuom	985	1,185	2296
Dominase	970	1470	2085
Mfoum	952	1,333	2037
New Obuasi	-	-	1,882
Nkotumso	-	1,844	1,842
Maudaso	1,182	1420	1,722
Asikuma	845	1,116	1,641
Jameso Nkwanta	885	986	1,411
Buabinso	838	904	1,297
Twifo Kyebi	109	139	1,280
Bethlehem	336	740	1,142
Buabin	880	988	1,135
Akropong	527	625	1,128
Nkronua	457	638	1,104
Akwaboso	426	841	1,072
Effiefiso	1008	864	978
Source: 2000 Population and Housing Census			

3.7.3.5 ***Age and Sex Distribution***

Table 37.11 shows the age and sex distribution of the Upper Denkyira District. Females represent the dominant sex in the District, Constituting 50.4% percent of the population whilst males make up 49.6% percent. This gives a sex ratio of 98.3 males to 100 females.

Table 37.11: Population Distribution by Age and Sex (2006) in the Upper Denkyira District

Age	Male		Female		Total population	
	No.	%	No.	%	No.	%
0-4	7,907	7.3	8,034	7.4	15,941	14.7
5-9	8,014	7.4	8,144	7.5	16,158	14.9
10-14	6,616	6.1	6,723	6.1	13,339	12.2
15-19	5,540	5.1	5,620	5.1	11,170	10.2
20-24	4,410	4.0	4,482	4.0	8,892	8.0
25-29	3,980	3.6	4,045	3.7	8,025	7.3
30-34	3,281	3.0	3,334	3.1	6,615	6.1
35-39	2,797	2.5	2,842	2.6	5,639	3.1
40-44	2,528	2.3	2,567	2.4	5,097	4.7
45-49	2,152	1.9	2,186	2.0	4,338	3.9
50-54	1,613	1.4	1,640	1.4	3,253	2.8
55-59	1,076	0.9	1,093	0.9	2,169	1.8
60-64	1,022	0.9	1,038	0.9	2,060	1.8
65-69	753	0.6	765	0.6	1,518	1.2
70-74	592	0.5	601	0.5	1,193	1.0
75-79	431	0.4	437	0.4	868	.8
80-84	376	0.3	383	0.3	759	.6
85+	699	0.6	711	0.6	1,410	1.2
TOTAL	53,788	49.6	54,656	50.4	108,444	100
Source: 2000 Population and Housing Census						

The age distribution shows that the population of the District is considerably youthful, with a medium age of 19.1 years, which is above the national average of 19.4. More than half of the population (i.e. 59%) is below 20years of age while children below 15 years constitute as much as 28.9%. Those aged 15-64 years, who form the potential labour force, constitute about 52% giving an age dependency ratio of 1.0.9. The youthful nature of the population is a potential for the development of the District so far as labour supply is concerned. However, it also calls for increasing investments in education, skills development and interventions that are secured towards human resource development. It also calls for conscious efforts to expand arenas for gainful employment.

Female of childbearing age (15-45 years) constitute 45.8% of the total female population, which poses potential for high fertility in the District. Therefore to ensure effective population management, there is the need to encourage female education, employment, family planning and other fertility control measures.

3.7.3.6 ***Ethnic Composition of the Population***

The Denkyira who are part of the Akan speaking tribe are the indigenous people of the District. They have over the years co-existed with several entrenched settler groups; prominent among whom are the Ashanti, Fanti, Akuapem, Ewes and the people of the Northern extraction. There exists a harmonious social relationship among these different ethnic groups as a result of tribal inter-marriages. Besides, sharecropping as a peculiar farming institutional practice has also fostered a solid bond of socio-economic co-operation among the ethnic groups. The kinship system is of matrilineal lineage and as such inheritance is traditionally passed on from brothers to their sisters' children.

3.7.3.7 *Religious Composition of the Population*

The people in the District are highly religious. There is a dominance of Christians. Other groups include Islam and Traditional Religion. The Christian group constitutes about 93% of the entire District population followed by Islam 4%, Traditional 1.7% and others 1.6%. Christianity as the major religion makes the church a possible forum for social interaction, information disseminations and community mobilization for development.

3.7.3.8 *General Employment*

Out of the total District population of 108,444 about 43% percent (46,683) are economically active whilst 12.5 percent (13,646) are economically inactive. About 92.6 percent of the economic active population are employed (socio-economic survey) of which 50.1 percent (23,383) and 49.9 percent (23,300) are females and males respectively. The unemployed economic active population constitute 7.4%. Of the employed, 62.5 percent are employed in the agricultural sector, 6.4 percent in the services sector, 9.5 percent in the commercial sector, 12.8 percent in the transport sector, 3.5 percent in the Administrative and clerical sectors and 1.3 percent are artisans and first time job seekers.

3.7.3.9 *Agriculture in Local Economy*

The local economy of the District is dominated by the Agriculture sector. The Upper Denkyira District lies in the semi-deciduous forest zone of the country. It has a mean annual temperature of 29ºC in the hottest months and 24ºC in the coolest months. The District has a bi-modal pattern of rainfall distribution with an annual rainfall ranging from 1,200mm to 1,500mm.

The District has about 75,626 hectares of arable land. The District Agricultural Development Unit (DADU) is divided into sectors. These are;

1. Crops sub-sector
2. Livestock sub-sector
3. Animal Production
4. Veterinary/Animal Health
5. Women in Agricultural Development (WIAD)
6. Extension sub-sector and
7. Management Information System
8. Fisheries sub-sector (now Ministry of Fisheries)

3.7.3.10 *Agricultural Employment*

Of the total employed labour force in the District, Agriculture employs 78% of the active population of the District. This is made up of 32% female and 68% male. Table 37.12 summarizes the age distribution of the farming population in the District.

Agriculture in the District is predominantly subsistence. Food is grown to feed the family and the excess is sold. However, cash crops are grown mainly for commercial purposes. Livestock and poultry are kept in the backyard as a supplementary source of food and income.

Table 37.12: Population (%) Engaged in Agriculture by Age Distribution in 2005	
Age (years)	**Population (% engaged in agriculture**
≤ 19	0.5
20 – 29	11.1
30 – 39	22.6
40 – 49	25.7
50 – 59	19.6
60 – 69	20.5
Source: Multi Ran Annual Crops and Livestock Survey 2005	

3.7.3.11 *The Crops Sub-Sector*

By virtue of the District's location in the forest zone, almost all of the entire agricultural population is engaged in crop production. The major crops grown in the District are; cocoa, oil palm, citrus, maize, cassava, plantain, cocoyam yam, pepper and the other vegetables.

The first three crops are considered as cash crops. Cocoa is the most significant since the others are still developing. According to records from the District cocoa office, cocoa occupies about 27,204 hectares which is approximately 40% of the arable lands in the District.

Extension activities are carried out to encourage farmers to adopt improved farming technologies to increase production. This is done through the establishment of demonstrations, field days and farmer trainings. This has helped to increase production as well as farmers' incomes and standard of living over the years.

3.7.3.12 *Livestock Sub-Sector*

The livestock sub-sector is not as developed as the crops sub-sector. Many rural households, however, keep a few numbers of local poultry or small ruminants. The sector is divided into two sections, 1) Animal Production and 2) Veterinary/Animal health.

The Animal Production section sees to the housing and general management of livestock (good management practices) in the District. Under this section, farmers are advised to keep their animals under good hygienic conditions and be given the right feed to ensure disease free and healthy animals. The Veterinary section sees to the treatment and control of livestock diseases in the District. The execution of this duty includes the vaccination of animals against scheduled diseases such as rabies for dogs, monkeys and cats, as well as against pests that are found in sheep and goats. In the area of poultry, vaccinations are done against Fowl pox, Newcastle, and Gumboro diseases.

3.7.3.13 *Public Health*

The veterinary section ensures that meat sold in the market is fit for human consumption. In this regard, an officer is scheduled to inspect all animals at the slaughter house before and after they are slaughtered.

3.7.3.14 *Women in Agricultural Development (WIAD)*

This sector educates women on kitchen improvement and proper nutrition and the preparation of balanced dietary ration and management of the home.

3.7.3.15 *Fisheries Sub-Sector*

Upper Denkyira has the highest comparative advantage over other districts in the region as far as aquaculture is concerned. This is due to the nature of the terrain, soil characteristics and water resources. However, the sizes of fish ponds are relatively very small. Currently there are an estimated 180 functional fish ponds in the District each with an average surface area of 0.2.

These notwithstanding, Upper Denkyira can still boast of a formidable coherent Fish Farmers Association which has been in existence since July 1997. It should be mentioned that the National Best Fish Farmer was selected from the Upper Denkyira District during the 2005 Farmers Day Celebration. Fish farming is an area that needs focus because of the importance of the commodity (fish) as a dietary input.

3.7.3.16 *Non-Traditional Commodities*

Educational programmes have been established in order to encourage farmers to consider grass cutter, snail, mushroom and honey production as alternative income opportunities. These opportunities have not yet been widely developed, but some progress is apparent. The District can boast of a formidable beekeepers association that has benefited from a loan facility provided by the Food and Agricultural Budgetary Support (FABS) to expand its projects. A few other individuals can be spotted across the District who have started grass cutter and snail farming.

3.7.3.17 *Forestry*

The Upper Denkyira District falls within the Forest Processing Zone of the Central Region. The Regional zone includes the whole of Upper Denkyira District and parts of the Districts of Twifo-Hemang Lower Denkyira, Mpohor Wassa East District and Wassa Amenfi East.

3.7.3.18 *Forest Reserves*

Forest Reserves covers 438.34km² (18%) whilst off - reserve covers 1948.08km² (82.6). There are five forest reserves in the District (Table 37.13).

Table 37.13: Forest Reserves in the Upper Denkyira District

S/N	Name of Reserve	Area (km²)	Location
1.	Minta	21.82	Beasense
2.	Bonso Benn	155.40	Imbraim
3.	Ben East	25.33	Oponso
4.	Opon Mansi	116.55	Twifo Kyebi
5.	Bowiye	119.24	

3.7.3.19 *Logging*

Logging which is a key activity in the District which occurs on the off- reserves. There are 65 registered contactors in the District. Out of this number only 29 are actively operating in both on - reserve and off - reserve areas.

3.7.3.20 *Plantation Development*

An area of 91 ha of land has been developed into plantation in Opon Mansi forest reserve. Total number of species planted are 100,612 comprising Teak, Cedrella, Ofram and Otie. Three (3) communities are involved in the programme namely Tegyamoso, Atobease and Faomanyo; i.e. communities living the Reserve. Unfortunately the programme had to be suspended for that fact that there were no more degraded areas in the reserve to enable the programme to continue.

3.7.3.21 ***Private Plantation Development***

There are about 60 private plantations developed by individuals within the District covering a total area of about 450ha with major species planted being Teak (*Tectona grandis*) and few indigenous trees ranging between 1 - 10 years old of age. The programme is on-going.

3.8 RADIOACTIVITY

3.8.1 Introduction

Radioactive studies have been carried out within and around the proposed eastern concession of Perseus Mining (Ghana) Limited to ascertain the baseline radioactivity levels of naturally occurring radioactive materials (NORM) prior to processing of gold ore at the area. The study was carried out based on in situ measurements of external gamma dose rate at 1 meter above ground level as well as laboratory analysis by direct gamma spectrometry to quantify the radionuclides of interest namely; ^{238}U, ^{232}Th and ^{40}K in soil, rock, ore and water. In addition, gross alpha/beta analysis was carried on the water samples. Three (3) exposure pathways; namely direct external gamma ray exposure from natural radioactivity concentrations in soil/rock-ore pads radioactivity due to ^{238}U, ^{232}Th and ^{40}K and internal exposure due to natural radioactivity were considered.

3.8.2 Objective and Scope of the Study

The primary objective of this study was to measure and assess the baseline radioactivity levels of eastern concession of the mine as well as the immediate surroundings so that reference data could be established before the mine starts processing of the gold ore in this area. The study focused on the determination of the activity concentration and distribution of the naturally occurring radionuclides of the U/Th decay series and ^{40}K in soil, rock, ore samples by gamma spectrometry and gross alpha and gross beta activities in water samples. Airborne absorbed gamma dose rates were also measured at 1 meter above the ground at all samplings points with a radiation survey meter.
The specific objectives of the study are:

- To determine the activity concentrations of the radionuclides from the U/Th series, ^{40}K.
- To determine the doses from these activity concentrations and compare with internationally

  recommended dose limits.
- Determine the gross alpha/beta activity concentrations in the water samples
- Assess the risk to the public associated with the measured dose values.
- Recommend a suitable radiation protection programme for the mine.

3.8.3 Local Geology of the Area

The gold ore in the area occurs both in classic Ashanti-style sediment of shear zones and with granitic plugs and sills or dykes situated along two or three regional shear structures. In excess of 24 gold occurrences exist in the Ayanfuri property of which granitic intrusives host majority of these and more than 80 % of the known gold resource. While the later deposits formed predominantly ductile regime with generally discontinuous, pinch and swell higher grade gold shoots, the granite hosted occurrences developed in a brittle rock and found to be significantly broader with more evenly distributed, though lower grade gold tenor. Most of the known gold resource at Ayanfuri is hosted by the granite plugs and sills or dykes, which occur along the same structures that contain the sediment shear, hosted gold occurrences.

The bulk grade of the granitoid hosted gold resource defined to date in six deposits is just under 1.5 g/t Au, while that defined in sediments averages more than 1.8 g/t Au. Gold mineralisation occurs in two to three generations of quartz veins and stock works with individual veins millimetres to centimetres in thickness and rarely more than a metre thick. The gold is associated with < 3% pyrite, lesser arsenopyrite and traces of sphalerite, chalcopyrite, galena and rutile. Gold occurs as very fine grains often along sulphide grain boundaries and in fractures in sulphides, usually at or near vein margins and coarse visible gold is occasionally observed in the quartz. Higher grade gold intercepts often tend to be associated with very coarse arsenopyrite plus or minus sphalerite, chalcopyrite and galena. The ore of the Central Ashanti Gold Ltd is made of two major types namely; granite with feldspar (oxidised) and granite with quartz which are fresh and not oxidised. The rock type of the area is metamorphic with intrusive igneous rocks containing minerals such as quartz, feldspar, pyrite (FeS) and asenopyrite (FeAsS), etc.

3.8.4 Methodology

A total of thirty (30) samples were randomly collected within selected areas of the mine concession and the surrounding communities. They included fourteen (14) soil, rock and ore samples and sixteen (16) water samples.
In the laboratory, each of the soil, rock and ore samples were air dried on trays for 7 days and then oven dried at a temperature of 105 ^{o}C for between 3-4 hours until all moisture was completely lost. The samples were grinded into fine powder using a stainless steel ball mill and sieved through a 2 mm mesh size and poured into one (1) litre Marinelli beakers and hermetically sealed. The Marinelli beakers with the samples were completely sealed and stored for 4 weeks, to allow the short-lived daughters of ^{238}U and ^{232}Th decay series to attain equilibrium with their long-lived parent radionuclides (ASTM, 1983; 1986). The soil samples were each counted using a sodium iodide detector for a period of 36,000 seconds (10 hours).

3.8.4.1 Instrumentation and calibration

The measurement was made by direct instrumental analysis without pre-treatment (non-destructive) with a computerized gamma spectrometry system made up of NaI (TI) detector and measuring assembly. The specifications of the detector system used for this study are as follows: the cylindrical scintillation detector Model 3M3/3-X, Serial number ETI 9305 has a 1.2" x 1.2" end window, and was manufactured by Saint-Gobain Crystals, USA. The detector system consists of a vertically sealed assembly which includes the NaI (TI) crystal and is coupled to ORTEC Multichannel Buffers (MCBs) for data acquisition and processing using a MAESTRO®-32 software program. A high voltage supply provides the appropriate bias to the detector system. The conversion gain of the detector is up to 1024 channels. In order to reduce background gamma radiation from the room in which the detector is installed, a locally fabricated cylindrical lead shield (20 mm) with a fixed bottom and a movable lid is used to shield the detector. Within the lead shield are also copper, cadmium and plexiglass (3 mm each) to absorb x-rays and other photons that might be produced in the lead. The ambient temperature around the detector varied between 20^{o}C and 27^{o}C during the period of measurement.
The identification of individual radionuclides was performed using their gamma ray energies and the quantitative analysis of radionuclides was performed using gamma ray spectrum analysis software, ORTEC MAESTRO-32.

For the analysis of soil/rock-ore pad-ore pad samples, the energy and efficiency calibration was carried out using liquid mixed standard radionuclide solution supplied by the IAEA with volume and density of 1000ml and 1.0 gm^{-3} respectively. The energy and efficiency calibrations were carried out by counting standard radionuclides of known activities with well defined energies in the energy range of 60 keV to ~2000 keV.

The background spectra were also used to determine the minimum detectable activities of ^{238}U (0.12 $Bqkg^{-1}$), ^{232}Th (0.11 $Bqkg^{-1}$) and ^{40}K (0.15 $Bqkg^{-1}$) of the detector.

3.8.4.2 Calculation of activity concentration and estimation of doses

For the soil, rock and ore samples, the activity concentration of ^{238}U was calculated from the average peak energies of 351.92 keV of ^{214}Pb, and 609.31 keV of ^{214}Bi. Similarly, the activity concentration of ^{232}Th was determined from the average energies of 238.63 keV of ^{212}Pb and 911.21 keV of ^{228}Ac. The activity concentration of ^{40}K was determined from the energy of 1460.83 keV.
The analytical expression used in the calculation of the activity concentrations in $Bqkg^{-1}$ is as shown in equation (1).

$$A_{sp} = \frac{N_D e^{\lambda_P t_d}}{p.T_c.\eta(E).m} \quad \textbf{(1)}$$

where; N_D is the net counts of the radionuclide in the samples, t_d is the delay time between sampling and counting, P is the gamma ray emission probability (gamma ray yield), η(E) is the absolute counting efficiency of the detector system, T_c is the sample counting time, m is the mass of the sample (kg) or volume (l), $\exp(\lambda_p t_d)$ is the decay correction factor for delay between time of sampling and counting and λ_p is the decay constant of the parent radionuclide
The external gamma dose rate (D_γ**)** at 1.0 m above ground for the soil/rock-ore pad-ore pad samples was calculated from the activity concentrations using equation (2) (Uosif, 2007).

$$D_\gamma\left(nGyh^{-1}\right) = DCF_K * A_K + DCF_U * A_U + DCF_{Th} * A_{Th} \quad \textbf{(2)}$$

where; DCF_K, DCF_U, DCF_{Th} are the absorbed dose rate conversion factors for ^{40}K, ^{238}U and ^{232}Th in nGy/h/$Bqkg^{-1}$ and A_K, A_u and A_{Th} are the activity concentrations for ^{40}K, ^{238}U and ^{232}Th respectively.

DCF_K = 0.0417 nGy/h/$Bqkg^{-1}$; DCF_U = 0.462 nGy/h/$Bqkg^{-1}$; DCF_{Th} = 0.604 nGy/h/$Bqkg^{-1}$

The average annual effective dose was calculated from the absorbed dose rate by applying the dose conversion factor of 0.7 $SvGy^{-1}$ and an outdoor occupancy factor of 0.2 (UNSCEAR, 2000) represented by equation (3).

$$E_\gamma = D_r * 0.2 * 8760 * 0.7 \quad \textbf{(3)}$$

where; E_γ is the average annual effective dose and D_γ is the absorbed dose rate in air.

For comparative analysis, similar average outdoor external gamma dose rate were determined through by taking an average of five measurements of the ambient gamma dose rates at 1 meter above the ground of sampling in μGyh^{-1} with a radiation survey meter. The annual effective dose ($E_{\gamma,\,ext}$) was then estimated from the measured average outdoor external gamma dose rate from the equation (4).

$$E_{\gamma,ext} = D_{\gamma,ext} T_{\exp} DCF_{ext} \quad \textbf{(4)}$$

Where; $D_{\gamma,ext}$ is the average outdoor external gamma dose rate μGyh^{-1}, T_{exp} is the exposure duration per year, 8760 hours and applying an outdoor occupancy factor of 0.2, DCF_{ext} is the effective dose to absorbed dose conversion factor of 0.7 $SvGy^{-1}$ for environmental exposure to gamma rays (UNSCEAR, 2000).

3.8.4.3 Determination of natural radioactivity in water samples using gross alpha and gross beta counter

Sixteen (16) water samples taken from bore-holes, tap water and surface water from streams and mine pits were analysed for gross alpha (α) and gross beta (β) radioactivity. Five hundred millilitres (500ml) of each water sample was acidified with 1ml of concentrated HNO_3 and evaporated to near dryness on a hot plate in a fume hood. The residue in the beaker was rinsed with 1M HNO_3 and evaporated again to near dryness. The residue was dissolved in minimum amount of 1M HNO_3 and transferred into a weighed 25mm stainless steel planchet. The planchet with its content was heated until all moisture had evaporated. It was then stored in a desiccator and allowed to cool and prevented from absorbing moisture.

The prepared samples were then counted to determine alpha and beta activity concentrations using the low background Gas-less Automatic Alpha/Beta counting system (Canberra iMatic™) calibrated with alpha (^{241}Am) and beta (^{90}Sr) standards. The system uses a solid state Passivated implanted Planar Silicon (PIPS) detector for alpha and beta detection. The alpha and beta efficiencies were determined to be 36.39±2.1% and 36.61±2.2 %respectively. The background readings of the detector for alpha and beta activity concentrations were 0.04±0.01 and 0.22±0.03 cpm.
The activity concentration of both gross alpha and gross beta were determined using the expression in equation (5) (Tettey-Larbi et al., 2013):

$$A_{\alpha/\beta} = \frac{Activity}{W_{Vol}} \quad \textbf{(5)}$$

Where $A_{\alpha/\beta}$ is the activity concentration of gross alpha or gross beta in Bql^{-1} and W_{Vol} is the volume of the water sample in litres. The activity of alpha or beta in Bq was obtained by subtracting the background activity of both gross alpha and gross beta from the total activity of the sample.
The average annual alpha or beta committed effective dose for a particular water sample was determined by averaging the individual annual committed effective doses contributed by the major alpha or beta emitters in the ^{238}U and ^{232}Th series of the naturally occurring radionuclides as shown in equation (2) (Tettey-Larbi et al., 2013):

$$E_{ing,w}(\alpha/\beta) = \frac{I_w}{W_{Vol} \cdot N_R(\alpha/\beta)} \sum_i^{R(\alpha/\beta)} A_{\alpha/\beta} \times DCF_{ing}(\alpha/\beta) \quad \textbf{(6)}$$

Where $E_{avg}(\alpha/\beta)$ is the average gross annual alpha or beta committed effective dose in the water sample, $A_{\alpha/\beta}$ is the gross alpha or beta activity concentration in the water sample in Bql^{-1}, I_w is the consumption rate for the intake of the water of 730 L/year (WHO, 2004), W_{Vol} is the volume water used for the analysis, $N_R(\alpha/\beta)$ is the number of radionuclides considered as major alpha or major beta emitters in the ^{238}U and ^{232}Th series of the naturally occurring radionuclides and $DCF_{ing}(\alpha/\beta)$ is the ingestion dose coefficient in Sv/Bq of the natural radionuclides from UNSCEAR report (UNSCEAR, 2000).

3.8.5 Assessment of Radiological Risk and Hazard

3.5.1 Determination of radium equivalent activity and hazard indices

The radiological risk of NORM in soils in the study area which may be used as building materials was assessed by calculating the radium equivalent activity (Ra_{eq}) and the external hazard and internal hazard indices.

The Ra_{eq} is a widely used hazard index and it was determined using equation (7) (Xinwei et al., 2006):

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_K \quad \textbf{(7)}$$

Where; C_{Ra}, C_{Th} and C_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K respectively. In its application, the definition of Ra_{eq}, it is assumed that 370 Bq/kg of ^{226}Ra, 259 Bq/kg of ^{232}Th and 4810 Bq/kg of ^{40}K produce the same gamma ray dose rate. The above criterion only considers the external hazard due to gamma rays in building materials. The maximum recommended value of Ra_{eq} in raw building materials and products intended for building purposes must be less than 370 Bq/kg for safe use. This means that the external gamma dose must be less than 1.5 mSv/year.

Another criterion used to estimate the level of gamma ray radiation associated with natural radionuclides in specific construction materials is defined by the term external hazard index (H_{ex}) as shown in equation (8) (OECD/NEA, 1979; Alam et al., 1999; Higgy et al., 2000).

$$H_{ex} = \frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \quad \textbf{(8)}$$

Where C_{Ra}, C_{Th} and C_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K respectively. The value of the external hazard index must be less than unity for the external gamma radiation hazard to be considered negligible. The radiation exposure due to the radioactivity from construction materials is limited to 1.5 mSv/y (OECD/NEA, 1979; Beretka and Mathew, 1985).

Also internal hazard index (H_{in}) due to radon and its daughters was calculated from equation (9). This is based on the fact that, radon and its short-lived products are also hazardous to the respiratory organs.

$$H_{in} = \frac{C_{Ra}}{185} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \quad \textbf{(9)}$$

Where C_{Ra}, C_{Th} and C_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K respectively. For construction materials to be considered safe for construction of dwellings, the internal hazard index should be less than unity.

3.6 Estimation of total annual effective dose

The total annual effective dose (E_T) to members of the public was calculated using ICRP dose calculation method (ICRP, 1991; 2007). The analytical expression for the total effective dose is provided in equation (10).

$$E_T = E_\gamma(U, Th, K) + E_{ing,w}(\alpha / \beta)$$

(10)

where; E_T is the total effective dose in Sievert (Sv), E_γ (U, Th, K) is the external gamma effective dose from the soil/rock-ore pad samples, $E_{ing,\ w}$ (α/β) is the effective dose from the consumption of water due to gross alpha and gross beta activity concentrations.

3.8.6 Results and Discussion

3.8.6.1 Results

Table 1: Average absorbed dose rate in air at 1 metre above sampling points in the study areas and calculated annual effective dose.

Sampling Location	Absorbed dose rate, μGyh^{-1}		Annual effective dose, mSv
	Range	Average±σ	
Chirawewa Pit Area	0.04-0.14	0.08±0.03	0.093
Bokiti Pit Area	0.04-0.17	0.10±0.05	0.124
Small Fetish Pit Area	0.04-0.13	0.09±0.03	0.109
Big Fetish Pit Area	0.06-0.14	0.10±0.03	0.126
Esuajah North Pit Area	0.09-0.12	0.11±0.01	0.133
Esuajah South Pit Area	0.02-0.10	0.05±0.03	0.066
Wampem Community	0.06-0.14	0.10±0.03	0.117
Ayanfuri Community	0.04-0.09	0.06±0.02	0.076
Gyaman Community	0.04-0.09	0.06±0.02	0.078
Nkonya Community	0.04-0.08	0.06±0.02	0.075
Odumkrom Community	0.03-0.09	0.06±0.02	0.078
Stream Water	0.08-0.16	0.12±0.03	0.142
PAS 1	0.04-0.13	0.09±0.03	0.112
PAS 7	0.03-0.08	0.06±0.02	0.067
PAS 9	0.02-0.06	0.04±0.02	0.047
PAS 11	0.03-0.10	0.06±0.02	0.075
PAS 20	0.04-0.08	0.05±0.02	0.066
Average±σ	**0.02-0.17**	**0.08±0.02**	**0.093±0.028**

σ- Standard deviation

Table 2: Average activity concentrations of ^{238}U, ^{232}Th and ^{40}K in soil, rock and ore pad samples in the study area.

Sample location	**Activity concentration, $Bqkg^{-1}$**		
	^{238}U	**^{232}Th**	**^{40}K**
Chirawewa Soil	97.0±2.4	70.8±2.4	1795.9±17.8
Bokiti Soil	72.0±2.3	84.2±2.2	1445.4±16.3
Bokiti Ore Pad	62.1±2.1	61.6±2.2	1470.6±17.2
Small Fetish Soil	86.8±2.1	64.4±2.1	1317.2±17.5
Big Fetish Soil	56.3±2.0	61.8±2.2	1722.4±14.6
Big Fetish Ore Pad	29.0±1.6	35.0±1.6	748.3±12.0
Esuajah North Soil	62.2±3.8	116.7±3.0	1445.0±20.4
Esuajah South Soil	74.3±2.3	89.6±2.4	1544.1±16.8
Wampem Community Soil	69.2±2.6	76.1±2.1	844.8±14.9
Ayanfuri Community Soil	70.0±1.9	83.7±2.0	720.8±14.6
Gyaman Community Soil	57.0±2.1	63.9±1.9	500.0±13.9
Nkonya Community Soil	61.3±2.1	68.7±2.0	749.5±14.6
Odumkrom Community Soil	48.4±1.9	47.1±2.1	811.3±15.1
Steam Area Soil	66.4±1.9	81.6±2.1	1241.2±15.0
Range	**29.0-97.0**	**35.0-116.7**	**500.0-1795.9**
Average±σ	**65.1±2.2**	**71.8±2.2**	**1168.3±15.8**
World Average (UNSCEAR, 2000)	**35**	**30**	**400**

σ- Standard deviation

Table 3: Absorbed dose rates, radium equivalent activity, external and internal hazard and annual effective doses due to ^{238}U, ^{232}Th and ^{40}K in soil and ore pad samples in the study area.

Sample Location	Absorbed dose rate, $nGyh^{-1}$	Radium equivalent activity, $Bqkg^{-1}$	External hazard index	Internal hazard index	Annual effective dose, mSv
Chirawewa Pit Soil	1121.5	336.5	0.9	1.2	1.38
Bokiti Pit Soil	914.9	303.7	0.8	1.0	1.12
Bokiti Pit Ore Pad	919.3	263.3	0.7	0.9	1.13
Small Fetish Pit Soil	829.0	280.2	0.8	1.0	1.02
Big Fetish Pit Soil	1071.2	277.4	0.7	0.9	1.31
Big Fetish Pit Ore Pad	469.3	136.6	0.4	0.4	0.58
Esuajah North Pit Soil	929.3	340.3	0.9	1.1	1.14
Esuajah South Pit Soil	977.1	321.3	0.9	1.1	1.20
Wampem Community Soil	548.3	243.1	0.7	0.8	0.67
Ayanfuri Community Soil	477.0	245.2	0.7	0.9	0.58
Gyaman Community Soil	333.9	187.0	0.5	0.7	0.41
Nkonya Community Soil	487.0	217.3	0.6	0.8	0.06
Odumkrom Community Soil	513.8	178.2	0.5	0.6	0.63
Steam Area Soil	790.2	278.6	0.8	0.9	0.97
Range	**333.9-1121.5**	**136.6-340.3**	**0.4-0.9**	**0.4-1.2**	**0.41-1.38**
Average±σ	**741.6±260.1**	**257.8±61.1**	**0.7±0.2**	**0.9±0.2**	**0.91±0.32**

σ- Standard deviation

Table 4: Gross-α and gross-β activity concentrations (Bql-1) and their corresponding committed annual effective dose in water samples from the Pits and surrounding communities

Sample Location	Type of water	Activity Concentration, Bql-1		Committe
		Gross Alpha	Gross Beta	Gross
Chirawewa Pit	Surface water	0.0013	0.0367	0.00
Bokiti Pit	Surface water	0.0042	0.0430	0.00
Small Fetish Pit	Surface water	0.0011	0.0389	0.00
Big Fetish Pit	Surface water	0.0019	0.0357	0.00
Esuajah North Pit	Surface water	0.0011	0.0391	0.00
Wampem	Surface water	0.0004	0.0319	0.00
Wampem borehole	Underground water	0.0013	0.0314	0.00
Ayanfuri	Treated water	0.0067	0.0311	0.00
Ayanfuri borehole	Underground water	0.0058	0.0392	0.00
Gyaman (PAS 24)	Surface water	0.0010	0.0390	0.00
Gyaman borehole (OPAG 16)	Underground water	0.0015	0.0243	0.00
Nkonya borehole	Underground water	0.0075	0.0354	0.00
Odumkrom (PAS 15)	Surface water	0.0020	0.0104	0.00
Camp water (Raw) water	Underground water	0.0065	0.0452	0.00
Camp water (Tap) water	Underground water	0.0050	0.0289	0.00
Stream water (PAS 1)	Surface water	0.0034	0.0310	0.00
Range		**0.0004-0.0075**	**0.0104-0.0452**	**0.0001-**
Average		**0.0032±0.0024**	**0.0338±0.0083**	**0.0007±**
Total Average				
GSB Recommended limit		**0.1000**	**1.0000**	
WHO Recommended limit		**0.5000**	**1.0000**	

σ- Standard deviation GSB – Ghana Standards Board WHO – World Health Organisation

3.8.7
3.8.8
3.8.9

Table 1 shows the absorbed dose rate measured in air at 1 metre above the ground at the soil/rock-ore pad and water sampling points in the study area and its surrounding communities. The table shows the range and average values of the absorbed dose as well as the calculated annual effective doses. As can be observed, measured absorbed dose rates varied in a range of 0.02-0.17 μGyh^{-1} (20-170 $nGyh^{-1}$) with an average value of 0.08±0.02 μGyh^{-1} (80±20 $nGyh^{-1}$) The corresponding average annual effective dose was calculated to be 0.093±0.028 mSv (93±28 μSv) in a range of 0.047-0.142 mSv (49-142 μSv).

According to United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) report, the worldwide average absorbed dose rate measured in air outdoor from terrestrial gamma radiation is 60 $nGyh^{-1}$ (0.059 μGyh^{-1}) (UNSCEAR, 2000). Comparing the results of the gamma absorbed dose rates in this study with the data in UNSCEAR report, the results of the absorbed dose rates in this study compare well with the range of dose rates values reported for other countries (UNSCEAR, 2000). However, the highest absorbed dose rate value of 170 $nGyh^{-1}$ was measured at locations around the Bokiti Pit. In general, the results of the study in this mine compared well with similar studies carried out in other mines in Ghana (Darko, et al, 2010; Faanu et al, 2013) although the average absorbed dose rate of 80±20 $nGyh^{-1}$ measured in air from the area is above the worldwide average. The reasons for the higher values of the doses for external gamma could be due to difference in geological formations as well as contribution from cosmogenic radionuclides in addition to terrestrial radionuclides.

Table 2 shows the activity concentrations of ^{238}U, ^{232}Th and ^{40}K in the soil/rock-ore pad samples. The average value of the activity concentrations of ^{238}U is 65.1±2.2 $Bqkg^{-1}$ in a range of 29.0-97.0 $Bqkg^{-1}$. For ^{232}Th, the average activity concentration is 71.8±2.2 $Bqkg^{-1}$ in range of 35.0-116.7 $Bqkg^{-1}$ and that of ^{40}K is 1168.3±15.8 $Bqkg^{-1}$ in a range of 500.0-1795.9 $Bqkg^{-1}$. The results of this study also compare with the previous study that was carried in Perseus Mining (Ghana) Ltd. The worldwide average activity concentration of ^{238}U, ^{232}Th and ^{40}K in soil samples from similar studies carried out around the world are 35, 30 and 400 $Bqkg^{-1}$ respectively (UNSCEAR, 2000). By comparison, it shows that the average values of the activity concentrations of ^{238}U and ^{232}Th in this study are about two times higher than the world average whilst that of ^{40}K is about three times higher than values in normal continental soils (UNSCEAR, 2000). The very high activity concentration of ^{40}K is because the rock ore of the mine is associated feldspar which belongs to a group of hard crystalline minerals that consist of aluminium silicates of potassium, sodium, calcium or barium. Even though the average values in this study are higher than the worldwide average values, activity concentrations are still far below the exemption values of 1 Bqg^{-1} for ^{238}U and ^{232}Th and 100 Bqg^{-1} for ^{40}K in materials that will warrant regulatory control [IAEA, 1996].

The average gamma dose rate and annual effective dose from terrestrial gamma rays calculated from soil/rock-ore pad activity concentrations are shown in Table 3. The average absorbed dose rate was calculated to be 741.6±260.1 $nGyh^{-1}$ in a range of 333.9-1121.5 $nGyh^{-1}$ which is by a factor of six to sixteen higher than the dose rate measured in air at 1 metre above the ground. The average absorbed dose rate due to the soil concentrations is also about twelve times higher than the worldwide average value of 60 $nGyh^{-1}$ (UNSCEAR, 1993; 2000). This difference could be attributed to vast differences in geology and geochemical state of the sampling sites. The corresponding average annual effective dose estimated from the soil concentrations is 0.91±0.32 mSv in the range of 0.41-1.38 mSv. It is observed that the annual effective dose from the soil concentration is about ten times higher than that from the external gamma dose rate measured in air at 1 metre above the ground.

Table 3 also shows the results of the hazard assessment of soil/rock-ore pad with respect to radium equivalent activity and external and internal hazard indices. The natural radioactivity in building materials is usually determined from the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K. Also because 98.5 % of the radiological hazard of uranium-series is due to radium and its decay products ^{238}U is replaced with concentrations of ^{226}Ra in hazard assessment. In order to assess if soil/rock-ore pad which could be used for building purposes could pose any radiation hazard, the three hazard indices namely; radium equivalent (Ra_{eq}) activity in $Bqkg^{-1}$, external hazard (H_{ex}) and the internal hazard (H_{in}) indices were calculated. The radium equivalent activity is related to the external gamma dose from the terrestrial radionuclides and the internal dose due to radon and its decay products of ^{210}Pb and ^{210}Po. The maximum value of Ra_{eq}, in building materials must be less than 370 $Bqkg^{-1}$ for the material to be considered safe for use. The external and internal hazard indices must also be less than unity in order to keep the radiation hazard insignificant. This implies that, the average external radiation exposure due to the radioactivity from these radionuclides in materials to be used for constructions must be limited to 1.5 mSv/year (OECD/NEA, 1979). In general however, the annual effective doses calculated from the various samples are considered insignificant in respect to the annual construction limit of 1.5 mSv/year.

The average value of the radium equivalent activity in this study is 257.8±61.1 $Bqkg^{-1}$ in a range of 136.6-340.3 which is below the recommended limit of 370 $Bqkg^{-1}$. The calculated H_{ex} in the soil/rock-ore pad samples ranged from 0.4 (Big Fetish Pit Ore pad) to 0.9 (soil sample from Chirawewa Pit and Esuajah North and South Pit) and an average value of 0.7±0.2 for the study area. Similarly for the H_{in}, the values ranged from 0.4 (Big Fetish Pit Ore pad) to 1.2 (Chirawewa Pit soil) with an average of 0.9±0.2. For the internal hazard 21.4 % of the samples had values exceeding the recommended limit of 1.0 which implies that these materials if used for building purposes could be a source of internal hazard due radon and to its progeny. Meanwhile, 14.3% of the samples have values exactly at the recommended limit of 1.0 whiles the rest were below he recommended limit.

The activity concentrations of gross-α and gross-β in water samples from the pits, surface water and underground water (bore holes) used in the surrounding communities of the study area and their corresponding committed effective dose are shown in Table 4. Radionuclide concentrations in groundwater depend on the dissolution of minerals from rock aquifers. The activity concentrations of gross-α in the water samples varied in a range of 0.0004 Bq/l in surface water at Wampem to 0.0075 Bq/l in surface water in Nkonya borehole with a corresponding average annual committed effective dose of 0.0007±0.0005 mSv. For the gross-β, the activity concentrations varied in a range of 0.0104 Bq/l for water taken from a stream in Odumkrom to 0.0452 Bq/l for water from the raw underground water at the camp site with a correspond average annual committed effective dose of 0.0170±0.0042 mSv. The average committed annual effective dose due to both gross alpha and beta was estimated to be 0.0089±0.0023 mSv. The WHO screening levels for drinking water below which, no further action is required are 0.5 Bq/l for gross-α and 1.0 Bq/l for gross-β (WHO, 2004). All the water sources had gross-α and gross-β values below the recommended levels. The guideline values ensure an exposure lower than 0.1 mSv/year assuming a water consumption rate of 2 litre /day. Comparing these results with the WHO guideline values, it can be observed that all the values of the gross-α and gross-β are lower than the guideline values. This indicates that all the water sources in the study area which are designated for drinking and domestic purposes do not have significant natural radioactivity.

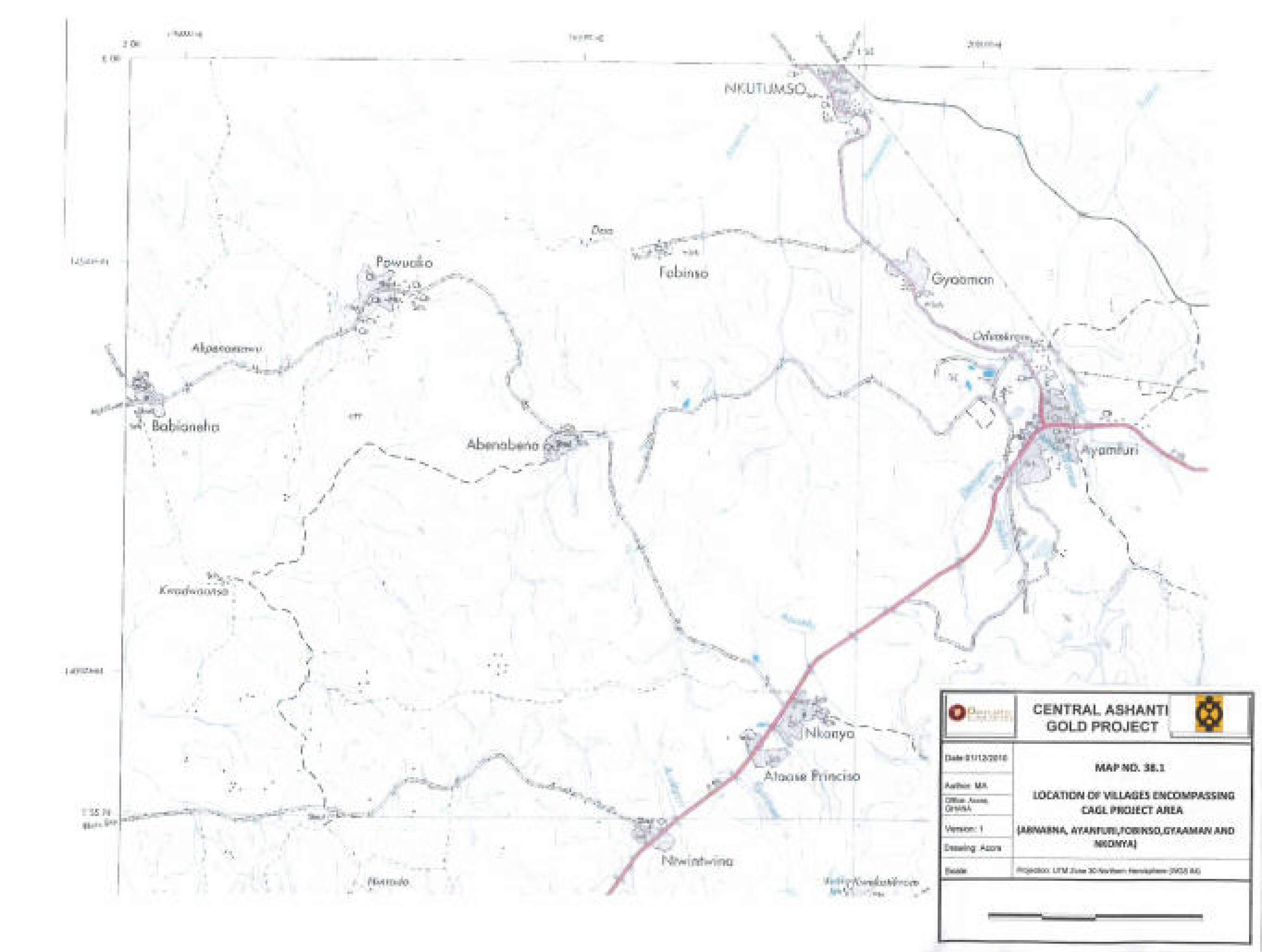
However, it is important to note that some of the surface water bodies which are located at restricted access areas of the mines are not accessible for use by the public for domestic purposes. Also, even though the mine has provided enough boreholes to serve as drinking water sources for the communities, some members of the communities continue to resort to the use of the surface water bodies in their vicinity for domestic purposes.

Figure 2 shows Comparison of annual effective doses from different sampling site due to airborne gamma exposure pathways of radiation. The pits give the highest average effective dose although the maximum value of was recorded around the streams.

A comparison of the activity concentrations of the radionuclides in soil and rock-ore pad with exemption levels recommended in the Basic Safety Standards (IAEA, 1996) are shown in Figure 3. The activity concentrations of the radionuclide in the different types of samples are quite uniform and do not show any significant variation.

Figure 4 shows the comparison of the results of the annual effective doses due to ^{238}U, ^{232}Th and ^{40}K calculated from the airborne gamma radiation and soil/rock-ore pad samples. The figure shows that the annual effective doses due to to ^{238}U, ^{232}Th and ^{40}K in the soil/rock-ore pads were higher than that due to the external gamma dose rates. The reasons for the higher values of the doses for soil/rock-ore pads could be due to contribution from the high concentration of terrestrial radionuclides especially ^{40}K since is a purely gamma emitter. It also compares the total annual effective dose to the recommended limit of 1 mSv for the public. These results also compared well with published results (UNSCEAR, 2000). In general however, the annual effective doses calculated from the various samples are considered insignificant.

3.8.10 Map 38.1: Location of Villages in the CAGL Project Area



3.9 ARCHAEOLOGICAL AND CULTURAL HERITAGE

3.9.1 Introduction

This section of the social assessment of the CAGL Project area presents the findings obtained from a field archaeological and cultural heritage resources survey in the concession area and the surrounding communities of the proposed Central Ashanti Gold Project (CAGP) that straddles the Central and Western Regions of Ghana. The investigation was done over in April 2009. The findings provide baseline data for assessing the archaeological and cultural heritage resources of the area investigated. It also evaluates the significance of these resources in line with sustainable heritage management and the preservation of indigenous lifestyles in Ghana.

3.9.2 Scope of Work

The scope of work included the following:

- Investigation and analysis of maps of the Project Area for insights on ancient and contemporary settlements and features.
- Undertake a physical survey of the Project Area to identify archaeological or cultural features of significance in the Project area.
- Development of a recognized procedure for the removal, transfer or protection of sites of archaeological and cultural significance.
- Provision of GPS positions for all sites identified.

3.9.3 Methodology

3.9.3.1 Map Sources

Two topographical maps were obtained from the Ghana Survey Department and studied in addition to maps provided by CAGL showing the approximate area and other relevant landscape features and proposed zones to be utilised by mining and its associated activities. These maps were examined for indications of ancient, historic, and contemporary settlements features.

3.9.3.2 Dialogue with Chiefs and Others

In line with customary practice, meetings were held with the Chief and elders of towns, the caretaker head of a village (*Odikro*) or their representatives. In the case of hamlets and farm villages, the founder, head, or elders were consulted. The purpose of all the meetings was to introduce the consultant, show the relevance of the research and seek permission to do archaeological and cultural heritage surveys in town(s) and villages. Where feasible drink was given for libation or for the ancestral burial ground and village or private shrine houses.

During the entire period of interactions with the chiefs, *odikro*s, family heads in the Project area, the consultant requested that he was accompanied by a resident of Ayanfuri, Mr. Isaac Ofori, Chief Security Officer of CAGL. Because he is a serving Assembly member and was a known community development-oriented person the residents gave the survey a higher attention. The Chiefs arranged for the consultant to be accompanied by traditional representatives during the oral, historical, and ethnographic data collection in the settler communities. A point was made meet with Chiefs after viewing the cultural sites and was allowed to meet with the village shrine priestesses as well as private shrine owners. This enabled the consultant to pose questions that had arisen from surveys, observations and interviews.

The interview and interaction involved the presence of both men and women, and young persons in the towns and villages. The local languages, Twi or Fante, were used during the interview in the villages. A combination of Ewe and Twi was used during the interview of the priestess of the private shrine found near Abnabna.

3.9.3.3 Data Collection

Data on shrines, cemeteries, festivals, customary commitments, and traditional prohibitions on both indigenous persons and settlers was collected. Where shrines were found the normal traditional requirements and scheduled ritual performances were noted. Attention was paid to this aspect of the research because it involved sensitive issues on the ideology, behaviour, worldview, and attachment of people to specific objects, and landscapes. The domains of the shrines were examined to determine whether it belonged to the entire village population or was the property of an individual and family. Questions were asked to include the relevance of the shrines to the local community and also to communities in other parts of Ghana.

Visits to cemeteries and sacred groves were designed to involve local persons and especially persons of high standing in the traditional set up. These persons were provided with drinks where needed and were asked several questions on beliefs and religious practices and behaviour in the community. This provided information that was critical in deeper understanding of the cultural underpinnings of life ways and socio-cultural behaviour.

3.9.3.4 Archaeological Survey

The archaeological survey involved the use of minimum of four persons (two or more local persons assisting the consultant and his archaeological assistant). This was necessary considering the time available and the size of land to be covered in both the specific project zone, and in none-project-zones that needed to be investigated for a better overview of the archaeological resources.

During the survey, an interval of 10m was maintained between the members of the survey team. This was helpful in forested areas where ground visibility is low. In more open and farmed areas, a maximum of 20m was applied. This hastened the amount of landscape covered per transect over a demarcated spaces. These are the proposed mine areas, Tailing Storage Facility (TSF) site, processing plant site, potential haul roads and options for access as well as existing haul roads and constructed land.

Farmlands and especially those freshly cleared and burnt or cultivated were closely investigated for archaeological evidence. Soil profiles or stratigraphies exposed by erosion in the towns and villages and deep gullies in the towns and villages) and on the sides of the existing main haul roads in the concession area were surveyed. All the paths in the Project area and in the villages and towns on which we walked were examined for archaeological materials.

The surfaces of all the walls of the mud houses in the villages and indications of exposed house foundations (sometimes standing as high as 1meter) were examined for evidence of artifacts. It was assumed that if the soil used in building the houses were obtained from the immediate area, their cultural content would reflect the archaeological content of the local area. In line with the above assumption, the surface and bottom of all pits, holes were examined.

3.9.3.5 Collection of Artefacts

During the archaeological survey, only a very limited number of diagnostic and important artifacts were collected for analysis. No excavation was done. Although the research was only for surface investigation, the consultant obtained a permit (GMMB/0136/Vol.12/221) from the National Museums and Monuments Board which is the legal authority and custodian of all the heritage and archaeological resources of Ghana.

The limited surface archaeological finds collected were washed, sorted, and labelled before they were categorized and studied for information on their origin, design, material composition, and chronological parameters. These were essential for the placement of sites and heritage features within time frames and for assessing their significance.

The GPS of all villages, archaeological, and heritage sites visited and investigated were taken in addition to digital photographs of materials, shrines, peoples and sites. Also taken were scenes of interactions with the members of the communities for oral information and indications of cultural practices and belief systems.

3.9.4 Description of Identified Heritage Sites

There are three forms of heritage sites from the survey namely; shrines (whether private of village owned), sacred groves, and cemeteries (public or royal or both) (Map 39.1). The term sacred grove is used loosely loose because every cemetery in the area surveyed qualifies to be called a sacred grove where human disturbances such as farming are not permitted. The severity of the sanctions imposed on trespasser on a cemetery increases with regards to the royal background of those interred there. The old settlements locations are used as burial grounds by contemporary villages. The communities then consider them as sacred groves.

Yet these sites also qualify as archaeological sites especially when evidence of archaeological artifacts and features of significance are documented or are predicted to be present (Map 39.2).

For Gyaaman, an old site that was used as a royal cemetery ground was later abandoned because it found to be too close to Ayanfuri. Consequently, a new site was established in relation to the present location of the town and at a distance that is considered secure and appropriate for a royal mausoleum.

There is an example of a water management based sacred grove established by the people of Nkonya. There is no shrine in this grove.

Abnabna provides a sacred grove associated with a river and its immediate environment. It is called *Asorniyer* or *Sorniyer* and it is the point for the establishment of the shrine of the community and the gods and spirits associated with the traditional stools of the Chief.

Nkotumso presented a case of a public cemetery that has been discarded recently (that is in 2008). The thick vegetation that used to signify the cemetery has been cut down. The cut trees, leaves and branches will be allowed to die without the use of fire. Then plantain will be planted on the land for some time after which cocoa trees will be planted. The Chief of Nkotumso and his elders are directly in charge of this exercise. The process shows that even when the cemetery has been tagged as no longer of use for burial, there is the element of cultural restraint with the avoidance of the use of fire which is common on all other lands being prepared for cultivation. The cultural status of the land has been reduced but not completely erased.

Table 39.1 provides a summary description of the various heritage sites found during the field survey.

Table 39.1: Description of Heritage Sites in the CAGL Project Area

Place	Heritage ID	Number on Map	Descriptive Information
Abnabna	Komfo Efua Pokuwaa Shrine	46	-A village shrine house - House # AB21, in the NW of the village. -Headed by a priestess called Efua Pokuwaa. -Cures madness, epilepsy and infertility etc. -Has a burial of preceding priest behind shrine room. -Use only water from Abnabna river or rainfall. -Houses the gods and materials of second village shrine priest called Komfo Donkor who is not only aged but is also the leader of the priestesses of Abnabna.
Abnabna	Komfo Yaa Shrine	45	-Found in a location off the Abnabna to Nkonya dirt road and very close to the Project area. -Headed by a priestess called Yaa. -Plays a role in the village ceremonies.
Abnabna	Public Cemetery	39	-Located to the SW of the town. -Has a separate burial ground for the Catholic, Atwea and Agona clan members and also the Chiefly family. There is a place for non-church-goers and traditionalists. Measures about 200m NS and 120m EW
Abnabna	*Erbermu*/ Royal Mausoleum	44	-Burial ground for Chiefs of old settlement and present one. -About 3km south of village. -Found on one of the highest points in the area (that 206m above sea level). -An important site for community rituals performed in April each year.
Abnabna	*Abnabna Sorniyer*	41	-Located on the left bank of Abnabna river close to the Nkonya-Abnabna dirt road. -Has two pots holding river water and schnapps offering. -Location for the performance of *Fofiye* rituals every March. -Location for purification of traditional stools.
Nkonya	Asuafu River Source Sacred Grove	9	-A sacred grove for water management of River Asuafu for community water supply located to the NW of the town. -A thickly forested area on the left side of the Abenebena-Nkonya dirt road.
Nkonya	Agya Buor Shrine	11	-A village shrine headed by a priestess and found in House No. NK/35. -Beneficial to community in the cure of physical and spiritual ailments, etc. -Consulted by Chief and elders for community-related spiritual matters.
Nkonya	Torgbey Gbey Shrine	12	-A private shrine kept in a room the enclosed compound of House No. NK/127. -Headed by a priest who is recognized for his herbal treatment. -Priest is also the deputy Chief of Nkonya.
Nkonya	Public Cemetery	10	-It is an old cemetery carrying graves of late 19th to early 20th century mine workers and settlers in the area. -Southern boundary is near the Nkonya taxi station and extends about 200m NS and 150m EW. -Also carries graves of corpses from other villages such Dabiasem and Broso.
Ataase	Old Settlement/ Public Cemetery	17	-Old settlement known as Atisokwa. Measures about 1km NS and 600m EW. -Northern part of old settlement is used as the public cemetery. -Carries corpses of Atisokwa (old Ataase) and present Ataase.
Ataase	Okomfo Nyantakyi Shrine	20	-Shrine found in the plot and house area (-House No. AT/53 of the *Odikro and h*eaded by a priestess. -Service to community in child disease cures and reversal of curses.
Ataase	Okomfo Dwira Shrine 'Akumawura	21	-A private Shrine house headed by a priestess that derives power from the Akumawura River and Lake Broso -Treats insanity, infertility and provides protection and business prosperity.
Ataase	Catholic Cemetery	19	-Established in 2004 and has a few graves. -Located to the SW at distance of about 500m.
Ataase	*Bermu* Royal Cemetery	18	-Cemetery for Chief and royal persons located north of the public cemetery. -Carries royal burials of both ancient and contemporary Ataase.
Princiso	*Krodada* Old Settlement	1	-A spaced out ancient settlement from the pattern of house mound remains. -Measures about 500m in diameter. Abandoned in the early 20th century. - Cultivated with cocoa and orange trees.
Princiso	Esuo Meretwe Komfo	3	-An important shrine named after the Meretwe River that flows into Lake Broso and headed by a priestess. -Relevant for cures of physical and spirit ailments, and reversal of curses. -Ritual performed at Lake Broso on the 25th December every year.
Princiso	Public Cemetery	2	-Located east of settlement. About 100m away after the last line of houses. -Land area measures about three (3) acres.
Broso	Lake Broso	37	-Storage point of water from three rivers: Meretwe, Kweku Nipa and Akumawura. -Abode of spirits and god for Princiso Village Shrine.

			-The private shrine of Ataase named after one of the rivers of Lake Broso
Broso	Public Cemetery	38	-Established in 1994. -Divided into Church denominations. -Located East of village. -Measures 100m NS and 200m EW.
Ayanfuri	Komfo Sarpong Shrine	4	-Also known as Larbi camp. -Village Shrine headed by a priestess. -Located on the right side after the public Cemetery and heading towards Nkonya. -Consulted by Chiefs and other persons.
Ayanfuri	Komfo Esua Yebunu Shrine	33	-A village shrine and deity of River Ofin. -Headed by a priestess who has been operating since 2001 -Located in House no. AYZ 25/10. -Has the grave of the previous priestess near the shrine room.
Ayanfuri	Komfo Bakan Shrine	35	-A village shrine, also a deity of River Ofin. -Headed by a priestess and located in House No. AYN 28/12.
Ayanfuri	Komfo Kwabena Korner Shrine	34	-A private shrine headed by a priest. -Located in House No. AYZ 24/29. -A Tigare and Brekuney shrine with spiritual origin from Yipala near Wa, UWR.
Ayanfuri	Public Cemetery	36	-Located SW of town and close to the Ayanfuri-Nkonya road. -Measures about 300m NS and 600m EW -Sub-divided according churches. -Space available for non-church goers at the southern-most end.
Ayanfuri	*Ahenfo Ersiyeyer* Royal Cemetery	30	-Located in the far eastern side of town off Ayanfuri-Dunkwa road. -A 2-acre heavily forested area. -A strictly no go area for all residents.
Wamperm	Public Cemetery	16	-Established in 1989 with approval from Ayanfuri Chief. -Measures about 200m NS and 80m EW. -Carries village head and elders on western part and all other burials on the east.
Nkotumso	Private Shrine	5	-A private shrine headed by a priestess aged about 60 years. -Shrine-house broke down sometime ago. -Cures insanity and solves spiritual problems for people.
Nkotumso	Public cemetery	6	-Located north of the town. Measures about 200m EW from road side to the west and 250m NS (along the road). -Has evidence of extensive burial.
Fobinso	Kwame Komfuor Shrine	24	-A private shrine house headed by a male. -Specialized in removing guns bullets and treating gunshot wounds. -Cures snake bits and cancerous wounds.
Fobinso	Public Cemetery	23	-Located to the SW of the village and measures about 500m NS and 800m EW. -Extends from the last line of houses. Evidence of heavy burial.
Oda	Public Cemetery	28	-Located in the NW part of the village and receives only burials of children. Measures 80m NS and 100m EW. -Adult burial terminated since 2002 and now done at Dominase or hometown of the deceased.
Gyaaman	Old Settlement and Ritual Site	27	-Found in the vicinity of Ayanfuri (on the northwestern side). -An Area of about 200m NS and 250m EW. -Served as a royal cemetery after movement to present Gyaaman site. -Used to be a place for village ritual performance.
Gyaaman	Public Cemetery	25	-Established in 2008 and has only about a dozen graves. - Measures about 120m NS and 180m EW.
Gyaaman	Old Public Cemetery	26	-Abandoned in 2008. Traditional reclamation process in progress. -Measures about 200m NS and 150m EW.

3.9.5 Description of Identified Archaeological Sites

Fourteen (14) archaeological sites were found after the survey of thirteen communities, with some within the Project and several cocoa farm mini-villages Map. Also, places earmarked for proposed mining or project structures and facilities such as the processing plant, the Fobinso Fetish Priest, Esuajah North, AF-Gap, Abnabna and Fobinso zones were investigated. The archaeological site found from this internal survey was in the Camp area and this was in the form of an iron slag remains. The land on which the evidence of iron smelting is found is one that has been graded during the construction of the Camp some years ago.

It was found that most of these land areas had been impacted upon through grading, digging of huge pits or the covering of their surfaces with excavated debris. About 90% of the land area of the Esuajah

North site has been impacted upon in this manner. The survey in Esuajah North was therefore limited to the eastern margins where undisturbed land was seen but no archaeological materials were found. It was also found that the land surface on which grasses and tress were growing was not the originally naturally existing one. Movement of heavy machinery in the past and grading activities has transformed the landscape completely. These are all representations from a previous mining activity.

The area earmarked for the Flotation Tailings Storage Facility (FTSF) was surveyed and found to be a waterlogged area with shallow valleys of the catchment area of the Akesoa stream. This low-lying area that is prone to possible flooding could not have been a potential settlement site for people who had alternative locations to consider. The soggy nature of the ground made survey difficult. There were no contemporary villages in this area and the ancient situation could not be different.

An area that was closely looked at is the site for the processing plant. Only settlements that were recent (maximum 10 years old) were encountered during the survey. These were living in settlements with a minimum of five and maximum of 30 persons. About 15 communities were estimated to be living in the area. No archaeological sites were found.

The settlements were useful for the survey because farmers were asked of their finding of archaeological remains. Secondly, the newly cleared farmlands provided land surface exposures in a heavily forested or cocoa farmland area. Holes created by the villages through the digging of clay for house construction were investigated in addition to the standing house walls.

The usefulness of these archaeological indications is that they provide earliest signs of human settlement in the Project area dating to the 16th and 17th centuries. These provide evidence of human settlement that pre-date the present leading villages such as Ayanfuri, Gyaaman and Abnabna. They are therefore historic sites. The remaining sites date to the later historic period of the 18th to the early part of the 20th century. This is represented by the few glass and bottle pieces that were encountered. The sites do not represent settlements of the indigenous people because the oral tradition makes no mention of that. The pottery site in Abnabna has no relation with the present people who have destroyed much of the site with the construction of their houses.

Iron slag was found from the survey. This shows that in the past iron was produced locally by indigenous people. This is a significant archaeological find because the knowledge on iron production in the western region is negligible. The evidence was found at Nkonya, Dabiasem and Ataase. It was also found on the premises of the Campsite being used by CAGL. The iron smelting activity could date to last 600 to 800 years and may have been associated with the production of durable tools and equipment for gold mining and agriculture in the past.

No Neolithic or early village sites dating to the Kintampo Complex (2001-1500 BC) were found. It must be indicated that the thick vegetation cover of the Project area and other forest environments of West Africa not only obscure visibility but also creates volumes of litter to cover much of the ground surface.

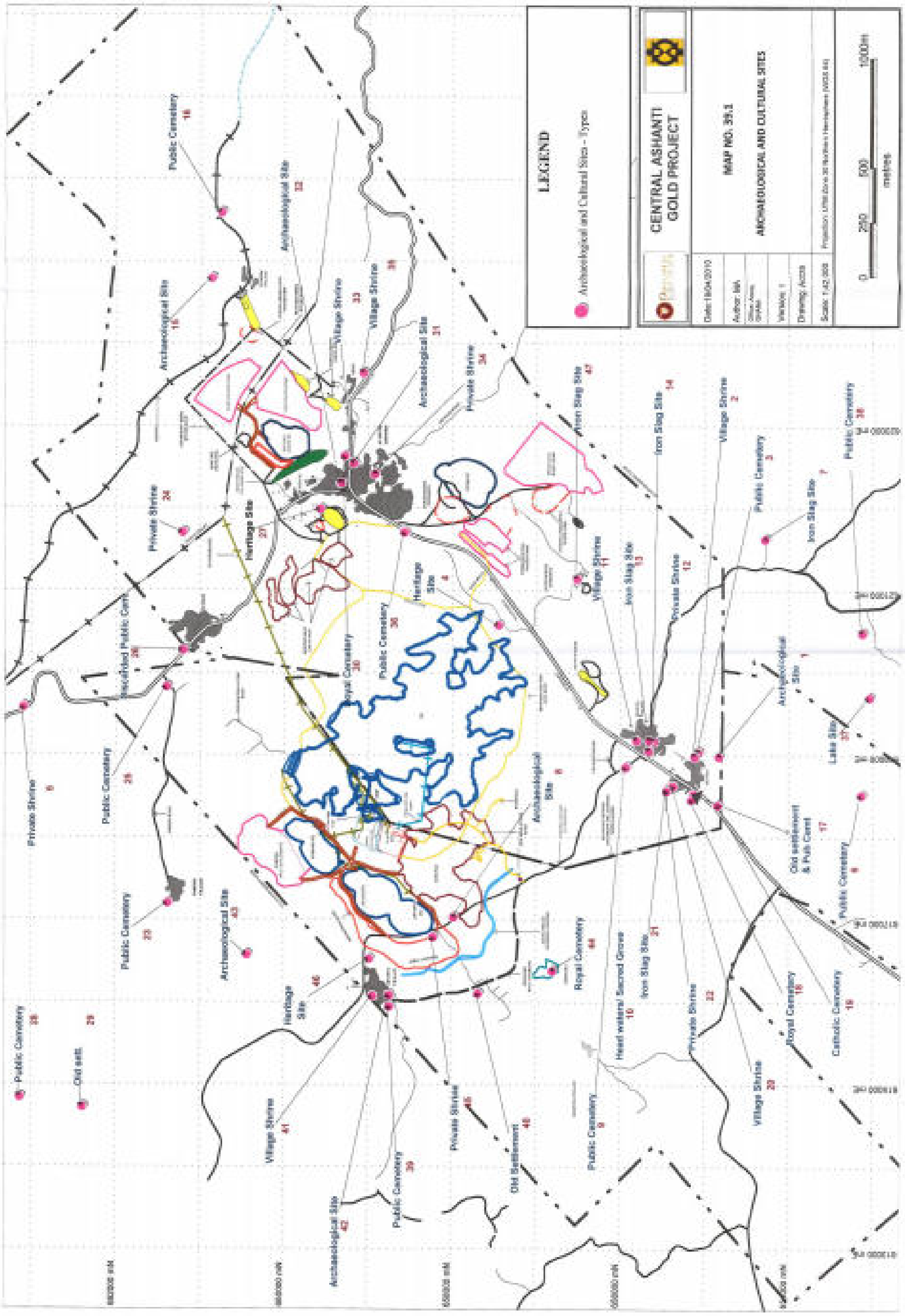
The number of archaeological sites found during the survey and the findings from the analysis of the survey data and the surface collected artifacts is presented in table 39.2.

Table 39.2: Archaeological Sites of Significance in the CAGL Project Area

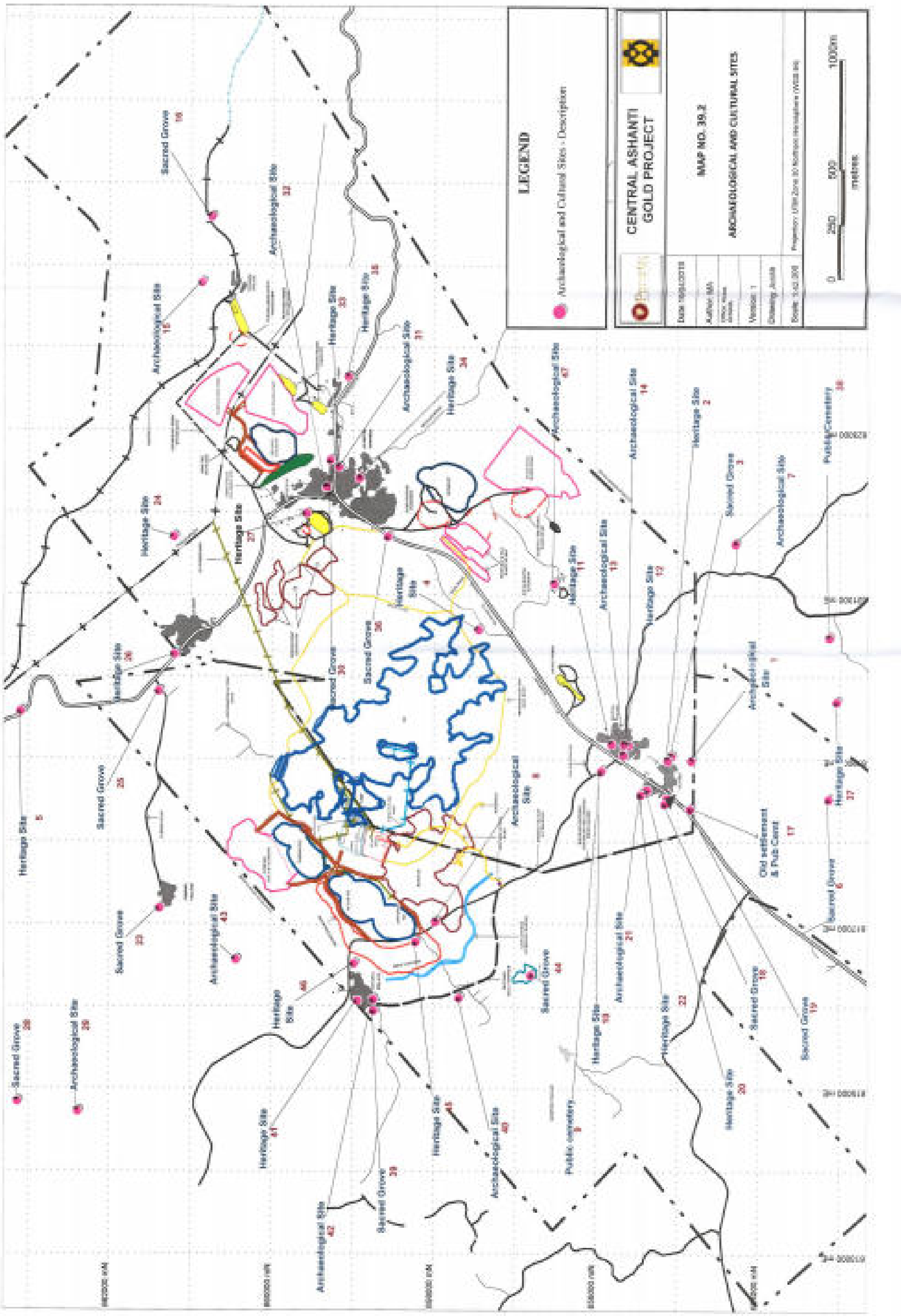
Place	Archaeol. ID	Number on Map	Artefact Features and Comments
Abnabna	-Bisease quarter Archaeological site -Located on a hill and its slopes near the Catholic Church building. East of the Public Cemetery.	42	-Heavy pottery exposure in eroded gully wall sides and on slopes of the high ground. -Covers an area measuring 40m NS and 20m EW. -Pottery reddish brown in colour. -Local oral tradition does not mention this site. -Site predates Abnabna and shows a settlement that may date to the 16th and 17th centuries and later.
Abnabna	-Apenkro, the old settlement of Abnabna before the relocation to the present site. -Located to the southwest of the village at quite a distance from it.	40	-The materials attributes on this site was not seen due the heavy cocoa leaf Covering of the ground. Minimal towelling did not produce any pottery. It yielded metal pieces of old farm tools. -There is evidence of low mounds that appear to represent house remains but this could only be confirmed with excavation. -The site may not date beyond the 19th century. -Said to have a cemetery but the site could not be given.
Abnabna	-Poku Manu farm Archaeological Site	43	-Site said to have had clay sculptures that were collected by local persons of both Fobinso and Abnabna. -Has a heavy surface distribution of reddish brown coloured pottery like those the Besease site. -The clay sculptures described are similar to the ones that have been seen in later Iron Akan sites in Ghana at Ahinsan, Abiriw, and Kwahu and dated to the 16th and 17th centuries.
Nkonya	-Abuorso, -Located on the right side of the Nkonya-Abnabna dirt road and inside the Project area	8	-Pottery and a few broken pieces seen. Site very thick and impenetrable. Located on hill and close to a river valley. Site of the old Asante settlement whose members moved to Nkonya. -An early 20th century site associated with mining in the Ataase and Nkonya area.
Nkonya	-Iron Slag site north of the Nkonya Market area	13	-A 13m wide slag area that was graded for road and market site. -Eight (8) more the slag features seen the area within areas of habitation in the village. -Evidence of indigenous iron smelting in the area.
Nkonya	-Catholic Church Iron Slag Site -Further north of the market slag site. -Located on a hill and its slopes.	14	-A wide area of 40m diameter of graded slag landscape. -Wall pieces seen. Too fragmentary to be used to determine furnace wall or tuyere parts. -Catholic Church and a few houses are standing on the site -More evidence of an intensive iron smelting in the Nkonya area that may predate the 20th century settlement -May date to the 16th and 17th centuries and may be associated with gold mining.
Ataase	-Old Settlement Site. -NE of Ataase.	_	-Pottery and bottle fragments seen in exposed profiles and on ground surfaces. -Soil from this site dug for making sun-dried bricks. -Site heavily disturbed and destroyed. -Part of land under cocoa cultivation and the rest is the forested public cemetery. -Oral tradition dates it to the early 20th century.
Ataase	-Akumawura Shrine area Iron Slag Site located in the northeastern end of the village. -Site is on NW side of the shrine house.	22	-Low Iron Slag accumulation over an area of about 20m diameter. -Evidence of iron smelting and settlements nearby probably that of the smelters. -Evidence of pottery seen on the eroded surface of nearby compounds.
Princiso	-Old Princiso -Locate south of present village	-	-Dated by oral tradition to the 1880's. -Located on the slope of river valley. -Has evidence of house that shows a huge settlement with wide spaces in between the one or two house compounds. -Measures about 500m in diameter. -Farmed with cocoa and oranges.
Ayanfuri	-Exposed 2m high stratigraphy underneath collapsed house in the Ohemaa section of the town.	31	-Bottle and Pottery fragments seen in the stratigraphy. -Material remains found between 22cm and 50cm from the surface.

			-The Ohemaa section was confirmed by informants as the oldest part of Ayanfuri. -A date of around the 17th century or earlier estimated. Site may predate Ayanfuri.
Ayanfuri	-Exposed 30cm stratigraphy beneath a collapsed house in the Ohemaa section of the town. House No. AYE/4/24.	32	-Pottery pieces sticking out of the foundation layer. -Evidence of old settlement being compactly built with only 2m spaces between houses.
Wampem	-Kwame Arkoh cocoa farm Archaeological site -Located about 200m north of the Village and within a mature cocoa plantation.	15	-Pottery exposed through the digging of the ground by the owner of the farm using a cutlass. -Site extends about 50m from the base of a huge Odum tree to the eastside of it. -Pottery is plain and made from yellowish brown alluvial clay.
Dabiasem	Slag remains found in the eastern end of the village.	7	-Slag lumps and pieces seen scattered over several areas in the built up landscape of the village. -Few pottery and bottle pieces seen on sloping eroded surfaces inside the village. -Smelting industry represented seems to march with those found at Nkonya.
Oda	-Old Settlement Site. -South West of Oda village.	29	-Marked by low house mound remains measuring 20m wide and 60cm high. -32 of such mounds counted and seen to cover an area of about 300m in diameter. -Now a mature cocoa farm with heavy surface leaf cover.

Map 39.1: Archaeological and Cultural Sites - Type



Map 39.2: Archaeological and Cultural Sites - Description



3.10 PUBLIC CONSULTATION

3.10.1 Introduction

CAGL understands and has accepted the importance of proactive community relations in its future operations. It has, therefore, begun structuring it's community relation activities to take into account the level of practical understanding available in an audience and then endeavour to explain issues in terms that can be best appreciated and understood.

AC&E International Ltd, a Ghanaian consulting firm, was contracted for organising village public hearings in five (5) main villages, Abnabna, Ayanfuri, Fobinso, Gyaaman and Nkonya most likely to be impacted by the Project[1]. These hearings were the first formal public meetings between the villages and CAGL.

Prior to the public meetings, informal meeting were held with the Chiefs and Elders of each village. They were informed that CAGL wished to hold public meetings to solicit comments, opinions and expectations should the CAGP be implemented. All were in agreement with the concept presented by CAGL.

At the same time, the villages were informed of CAGL intention to form a Social Development Consultative Committee (SDCC) whose purpose was to act as a liaison between the Company and all major stakeholders and Special Interest Groups. Each village was asked to consider which members they would like to have represented on the SDCC, including Women and Youth groups representatives.

3.10.2 Objectives of 1st Public Meetings with Villages

The objective of the public hearings was to formally and publicly introduce the potential Central Ashanti Gold Project to members of the communities in the Project area. These hearings were a forum where three important questions were asked:

- Do community members want the mine to be reopened?
- What benefits would they wish to see from the mine being reopened?
- What concerns do they have if the mine is reopened?

3.10.3 Stakeholder Representation

Traditional Representation

In each town the Chief and his elders were fully represented. In Fobinso where the Chief is a caretaker for the Nkutomso Chief, two elders were present to represent the Nkutomso Stool Chief. During the time of the Public Hearing, the Abnabna Chief noted that Nkonya belongs to his stool thus the Nkonya Chief is a sub chief under his jurisdiction. This was later confirmed by the Nkonya Chief.

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[1] AC&E International had previously been contracted to undertake, a census survey of 11 villages in the CAGL Concession in July and August 2008. Data was collected from each household in each village on ownership, family, occupation, income, type of housing, number of rooms per household and other categories. The survey provided AC&E with an depth understanding of the villages and their socio-economic structure.

Political Representation

The Member of Parliament for Upper Denkyira West Constituency, the person of Honourable Ben Ayeh was present to Chair the function in Ayanfuri, Gyaaman and Fobinso. Also present was the Upper Denkyira West District Chief Executive.

The District Chief Executive of Wassa Amenfi East District, Honourable x. Badu, Chaired the program in Abnabna and Nkonya.

Representation From Local Authorities

The Wassa Amenfi East District Assembly was represented by Department Heads from Health, Environment and Education.

The District Coordinating Director and his Assistant from Upper Denkyira West District Assembly (UDWDA) were present for Ayanfuri and Gyaaman meetings. At Fobinso, the District Office was represented by Mr. William Oran, District Planning Office.

Mr. Darko, Presiding Member of from Wassa Amenfi East District was also present as a District Assembly.

Farmers Representation

There was a fair representation of potentially affected farmers in all the meetings. Members of the Concerned Farmers Group were available in each forum and its leaders helped in answering questions that were pertaining to farmers during the forum.

3.10.4 Format of the Meetings

The five public meetings were held from May 19 to 23 2009. Each meeting was formalised under canopies and seating provided for the community. A "top table" at which a Chairman, DCE's and/or or their appointed representatives, local Assembly persons and the CAGL team were seated. The Chairman at each meeting was an independent person from the appropriate District Assembly or Member of Parliament. The language of the meetings was Twi. Following formal ceremonies and introductions, a presentation outlining the present status of the Project was made by the CAGL Senior Mining Engineer. Afterward, the meetings were opened to public discussion. Each meeting was recorded on video and minutes taken (Appendix 3.10.4 for example).

3.10.5 Positive Reactions to the Project

Chiefs and Elders

The chief and elders in each village warmly accepted the idea of re-opening the mine. They see this as a good opportunity for their subjects. In general each town remarked that there are customary rites that need to be respected and that CAGL has failed to do so far. CAGL was encouraged to ensure these rites are duly performed as soon as possible . The chief in Abnabna requested that a formal courtesy call should be made to his elders and the paramount chief.

Government Leaders

The leaders from the government also showed warm acceptance of the Project. The Member of Parliament stated that the reopening of the mine would be a dream come true and also (an opportunity) to end of countless criticisms and allegations. In his remarks he encouraged the community to create a peaceful and cordial environment for the mining company at all times.

Local Authorities

The District Assemblies of Wassa Amenfi East District and Upper Denkyira West District also showed acceptance of the Project. However they lamented that CAGL has not yet registered with the District.

The Assembly Men and Women in each town were likewise overjoyed that this Project is coming to their community, they encouraged CAGL to keep up the good work they have already started.

Artisanal Miners Leaders

The Secretary of The Association of Small Scale Miners was present at the Abnabna and Nkonya meetings. Although he accepted the re-opening of the mine in the area his concern was that (a portion of land or a concession) should be made available for galamsey activities.

3.10.6 Future Concerns About the Project

Concerns about the Project were fell mainly into two categories:

1) various past practices of the previous mining companies; and

2) a failure by CAGL to recognise traditional rites

Chiefs and Traditional Leaders

In Abnabna the Chief noted that most of the towns around him such as Nkonya, Ataase Princiso Mampong etc are communities under his jurisdiction and the lands belong to him. Thus CAGL should find time to be briefed and which lands are for him. He also complained bitterly that the customary rites need to be performed. For instance there is a forest demarcated only for the burial of their chiefs. Such place cannot be entered into by just anybody and before one can do that there are rites that need to be observed.

Gyaaman also notified CAGL that there are lands that have gods and there are customary rites to be observed before these lands can be used peacefully.

Ayanfuri likewise lamented that there are rites to be performed and CAGL should consult the chief and his elders to know what rites should observed.

Women

Several married women from Ayanfuri and Gyaaman at complained bitterly that they were not enrolled into the previous mining companies when they disclosed their marital status. They pleaded that CAGL should consider both the single women and the married women. Also, the elderly women complained that once their farms have been taken they would not have any other source of livelihood and they are too old to be employed into the company. They pleaded that CAGL should be considerate to them.

Farmers

There were various complaints and concerns from farmers. Some of them complained that assessors of their farms were in the past disrespectful and rude. They also complained that sometimes trees were fell without prior notice to the farmer. Compensations were not made according to agreed on plan. Also payment for compensation was made in Banks that are far and out of the district. They requested that payments should be made in Banks that were close to the town.

Central Government

The Member of Parliament showed much concern for future generations who may not have the opportunity to farm the lands that their fathers would have left behind for them if there were no mines in the community. He encouraged CAGL to consider helping the community to develop small scale industries, or a trust fund or revolving fund for future generations. He was also concerned about the level of unskilled labour in the area and encouraged youths in the community to engage in skill development programs as soon as possible to enable them have appropriate employment in future.

Local Government

The main concern of the two District Assemblies was that CAGL should formerly introduce itself to the Districts and also make all necessary registration and documentation.

The DCE of Upper Denkyira West District Assembly was concerned about the environmental hazards brought by mining operations. He cautioned CAGL that all pollution should be management adequately and efficiently. He also encouraged the community to resolve disputes amicably and not in violence. The District Coordinating Director encouraged CAGL to provide alternative livelihoods for the members of the community whose farms and lands would be taken way. He cautioned that CAGL should provide an adequate opportunity for members of the community to lodge their grievances so that confrontation and violence be may minimised or eliminated completely. He requested that a copy of the environmental plan for CAGL should be given to the District Assembly.

Other

Questions and concerns came from all walks of life. In Ayanfuri youth from Zongo, complained that they were discriminated against during employment when previous mining companies were operational, this time round they have many skilled personnel in their midst, this pattern should not be followed by CAGL.

Another concern was that previous mines did not back fill the pits. CAGL was encouraged to ensure all pits are back filled as members of their community have lost their lives in these pits.

When previous mining companies were operational the criteria of employment into any post was not made public, so that applicants were disqualified without being given a reason. CAGL should make all vacancies and required qualification open to the community.

Others showed concern that accommodation facilities in the community were not patronised, in its stead employees of previous mining companies stayed at Dunkwa-on-Ofin and travelled back and forth each day. To offer an alternative source of income, they thought CAGL's employees should be encouraged to stay within the communities.

Also others lamented that deceased employees of the previous mining companies were not compensated in any form – not even a burial was offered by the company. Their concern was that what would CAGL do if faced with similar situation.

A Fobinso elder was of the opinion that communal labour should be encouraged in the communities so they can help in developmental projects.

3.10.7 Requests for Assistance by Villages

A list of requests for provision of infrastructure and other assistance made by the five villages is presented in Appendix 3.10.7.

3.10.8 Response to Requests for Assistance

CAGL reviewed the list of requests for assistance made by the various villages. In consideration of the fact that CAGL is not yet an operating company with income, assistance projects have had to be judiciously selected. Those projects that have been approved for implementation are presented in table 3.10.1.

Table 3.10.1: Assistance in Progress to Villages in Project Area

Village	**Immediate Implementation**	**Cost New GHC**
Abnabna	Borehole B/H01 Afriden – Repairs	647
	Borehole IM2 B/H02 - Repairs	1,891
	Borehole Renovations	1,092
Nykonya	Borehole	1,237
Ayanfuri	Fumigation & Emptying of Public Toilets	1,088
Gyaaman	School Renovation	1,620
	Mechanization of borehole Water Tower Construction	6,246
Fobinso	Borehole Repairs 2	3,280
	Estimated cost	**17,101**
Village	**Call for Tenders**	**Cost New GHC**
Abnabna	School Rehabilitation	6,648
Nykonya	Three (3) Classroom Block	13,990
Ayanfuri[1]	-	-
Gyaaman	Construction of No.1 Seater Aqua Privy Toilet Block	20,062
Fobinso	School Block renovations	34,148
	Estimated Cost	**74,848**
[1]. **CAGL recently contributed GHC 33,000 to construction of piped water scheme for** village		

3.10.9 Performance of Traditional Rites

Following the comments made at the public meetings CAGL has completed the Traditional Rites requested by the Chiefs of the villages (Appendix 5.10.3.9).

3.10.10 CAGL Introduction to District Assemblies

Following the comments made at the public meetings CAGL has completed formal introductions to the District Assemblies of Wassa Amenfi East and Upper (Diaso) and the Upper Denkyira West Municipal Assembly (Dunkwa-on-Ofin).

3.10.11 Social Development Consultative Committee

CAGL has initiated the implementation of a Social Development Consultative Committee (SDCC). The SDCC will include representatives of the five major villages within the Project Area. The committee will comprise of representatives from the following groups:

- Traditional Leadership
- Political Leadership
- Local Administration
- Farmers
- Women
- Youth
- Ministries (Local and/or Regional Offices
- Local Police Administration.

The Committee will meet at least once a quarter and will have the following objectives:

- To provide the residents of the Project Area with a forum for raising their issues;
- To identify issues of concern regarding the proposed Project;
- To receive information from CAGL about the proposed Project, and to distribute information to their communities;
- To provide input into the Environmental Impact Assessment process;
- To decide on issues discussed based on consensus of members of the committee and CAG.

The Social Development Consultative Committee will function under the following structure:

- A suitable local representative will chair the Committee.
- A suitable representative from CAGL will serve as the secretary and will ensure that minutes are kept and distributed to all members.
- All members will receive written invitations to meetings.
- The Committee will meet at a suitable venue agreeable and convenient to the members.
- Meetings will be held on a quarterly basis, but additional meetings may be convened to discuss specific issues / events should it be necessary.
- Additional sub-committees may be set up under the Social Development Consultative Committee to address specific issues as part of the consultation.
- Committee members will receive a transportation and food allowance for days attending the meetings.
- Should it be necessary, additional committee members may be included in the Committee.

The Committee will:

- Provide information and education about the Project’s activities to local communities,
- Provide advisory resources to the CAGL,

- Act as a sounding board for potential changes to CAGL policies and procedures as they affect Stakeholders.

Probably the most important aspect of effective and regular local community relations is that it imparts a sense of respect towards the local officials, which then helps to strengthen and stabilise the local community on both the traditional and local government levels. Local residents see that their leaders have achieved the respect of the Company and are therefore able to effectively act as their representatives and get a fair deal for the community. This is extremely important, as it is almost impossible to negotiate with a group or community when its leadership is constantly under question or change.

It is the intention to have the SDCC in place and operative by the time of the planned 2nd Village Public Meetings in September 2009.

3.10.12 Received Comments at EPA Public Hearing

13.10.12.2 Introduction

The EPA conducted a Public Hearing at Ayanfuri on November 17, 2010 to receive comments on the proposed Central Ashanti Goldfields Limited Project. Notice of the hearing was published in the national newspapers 22 days before the hearing date.

The Public Hearing was held in accordance with Environmental Assessment Regulations L.I. 1652, Section 17(1). This section mandates the EPA to hold a Public Hearing where, among other:

1) the undertaking will involve the dislocation, relocation or resettlement of communities -17(1)(b).

2) the Agency considers that the undertaking could have extensive and far reaching effects on the environment – 17(1)(b).

In its press notice, the EPA stated that the decision to hold the "Public Hearing relates to issues concerning the previous operations by the then Ashanti Goldfields Corporation Limited (AGC), the Social Concerns/Implications and the Potential Environmental Issues of the New Project Proposal."

In addition to the above press notice, formal letter invitations to attend were given to six villages in the Project area and to hamlet dwellers living in the proposed active operations mining area. The District Assemblies of Wassa Amenfie East and Upper Upper Denkyira West were also formally invited to attend.

13.10.12.2 Public Comments Recorded at the Hearing

As recorded by the EPA, the following are the major comments that were made at the Public Hearing by village representatives and individuals and which require addressing by CAGL.

1 The company must examine the possibility of releasing marginal deposit/noneconomical pits/areas for use by communities and incorporate the same in the report.

2 Compensation payments must take cognizance of the land tenure system in the Project area and commitment must be made in the report.

3 The company must consider assisting the catchment communities in the provision of health, educational and other facilities (refer to sub-section 4.11.2.3) and scholarship schemes for brilliant pupils/students.

4 Prompt payment of adequate compensation to affected farmers.

5 Observe the necessary traditional rites before commencement of work.

6 Contractors to contribute part of their profits to support community development programmes.

7 Incorporation of livelihood enhancement programmes and vulnerable schemes as part of Corporate Social Responsibility

8 Establishment of Community Development Fund

3.10.12.3 CAGL Response to Comments

"The company must examine the possibility of releasing marginal deposit/non-economical pits/areas for use by communities".

The request has arisen because the Chief of Ayanfuri is aware that not all the old pits are planned for redevelopment and that some of them are to be backfilled with waste from the proposed new mining operations. It had been proposed that CAGL relinquish its mining rights to these areas and that the Minerals Commission permit them to local interested parties as Small Scale mining areas. The old pits in question are those of the Besem, Bokitsi and Chirawewa mining complexes. CAGL has carefully considered the request and drawn the following conclusions:

The Besem pits were backfilled and largely revegetated by AGC; consequently there are no exposed possible gold bearing areas. Access to such areas would require removal of the backfill.

The South Bokitsi pits (3 in number) and the Chirawewa pits (4 in number)(see Map 1.2) are planned to be backfilled with waste from the proposed redevelopment of the Fetish South pit. If the Fetish waste is not placed in these old pits new waste dumps will have to be created on one or more greenfields areas which current land use is natural vegetation and farmlands. This would extend the footprint of the planned mining operations.

CAGL will undertake further sterilisation drilling before backfilling these pits. Should economic ore be identified it may be removed prior to backfilling. CAGL will not backfill areas that it deems to be economic for small scale mining.

CAGL will consider shedding areas not economic for large scale mining to allow access to small scale operators, once sterilsation drilling has deemed the pits uneconomic. However for safety reasons no areas inside the "mine area" can be made available whilst large scale mining is or will become active. If CAGL sheds any areas it will notify the Small Scale Mining division of the Minerals Commission and the EPA so issues of safety and pollution can be addressed.

It is not known what environmental controls would be required and enforced upon the activities of the small-scale miners. CAGL is committed to preventing its operations impacting on the atmospheric, land and water environment within and around its sphere of operations. It would have no control over any impacts on air, land and water that may be caused by other adjacent mining activities.

"Compensation payments must take cognizance of the land tenure system in the Project area and commitment must be made in the report."

CAGL has signed an agreement to compensate those local farmers whose crops will be destroyed by Project development. The Agreement was signed in September 2009 following negotiations between

CAGL and representative of the local farmers including the Chief Farmer for the area, representatives of the Wassa Amensie East and Upper Denkyira West District Assemblies and ten (10) representatives of the Concerned Farmers Association (Appendix 3.10.15-1). A subsequent amendment was made to the Agreement to reflect the increase in cocoa purchase price that was announced by the Ghana Government shortly after the Agreement was signed.

Those farmers whose farms are on the Abnabna stool and the Chief of Abnabna have reached an agreement that 5% of their farm compensation should be deducted to the Abnabna Stool. The farmers have written a letter to advise CAGL of this agreement. (Appendix 3.10.15.2).

The farmers on the Ayanfuri Stool Land have not yet advised CAGL of any agreement between themselves and the Chief of Ayanfuri.

"Prompt payment of adequate compensation to affected farmers."

CAGL is cognisant of the fact that many local farmers will paid compensation sums that are far above any sums that they have experienced or managed before in their life. Experience in other monetary compensation programmes related to mining in Ghana has found that the likelihood of this compensation being frittered away in relatively short time spans is quite large.

As farmers are one of the most impacted groups in the proposed Project, an investment seminar was coordinated by AC&E International on behalf of Central Ashanti Gold Ltd. for farmers within the five villages of its Project catchment area (Abnabna, Nkonya, Ayanfuri and Fobinso/Gyaaman jointly) on Wednesday December 15, 2009 and Thursday December 16, 2009. The aim of the seminar was to:

- Strengthen the knowledge base of farmers especially in finance management and investment.
- Strengthen the skills and abilities of these farmers in preparation of alternate livelihoods.
- Strengthen positive behaviours to improve their daily lives- especially in their spending/saving habits.

Barclays Bank Accra coordinated with their Kumasi Branch and a team of ten people who were led by Nana Obeng Brentuo and Mr. George K. Arthur, presented Barclays and Barclay's investment opportunities to the farmers. They indicated that Barclays has been in the country for over a hundred years and thus is the most reliable bank, convenient and best bank amongst the rest. This is mainly because the banks integrity is circumspect.

Mr. Brentuo explained that since Barclays has been in the Banking industry for an over a hundred years, the bank has various types of accounts to offer its wide range of customers. He indicated that the accounts listed below maybe appropriate for the farmers:

a. Fixed Deposit: interest rate is as high as 16% per annum.

b. Treasury bill: This had an interest rate of 25.7% per annum and could be purchased for 90days, 180days, or even one year.

c. Educational Policy: He indicated that there were various educational policies that could be patronized from the infancy of the child to adulthood; this aids parents to pay for their wards without stress.

There was an extensive question and answer after the presentation. Almost everyone that attended the program was willing to open a bank account immediately. Sales personnel from Barclays Bank filled forms immediately for all parties. At least all affected farmers will have a bank account. Barclays have stated that it is considering opening a new branch in Dunka-on-Ofin.

"Observe the necessary traditional rites before commencement of work."

CAGL has ensured the local community has been given the opportunity to observe the necessary traditional (customary) rites to date. In some instances, a CAGL staff member has attended the observance. Customary rites were held at Abnabna on, July 15, Ayanfuri on July 16, Fobinso on July 18, Gyaaman July 21 and Wassa Akropong on July 16. Additional details and photographs are presented in Appendix 5.10.3.9.

CAGL undertakes to ensure any remaining requirements for the community to observe customary rights will be facilitated. Customary rites that will have to be performed in the near future are:

- Customary Rites will have to be performed prior to commencement of clearing.
- Customary Rites will have to be performed for diverting the Asuafa stream into the Abnabna. (prior to commencement of stream diversion works
- Customary Rites prior to the re-location of any shrine.
- Customary Rites for the re-location of Royal Cemetery

"Contractors to contribute part of their profits to support community development programmes"

CAGL will enter into contracts with several major contractors particularly for Project construction and subsequently the actual mining operation itself. These contracts are awarded on a competitive tender basis. While CAGL (through Perseus Mining Limited) has its own commitment to Corporate Social Responsibility (see below), it cannot impose this commitment on a third party. Nevertheless, CAGL will encourage its major contractors to contribute to its Community Development Programmes whether it be a financial contribution, provision of equipment or specific skills and expertise.

"The company must consider assisting the catchment communities in the provision of health, educational and other facilities and scholarship schemes for brilliant pupils/students."

"Incorporation of livelihood enhancement programmes and vulnerable schemes as part of Corporate Social Responsibility"

"Establishment of Community Development Fund"

Perseus recognizes that successful community management is essential to the successful establishment and operation of the Central Ashanti Gold Project. . While the company recognizes the potential impacts associated with development, it is also aware that mine and the associated development can improve the overall well-being and livelihoods of the affected communities. Thus the Company is committed to developing and implementing an Economic and Social Development Program (ESDP) that is consistent with internationally accepted principles for Development. This includes a commitment to treating all affected parties with dignity and respect and ensuring that all processes relating to Development will be transparent, fair and equitable.

Objectives and outcomes of the ESDP include:

- Create sustainable settlements;
- Develop local skills levels;

- Guide future development in the area so that is does not impact on current and future mining areas
- Promote and support the development of the major regional economic centre;
- Ensure that the development process is structured, transparent, fair and orderly;
- Ensure that the development process complies with accepted international principles and can be audited;
- Development completed within reasonable and acceptable financial and time constraints.

As part of the Development process there will be on-going consultation with the local communities. This consultation will be affected through the SDCC (see 3.10.11 above). This consultation will extend beyond the consultation process associated with the Environmental Impact Assessment, and will include both formal (meetings with the Development committee, see below) and informal (discussions with individual household members etc) interactions.

The Company is aware that it has a general responsibility to contribute to socio-economic infrastructure in the communities of the immediate area in which it will be operating. This responsibility will be enacted in co-operation with local communities and local government (see 3.10.8 above). It does not mean, however, that CAGL can provide unlimited assistance and fulfil all requests for improvements made by local communities. Assistance will have to be tailored and budgeted according to the economic realities of mine operations and revenue received.

The Managing Director of CAGL has made a public commitment to the establishment of a Community Development Fund (EPA Public Hearing, Ayanfuri, November 17, 2010). The establishment of the Fund is partly dependent upon when CAGL begins operations and establishes a cash flow. During the construction period CAGL will complete already approved projects for the various villages (see 3.10.8 above). The amount of money to be committed to the fund will be New Ghc 750,000 per annum and this amount may be reviewed upwards by the board of CAGL.

One result of the two sets of Public Meetings held at the five main villages in the Project area in 2009 was that CAGL was able to compile a list of requests for assistance by the villages (Appendix 3.10. 7). The selection of requests for implementation under the auspices of the future Community Development Fund will be determined by the SDCC. CAGL does not intend to decide and implement any requests in whatever field – health, education, infrastructure improvement, etc. Its role, apart from funding assistance, will be to assist the communities in obtaining community development objectives. This assistance will be particularly prominent in the development of women and youth groups.

4.0 ASSESSMENT OF IMPACTS

4.1 INTRODUCTION

All mining activity effects some changes in the natural environment. The extent and nature of the impact can vary widely depending upon the method of mining, the characteristics of the mine site and its surroundings and the control and management of the mine operation.

This section of the EIS presents an assessment of the possible direct and indirect environmental impacts associated with the location, construction and operation of the Central Ashanti Gold Project (the Project) involving surface mining from five (5) different deposits and ore processing using gravity flotation and intensive leaching (GFIL). This process is essentially a flotation concentration in advance of a Carbon in Leach (CIL) process.

Mitigation measures proposed by CAGL to minimise the environmental impacts associated with the construction and operation of the Project are presented in chapter 5.0. Also, a specific section outlining the intent and proposed form of the CAGL Environmental Management Plan (EMP) has been prepared. A full EMP will be produced during the first year of operation. The Preliminary EMP outlines the plans to monitor environmental impacts that are predicted to occur as well as proposed mitigation measures which comprise all relational aspects between the Company and the local populations.

CAGL will operate the Project in accordance with Ghana legislation, regulations, guidelines and standards, other appropriate international environmental standards and CAGL's own internal standards and procedures to contain all chemicals/solutions and to minimise any adverse effects on the health and safety of the workers, the local population as well as the Project Area and regional environment.

4.2 METHODOLOGY OF THE ASSESSMENT

The methodology used to identify the potential impacts of the proposed mining Project and to predict their significance has been based on the following information:

⇨ **Evaluation of existing information describing the development, operational and closures phases of the Project:**

CAGL has prepared a Definitive Feasibility Study (DFS). Major decisions in term of mining type, mineral processing, water supply, tailings disposal, site accommodation, etc. have been made. Final design details and operation schedules will be refined should the Project be developed.

⇨ **Comments and concerns raised by the relevant governmental agencies in Ghana, village chiefs, other traditional authorities and local people to assess their perceptions and concerns about the proposed Project.**

⇨ **Existing environmental regulations and procedures prevailing in Ghana and as referred to in the Introduction chapter of this document.**

⇨ **An examination of the data obtained to characterise the existing environment of the Project Area. The baseline study assessment focused on the following aspects:**

- Climate;
- Air quality (Mainly dust deposition and noise values);
- Hydrology;

- Hydrogeology;
- Surface and ground water quality;
- A synthesis of the ecological environment, which included fauna and flora surveys;
- Soil classification survey and soil suitability for agriculture;
- Landuse survey including a detailed inventory of farms which may need to be compensated;
- Socio-economic characteristics of the Project Area and its environs including a detailed inventory of settlements, which will be affected by Project development.

All these data were obtained following several site visits and field surveys undertaken by independent consultants and scientists who are very knowledgeable about the existing environment in Ghana and the Project Area in particular.

⇨ **Experience from similar gold mining operations developed in equivalent environmental conditions.**

4.3 SUMMARY OF POTENTIAL IMPACTS

A summary of the potential impacts arising from the development and operation of the Project is presented in table 4.2. The nature and level of the potential impacts and the need for mitigation measures is then discussed.

The summary takes cognisance of the following:

- Potential impacts on the on the physical, chemical and biological aspects of the Project environs,
- Impacts on occupational health and safety,
- Location of villages relative to the Plant site activities of the Project (Table 4.1).

Table 4.1: Distance between Villages and Plant Site

Village	Measured Point to Point[1]	Distance (metres)
Abnabna	Plant site	1391
Fobinso	Plant site	2357
Nkonya	Plant site	2827
Ayanfuri	Plant site	3782
Gyaaman	Plant site	3076

Points measured in a direct line from nearest edge of village to the nearest edge of the facility Map 2.2) ignoring any topographical features along the line.

The nearest facility to Nkonya is the haul road (Year 5 development) from the Fetish pit to the Plant site, a distance of 1.12 km. The Plant site is 2.8 km distant with a forested area in between. Consequently the impact of construction and operational activities will be virtually none. Social impacts on the village arising from mine development are discussed in section 4.11 as are those for the other villages.

Gyaaman village is also distant from mine facilities. The nearest facility is the FTSF (boundary at full development) at 1.8 km distant. The Plant site is 3 km distant. Consequently the impact of construction and operational activities will be virtually none. Social impacts on the village arising from mine development are discussed in section 4.11 as are those for the other villages.

4.4 SITE PREPARATION AND CONSTRUCTION PHASE

4.4.1 Introduction

The construction phase of the Project will involve site preparation activities, development and/or construction of Abnabna, AF-Gap, Fobinso, Fetish and Esuajah North pits, four major waste dumps, the water storage facility, two tailings storage facilities, the process plant and other support facilities.

According to the current Project layout (Map 2.2) the total area designated for the various Project facilities will cover a surface of approximately 998 ha. The land take will correspond to 10.7% of the two CAGL mining leases (93.1 km^2). The distribution of the land areas by facility is detailed in table 2.2 and a summarised version is presented below:

- The open pits development will cover an area of 132 ha,
- The waste dumps will cover approximately 306.8 ha,
- The new haul roads will cover approximately 12 ha,
- The flotation tailings storage facility area will cover approximately 339 ha,
- The CIL tailings storage area will cover approximately 14 ha,
- The plant site/contractor area (mine services, fuel) will cover 22 ha,
- ROM pad will cover approximately 119 ha,
- The process pond will cover approximately 2.5 ha,
- The new access road from the highway to the existing Nkonya-Abnabna road will require approximately 1 ha,
- The Abnabna road diversion will require approximately 14 ha,
- The power line right-of-way to the site will require approximately 9 ha.
- The Asuafa stream diversion will require approximately 14
- Delivery to site of plant components and erection.
- Compensation for mining areas commencement of mining at AF-Gap and Abnabna.
- Development of haul roads and mine infrastructure.
- Flotation TSF and CIL TSF.
- Refurbishment of the current accommodation village.
- Construction of offices, mess and infrastructure at the site.
- Commissioning and commencement of operations.

4.4.2 Construction Phase

The construction phase or overall development period will take approximately 12 months. This phase will begin with site preparation activities of the main Project facilities areas listed below and is planned to occur as much as possible during the dry season. This can minimise impact due to soil erosion, particularly in regard to potential increase in the level of suspended solids in the local water bodies. For the wettest period of the year, settling ponds will be built at appropriate locations downstream from some of the Project facilities such as the treatment plant and the mine services area.

Table 4.2: Summary of Potential Impacts of the CAGP on the Environment

Type of Impact	Activity Contributing to Impact	Potential Recipients
Visual Impact Construction and Operation Phases		
Visual intrusion	Surface developments for pits, FTSF, process plant and other facilities	• Residents of Abnabna and Ayanfuri during construction and early operations
Air Quality Construction Phase		
Airborne Particulate (dust)	Site clearance (starter pits, waste dumps, process plant, TSF, water storage facility, housing, haul roads and access roads)	• Workers • Adjacent fauna and flora
	Vehicle movements on Project site	• Vehicle drivers • Dwellers walking along roads
	Hauling of construction material	• Travellers and vehicles along sections of the site access road
Air Quality Operation Phase		
Airborne Particulate (dust)	Site clearance (ongoing development of pits and waste dumps)	• Workers • Adjacent fauna and flora
	Blasting at the pit (area evacuated)	• Atmospheric Environment(1)
	Excavation of the pits	• Workers
	Haulage of waste and ore	• Vehicle drivers
	Crushing at the treatment plant	• Workers
	Vehicle movements on Project site	• Vehicle drivers
	PM10 from diesel engines	• Atmospheric Environment(1)
Gaseous Emissions (CO_2, SO_X, NO_X, CO)	Diesel engines (vehicles and generators)	• Atmospheric Environment(1)
Physical Impacts Construction Phase		
Noise	Increase in road traffic and heavy equipment used for construction of the various mine facilities	• Workers •Travellers to villages beyond the access roads e.g. Abnabna and Wampem
Physical Impacts Operation Phase		
Noise & Vibrations	Blasting (This will be Intermittent and irregular)	• Inhabitants of Abnabna and Ayanfuri (north)until waste dumps of sufficient height to provide some attenuation • Fauna
Noise	Pit excavation and processing activities at the plant	• Workers • Fauna
	Road traffic (including haulage of ore)	• Workers . Travellers/vehicles along section of the site access road and to/from Wampem . Haul roads crossing highways
Water Resources Construction Phase		
Deterioration of water quality (streams in the Project Area are highly seasonal)	Increase in suspended solids from site clearance (only if activity is conducted in wet season)	• Tributaries of the Subin and Fobin rivers • Farmers and inhabitants of villages downstream of Project Area (2) • Aquatic fauna (micro-organisms, insects, maybe some fish)
	Accidental oil spillages from drums or heavy vehicles	
Water Resources Operation Phase		
Localised changes in surface water hydrology (flooding, drought)	Impoundment of raw water for Project supply requirements and permanent storage of tailings	• Tributaries of the Akesoa stream (localised modification of flow regime)
	Foot print of Project facilities resulting in local modification of the topography and hence catchment characteristics including Asuafu stream diversion	• Tributaries of the Subin and Fobin rivers and the Ofin as final receptor (localised modification of flow regime) • Farmers and inhabitants of villages in and downstream of Project Area (2)
	Discharge of mine water from pit dewatering.	

Table 4.2 continued: Summary of Potential Impacts of the CAGP on the Environment

Change in surface water quality (pH, suspended solids, cyanide, heavy metals and oil & grease)	Limited discharge of mine water.	• Asuafu stream and Subin river • Farmers and inhabitants of villages in and downstream of Project Area (2) • Aquatic fauna(2)
	Accidental discharge of process effluent Runoff from the waste dumps and other Project facilities Leaching of waste and potential of acid mine drainage Sewage Disposal Accidental oil spillages from drums or heavy vehicles	• Tributaries of the Akesoa, Asuafu streams and the Subin river. and • Farmers and inhabitants of villages in and downstream of Project Area (2) • Aquatic fauna(2)
Modification of groundwater resources (quantity)	Pit development and dewatering	• Localised lowering of water table
Changes in the quality of groundwater resources	Potential seepages from tailings storage facility, waste dumps and stockpiles	• Localised pollution of aquifers • Inhabitants using groundwater(2)
Ecology Construction & Operation Phases		
Deforestation	Pit, Plant and TSF site development	• Flora • Loss of timber resources(2)
Loss of immature or degraded secondary forest, thickets, etc.	Distribution of Project facilities s and risk of fire outbreaks	• Flora and fauna
Destruction and fragmentation of habitats	Pits and waste dump development	• Fauna and flora
Habitat avoidance	Operation of Project activities that generate nuisances (noise, dust, fumes)	• Fauna
Soil and Land Use Construction & Operation Phases		
Loss of agricultural land	Project development	• Farmers (Loss of farm-holding)
Soil erosion resulting in sedimentation	Clearing of large areas for Project development	• Soil environment (loss of fertility) • Tributaries of the Akesoa, Asuafu streams, the Subin and Fobin rivers 2)
Socio-Economic Construction & Operation Phases		
National and regional increase of employment Improvement of local and national infrastructures Improvement of local skills	Operation of the Project, which will involve training with emphasis on local labour, purchase of goods manufactured in the country, payment of taxes, royalties and dividends	• Ghanaian economy • Districts located in Project Area • Local communities
Loss of habitations and farm-holdings	Land take and loss of farm-holding for Project development	• Farmers in and around the Abnabna-AF Gap – Fobinso pit areas and Plant site
Demographic changes	Influx of peoples looking for employment	• Inhabitants of the Project Area
Increase in local cost of living	Competition for food resources and services. Workers with higher revenues	
Increased pressure on utilities in particular water resources	Increase in demography	
Waste Generated Construction & Operation Phases		
Pollution/contamination of the local environment	Household waste, waste oils, hazardous waste, laboratory waste	• Soil and water resources
Health and Safety Aspects of the Project		
Illness, loss of life and injuries	Various operations of the Project	• Workers

(1) Means there is no direct recipient, but the activity identified as contributing to an impact may increase the concentration of a particular environmental indicator (e.g. increase concentration of dust in the atmosphere or increase the level of suspended solids in a water body, *etc.*)
(2) Identified as potential secondary recipient

The construction phase will include the following sequential steps:

- Compensation of farms and negotiated access to the site for the western area only.
- Preparation of the access road to the main Project site which will involve development of a temporary access road cut from near the Fobinso pit to the plant site approximately 800m.
- Clearing and earthworks for the infrastructure development at the plant site.

4.4.3 Description of Clearing Activities

4.4.3.1 General

Preparation of the various Project sites (for starter pits, waste dumps, tailings storage facility, water storage facility, treatment plant, mine service area and accommodation) will start concurrently to the construction of the access road upgrade. This will involve activities such as felling of trees, clearing of vegetation, stockpiling of wood and branches, where possible segregation and stockpiling of topsoil and where necessary surface compaction. Stockpiled topsoil will also be used for early revegetation purposes required to stabilise certain structures such as embankments or earth mounds.

The activities of clearing, grubbing and topsoil segregation will be co-ordinated by the Environmental Department to minimise the negative impacts on the environment and local community.

It must be pointed out that deforestation or vegetation clearance of the various sites will be a gradual process and will not exceed the surface of the area required for each Project facility. For example, it will not be necessary to initially clear the entire surface of the waste dumps as waste rocks are produced and stored progressively from the beginning to the end of the life of the Project. Similarly, mining of the deposits located in the northern and eastern areas and associated clearing activities will not start before year three and year five respectively.

4.5 VISUAL IMPACT

4.5.1 General Description of the Project Site

The Project will be developed on a land area of approximately 998 ha. (Map 2.2, Table 2.2). Topography in the CAGL licence areas is largely gently undulating, ranging from 120m to 240m ASL. Areas of lower relief are generally vegetated by open secondary forest of various ages and agricultural land. Agriculture in the area consists mainly of cocoa farms with lesser subsistence farming. There are no villages within the boundary of the active Project area, however, a number of small settlements (cocoa farming hamlets) occur within areas designated for pits, tailings disposal and plant site development. It should be pointed out that the Project Area is not located within or near a location with significant tourism potential.

4.5.2 Methodology

This visual impact survey is based on the concept of assessment of visual impacts from identified critical viewpoints which will be limited to the communities of Abnabna and Ayanfuri (northern edge) identified below.

4.5.3 Sources of Visual Impact

The potential sources of undesirable visual intrusion associated with the development and operation of the Project were identified as the Abnabna and Esuajah North waste dumps.

4.5.4 Assessment Results

The development and implementation of the Project facilities will result in modification of the site configuration through the creation of artificial lines (holes for the pits, mounds of 25m (Abnabna) to 70m (Fetish) height for the waste dumps, etc.). Because of the natural topography of the area and the proposed location of the various mine facilities, the Project will have very limited visual impact on communities around the Project area.

Abnabna and Ayanfuri were identified as potential critical view points. Abnabna will face the western face of the Abnabna pit waste dump. The footprint base of the final waste dump will be approximately 250 m from the village boundary. The dump will have a maximum height of 25 m. This waste dump has been specifically designed to provide a degree of noise and light attenuation between the village and mining activity.

The southern edges of the waste dump east of Esuajah North pit will be visible from the northern limit of Ayanfuri. The dump height will be 35m high.

The north-western face of the final Fobinso dump (50m height) will be visible from Fobinso village.

This impact category can be classified as very localised and will require implementation of specific mitigation measures.

4.6 EVALUATION OF IMPACT ON THE ATMOSPHERIC ENVIRONMENT

4.6.1 Airborne Particulate

4.6.1.1 Definitions

The quality of the ambient air can be seriously affected by an increase in airborne particulate. This type of pollutant is generated from various sources generally classified in two categories:

- easily defined sources such as crushing, screening, conveyors, machinery etc.; and
- dispersed sources such as blasting, hauling, dust blow from working area and stockpiles, etc.

These are, respectively, point and non-point sources.

4.6.1.2 Evaluation During the Construction Phase

The potential sources of airborne dust associated with the construction phases of the Project are:

- Vehicle movement from delivery of construction equipment and materials to the main Project facilities area along the upgraded portion of public road that is part of the proposed new access road to the site;
- Site clearance of areas required for Project development as discussed under 4.4.2;
- Vehicles movement on the Project site roads.

Considering the prevailing wind conditions in this part of Ghana (less then 6 m/s), dust generated in the atmosphere is expected to settle rapidly and to travel only a few metres (20 to 50 m) from the source.

Therefore, dust from clearing activities may affect the health of the workers and dust generated from vehicle movements on roads can reduce visibility for the road users, and affect nearby vegetation by reducing photosynthesis of leaves that become covered with dust.

Users of the road from Abnabna to Nkonya are the most likely to be impacted by dust during construction activities (construction of the new road and from vehicles delivering construction supplies to the Plant site. However, this will partly alleviated by the use of another access road to be constructed from the old haul road between Abnabna and Fobinso pits into the Plant site. A new access point off the Ayanfuri to Bogoso highway (north of Nkonya) will eliminate dust and noise impact at the present junction (see section 2.11.2).

This impact category can be classified as short term, localised and reversible and will require mitigation measures.

4.6.1.3 Evaluation During the Operational Phase

Potential Sources of Impact

The potential sources of airborne dust associated with the operational phase of the Project will involve the following activities:

- Open pit development blasting and grade-control drilling;
- Digging, loading and haulage of ore and waste;
- Vehicle movement;
- Ore crushing at the process plant area;
- Dust blow from excavated or cleared areas, *etc*; and
- Fine particles (PM10) generated from the combustion of diesel engines.

For the purpose of this assessment, source emissions have been classified into point sources and non-point sources of dust.

Assessment of Impact

Point Sources of Dust

The two main point sources of dust emission will be the crusher (and associated discharge conveyors) and the carbon regeneration kiln both located within the premises of the treatment plant. In general, ore moisture should be around 10 to 15%, but dust generated during crushing may exceed the 50 mg/m^3 maximum quoted by the World Bank (WB) for this category of emission. This impact can be considered as very localised but will require mitigation measures to prevent impacts on worker health.

Concentration of fine particles generated by diesel fuelled engine exhausts at the plant should be within acceptable limits as all equipment to be purchased by CAGL will be typical for this type of mining operation and comply with international standards (e.g.: The WHO/WB quote a maximum 24 hour average of 150 μg/m^3). Mitigation measures will be required.

There are no villages that will be affected by operations on the Plant site as the villages of Abnabna, Fobinso and Ayanfuri are approximately 1.4 km, 2.3 km, and 3.8 km respectively from the Plant site.

Non Point Sources of Dust

Fugitive dust from non-point sources is governed by two major climatic factors, wind speed and material moisture content. Based on the average number of rainy days per year recorded at Dunkwa-on-Ofin it is estimated that site conditions will be wet between approximately 25 and 44 % of the year (number of rainy days per year range from 87 to 156). Such conditions will assist in damping down airborne particulate. At other times dust emissions could be significant, particularly during the driest months of the year from December to March where they will reach a maximum due to the contribution of Harmattan dust. The particle size distribution of this Harmattan dust has been reported by Orange & Al (1993) as 6.5% less than 2 µm, 91% between 2 and 50 µm and 2.5% more than 50 µm.

The principal non-point sources of airborne particulate will be:

- dust arising from blasting activities,
- fly rock generation,
- Movement of vehicles on Project roads and
- Fine particles (PM10) generated from diesel engines of haul trucks and other vehicles.

Other potential sources such as dust blow from the tailings dam area or the waste dumps can be considered as negligible. Indeed, wind speeds expected in the region are generally very low except just before a storm event.

Dust from blasting is the source which so far appears to defy total control. Traditionally, the only practical control was to blast only when climatic conditions preclude the spread of dust to particularly sensitive locations.

Fly rock arising from blasting can have a major impact on local and plant areas unless careful blasting measures are in place. Mitigation measures will be required.

In the context of the Project, dust from blasting from the open pits should not be a major problem as all settlements which have not been resettled will be a minimum 500 m distant from pit boundaries (Maps 2.2) except Ayanfuri which is 250 m from the Fetish pit boundary at the full development. These distances must be treated with caution as they are measured from designated village boundaries and do not necessarily mean that there are populated areas at those points. Similarly, low values for wind speed and the hilly topography of the site should all contribute to limit conditions in which dust can be dispersed in the environment.

On haul roads, dust arises from spillage from trucks and abrasion by their wheels. All the major mine haul roads and access roads will be located well away from human settlements. Minor nuisance dust generation may be expected where haul roads cross public roads – the haul road from Esuajah North pit and that from the Fetish pit as per existing level crossing around Ayanfuri used during previous mining activities.

Dust impacts would be likely for users of the new Abnabna – Nkonya road that will become the main access route to the Plant site.

Based on observations made within several mining operations in West Africa and Ghana, this impact can be classified as locally significant, intermittent and reversible. Appropriate mitigation measures will be required.

4.6.2 Gaseous Emissions

4.6.2.1 Potential Sources of Impact

No noxious gases will be generated from the process plant and the operation of the mine in general. The ore of the Project is not refractory and, therefore, will not require any oxidation step such as roasting which can produce toxic fumes containing sulphur dioxide and/or arsenic when present in the mineralisation.

Potential sources of gaseous emissions resulting from the operation of the Project will be limited to diesel engine fumes from vehicles, carbon regeneration kiln, the wet laboratory and stand-by generators when used during power supply failures.

It must be noted that, blasting fumes (containing low quantities of nitrous oxide and carbon monoxide) will be generated in quantities, which are generally neither detectable nor measurable at the pit limits.

4.6.2.2 Assessment of Impact

Gaseous Emissions from Diesel Engines

Besides carbon dioxide (CO_2), the main gaseous substances resulting from diesel engine combustion are sulphur oxides (SO_X), nitrous oxides (NO_X) and carbon monoxide (CO).

Concentration of fine particles generated by diesel fuelled engine exhausts should be within acceptable limits as all equipment used by CAGL is typical for this type of mining operation and comply with international standards. The volume of particles produced will be rapidly dispersed and any effect of deposition is considered negligible. Mitigation measure will, nevertheless, be required.

4.7 NOISE AND VIBRATIONS

4.7.1 Definitions

Noise is normally defined as objectionable or unwanted sound which is produced by a source causing vibrations (air over pressure) in the medium surrounding it. It is usual to segregate noise problems into physical, physiological and psychological effects.

4.7.2 Potential Sources of Impact

Project operations will increase the general level of noise and vibration within the vicinity of its operations. Both mining and processing activities will generate noise and vibrations which can be classified as follows:

- Continuous or semi-continuous noise as a result of processing activities (mill, compressors, pumps, etc.) and vehicles (mainly heavy vehicles for mining activities and ore transportation). Vibration associated with these sources are generally low and localised; and
- Intermittent noise (air over pressure) and vibration resulting from blasting of the pits.

The recipient media will be mainly the Project workers, hamlets and nearby communities.

4.7.3 Assessment of Impact During the Construction Phase

During the construction phase, noise will be generated from an increase in road traffic along the proposed access road (Map 2.2) and the operation of heavy equipment used for the preparation of the various Project sites (starter pits, waste dumps, tailings storage facility, water storage facility, treatment plant, mine service area and accommodation).

There are no villages that will be affected by construction noise at the Plant site as the villages of Abnabna, Fobinso and Ayanfuri are 1.3km, 2.3 km, and 3.8 km respectively from the Plant site.

The hamlets relocation programme will ensure that there are no recipients within the immediate vicinity of major facilities construction.

Users of the Nkonya – Abnabna access road will be subject to intermittent noise from heavy traffic.
This impact is considered low and irreversible.

Abnabna village limit will be >530m and >130 m from starter pit development and waste dump clearing respectively at the time of development. Ayanfuri village limit will be 320m from Esuajah North pit at beginning of mining activities. Ayanfuri village limit will be >380m from the Fetish pit at start up of operations.

This impact category can be classified as short term, localised and reversible, but will require implementation of specific mitigation measures as part of the overall strategy to minimise the effect of noise.

4.7.4 Assessment of Impact During the Operation Phase

Continuous or Semi-continuous Noise

Semi-continuous noise will result from the operation of heavy vehicles for mining activities, transportation of the ore to the proposed treatment plant and processing activities at the plant site. Vibration associated with these sources is low and localised.

The relative remoteness of the haul roads and the plant site from communities that will remain in the Project Area after hamlets relocation and the existing vegetation cover indicates that noise and vibration will not be a significant issue. This impact can be considered as low and reversible.

Impact on fauna will also include species (particularly birds and small terrestrial mammals) which may leave temporarily, or permanently, the active Project area. In West Africa, there is no extensive data regarding animal behaviour in relation to noise level. However, investigations elsewhere have shown that response and adaptation is species dependent. Birds and small mammals can adapt to an increase in noise level providing their habitat is not destroyed, heavily fragmented or subject to high human intrusion.

Intermittent Noise and Vibrations

The majority of the ore will require drilling and blasting. Vibration induced by blasting, however, will be minimal because of controlled blasting technology. Following the resettlement of various hamlets in immediate proximity to the Abnabna/AF Gap and Fobinso pits there will not be any inhabited areas within the designated blasting safety zone of 500m.

Although straight line distances between Abnabna and Ayanfuri villages to the perimeters of Abnabna/AF Gap pits and the Fetish pit respectively will be less than that, blasting will occur at ever increasing depth in these pits, thus reducing the necessary safety zone requirement. A similar situation is envisaged at Esuajah North where the distance between the final pit edge and the current northern boundary of Ayanfuri will be approximately 260m.

However, noise arising from blasting operations can have a generally psychological impact on some people even if such nuisance occurs once a day or only every few days. It is relatively common to have people confusing air over pressure with level of vibration. It will therefore be the responsibility of the mine to deal with the local population by providing continuous information and education. Impact from blasting activities can be classified as locally significant, intermittent and reversible. Appropriate mitigation measures will be required.

4.8 EVALUATION OF IMPACT ON THE AQUATIC ENVIRONMENT

4.8.1 Surface Water

4.8.1.1 Introduction

The majority of streams in the Project area eventually drain into the Ofin River via the Subin and Fobin rivers. The Chirawewa pit complex area is drained by the Kyiriawewa and Meretwe streams that form part of the Mansi River catchment of the Ankobra River.

The main tributaries of the Subin River are the Aponapon, Bowodinanwu, Asuaa, Danyami and the Nsanka streams. The main tributaries of the Fobin River are the Akesoa, Asuafu, Abnabna, Takrowa, Maninwu, Amantifuawura and the Kyiritwe streams.

The streams and rivers draining the Project Area receive flow contributions, which originate from an area where the deposits are located. Therefore, the main mining area is comprised of headwaters for these tributaries. The exception would be any drainage originating from the Fetish Main waste dump.

Within the Project Area, these water bodies have metal concentration within prescribed limits for potable water. Typically though, total suspended solids can be higher than acceptable limits: bacteriological limits are commonly above prescribed levels for drinking water. Some streams are used for drinking water and other purposes (Chapter 3, section 3.8, Table 38.2) mainly during the rainy season. These streams are very seasonal, and dry completely except during exceptionally wet years. The five main villages, however, have boreholes to provide an alternative source of drinking water.

4.8.1.2 Identification of Major Impact Categories

Without adequate safeguards and management, the possible impacts of the Project on the surface water regime would include:

- Modification of stream hydrology through alteration, erosion and siltation giving rise to the more frequent occurrence of extreme events within the catchment area;
- Possible deterioration in surface water quality with particular respect to pH, suspended solids, cyanide, heavy metals and oil & grease.

Such modifications may have consequences for the ecological surface water environment and could affect downstream users, particularly those who are dependent upon streams for their source of drinking and domestic water because of distance from boreholes.

4.8.1.3 Potential Sources of Impact

Potential sources of impact on the surface water environment associated with the development and operation of the Project are:

During the Construction Phase:

- Site preparation and land clearance activities of the various Project sites, which can result in an increase of suspended solids in the streams; and
- Accidental oil spillages from drums or heavy vehicles, which can potentially deteriorate the quality of surface water.

During the Operational Phase:

- Impoundment of raw water for Project supply requirements,
- Footprint of Project facilities resulting in local modification of the topography and hence catchment characteristics,

(It should be noted that of mine water from pit dewatering will be returned to the FTSF thus avoiding any impact from suspended solids).

- Accidental discharge of process effluent,
- Runoff from the waste dumps and other Project facilities,
- Leaching of waste rock,
- Leaching from tailings disposal areas,
- Sewage disposal,
- Accidental oil spillages from the various workshops or heavy vehicles,
- Effluent discharges from oil/water separators.

The recipient media will be the tributaries of the Subin, Fobin (Ofin catchments) and Kyiriawewa and Meretwe streams of the Mansi sub-catchment ((Ankobra). All these sources of impact (generally related to a particular activity) may have an influence on either water hydrology and/or quality. This is discussed in detail in the following paragraph where each impact is related to a potential recipient.

No process effluent will be discharged from the tailings dam or the plant until the end of the Project. For average climatic conditions, and based on FTSF performance the water balance will be positive for the first six years. Years 7-10 will have a water deficit. This water will be pumped from Fobinso, Fetish, Esuajah South and from other surface sources on the leases.

4.8.1.4 Assessment of Impact During Construction Phase

Impact on Stream Users

Site preparation activities of the various Project sites (starter pits, waste dumps, tailings storage facility, water storage facility, treatment plant, mine service area and accommodation) will involve land clearance which may induce erosion and potentially increase the level of suspended solids in some of the streams of the Project Area (Map 32.2) identified as follows:

- The Akasoua, Asuafu Abnabna and Takorowa tributaries of the Fobin may be affected by clearing activities of the starter pits, waste dumps, treatment plant and mine service area, with consequent impacts (total suspended solids) on villagers from Abnabna and Fobinso who use these streams for domestic purposes (but not usually for drinking water as this is obtained from boreholes.

- The Subin may be affected by clearing and development activities of the Fetish pit, with consequent impacts on villagers from Ayanfuri who use these streams for domestic purposes (but not usually or drinking water as this is obtained from boreholes.
- The Subin, one of its tributaries, the Asuafu, and a small unnamed tributary may be affected by clearing activities for Esuajah North pit and waste dump.

Site starter preparation activities will be undertaken mainly during the dry season and therefore, major impact on the surface water environment is not expected in general. Due to the length of the construction phase (12 months), some minor suspended solids pollution may not be totally avoidable. Mitigation measures will be required to ensure that these temporary and reversible impacts are kept to a minimum and mitigated.

Impact on Hamlets

Many of the cocoa farming hamlets located within the Project Area rely on the Asuafu and its small unnamed tributaries. Due to the seasonal character of most of these streams, the hamlets have to obtain water from more than one source. Those with a single stream water source still manage to obtain water through dugouts in the stream bed during the dry season or walk up to 1 km to have access to a well or borehole. Since the hamlets are to relocated or resettled mitigation measures will not be required.

Impact on the Asuafu Stream

The Asuafu stream passes through the mine site and is the current source of main drainage from the area. The placement of the ROM pad interrupts this stream and effectively creates a catchment area behind it. Mitigation measures will be required.

Accidental oil spillages

Probability for accidental oil spillages to occur will be relatively low but should not be ignored. These spillages may result from drums stored in inappropriate conditions or from heavy vehicles which suffer breakdowns. Mitigation measures will be proposed.

4.8.1.5 Assessment of Impact on the Site Hydrology During Operational Phase

General

Several activities, listed below, may have an influence on the site hydrology:

- Impoundment of raw water for Project supply requirements,
- Footprint of Project facilities resulting in local modification of the topography and hence catchment characteristics of the water bodies, and
- Discharge of mine water from pit dewatering.

4.8.1.6 Impoundment of Raw Water

The primary source of raw water will be the catchment area in which the FTSF is located. Its purpose is to provide a secure source of raw water supply required for processing operations during both the start-up period and subsequently to compensate for the shortfall in process water between recycled water (from tailings decant) and plant requirements.

The Process Water Storage Facility (PWSF) will be located in a small valley adjacent to the Plant site and to the south-west of the FTSF. The facility has been designed to store approximately 1,050,000 m^3 and will also be recharged by from groundwater boreholes located upstream of the proposed diversion drain on the Asuafu stream and from pit dewatering bores.

Impact on the Ofin River Hydrology

The total catchment area of the FTSF has been estimated at less than 500 ha (see catchment boundary on see the map: Tailings Storage Facility Design – General Design) within the Ofin Catchment of 8,344 km2. Thus <0.1% of the Ofin catchment area will be effected by the Project during operations. At closure the runoff will be directed back into the Ofin River.

Assessment of FTSF Flood Conditions

The facility will have the potential to contain a considerable body of water during a rainstorm. The minimum Total Freeboard is 500 mm which comprises operational freeboard (the distance between the embankment crest level and the maximum allowable tailings solids level immediately adjacent to the embankment wall, plus an additional minimum 200 mm which represents the maximum water level after the design storm, 1 in 200 year 72 hour storm, which equates to 300 mm or a volume of 1,029,000m^3 above the normal operating pond level. The normal operating pond level should therefore be no more than 800 mm below the embankment crest level.

From the above evaluation, it is considered that the FTSF has been adequately designed for flood conditions and protection of the only major village, Nkotumso, between the facility and the Ofin River.

Assessment of CIL TSF Flood Conditions

The CIL TSF has a storage capacity of approximately 1.8Mm^3 with placement of 0.18Mm^3 per year. The total containment volume has no runoff and catchment control will see very little runoff entering the CIL TSF. The return solution from the CIL TSF will managed to ensure that direct precipitation will not result in overfilling of the CIL TSF.

Changes in the Topography

The development and operation of the CAGP will result in the direct utilisation of a few small sub-catchment areas of the Ofin River and one of the Ankobra River (Map 32.1). These are described as follows:

- All Project facilities will result in the direct utilisation of approximately 6.2% (or 8.4 km^2) of the Subin and Fobin sub-catchments (135.1km2) of the Ofin River (8,344km^2).

- The utilisation of the Subin and Fobin sub-catchments will represent 1 % of the Ofin River catchment area.

- The utilisation of Fetish waste dump area (if the fact that this will largely be the backfilling of an existing pit is ignored) will result in the direct utilisation of approximately 105 ha of the Mansi sub-basin of the Ankobra River and is therefore insignificant.

Changes in topography resulting from development of Project facilities would have an effect on the catchment characteristics of the sub-catchment areas listed above. Overland runoff could be faster as a result of removal of vegetation for land development. Consequently, the surface water flow regime in the area may be changed.

From a hydrological point of view, only the impact on the individual tributaries of the Subin and Fobin River could be locally appreciable as the upper parts of their catchment will be modified. This impact must be placed in the existing local context (seasonal flow, small size of sub-catchment, no commercial uses of the water, etc.) and it is unlikely that any changes will be measured on the Ofin River or the Ankobra River downstream of the Project Area. Nevertheless, mitigation measures and monitoring will be required to minimise any adverse impact and to verify effectiveness of mitigation methods included as part of the design and management of the Project to preserve the water resources of the area.

Mine Effluent

Expected groundwater inflows to the pits will be generally less than 10% of the total dewatering requirements. The major contributor will be direct precipitation. Dewatering requirements to avoid flooding of the pits are considered to be relatively small. Perimeter drains will be established at each pit to prevent the inflow of rainwater. Pit rims will be bunded to protect against inflow in the event of high rainfall events.

With the exception of Esuajah North and Fetish pits, water from pits dewatering (mine effluent) will be discharged into the FTSF. Mine effluent from the Esuajah North and Fetish pits will be directed to the Subin stream (only after seeking and gaining EPA and WRC approval). Water released to the environment is considered to be negligible but will contribute to the base flow of the Subin river particularly during the dry period of the year. Mitigation measures will be required.

4.8.1.7 Assessment of Impact on Surface Water Quality During Operational Phase

General

A certain number of activities listed in paragraph 4.8.1.3 (Potential Sources of Impact) may have some influence on the quality of the surface water environment mainly during the rainy season. Those changes could affect some parameters such as pH, turbidity, colour, suspended solids, cyanide, heavy metals and oil & grease. However, it must be pointed out that no effluent will be discharged from the process as water is not in excess of Project requirements. Only accidental spillages may be responsible for a pollution of the aquatic environment. Also, most streams are dry for a significant portion of the year.

Accidental Discharge of Process Effluent

Two tailings streams will be discharged from the Process Plant – flotation tailings and CIL tailings. The former stream will not contain cyanide or elevated metals concentrations and are considered benign. Tailings from the CIL stream will be discharged at relatively high cyanide concentrations and consequently to minimise any seepage, will be HPDE lined. Discharges of water containing non-acceptable concentrations of cyanide will be prevented by operating all gold extraction and processing operations on a 100% water/chemical solutions recycle system.

Even though the CIL TSF system has been designed as a 100% recycle operation, the effect of accidents or mechanical failures cannot be ignored (leakage in a pipe, defective pump, etc.). The routes for the pipe to the tailings dams feature concave, HDPE lines channels. This is to ensure that if there is in fact a rupture of the said pipe that (depending on the location of the rupture) the fluid that was leaked would be contained within this channel and run, (without seepage to the environment,) to either the TSF or back to the plant area. If a material spill were to occur outside of this area, then standard operational risk mitigation and cleanup procedures would be enacted, considering and acting upon environmental risk.

After three years of operation, controlled recycling of CIL tailings solution will need to commence to ensure adequate space is maintained for storage of solids. At this point in time a cyanide destruction circuit is required and shall be constructed for use in year 4 and beyond. The Cyanide destruction circuit will be a SO2/Air circuit which will treat a bleed stream from the CIL decant return water, with the treated solution being discharged into the FTSF.

Runoff from the Waste Dumps and Other Project Facilities

Another consequence of overland runoff from the waste dumps and other Project facilities is the transport of earth particulate during heavy rains into water bodies, resulting in siltation and increase of suspended solids.

Mitigation measures aimed to minimise such potential impact have been included in the Project design and presented in chapter 5.0.

Leaching of Waste and Potential of Acid Mine Drainage

Acid drainage arises from rapid oxidation of certain type of sulphide minerals, and often occurs where such minerals are exposed to air and water. This phenomenon is often accompanied with leaching of heavy metals contained in the rock material. The environmental consequences of acid drainage can be substantial, but prevention measures are available. Seventy-nine (79) ninety rock samples representing granite and sediment hosted ore and waste from the pits of Abnabna, AF Gap, Fobinso, Fetish and Esuajah North were selected for ARD analysis by site geology staff.

Based on the review of the sulphur species concentrations, carbonate values, the AP, NP and net NP values and the NP/AP ratios only one sample (sediment hosted ore at AF- GAP) was classified as having a strong ARD potential; four samples were classified as medium ARD potential (three at AF-GAP, two ore and one waste and one at Fobinso, waste); and two samples as low AGP potential (one ore at Fobinso and one waste at AF-GAP). All others samples were classified as " uncertain/possible AGP or NP – 12 samples", "low NP-18 samples", "medium NP – samples 14" and "strong NP- 26 samples).

The main conclusions of the geochemical characterisation of the waste rock from the Project were summarised as follows:

- The greater majority of the ore and waste rock samples have been classified as Non-Acid Forming.
- Only one sample of ore was classified as strongly acid forming.
- All the waste rock samples had a low sulphide content ranging from 0 to < 0.5%, resulting in low Maximum Potential Acidity values.

The results from this test work indicate that there should be none or very limited potential risk of acid mine drainage from the various waste dumps and it will be permissible to allow runoff and percolation from the waste dump directly into the local waterways without treatment. This will not, however, exempt the mine from continuously monitoring waste properties and waste dump drainage in general to ensure that such drainage is not having an environmental impact.

Sewage Disposal

Sewage systems will be required for the plant site ablutions, the administration office ablutions and the medical centre workshop/maintenance office ablutions. The treatment and disposal of sewage will be through a package treatment plant with treated effluent pumped to the FTSF. At the senior staff accommodation site, sewage disposal will be through septic tank systems. Therefore, the potential to impact on the local water bodies is considered to be non-existent.

A packaged sewage treatment plant using aerobic treatment will be installed on the Plant site. Discharge of treated effluent will to the FTSF. There are many different makes and models of packaged sewage treatment plants, each with a slightly different treatment technique, but each type provides a treatment unit or biological zone where the sewage comes into contact with micro-organisms that break down the organic matter in the sewage. Final selection of the plant type has yet to be determined.

The selected packaged plant will be required to conform to one of more standards such as Australian Standard AS 1547:2000 Onsite Domestic Wastewater Management, Australian Standard AS 1546:3 2001 Onsite domestic wastewater treatment units – Aerated wastewater treatment systems, the USA National Sanitation Foundation (NSF) International Standard NSF 40 - 1996, or European Union Standard - EN12566-3 2005. The selected standard will depend in part upon the sourcing of the packaged plant.

Oil & Grease Spillages

Oil or grease can be accidentally introduced into the environment following a mechanical breakdown of mining equipment or from workshop areas. Oil and grease spillages in the field or on bare ground around workshops have the potential to contaminate soil. Rainfall can cause erosion and runoff into nearby streams with consequent impacts. Under normal circumstances, groundwater pollution is unlikely given the degree of compaction of lateritic soil that occurs in these working areas from previous construction and operational activities. In order to avoid contamination, specific mitigation measures will be required.

4.8.2 Groundwater

4.8.2.1 Introduction

In the Project area, due to the heterogeneity of the aquifers and their dependence on secondary permeability, such as fractures and quartz veins among others, flow of groundwater within aquifers occurs predominantly in the fractures and other discontinuities rather than as interstitial flow. There are many barriers to continuous groundwater flow laterally as well as with depth. The rock types are varied and as such, weather to different depths. The nature and degree of weathering also varies spatially. Similarly, unfractured rocks are very common giving credence to lateral barriers to groundwater flow.

4.8.2.2 Potential Sources of Impact

Potential sources of impact on groundwater resources are associated with the following Project activities:

- Exploitation of groundwater resources for Project supply requirements;
- Dewatering of the open pits; and
- Seepages from Project facilities resulting in the introduction of pollutants into the aquifers.

4.8.2.3 Exploitation of Groundwater Resources

Exploitation of groundwater resources will be limited. The raw water supply for the Project will be obtained from groundwater bores located upstream of the proposed diversion drain on the Asuafu stream. The bores will be installed adjacent to the plant access road and will pump to a raw water storage tank located on the plant site. Other groundwater sources include bores placed downstream of the dam walls, beside and within the swamp areas.

It is proposed to initiate FTSF dam construction sufficiently in advance of project start-up in order to ensure that effective catchment is achieved to provide sufficient water to commence the project and effective water return immediately from the tailings dam. To achieve the availability of water required in the early stages of the Project it will be necessary to pump all runoff initially to the tailings dam to maximise the start up stored water volume. Water from the dewatering of the Abnabna and two Fobinso pits will be pumped the FTSF as well.

The above plans preclude the necessity for extensive large scale abstraction of groundwater from boreholes and water abstraction from local streams and rivers.

Potable water will be derived from taking water from the raw water tank and delivering it to a potable water tank. From there, it will be reticulated delivered to the plant and buildings through the a chlorination and UV sterilisation plant to plant emergency shower and eyewash facilities, the administration and plant area buildings and the mining contractor's area.

4.8.2.4 Pit Dewatering

Dewatering of the open pits, though limited due to the nature of the aquifer, is likely to have some effect on groundwater levels in the close vicinity of the mine. Localised lowering of the groundwater level can be expected within 200 m. The existing hydraulic relationship between recharge and discharge can be disturbed and could affect the quality of the groundwater as increased pumping induces rapid flow and thereby reduces the retention time of groundwater. Mitigation measures will be required.

This typical and localised impacts of open pit mining cannot be avoided. Mitigation measures will be required to ensure continuity of borehole supply in any impacted villages.

4.8.2.5 Potential Impact from Seepage

Seepage from the FTSF has very little potential to impact on the groundwater quality as the grains of fresh rock will have nearly all of the heavy metals removed (estimated at 98%) and no toxic chemicals will be used in this aspect of process. Deposition of flotation tailings material is not expected to be a source of pollution to groundwater resources. The selected location was deemed suitable for a TSF as the soils appeared, from test pit profiles, to be stable with low permeability. Therefore movement of water into the groundwater system will be restricted. Nevertheless, appropriate mitigation measures have been incorporated into the FTSF design.

The very low potential for acid mine drainage of both ore and waste rock material indicates that potential seepage from these facilities should not present any negative consequences on groundwater resources of the Project Area.
Mitigation measures through monitoring of groundwater will be required to confirm the above predictions for facilities such as the TSF, waste dumps, ore stockpiles and villages.

4.9 IMPACT ON THE ECOLOGICAL ENVIRONMENT

4.9.1 Introduction

The Project area lies within the tropical rain forest zone of the country and the vegetation has been classified by Hall and Swaine (1981) as a Moist Semi-Deciduous forest of the Northwest sub-type. The CAGP area was an active mining site between 1994 and 2001, thus the current vegetation in the area has been severely disturbed and bears very little structural resemblance, if any, to the original primary forest classified by Taylor (1952) as belonging to the Celtis-Triplochiton Association.

Although commercial mining has been a destructive force of the forest vegetation, agriculture, particularly food and cash crop farming, has and continues to be another major land use system in the area. Food crops such as plantain and cassava and cash crops, mainly cocoa and oil palm are prevalent in the area. At present, there is no evidence of commercial logging activities but it may be assumed that parts of the Project area must have been logged some time in the past. This assumption is based on the type of left-over primary forest tree species identified in the area. However, logging with chainsaws by the local people is still evident in the area.

4.9.2 Potential Sources of Impact

Mining projects, like many other industrial and agricultural developments will effect some changes on the ecological environment of an area which may result in modifications of the local species composition. Impact of the Project on the ecological environment can have the following origins:

- Localisation and distribution of Project facilities, which may result in the destruction of ecologically important areas and/or disrupt migratory movements of particular fauna species; and
- Development and operational activities, which generate nuisances (noise, dust, *etc.*) having a potential to effect certain species.

Past and current anthropogenic activities have resulted in the severe disturbance of local types of plant communities and no areas of conservation importance exist in the immediate Project area and its surrounds. Similarly, such activities have reduced or eliminated habitats suitable for large mammals and to a considerable extent for smaller mammals and reptiles. Only bird fauna has retained a semblance of species richness.

None of the Project facilities impact on closed forest. The greater majority of the major facilities are located in areas characterised by Isolated/Treeless, Mixed Bush and Isolated Trees and Moderately Open Forest (<60 %) (see Map 36.1). Development and operational activities that generate nuisances are therefore, are considered to have only minor impact on flora and fauna in the Project area. Nevertheless, mitigation measures will be required to minimise noise and dust generation.

Activities contributing to the loss of fauna include:

- Site preparation activities such as surface earthworks and stripping of vegetation and topsoil for the creation of project infrastructure – pits ,waste dumps, Plant Area, Tailings Storage Facility and haul roads. Increase in noise, lights, traffic and general disturbance to area of influence
- Increase in demand for 'bush meat' as a result of influx of construction workers and increase in general development in area as a result of increased economic activity

4.9.3 Assessment of Impact on Flora

Development of mining and associated operational facilities will not result in the destruction of any ecologically important areas of vegetation or sensitive habitat. The vegetation of the area is very dispersed, comprising a whole landscape that has been heavily modified by human impact. It now contains mixtures of forest trees, tree crops (cocoa) and grasslands in a dispersed, heterogeneous mosaic, and advanced stage of forest fragmentation.

From the flora point of view, all the species encountered were common and occur elsewhere in the region. There are only a few isolated timber trees of marketable size worth salvaging. No rare or endangered species were observed in the Project area as a whole.

No tree species of Black and Gold Star classification (i.e. of very high conservation concern) have been recorded in the CAGL project area. Most of the left over trees can also be found in degraded moist semi-deciduous forests associated with other mining areas in the Western, Eastern and Ashanti regions. Typical examples of such species include *Alstonia boonei and Ceiba pentandra.*

Specific mitigation measures will not be required for plant species conservation in the Project area. Mitigation measures will only be required in preserving vegetation cover as a means of control of soil erosion.

4.9.4 Increased Demand on Flora Resources

The development and operation of the Project will lead to an increase in local housing and small business construction activity as reflected by similar increases around other new large-scale mining projects in Ghana. There will be increased demand for building timber. There is also likely to be an increased demand for firewood due to the demands of an increased population.

The limited timber resources of the Project area and its area of influence will entail the importation of building timber from other localities near and far. The actual demand, and thus the level of impact on secondary forest areas, is almost impossible to quantify at this stage.

The increase in building construction will likely increase demand for bamboo poles for use as scaffolding and also on young timber for such use as well. An increased demand for firewood will increase pressure on an already limited woody plant resource

4.9.5 Assessment of Impact on Fauna

The terrestrial fauna survey of the Project Area as a whole indicate that habitat disturbance resulting from earlier commercial and illegal mining activity, subsistence farming, logging and hunting pressures has all but destroyed good faunistic diversity, especially for the larger mammals one time found in the region.

Poor faunistic quality was emphasised by the fact that small terrestrial mammals were caught in only one site (Chirawewa pit). Although the presence of bats in the area was considered fairly good only two species of Ghana's megachiropteran bats were caught. These were Epomops (*Epomops franqueti*) and Epomorphorus *(Epomorphorus gambianus).* Most of the catch was made at the originally proposed plant site that had not been disturbed by the earlier mining and is covered by good cocoa farm of about 18-20 years old interspersed with remnant secondary forest. The presence, however, of Afrixalus dorsalis (Striped Spiny Reed Frog), a very sensitive species to pollution, in the concession is an indication that the study area did not face serious water pollution in the past.

During the development phase, the proposed project poses impacts on terrestrial fauna within and close to the development footprint. Impacts on the fauna environment include a loss of habitat, an increase in general disturbance levels and hunting pressure. Overall, development in the Project area will not have any significant adverse impact on the existing and terrestrial fauna of the area. Specific mitigation measures will not be required for the Project area as a whole.

4.9.6 Assessment of Impact of Dust on Flora

The effect that dust will have is determined by a number of variables, including:

- The concentration of dust particles in the ambient air and its associated deposition rates,
- Size distribution of dust particles,
- Vegetation characteristics such as the surface roughness and wetness of leaf surface can influence the rates of dust deposition, on vegetation, such as surface roughness and wetness,
- Meteorological and local microclimate conditions and degree of penetration of dust into vegetation,
- Dust chemistry - ranging from inert dusts to highly alkaline dusts and acidic dusts.

Dust may have physical effects on plants such as blockage and damage to stomata, shading, abrasion of leaf surface or cuticle, and cumulative effects e.g. drought stress on already stressed species. The chemical effects of dust, either directly on the plant surface or on the soil, are likely to be more important than any physical effects.

The major source of dust that will have an impact on vegetation will be from traffic on untarred public (primarily the access road from Nkonya to Abnabna) and Project haul roads and from stockpile blow. Mitigation measures will be required

4.10 IMPACT ON SOILS AND LANDUSE

4.10.1 Introduction

4.10.1.1 General

The Project area is rural. Intensive farming activities for the production of both plantation and food crops and other human activities within this relatively well populated area have greatly influenced the nature of the soils resulting in nutrient depletion, soil erosion, iron pan formation and land degradation. The intensive farming activities for both plantation crops (mostly cocoa) and food crops (mostly plantain, cocoyam and maize) and forest degradation for slash and burn farming activities and other human activities have influenced the natural conditions of the soils and have resulted in nutrient depletion, soil erosion and land degradation in some parts of the Project area. The soils are acidic in reaction due to leaching of the bases as a result of intensive rainfall.

4.10.1.2 Soils

A detailed soil survey according to FAO 2006 guidelines for soil description was employed to identify and describe the soils of the project area at the series level. The soils belong to the Bekwai-Nzima/Oda compound association. On a typical topo-sequence, *Bekwai series* occupies the summit and upper slope sites followed by *zima series* on the upper to middle slopes, whiles *Kokofu series* follows on the middle to lower slope sites. The narrow valley bottoms are occupied by alluvial soils of *Oda, Kakum* and *Temang series*. Both *Bekwai and Nzima series* are developed in-situ whereas *Kokofu series* is a colluvial material from slope wash.

In general, the project area has good agricultural soils that are suitable for a wide range of tree and arable crops. The well to moderately well drained soils of *Bekwai, Nzima* and *Kokofu series*, are extensively used for cocoa cultivation, even though, the results of the suitability evaluation showed that oil palm is highly suitable.

This shows the preference of farmers to cultivate cocoa rather than oil palm. The valley bottom soils were rated as suitable to moderately suitable for vegetables, rice and sugarcane.

The major agricultural land uses are cocoa farming, food crop farming, and bush fallow. The non-agricultural land uses include human settlements (towns, villages and hamlets) and undeveloped inland valleys with swamp vegetation.

In the area potentially earmarked for process and support infrastructure some good cocoa and food crops (plantain, maize, cocoyam, cassava, and rice) occur. The area intended for the tailings and water storage dam is an undeveloped inland swamp valley with a few rice farms.

4.10.1.3 Potential Sources of Impact on Soils

The potential source of major impacts associated with the development and operation of the Project are:

- Land preparation and clearing during Project development and operation;
- Soil erosion from areas cleared but not subsequently revegetated; and

  Loss of soil forming material from embankments cut and fill areas on haul/access roads and topsoiled areas awaiting revegetation.

4.10.1.4 Assessment of Impact

Erosion occurs as a result of rapid water flow over a particular area. The loss of soil will be a function of the erosivity or intensity of the rainfall, the erodibility of the soil, the area of catchment, the length and gradient of the slope, the amount of vegetation cover and the erosion control measures undertaken. Soil erodibility depends on soil texture, structure and the degree to which soil particles disperse when in contact with water.

Land preparation associated with infrastructure development and operation of mining Projects will remove vegetation and topsoil. These operations will induce soil erosion, including subsoil erosion, and lead to degradation of soil structure, decreasing soil fertility and in the long term, agricultural production or the establishment of a vegetation cover. Another consequence of land clearing and erosion is the transport of soil during heavy rains into water bodies, resulting in siltation and increase of suspended solids.

In the absence of specific erosion control and management procedures Project development and operations will have a significant impact on loss of soils and soil-forming materials. Mitigation measures will be required during the construction and operational phases of the Project.

4.10.1.5 Land Use

Both agricultural and non-agricultural land uses are found within the Project Area. Agriculture is the predominant form of land use with the majority of people living in the area depending on farming for their livelihood and as the principal means of employment.

The major agricultural land uses can be divided as follows:

- Cocoa farming;
- Mixed food crops farming;
- Rice farming in inland valleys;
- Bush fallows.

The non-agricultural land uses include:

- Human settlements (villages and hamlets);
- Undeveloped inland valleys;
- CAGL exploration areas; and
- Feeder roads and footpaths/tracks.

4.10.2 Loss of Agricultural Land and Farmholdings

4.10.2.1 Potential Sources of Impact

The potential source of major impacts associated with the development and operation of the Project is:

- Land take for Project facilities; and
- Resettlement of farmers whose land is required for Project facilities.

Quality of Agricultural Land

The area of land required for Project development is approximately 998 ha including redevelopment land disturbed by earlier commercial mining operations. Though not all this land area is cultivated, agricultural land use largely dominates with majority of people depending on farming as the source of livelihood and the principal means of employment. The proliferation of hamlets in part of the Project Area is a clear indication of the economic importance of cocoa in the area. The importance of cocoa has attracted migrant farmers and motivated some indigenous farmers to establish cocoa farms. The soils in the greater CAGL Project area have been classified as from highly suitable to moderately suitable, depending upon the crop selected and the provision of inputs, particularly fertilizers.

The distribution of the major crops (cocoa, oil palm, mixed crops including cassava and plantain) in the three main development areas delineated for crop compensation purposes (Mining, Plant Site and

FTSF) is depicted in Map 4.1. The area (hectares) of each major crop in the three is presented in table 4.3. The total number of hectares on which crops are being grown is 380.7. Cocoa farming is by far the greatest farming activity at 341.8 ha. The largest cocoa growing area occurs in the designated Plant Site corridor followed by the Mining corridor and lastly FTSF corridor. Oil palm growing is the second largest crop grown, 27.74ha.

Table 4.3: Area of Major Crops (Ha) and Their Distribution in Planning Corridors

Item	Block	Cocoa Farm	Oil Palm Farm	Mixed Farm	New Farm	Bush Area	Total Area
1	FTSF Corridor	71.56	4.54	4.21	2.03	0	82.34
2	Mining Corridor	96.64	10.63	1.38	0.48	0.02	109.15
3	Plant Site Corridor	173.60	12.57	2.15	0.93	2.40	191.65
	Total	**341.80**	**27.74**	**7.74**	**3.44**	**2.42**	**383.14**

Farm Survey Data

CAGL has undertaken an intensive survey of farms and crops within and around the area potentially earmarked for Project facilities. The number of farms, total area of farms and % survey completion presented in table 4.4. No surveys have yet been carried out in the Esuajah North and Fetish pit area.

Table 4.4: Phase 1 Farm Survey Data in Three Major Development Zones

Location	No. of Farms[1]	Hectares	% Survey Completed
Mining Area	380	111	100
Plant Site Area	400	184	100
Flotation TSF	200	82	56
[1]: January 15, 2010			

Number of Farm Hamlets

Surveys have identified 51 farm hamlets in the western development areas of the Project. There will be a need to relocate these hamlets, providing relocation and crop compensation. No surveys have yet been carried out in the Esuajah North and Fetish pit area since development will not begin until mining year 3.

4.10.2.2 Impacts on Agricultural Land and Farms

The development of the CAGP will have a high impact on agricultural land use and the hamlets and farmers working in the areas that will include the Abnabna and Fobinso pits, the Plant site with its associated facilities and the FTSF **(Map 2.2). Not all hamlets and farmers would be directly affected but safety factors will necessitate their relocation and/or crop compensation.**

Within the Project Area, approximately 383 ha of agricultural land will be directly and indirectly affected.. However, not all the land that will be required by project development is under cultivation or agricultural land. Areas of forest regrowth areas, undeveloped inland valleys, previous mine facilities and roads occur. Within the context of the Districts of Wassa Amenfi East and Upper Denkyira the area of land that will be lost is considered to be insignificant.

Mitigation measures will be required to offset the impact of farm loss and farmers livelihoods. This is discussed below under the heading "Socio-economic environments."

4.11 THE SOCIO-ECONOMIC ENVIRONMENT

4.11.1 Introduction

The present Project Area consists of parts of two neighbouring District administrative areas, Wassa Amenfi East and Upper Denkyira West. Both the Districts are almost entirely based on a "rural" cultural and economic way of life. The predominant economic activity in these areas is farming.

The main communities occurring within, or on the fringes of the Project Area are Abnabna, Ayanfuri, Fobinso, Gyaaman and Nkonya. In addition to these villages, there is a preponderance of scattered hamlets in the proposed active mining and operations area. A striking feature of the Project area is the paucity of modern socio-economic infrastructure (roads, health facilities, schools, water, etc).

The development and operation of the Project will, without doubt, have both positive and negative impacts on the socio-economic structure of the Project Area and its environs, as well as impacts at a District and National level. It is considered, however, that the positive impacts will considerably outweigh the negative ones.

4.11.2 Assessment of Positive Impacts

4.11.2.1 Introduction

The positive impacts of the Project will relate mainly to the economic advantages which will have immediate and long term benefits on the sociological environment. This will be achieved in various ways at National, District and Local levels.

4.11.2.2 National Considerations

On a national basis, the Project will have positive impact through the direct payment of royalties and taxes related to gold production and Company profits respectively; indirectly through income taxes on the increase in direct and indirect employment; increased incomes and profits of local businesses and major suppliers, the purchase of goods and services manufactured and supplied in Ghana.

Based on the magnitude and far reaching implications, the impact of the Project on the national economy is considered positive.

4.11.2.3 District and Local Considerations

On a District and local basis the Project should have a positive impact. Some of the ways these impacts are envisaged are:

- Improvement of road structures within and around the Project Area .
- Establishment of new water sources and renovation of existing sources (boreholes and pipes).
- Assistance in improving health and sanitation facilities in villages.
- Contribution to education facilities and teachers and students development.
- Training and employment of local youth for the Project.
- Training in specific skills and business assistance to women groups in the villages.

- Assistance to handicapped or disadvantaged children.

Which positive impacts to select as priority for development is not known at the moment. Selection would consider the wishes of the local villages which will be expressed through their representatives on the Project Consultative Committee and the set up of the Community Development Fund by CAGL. The latter is dependent upon the time of operation start up. As a result of the two public meetings held at each of Abnabna, Ayanfuri, Fobinso, Gyaaman and Nkonya CAGL has compiled a list of the many developments items that the communities would like to see implemented. These are presented in Appendix 3.10.7 for each village.

Based on the positive contribution to local infrastructure, the impact of the Project is considered positively significant.

4.11.2.4 CAGL Assistance to Local Communities

During the exploration phase of the Project, CAGL has already actively assisted local communities in the Project Area. Assistance in excess of USD 50,000 has been provided in the form of

- Renovation of existing water sources (Abnabna and Fobinso and assistance with repairs at others.
- Financial assistance to Ayanfuri village for the development of its piped water scheme.
- Improvements to school buildings at Abnabna, Fobinso and Nkonya.
- Ground preparation for an improved multi-user water borehole at Gyaaman is in progress.

Other projects already approved by CAGL are the construction of new primary schools at Abnabna and Fobinso to replace existing buildings. Consultation with the Wassa Amenfie East District Assembly on its building requirements for new schools has taken place and the Chief of Ayanfuri has provided a suitable land area.

The contribution of CAGL to the development of the Ayanfuri piped water supply was acknowledged has been recently acknowledged (Appendix 4.11.2.3).

The Company is aware that it has a general responsibility to contribute to socio-economic infrastructure in the communities of the immediate area in which it will be operating. This responsibility will be enacted in co-operation with local communities and local government. It does not mean, however, that CAGL will provide unlimited assistance and fulfil all requests for improvements made by local communities. Assistance will have to be tailored and budgeted according to the economic realities of mine operations and revenue received.

Based on the positive contribution to local infrastructure, the impact of the Project is considered positively significant.

4.11.2.5 Employment for Exploration

During its exploration CAGL (through a related company, Sun Gold Limited) has had a permanent staff of three senior Ghanaians, up to 30 junior Ghanaian contract geotechnical and support staff plus up 100 local people at a time as casual staff. In addition, the refurbishment of a gold heap leach plant is employing about 18 local people in Obuasi.

The number of employees employed directly by CAGL is expected to be around 230 on start-up. Contractors will be employed for mining, drilling, security, vehicle and house maintenance, bus service and catering. Although the number of contractor employees has not been fully determined yet, it is expected that it will exceed 200 persons. Construction activities will also have a positive effect on employment as more than 200 people will be employed to fulfil this task over a period of 18 months.

Construction contractors will be required to source employees locally to the maximum extent possible and provide training. The maximisation of local labour resources and skills will have long– term benefits which can only strengthen community relations and ultimately provide a stable work force and work environment.

These few statistics do not account for indirect jobs which will be created to service the new mine as well as to satisfy the needs of the various employees. The normal job creation multiplier for local service industries in the gold mining industry is in the range of 3 to 6 for each direct employee. Whether or not, this level of multiplication will occur in the Project Area remains to be seen but it should be noted that the area currently has very little support services industries, hence a higher potential for new developments.

Based on the positive contribution to local employment the impact of the Project is considered positively significant.

4.11.2.6 Training of Employees

Given the location of the Project, it is intended that the operations will be self-sufficient in as many areas as possible. To the maximum degree possible personnel will be sourced from within Ghana. Given that the area is a rural one and relatively isolated, there is a consequential shortage of industrial skilled workers in the area. The Company will undoubtedly have to import a number of workers with the required skills from other areas in Ghana. It also recognises, however, that bringing in such workers can be socially disruptive, both from an economic and cultural aspect.

CAGL proposes to develop the local community and promote local employment through educational and career-based training programmes. These programmes have been adopted in other mining operations and have been found to provide various positive impacts listed as follows.

- Provides stable long term employees;
- Maximises local resource usage;
- Provides training and indirect communication with the local communities;
- Increases the skills in the local area;
- Reduces migration and thus disruption to the existing authority structure;
- Builds a base for trust within the local communities; and
- Minimises pressure on local housing, educational and medical services.

CAGL has conducted a census survey of the five main communities (Abnabna, Ayanfuri, Fobinso, Gyaaman and Nkonya) within or on the fringes of its Project area. These surveys have provided useful information on the nature and demographic status of the communities. This information will be used to assist in the continuing development of the CAGL draft Public Consultation and Economic Development Plan.

Based on the positive contribution to the development of employment skills the impact of the Project is considered positively significant.

4.11.2.7 Non-Displacement of Village Populations

All of the five main communities are located outside the mining and other operational areas. No resettlement will be necessary, either wholly or in part of any of the communities.

Based on the absence of any need to resettle established villages the impact of the Project is considered positively significant.

4.11.3 Assessment of Negative Impacts

The Project is not considered to have any negative impact at a National or District level. It is considered to have negative impacts at a Local level only. The general categories in which negative impacts will occur are:

- Project Impacted Land.
- Project-Impacted Households.
- Project-Impacted Structures.
- Project-Impacted Public Facilities.
- Project-Impacted Businesses.
- Project Impact on Livelihood
- Project Impact (Indirectly) on social structure within communities.
- Project Impact on Water Resources

4.11.3.1 Project Impacted Land

The Project Footprint includes open pits, waste rock dumps, plant site, contractors yard, a flotation tailings storage facility, a CIL tailings disposal facility, a small water storage pond at the plant area, haul roads, and other support facilities. The total land take of these facilities is approximately 998 ha. The total includes land area disturbed by the previous mining and waste dump disposal activities of Cluff Resources and Ashanti Goldfields Corporation. The total land take will be required for life-of-mine.

The area of different land types in the western part of the project area is presented in table 4.5. This is based on Map 36.1 prepared as part of the land use baseline (Chapter3: section 3.6). An evaluation of land types in the eastern part of the Project area has yet to be undertaken.

Table 4.5: Land Use in the Phase 1 Mining, Process and Tailings Disposal Areas

Isolated Trees Arable	Closed Forest	Oil Palm	Standing Water	Exposed Surface	Cleared current cultivation	Mixed Bush	Mod Open for Tree Crop	Thicket
178.49	72.01	2.83	14.83	21.30	17.51	134.92	464.73	631.22

The figures demonstrate the paucity of closed forest (>60%) in the Project area (see photo 3.6.1). The majority of this forest is located on the southern side of the Project area and will be impacted by the development of the Abnabna waste dump. The development of the Abnabna, AF-Gap, and Fobinso pits, the Fobinso waste dump, the Plant site and the FTSF will variously impact on moderately open forest (<60 forest - > 30% tree crops), isolated treeless arable land, moderately open for tree crops land ands mixed bush and thickets. Oil palm lands are noticeably absent from the Project area.

4.11.3.2 Project Impacted Households

There are no households within the five main villages that will be physically affected by the Project development.

The Project impacted households are those of the 51 hamlets located in the immediate Project area (Map 4.1). A more detailed map showing those hamlets within and near to the Plant site and Mining Contractor Yard is presented as Map 4.2. A full description of these hamlets is presented Chapter 3: 3.8.17. In brief, these were observed to be in areas that would be developed for project facilities or sufficiently close to them to represent a potential safety hazard. These hamlets are generally owned by farmers who have developed a place of abode in close proximity to their farms. Most of the inhabitants are migrants from other towns and regions some who been settled in the locality for up to 50 years.

Approximately 575 people including men, women and children are believed to be associated with the hamlets. The majority live permanently and only travel to their hometowns for visits on special occasions like Christmas, Easter or funerals.

Of the 51 household, 41 have indicated that they would opt for relocation back to their town of origin rather opt for resettlement locally. Four household have indicated that they would opt for resettlement (3 to Dunkwa-on-Ofin and one to Kumasi). Four household have opted for relocation and/or resettlement in Ayanfuri. The choice of two households is unknown.

To ensure that the relocation and resettlement procedure is transparent and understood by all the stakeholders, CAGL is developing a detailed policy which outlines the established management procedures and practices for the resettlement process and will proceed through the CAGL Relocation Action Committee. The Committee will be chaired by an independent person and include representatives of all local stakeholders. It must be recognised that relocation/resettlement is a very complex issue as it is likely to affect the socio-cultural patterns, economic stability and the trajectory of local cultural life and history of the area and, therefore, must be planned with all these variables in mind.

The aspects of this resettlement, and relocation, process are discussed in Chapter 5.0: Mitigation Measures.

4.11.3.3 Project Impacted Structures

The 51 hamlets vary considerably in number of completed and uncompleted structures present. The total number of completed structures is approximately 188 and the number of uncompleted structures is 108. The number of completed structures per hamlet varies from 1 to 10 while uncompleted structures vary from 0 to 29. The total area of completed structures is approximately 1891 m^2 and for uncompleted structures it is 825 m^2.

There is one shrine in the Project area that will require relocation. This is the Komfo Yaa Shrine in a location off the Abnabna to Nkonya dirt road and very close to the project area/

There are no burial places in the Project area that require relocation due to Project activities.

4.11.3.4 Project Impacted Public Facilities

There are no public facilities in the Project area.

4.11.3.5 Project Impacted Businesses

There are two businesses within the Project area that will be affected by the Project. They are:

1) A hamlet that grinds corn. It is situated on the edge of Abnabna pit near the Nkonya – Abnabna road.
2) A small oil palm processing unit situated between the Abnabna pit junction on the Nkonya – Abnabna road and Abnabna village.

The first business will need to be moved as its location occurs within the expanded Abnabna pit. The second business does not occur in a Project active area but may have to moved for safety considerations because of proximity to the expanded Abnabna pit.

4.11.3.6 Project Impact (Indirectly) on Social Structure

In Ghana, all people have total freedom of movement within the country. Consequently, there is no means to prevent or control the influx of people into towns and villages of the Project area. This area, as previously noted has farming based rural economy. A significant influx of people into the area looking for employment by the Company or expanding local businesses and services would result in undesirable social and economic pressures. These could include inflation of local food and accommodation costs with a converse reduction of availability, a heavy additional burden on the community water resources, sanitation and garbage management, healthcare resources and policing along with unwelcome social problems like prostitution, crime and drunkenness

CAGL is aware that it has a social obligation to assist government and traditional authorities in preventing too much disruption from the influx of people. It can assist by developing local training initiatives that enable local residents to be able to compete for, and acquire the skilled jobs available at start-up (see section 4.11.3.7 below).

Prior to, and during operations, CAGL will hold periodic information meetings with official and traditional authorities who will be the key to controlling the impacts of the influx of people. The main objective of these meetings will be to inform on the potential level of employment as a measure to control influx by reducing the level of expectation of those arriving in search of a job.

Measures that should contribute to minimise social impact related to an increase in population are proposed in Chapter 5.0.

4.11.3.7 Project Impact on Livelihood

Employment

Project impact on the livelihood of the area communities will take several forms. The employment opportunities offered during construction and then during operations will be financially beneficial to the communities. Employment opportunities will be greatest during the construction period, especially for the unskilled and semi-skilled males and females. Such employment offers 1) wage earning opportunities for a period of time and 2) an opportunity to upgrade skills that could be required by CAGL, e.g. electricians, carpenters, mechanics and heavy equipment operators. There will also be employment opportunities with local and national service companies to be utilised by the Project build contractor and then by CAGL e.g. in the areas of camp services, cleaning and security contractors. CAGL is committed to the employment of local people as much as possible. An employment procedure will be developed to ensure this. Informal discussions with the Chiefs of Abnabna and Ayanfuri have already taken place on how an equitable distribution of employment among the various villages could be achieved.

Loss of farms

The loss of the farms in the Project area will affect two groups of farmers, those who are local residents and the hamlet owners. The local farmers will be able to approach the Chiefs of the villages for alternate farmlands if that is their wish. The extent of available farmland is, however, not known. The farmers will also have opportunities for low skilled employment with the Construction contractor and later with CAGL. Those with aptitude for retraining will be given opportunities for such. It may well be though that most opportunities will occur with the younger farmers and the older farmers may have to stay with relatively unskilled work e.g. such as security guards and gatekeepers.

Those hamlet owners who choose relocation to their original hometown will have to develop their own livelihood alternatives following the loss of their farms. They will be assisted in this by the CAGL proposed CAGL relocation package that will include the building of a new sandcrete house to replace their existing dwelling and a rental allowance for 12 months or longer if the new house is not completed in that time.

Alternative Livelihood Programmes

The diversification of non-farm income generating activities as well as agriculture growth among other farmers in the area to meet the demands of an increased population are necessary to ensure food security, especially of the vulnerable relocated or resettled populations, and is critical to the enhancement of rural livelihoods and community security. Unless there are rapid improvements in agricultural productivity as well as alternative livelihood creation those farmers displaced by the Project could remain vulnerable and impoverished.

CAGL has already begun to organize womens and youth groups in each village with the intent to diversify and increase income. A number of income-generating activities, training to provide vocational and technical skills training in, for example, tailoring, masonry, carpentry, catering, food processing and value added technologies, and training in small- and medium-sized enterprise creation and expansion to encourage development of viable businesses are under consideration.

CAGL will consider the provision of business development services to the above groups. The intent is to support some of the new services and needs that will arise out of a population influx into the community due to the Project. These include businesses such as tailoring for mine worker uniforms, block-making for construction, high value vegetable and fruit production, bread making, hairdressing and other clothing items.

CAGL will explore the opportunities to work with local and international NGO"s in the development of local skills and services.

It must be recognised that the development of alternative livelihoods is not an instant process. It has to take into account local willingness, skills, and aptitude to develop new opportunities. Some will succeed, others will not. Nevertheless, the planned life-of-mine (10 years) offers a time frame in which some alternative livelihood can be developed to replace the livelihood opportunities for local people offered by Project development.

4.11.3.8 Project Impact on Water Resources

The existing drinking and domestic water supply resources of some settlements in the immediate vicinity of, or downstream, of the various facilities may be affected by development and subsequent operations. Some communities such as Ayanfuri may find that their current water supply resources will be inadequate to supply increases in demand resulting from the influx of new inhabitants. Table 4.8 presents the impact assessment on drinking and domestic water supplies of the main settlements in the active Project area.

The borehole water supply sources of Gyaaman, Nkonya and Nkotumso will not be affected by mining operation per se. They are too distant to be affected by any groundwater drawdown from mining. If there are to be impacts they are more likely to arise from increased demand from an increase in population due to the anticipated influx of workers and job seekers into the area. The borehole water supply sources of the villages of Abnabna, Fobinso and Ayanfuri (includes Odumkrom) could be affected by increase in population for the same reasons. The CAGL project to facilitate water users in Gyaaman has found that a deepened or new well is required to provided a single point multi-user facility. Mitigation measures will be required to monitor borehole water supply status in this last group of villages.

Surface water users in Gyaaman, Nkonya and Nkotumso will not be affected by mining operations. Those in Abnabna, Fobinso and Ayanfuri who use the Abnabna, and Subin for domestic purposes and for construction purposes could be affected by mining activity (see section 4.8). In these cases alternative water supplies are available but they may not be conveniently located for their domestic and construction activities.

Table 4.6: Community Water Resources and Usage in the CAGL Project Area[1]

Community Name	No. of Boreholes and status	No. of Hand-dug wells with pump & status	Name of River water supply	Present uses of river water and surrounding environment
Abnabna	2	0	-Abnabna	-House construction -Site and Environment for village god and ritual.
Nkonya	2 (1 spoilt 3 months ago)	1 (has no hand pump)	-Asuafu -Amabri	-Wells in the river valleys - Drinking - House construction -Water management sacred grove.
Ayanfuri	6 (1 spoilt 8 years ago)	Several personal hand-dug wells	-Asua -Afuaworaa -Subin	-Block making -House construction
Odumkrom	0	Nil	-Subin	-Drinking -Block-making -Household chores -House construction -Bathing
Nkotumso	4 (2 spoilt)	1	-Fobine -Awiaawia -Akesoa -Ofin	-Drinking -House Construction -Household Chores
Fobinso	1	Nil	-Fobine -Takrowa	-Fobine was drunk in the recent past, now polluted -Takrowa drunk -Both used for bathing and also for house construction.
Gyaaman	3 (working)	Nil	-Beporso	-Drinking - Household chores -Bathing -House construction.

1. Revised version of table 38.2

4.12 IMPACTS OF NON-MINING WASTE GENERATED

The development and operation of the Project will produce several types of solid waste such as household waste, waste oils, hazardous waste, etc.

The various type of waste identified are:

Household Waste:

This type of waste will be produced by administration and technical offices, the canteens and households living at the accommodation village. The main items will be paper, office and domestic packaging and canteen waste. The impact of this waste is considered locally significant, low and short-term. Mitigation measures will be required.

Non-toxic Industrial Wastes:

This category of waste includes heavy and light equipment tyres, worn metallic parts and fittings and packaging material for non toxic products (plastics containers, papers, wood, etc). Visual impact, sources of pest and disease infestation are the main impacts of this waste. The impact of this waste is considered locally significant, low and short-term. Mitigation measures will be required.

Waste oils:

Waste oils, oil filters and other small oil containers and grease will be produced at the plant and at the light and heavy vehicle workshop. Contamination of surface water and groundwater is possible. The impact of this waste is considered locally significant, high and could be long-term. Mitigation measures will be required.

Hazardous Industrial Wastes:

This category of waste will consist of cyanide packaging – plastic liners and wooden crates. Risk that cyanide containers or bags are reused by the local inhabitant. The impact of this waste is considered locally significant, high and short-term. Mitigation measures will be required.

Laboratory Waste:

The on-site laboratory will only undertake sample preparation or environmental analyses using portable kits. Water samples will be sent off-site to an independent laboratory. Consequently, no laboratory chemicals or chemical wastes will be need disposal.

Clinical Waste:

Waste at the small clinic will be segregated into office waste and nursing station waste. The latter will be such items as swabs, tissues, bandages, sharps and capsule packaging. Used swabs, tissues, and bandages and sharps have the potential to cause infection if not correctly managed. The impact of this waste is considered locally significant, high and short-term. Mitigation measures will be required.

The principles of waste management which will be adopted by the Company are presented in the following section (5.0) as part of the mitigation measures for the Project.

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5.0 MITIGATION MEASURES

5.1 INTRODUCTION

This section of the EIS presents the mitigation measures proposed to minimise the environmental impacts associated with the construction and operation of the Central Ashanti Gold Project (CAGP). The impacts were identified and discussed in Chapter 4. Under normal circumstances, most of the impacts assessed can be mitigated by good planning and environmental management practices during the life of the mining operation.

The mitigation measures described herein are concerned with:

1. General aspects of the Project,
2. Project operations over the currently estimated 10 year mine life.

5.2 GENERAL MEASURES UNDERTAKEN DURING SITE PREPARATION

In order to minimise the potential negative impacts of clearing activities on both the environment and the local communities, the following mitigation measures are proposed:

Site preparation activities, which involve vegetation clearing, grubbing and topsoil segregation will be co-ordinated by the Environmental Department.

The plan will address issues such as available quantities of topsoil per area, demarcation of vegetation and topsoil dumping sites, felling and use of timber species, allocation of responsibilities and monitoring of the process. The plan will contain clear instructions and procedures for distribution and implementation by the various contractors involved with clearing activities.

Topsoil required for rehabilitation of the exposed faces of the pits and the haul roads will be stockpiled at dedicated sites within active Project area (see 2.11.1, 2.11.3).

Stockpiled topsoil will be used for early revegetation requirements to stabilise structures such as embankments or structural earth works. Additional site clearing during operation will also involve segregation and stockpiling of topsoil.

Settling ponds will be built at appropriate locations downstream from some of the Project facilities such as the waste dumps, the treatment plant and the mine services area (see section 2.18.9.4).

5.3 VISUAL IMPACT

The villages of Abnabna and Ayanfuri were identified as potential critical view points from which the Abnabna and Esuajah North mining activities will become visible.

A waste dump not exceeding 25m height will be constructed between Abnabna village and the Abnabna pit. Several rows of fast growing tree species (Acacia and Cassia species) will be planted close to the final footprint edge as a visual screening barrier. This will be done after construction of the Asuafa stream diversion but prior to the start of main dump construction. As the dump is developed, the dump faces will be planted with herbaceous plants and a mixture of native and introduced tree species which are found in the region.

The redesign of the Esuajah North waste dump has reduced the visual impact of the dump. A screening barrier comprised of fast growing tree species (Acacia and Cassia species) will be planted along the section of the current access road from Ayanfuri to Wompen that passes in front of the pit and the split waste dump (Map 2.2). The intent of this planting is to establish a ”green zone” to assist in screening this mining area from Ayanfuri village. As the dump is developed, the dump faces will be planted with herbaceous plants and a mixture of native and introduced tree species which are found in the region.

5.4 THE ATMOSPHERIC ENVIRONMENT

5.4.1 Airborne Particulate

5.4.1.1 Mitigation Measures - Construction Phase

During the construction phase, fugitive dust will be generated from site clearance in the Plant site and Contractors Yard. Dust will also be generated by vehicle movements and haulage of construction material along a section of the Nkonya to Abnabna site access road. Dust from the access could have an impact on pedestrian users, natural vegetation and farm crops. To mitigate these impacts:

- Dust suppression will be carried out by water spraying on the Plant site and Contractors Yard. The access road will also be watered. Watering will be done using the water bowsers that are part of the construction contractor’s vehicle fleet. This measure should be sufficient to prevent the formation of high quantities of dust considered to be a nuisance to human health or vegetation.
- Specific measures will be taken to prevent over-speeding of vehicles when driving through or near towns and villages on their way to the site as well as on the site itself. To that effect, strict requirements will be sent to contractors and drivers, and speed limit sign boards and speed bumps will be posted at appropriate locations along the access road and in the Project Area in general.

5.4.1.2 Mitigation Measures - Operational Phase

Point Sources of Dust

The crushers (and associated discharge conveyors) and the carbon regeneration kiln both located within the premises of the treatment plant will be the only point source of dust emission. These sources, though very localised, can have an impact on workers health and Company productivity.

Specific dust suppressors and in-plant dust control measures have been included in the design of the crushing plant (e.g. at the conveyor transfer points). They will maintain the amount of airborne particulate below levels considered to be hazardous for human health.

CAGL will ensure that all diesel fired equipment purchased will comply with EPA standards. Consequently, levels of particulate generated from this type of equipment will be within international guidelines values (e.g. maximum 24 hour average for PM10 of 150 $\mu g/m^3$ as quoted by the WHO/WB).

Non Point Sources of Dust

Non-point sources of airborne particulate will be dust arising from blasting activities and movement of vehicles on access and haul roads.

Mitigation measures to reduce the impact of blasting, including prevention of fly rock generation will be as follows:

Blasting Procedure

- Selective mining practises will be employed which dictates that control blasting will be used.

- Prior to each blast being drilled the Blasting Superintendent will approved the design of the blast, after consideration of the layout, explosives per delay, sequencing of the blast, the stemming and soft blasting areas.

- Through the transition from free dig material to hard rock blasting, the explosives used, the kilograms per delay and the hole spacing will be reduced to allow for the heterogeneous nature of the transitional rock.
- Once the blast has been charged the Blasting Superintendent will manage the blasting to ensure personal safety during the blast.

- Generally control blasting techniques allow for a safe distance from the blast to be assessed. The Blasting Superintendent will determine the safe distance from the blast when approving the design and will be mandated to clear personnel to that safe distance prior to the blasting.

- Noise will be controlled through the use of quality stemming to reduce the air over pressure.

- The ground vibration will be controlled though managing the kilograms of explosives per delay.

- Fly rock will be managed through directional blasting, usage of controlled charge quantities of explosives, design of the stemming column, use of water proof explosives and well defined procedures.

- Regular blasting times will be established. Blasting will be postponed where lightening is imminent or where a temperature inversion may in the opinion of the Mining Manager cause a safety issue in respect of blasting fumes.

- Sign boards and notices will be provided to advice of blasting times. Sign boards will be located at Abnabna and Odumkrom/Ayanfuri North).

Monitoring of Dust

During the construction period CAGL will undertake quarterly monitoring of total suspended particulate (TSP) dust at the same locations as were sampled during the baseline studies for the EIS.

CAGL will initiate a dust monitoring programme based on gravimetric collection techniques, which accord to the Australian Standard: AS 3580.10.1-1991, "Methods for Sampling and Analysis of Ambient Air; Method 10.1: Determination of Particulate - Deposited Matter - Gravimetric Method."

Deposit gauges will be installed at the following locations across the Project Area:

1. At Abnabna village in the vicinity of the existing school/sports field.
2. At the Plant site.

3. At the Senior Camp site.
4. At a location east of the Flotation Tailings Storage Facility.
5. At a location between the Fetish pit and Ayanfuri village.

During the operational phase, the existing programme will be complemented by volumetric sampling methods, which provide specific information appropriate to assess the degree of impact in relation to health and safety issue (e.g. PM10).

Monitoring of Blasting Vibration

As instructed by the EPA, CAGL will arrange for structural surveys of the houses on the eastern edge of Abnabna village and on the northern edge of Ayanfuri village. The survey will be undertaken by an independent surveyor. Each survey will be completed prior to the mining of the Abnabna and Esuajah North pits. The purpose of the survey is to have baseline data to be able to assess any complaints by residents of blasting vibration affecting the structural integrity of their houses.

CAGL will support the surveys through the establishment of a photographic data base of the buildings at Abnabna and Ayanfuri North. CAGL will start to build the database during the construction phase of the Project.

Considering the existing environmental conditions of the area and the mitigation measures to be adopted by CAGL, dust levels within and around the Project area should be maintained within acceptable limits and guidelines values.

5.4.2 Gaseous Emissions

No noxious gases will be generated other than those from vehicles, carbon regeneration kiln and emergency standby generators. No specific mitigation measures are required apart from regular maintenance of all Project equipment and vehicles.

5.5 NOISE AND VIBRATIONS

Noise from hauling of construction material will create a temporary and intermittent increase in road traffic and associated noise levels only in the area occupied by the existing Abnabna and Fobinso pits and waste dumps and the new Plant site area. There will be no impact on local communities; dust suppression will be undertaken and employees will be supplied with and required to wear dust masks in designated areas.

The Contractor shall carry out its blasting operations in such a manner as to ensure that vibration does not result in valid public complaints. Blast patterns and powder factors shall be designed such that vibration is minimised.

In the event of a complaint being received regarding blast vibrations the Contractor shall investigate the complaint. The Contractor shall provide the CAGL Mining Manager with a detailed report within twenty-four (24) hours of the complaint. This report shall include, but not necessarily be limited to, the following information:

- full details of the nature of the complaint;
- an assessment of the validity of the complaint;

- a full description of the relevant blast pattern and powder factor used
- details of corrective action being taken or to be taken to eliminate future complaints.

CAGL will construct a new access road (0.8 km) some 350 m north of the Nkonya junction to connect with the existing Nkonya – Abnabna road. This will mitigate the impact of noise on the residents and commercial activities located at the junction. It will also result in improved safety conditions for traffic using the highway, as the current junction has limited visibility for fast moving traffic travelling from north to south.

Specific instructions will be issued to contractors to avoid as much as practicable transportation of material at night and over-speeding of vehicles when driving through or near towns and villages. Mine employees will be trained in the site driving rules, will required a valid Ghanaian driving licence as well as a CAGL driving permit. Signage indicating speed limits will be erected around site. As part of the employees safety induction, speed limits will be explained as well as the consequences of not adhering to them.

The Environmental Department will prepare procedures for noise measurement, establish specific sample locations and undertake regular noise assessments in the Project area. Sample locations will be established within operational areas and locations outside these, such as Abnabna, Fobinso and Ayanfuri villages.

The wearing of Personal Protection Equipment in the workplace will be mandatory for all employees where noise levels exceed EPA guidelines in industrial situations. Occupational noise monitoring during operations will be a routine procedure carried out by the Occupational Health and Safety Department.

5.6 THE AQUATIC ENVIRONMENT

5.6.1 Surface Water

Project activities including site preparation activities of the various Project sites (starter pits, waste dumps, tailings storage facility, water storage facility, treatment plant, mine service area and accommodation) will involve land clearance which may induce erosion and potentially increase the level of suspended solids mainly in the Fobin River and some of its tributaries. Any settlements located downstream of the construction sites may have their main source of water affected.

For preventive purposes, the following mitigation measures will be implemented by CAGL during construction and operations:

A) General

- Appropriate drainage control measures to minimise soil erosion will be put in place during preparation of each site. These measures will include construction of settling ponds at appropriate locations downstream of Project facilities such as the waste dumps, the treatment plant and the mine services area.
- Vetiver grass will be planted on the crests and slopes of waste rock dumps and on exposed surfaces to prevent sedimentation due to erosion.
- Land clearance will be progressive and as required for the development of a particular area;

- Necessary earthworks will be undertaken to ensure effective drainage around the perimeter of the pits, haul roads and access roads;
- Early revegetation of disturbed areas will be undertaken as much as practicable using topsoil and/or subsoil segregated during the preparation phase;
- The vegetation and swamps along the various water courses (riparian flora) will be protected as much as possible.

B) Community Water Sources

- CAGL will ensure that current boreholes at the five main communities of the Project area will be maintained in working condition.
- CAGL will sample, on a routine basis (monthly during construction period and quarterly thereafter) the boreholes in the villages of Abnabna, Ayanfuri, Fobinso, Gyaaman and Nkonya for water quality testing by an independent laboratory. This monitoring will be undertaken to instil confidence in the communities that their water supplies are not being impacted by Project development and operations. Any water bore samples that show contaminants in excess of World Health Organisation (WHO) standards shall result in that bore being decommissioned for human consumption until such time as the reason for the contaminant has been investigated and the bore has been pumped until the sample analysis is within WHO guidelines.
- Observation bores will be established in the villages of Abnabna and Fobinso prior to mining. The purpose of these bores is twofold. Firstly to determine if groundwater inflows into the Abnabna, AF Gap and Fobinso pits are impacting on groundwater by drawing done groundwater levels in the locality. Secondly, if this is the case and this drawdown is impacting on water levels in the village boreholes, remedial action can be taken e.g. deepening of the existing wells or constructing new boreholes.
- Hamlets listed in Chapter 3, section 3.8, table 38.3 will be relocated (this is the preference of the majority of the migrant settlers living in the hamlets) due to their close proximity to the Project facilities. Therefore, the destruction of water sources within the present hamlet area is not considered a social impact.
- CAGL will ensure that proper requirements to protect the environment and prevent oil contamination of surface and groundwater are included in all contractor agreements. Example of typical requirements are: the use of well maintained vehicles, storage of oil drums within bunded areas, provision of decontamination kits for each vehicle or decontamination of a site after being accidentally polluted by such products.

C) Impoundment of Raw Water

The FTSF has been adequately designed for flood conditions and protection of downstream locations.

A preventive measure is, however, proposed as follows:

- CAGL will ensure that no settlements are developed in the valley downstream of the FTSF spillway.

D) Surface Water Quality

- CAGL will prevent impact of its operation on the water quality of the area streams by ensuring that discharges of effluent containing cyanide or other pollutants are sent to the self-contained HDPE lined CIL Tailings Storage Facility.

The CIL TSF has a solids capacity of 10 years. From years 1 to 3 exposure to sunlight, the best and most cost effective form of cyanide degradation will be utilised. After three years of operation, controlled recycling of CIL tailings solution will need to commence to ensure adequate space is maintained for storage of solids. At this point in time a cyanide destruction circuit is required and shall be constructed for use in year 4 and beyond. The Cyanide Destruction Circuit (CDC) will be a SO_2/Air circuit which will treat a bleed stream from the removed CIL tailings solution. The treated solution will be used in the plant. The CDC will be located adjacent to the CIL tanks in the process plant

- Management practices will be implemented to avoid or limit any occurrence of accidental spillages which may result in a deterioration of the aquatic environment.

In order to further ensure a controlled situation over water quality additional measures will be adopted by CAGL:

- **Regular monitoring** of all sources of water will be undertaken. Sampling points locations or sources will include all streams located downstream the Project facilities in particular various tributaries of the Subin and Fobin Rivers, as well the rivers themselves, the sub-catchment of the Ankobra River below the Fetish waste dump and backfill area, runoff from Project facilities (mainly the plant site and mine service area). The baseline water monitoring programme will be adapted to the conditions prevailing at the time of Project development.

- **Cyanide** will be delivered as solid briquettes in 1 tonne sealed wooden boxes with internal plastic linings, in large batches on approximately a quarterly cycle to minimise frequency of transport risk, and stored away from any acidic substances in a secure area located within the plant perimeter. All operations related to cyanide handling will be highly regulated, proceduralised and under the supervision of a qualified person. At site an emergency spill control function will be available to assist with any spillage that occurs outside of the controlled area. This will be a mobile (likely trailer mounted) spill kit with various neutralisation agents, safety equipment and other required apparatus. CAGL understands the principles of "The International Cyanide Management Code" (www.cyanidecode.org) as such will manage the storage and handling accordingly (Table 2.9).

- **Acid mine drainage potential** will be monitored through analysis of waste by monitoring waste dump drainage and regular testing of waste rock samples during the life of the Project. Should an acid drainage problem occur during the life of the Project, appropriate prevention measures such as encapsulation of acid forming materials within a waste dump will be implemented.

- **The Asuafu stream** passes through the mine site and is the current source of main drainage from the area. The placement of the ROM pad interrupts this stream and effectively creates a catchment area behind it. A diversion channel will be constructed to redirect the water into the Abnabna stream that runs along the western side of Abnabna - AF Gap pit. A bund will also be constructed along the western wall of Abnabna - AF Gap pits to prevent the diverted Asuafu stream from entering the pits.

- **Where the first section of the diversion channel** empties into a natural swampy low spot adjacent to the south western arm of the ROM pad, this section will be constructed in a similar manner to the upstream plant site access causeway. Due to the existing ground conditions, a silt trap that can be cleaned out in the dry season will be constructed using gabion baskets.

- **Oil and grease contamination** from workshops will be controlled by all workshops being constructed with an appropriately graded concrete floor and perimeter drains that will direct any the runoff into oil separators prior to discharge. Specific procedures will ensure that the workshop floors will be kept clean at all times.

- **The mining contractor** will be contractually obliged to clean up and adequately dispose of any spillages of oil or grease on the open pit floors that may occur during the repair of mechanical breakdowns should the piece of equipment involved not be able to be taken to the workshop. Accumulated waste will be regularly collected and appropriately disposed off by the fuel supplier.

- **Sewage effluent on the Plant site** will be treated in a package sewage treatment plant installed. The treatment plant will use aerobic methods and the treated discharge directed to the FTSF. The selected packaged plant will conform to one of more standards such as Australian Standard AS 1547:2000 Onsite Domestic Wastewater Management, Australian Standard AS 1546:3 2001 Onsite domestic wastewater treatment units – Aerated wastewater treatment systems, the USA National Sanitation Foundation (NSF) International Standard NSF 40 - 1996, or European Union Standard - EN12566-3 2005. The selected standard will depend in part upon the sourcing of the packaged plant.

- **Sewage effluent at the senior camp** accommodation will be through a series of septic tanks. These will be inspected on a regular basis by the Environmental Department to ensure working efficiency.

5.6.2 Groundwater

Impact of the Project on the groundwater resources of the area is expected to be localised. The very low potential for acid mine drainage of both ore and waste rock material and inclusion of environmental safeguards in the design and operation of these facilities should adequately prevent groundwater quality from contamination.

Nevertheless, CAGL will install twelve boreholes to monitor the FTSF and CIL FTSF facilities. The location (including GPS coordinates is shown on the figure following section 2.16.18. Four (4) groundwater monitoring bores (BH 5, 6, 7 and 8) will be located downstream of the main FTSF embankment. Additional borehole monitoring locations (7) covering the main the saddle embankments are also shown (BH 9, 11, 12, 13, 14, 15 and 16). Only additional borehole (BH 10) will be installed to monitor the CIL TSF facility due to the close proximity of BH 16 and the CIL TSF sharing a common boundary with the FTSF.

CAGL will sample, on a routine basis (monthly during construction period and quarterly thereafter. A monitoring program will be established including water level readings and the taking of water samples for water quality testing purposes. Regular monitoring will be undertaken by its tailings management consultants. Collected information will be reviewed regularly and reported in an annual FTSF audit.

5.7 THE ECOLOGICAL ENVIRONMENT

5.7.1 General

The development and operation of the Project will not have any major pollution effects or cause loss of rare or endangered flora and fauna species. The baseline flora and fauna studies did not find any flora and fauna species of conservation importance. Nevertheless, CAGL will endeavour to preserve, or avoid any serious impact on the ecological environment and adopt several measures promoting conservation of certain areas.

5.7.2 Mitigation Measures

Land clearing will be progressive and as required for the development of a particular area. Any timber and wood resulting from clearing activities will be properly managed in collaboration with the

Concessionaire of the Abnabna Off Reserve Stool Land for harvesting of economic trees - Amigros International Co. Ltd, P.O. Box 8265 Accra North, Accra.

- CAGL will implement a land reclamation programme as part of its overall environmental management strategy and this will start at an early stage of the Project (erosion control procedures during construction period).
- Topsoil and overburden will be appropriately stockpiled and later re-spread in order to assist vegetation establishment on waste dumps, tailings dam and other disturbed areas during operations as feasible and on closure (see section 2.11).

5.8 SOIL AND LAND USE

5.8.1 Soil Erosion and Sedimentation

Land preparation associated with infrastructure development and operation of the Project will remove vegetation and top soil, so inducing soil erosion. CAGL will adopt measures to limit these impacts and to promote soil conservation, particularly during design and construction of the Project facilities.

Erosion control practices are proposed as follows:

- Deforestation and land clearance will be limited to the strict minimum;
- Measures to protect the soil from water erosion will be carried out on a catchment basis;
- Drainage from external catchment will be controlled by diversion channels or appropriate holding structures;
- Side drains and road camber will be constructed to ensure adequate drainage;
- Whenever possible, early revegetation of waste dump slopes and disturbed areas will be undertaken as part of the land reclamation programme;
- Visual assessment of erosion and analysis of run-off water quality as a preventative measure carried out on a routine basis, which will provide rapid evidence of where control measures need repair or implementation.

5.8.2 Loss of Agricultural Land and Farm Holdings

The number of farms identified in the active Project area is 726.

The area of land required for Project development is approximately 998 ha including redevelopment land disturbed by earlier commercial mining operations. Though not all this land area is cultivated, agricultural land use largely dominates with majority of people depending on farming as the source of livelihood and the principal means of employment. The number of hamlets in part of the Project Area is a clear indication of the economic importance of cocoa in the area. The importance of cocoa has attracted migrant farmers and motivated some indigenous farmers to establish cocoa farms. The soils in the greater CAGL Project area have been classified as from highly suitable to moderately suitable, depending upon the crop selected and the provision of inputs, particularly fertilizers.

The distribution of the major crops (cocoa, oil palm, mixed crops including cassava and plantain) in the three main development areas delineated for crop compensation purposes (Mining, Plant Site and FTSF) is depicted in Map 4.1 in Chapter 4. The area (hectares) of each major crop in the three was presented in table 4.3 which is repeated below as table 5.3

Table 5.3: Area of Major Crops (Ha) and Their Distribution in Planning Corridors							
Item	**Block**	**Cocoa Farm**	**Oil Palm Farm**	**Mixed Farm**	**New Farm**	**Bush Area**	**Total Area**
1	FTSF Corridor	71.56	4.54	4.21	2.03	0	**82.34**
2	Mining Corridor	96.64	10.63	1.38	0.48	0.02	**109.15**
3	Plant Site Corridor	173.60	12.57	2.15	0.93	2.40	**191.65**
	Total	**341.80**	**27.74**	**7.74**	**3.44**	**2.42**	**383.14**

The destruction of these farms represents a fairly significant impact on a local basis, but not on a District basis.

Mitigation Measures

CAGL is committed to pay compensation for crops grown on land required for Project development. Following a series of meetings a Compensation Agreement has been negotiated with the local farmers group. This group was represented by their elected representatives from Abnabna, Nkonya, Fobinso, Ayanfuri, Gyaaman, Mampong and Oforikrom, in the Upper Denkyira West and Wassa Amenfi East Districts. A copy of the draft Agreement is provided in Appendix 3.10.15.1.

As farmers are one of the most impacted groups in the proposed Project, an investment seminar was coordinated by AC&E International on behalf of Central Ashanti Gold Ltd. for farmers within the five villages of its project catchment area (Abnabna, Nkonya, Ayanfuri and Fobinso/Gyaaman jointly) on Wednesday December 15, 2009 and Thursday December 16, 2009. Barclays Bank Accra coordinated with their Kumasi Branch and a team of ten people to present the seminar. The objective of the seminar was to:

- Strengthen the knowledge base of farmers especially in finance management and investment.
- Strengthen the skills and abilities of these farmers in preparation of alternate livelihoods.
- Strengthen positive behaviours to improve their daily lives- especially in their spending/saving habits.

Farmers living in the Project area whose farms are not directly by Project activities will be encouraged to continue their farming activities as long as safety conditions allow.

CAGL will also encourage compensated farmers to participate in various Company sponsored alternative livelihood support projects that will be implemented by the Company in collaboration with NGO's, under the auspices of its Community Development Fund.

5.9 THE SOCIO-ECONOMIC ENVIRONMENT

5.9.1 General

CAGL is obligated to compensate people who, because of the proximity of their farms and/or buildings to areas needed for Project development, or because of public safety concerns, are required to be relocated or resettled.

5.9.2 Compensation for Hamlet Owners

The greater majority of the affected hamlets (41 of 51 have indicated to CAGL that relocation is their preferred choice. Their preference is to return to their home towns in other parts of Ghana. The remainder have indicated that they would prefer to relocate to Ayanfuri or Dunkwa-on-Ofin.

Mitigation Measures

CAGL has established a Relocation Action Committee to prepare a Relocation Action Plan. The Plan will involve extensive consultation with all local and district stakeholders. It has independent Chairman, and includes representation from the Abnabna and Ayanfuri stools, the two District Administrations within which the Project area occurs, the Chief Farmer of the area and representatives from the hamlets. The hamlet owners have also formed small committees to whom their representatives on the RAP committee will report back to on the relocation offered by CAGL. Hamlet owners will be compensated for both crops and buildings. It is the intent of CAGL to build sandcrete houses with ownership title for hamlet occupiers wishing to return to their original towns in Ghana and to a rental allowance in those places while the houses are being built. This form of compensation requires that they agree not to relocate within the Project area during the life-of-mine

CAGL agrees with the principle that house/building compensation should ensure that people displaced from their homes or buildings are better off than they were prior to resettlement. This does not solely mean the quality of their buildings but also their overall situation such as access to potable water or other “essential” infrastructures.

The valuation of each completed and uncompleted structure is to be mutually agreed between the owner/farmer, the RAP committee and CAGL. In the case of an unresolved dispute about the valuation, an independent arbitrator, approved by the committee, will be appointed.

The summarised details of this policy and the implementation procedures are as follows:

- Acceptable standards of relocation is one of the most visible and material expressions of CAGL’s responsibilities to its stakeholders and the local community.
- Relocation will be managed with an understanding of the cultural concerns of the involved stakeholders and will be carried out with compassion and consent for the people affected by the development.
- All stakeholders receiving monetary compensation from CAGL will be offered assistance and advice from appropriate specialists to enable them to plan and manage the monies received. CAGL will ensure that experienced persons will carry out the compensation assessment. These people will be familiar with the actual assessment works as well as the associated issues as raised by stakeholders in the consultative process.
- In consultation with stakeholders, including local communities, the documentation of compensation works will follow established procedures to ensure transparency, fairness and honesty towards all involved stakeholders.
- The relocation project schedule will reflect the timing of the associated mine infrastructure development.

5.9.3 The Issue of Influx of People into the Project Area

In Ghana, all people have total freedom of movement within the country. Consequently, there is no means to prevent or control the influx of people into towns and villages of the project area. These may be people seeking employment directly with CAGL or any of the contractor companies or conducting their own businesses in the communities.

Mitigation Measures

The mitigation measures proposed to deal with impacts associated with influx of people to the project area include:

- CAGL assisting in developing local training initiatives that will enable local residents to be able to compete for, and acquire the skilled jobs available at start-up. Also Company policy requires all unskilled labour to be sourced as much as possible from within the mine's "zone of impact". Construction and mining contractors will also be required to source locally.
- Prior to, and during operations, CAGL will hold periodic information meetings with official and traditional authorities who will be the key to controlling the impacts of the influx of people. The main objective of these meetings will be to give information on the level of potential for employment as a measure to control influx by reducing the level of expectation of those arriving in search of a job.

5.10 WASTE MANAGEMENT

5.10.1 Principles of Waste Management

CAGL has identified the various types and their potential mode of disposal. Any waste, such as oil filters, waste paper and wood packing will be disposed of in accordance with best practice applicable in Ghana and CAGL will ensure that all contractors are made fully aware of their environmental responsibility toward waste management.

The following principles related to waste management has been adopted by CAGL:

- Identification of materials and preparation of waste inventories;
- Preparation of a waste management plan;
- Minimise generation of waste;
- Sorting of waste by type and seeking alternative to disposal such as reuse and recycling;
- Appropriate storage of waste prior to disposal;
- Appropriate disposal of waste at a cost economically acceptable;
- Seeking collaboration with other industrial partners;
- Ensure that all contractors are made fully aware of their environmental responsibility toward waste management.

5.10.2 Classification and Management of Waste

The various type of waste identified and associated method of disposal are:

Household Wastes:

This type of waste will be produced by administration and technical offices, the canteens and households living at the accommodation village.

A landfill planned for non hazardous solid waste disposal will be constructed on a well-drained and accessible site such as a waste dump. Exact site selection and construction methods will minimise both the rate of infiltration and the quantity of run-off available for infiltration. Operating procedures will ensure that materials having undesirable, potentially leachable constituents (e.g. batteries from flashlights and electronic equipment) are not placed in the landfill. Material in the landfill will be compacted, burned or covered with earth as required to avoid wind-blown garbage and to reduce scavenging by animals and bird.

Non-toxic Industrial Wastes:

This category of waste includes heavy and light equipment tyres, worn metallic parts and fittings and packaging material for non toxic products (plastics containers, papers, wood, etc.). Disposal of materials will be considered only after all other options of reduction, reuse and recycling have been eliminated. Waste belonging to this category will be buried in the non hazardous solid waste landfill.

Waste Oils and Oils Filters:

Used waste oils and grease may be produced as the result of on-site servicing and repairs of machinery, light vehicles and mining and drilling equipment. Waste oil management will be the responsibility of the fuel/oil supplier which will ensure that used waste oils will be stored in 200 litres drums and sent to a recycling facility available in Ghana. Oil filters and other small oil containers will be collected separately, well drained and flattened before disposal into the non hazardous solid waste landfill.

Clinical Waste

Waste at the small clinic will be segregated into office waste and nursing station waste. The latter will be such items as swabs, tissues, bandages, and capsule packaging and sharps.

Sharps waste will be placed in an approved safety container for such. The other waste will be collected daily and placed in yellow plastic bags marked with black biohazard symbol. Container and bags will be incinerated on a scheduled basis in a purpose built incinerator to be purchased by CAGL.

Hazardous Industrial Wastes:

This category of waste will consist of cyanide packaging, plastic liners and wooden crates. This waste will be stored in a designated safety area prior to collection by the cyanide supplier and disposal by it.

5.11 HEALTH & SAFETY ASPECTS

5.11.1 General

Safety will be an integral part of the mine operations as it contributes to maximisation of productivity and lowered costs. Good safety practices are reflected in having a clean work environment and attention to procedures and routines: which if improperly managed can lead to environmental incidents,

Employee training, preparation of health & safety procedures, provision of suitable personal protective gear equipment, protection against fire potential and monitoring of employee health will be the very important aspects of the safety programme.

5.11.2 Training

Operators will be trained not only in detailed aspects of their work station but also in such matters as hazard recognition, chemical handling procedures, first aid, personal hygiene, electrical safety, rigging and lifting, vehicle safety, pond safety, fire safety, safety practices for working around machinery with moving parts, among other topics. A major effort will be focused on personal protection gear and equipment training. Only qualified operators shall be permitted to operate equipment.

Foremen and supervisors will receive more detailed training on these topics through regular safety meetings. Assistance will be provided by the Fire and Safety Officer in the form of instructions, inspections and safety training. Safe work practices are encouraged and reinforced by various safety-based incentive schemes, bonuses and awards to be operated by the Company.

5.11.3 Documentation

Work plans will be generated in terms of appropriate documentation. These standards, manuals and procedures will be drafted as required and will cover, inter alias, topics such as transportation, handling and storage of hazardous materials, use of specific equipment, safety data sheets for all the chemicals/products used, emergency procedures, etc.

5.11.4 Personal Protection Equipment

Personal protective gear will be mandatory under Company policy for all activities in all departments. At a minimum, all employees will be required to wear hard-hats and hard-toes boots. Rubber gloves, rubber arm protectors, full protection rubber (rain suit) coveralls, face shield, splash goggles, safety glasses, safety belts and lanyards, life vests and flotation rings, dust respirators hearing protectors, welding hoods and goggles, thermal protection suits and high voltage insulated gloves and sticks will be available and used where appropriate. Safety showers will be provided at strategic locations within the processing plant, work shop, warehouse, etc.

5.11.5 Fire Potential

Several types of fire extinguishers will be positioned at numerous locations throughout the processing area, explosive magazine and on mobile equipment.

Firewater to the plant will be sourced from the raw water dam. Electrically driven pumps will deliver water to the plant area, mine service area and senior and junior staff villages.

5.11.6 Medical Facilities

First aid equipment will be stationed at all work locations including sophisticated cyanide antidotes at the plant. A clinic staff with a physician and supporting ambulance will be located on site.

5.11.7 Working Environment

All building or work places will be constructed and equipped on ergonomic principles.

6.0 ENVIRONMENTAL MONITORING PROGRAMME

6.1 BACKGROUND

This chapter a generic summary of the proposed Environmental and Social Monitoring Programme to be implemented by CAGL. A detailed and specific Programme shall be written prior to production. The social aspects of the programme shall be done in conjunction with Social Development Committee to ensure that it has input from all appropriate stakeholders.

Environmental and Social Monitoring will have the following objectives:

- Continued gathering of baseline data in the Project Area,
- Evaluation of impacts resulting from the development of the Project,
- Evaluating of success of mitigation measures implemented by the company,
- Identifying situations requiring corrective measures and additional mitigation measures,
- Provide management with information regarding the effectiveness of environmental management,
- To detect changes in the receiving environment and enable analysis for their causes,
- To enhance effective liaison with communities, including addressing complaints that may arise from communities,
- Accord with EPA standards and guidelines.

As part of the EIS, once-off surveys on the Flora and Fauna, Soil and Land Use, Hydrology, Hydrogeology, Archaeological and Cultural environment of the Project Area have been supervised by Tagit. In July 2008, Perseus contracted with SGS Laboratory Services, Accra to conduct quarterly monitoring of surface water and groundwater and to undertake baseline measurements for air and noise in the Project area. It is proposed that this quarterly monitoring will continue until production starts after which the frequencies of monitoring and sampling locations will be reassessed.

6.2 MONITORING ASSESSMENT CRITERIA

6.2.1 General

In developing a monitoring program, there is a need to establish appropriate levels of environmental protection, identify applicable water, air quality and other criteria and establish appropriate monitoring compliance points.

This proposed monitoring program will therefore be assessed against the Ghana EPA guidelines (January 2001) and international best practice guidelines for the mining industry, including:

- IFC Environmental, Health & Safety Guidelines – Mining (December 2007),
- IFC Performance Standards on Social and Environmental Sustainability (July 2006),
- "Equator Principles" 2006,
- “The Community Development Toolkit” ESMAP Formal Report Series, Report No. 310/05, 2005.
- The Government of Ghana and EPA’s Environmental Rating Methodology for Mining Companies (AKOBEN Program). CAGL will be aiming to achieve Gold status under this program.

Environmental Monitoring may be classified into a number of categories as follows:

- *Operations or surveillance monitoring*: The comprehensive routine monitoring that is undertaken for process control, cost control, technical efficiency and safety reasons, as well as for environmental purposes. Operations monitoring typically includes monitoring of process reagent consumption, process water quality, tailing cyanide concentration etc. Often, but not exclusively, such monitoring is the responsibility of a mine Process Department, not the Environmental Department but with the results provided to the latter.
- *Discharge or compliance monitoring*: The monitoring of potential contaminants being discharged or emitted from the project to the environment. Such monitoring is usually undertaken either at the point of discharge or at the license boundary. Discharge monitoring provides direct information concerning the concentrations and loads of potential contaminants being discharged from the operation, and also serves as a link between ambient monitoring results and the operational monitoring. Discharge monitoring would typically occur where site runoff or pit waters are discharged to downstream drainage lines, or where sediment traps overflow. It could also be used as nominated compliance monitoring points for meeting local and international guidelines for effluent discharge etc.
- *Ambient or baseline monitoring*: The monitoring of the receiving environment beyond the project boundary. While operational and discharge monitoring should determine if environmentally significant releases have occurred, effects on the ultimate receptors within the receiving environment can be determined only by ambient monitoring. Ambient monitoring typically includes the monitoring of upstream and downstream water quality, potentially affected community water sources, and air and noise quality at nearby habitation.
- *Investigation or opportunistic* monitoring: Monitoring undertaken as part of a specific investigation, typically to determine the occurrence, nature and extent of possible impacts following a major environmental incident or to verify/refute third-party claims of environmental impact.

6.2.2 Socio-Economic Monitoring and Indicators

As discussed in Section 3, the Company has initiated the implementation of a Social Development Consultative Committee. The Committee will include representatives of all stakeholders in the five major villages within the Project Area including minority groups.

It will be the responsibility of this Committee to determine the community needs and how the Community Development Fund shall be fairly divided between the 5 participating communities and on what projects with funds will be allocated to within each community. As stated in the CAGL Community Relations Policy the process of ‘Participatory Rural Appraisals’ shall be used to ensure the Community has full involvement and ownership of all projects that the Company partners in. The Company’s considered areas of involvement will include but not necessarily be limited to health, education, women’s groups, the disabled and agricultural projects.

It is not the Company’s role to dictate to the community what they need and as such, from this participatory process, the Company shall be able to develop its Community Development Plan. The Company shall develop the Plan, in conjunction with the stakeholders, prior to commencement of production.

The Company proposes the following methodology for monitoring and indicators of the outcomes of social development initiatives.

- Define project in consultation with the community.
- Seek formal acceptance of project and activity from the Social Development Committee (SDC).
- Describe the goal (s) the activity/ project is being designed to deliver as accepted by SDC and the relevant interest groups/stakeholders.

- Determine the time frame for the activity/project/goal.
- State and describe the important assumptions of external factors that may likely affect the achievement of objectives.
- Periodic checking & reporting of inputs: - such as money/time contributed, number of meetings held or number of scholarships awarded.
- Regular assessment & reporting on the direct results of the activity/ community development – this includes direct communication and feedback with the benefactor(s).
- Periodic assessment and reporting on the overall desired returns on investment for a particular activity/project (that is improvement in the community's quality of life, health or economic well being).

Some examples of indicators for social project are:

- Increase in student enrollments in schools the Company works with
- Increase in the standard of education in the school the Company work with, measured by an increase in the students exam results
- The increase in employment of women through income generating projects.
- General increase in health through the provision of clean potable water bores and malaria prevention workshops in the community, measured by a decrease in attendances at local medical clinics

Once the Social Development Committee and Company has finalized the Social Development Plan, a thorough list of measures and indicators can be applied to it.

6.3 QUALITY ASSURANCE / QUALITY CONTROL

Sampling, handling, analysis and data management procedures are essential if the proposed baseline and operations monitoring programs are to produce reliable, useful and defensible data. A pre-requisite of effective quality assurance/quality control is the establishment of a capable, well-trained, well-managed and well-equipped environmental department.

CAGL will develop or obtain appropriate written sampling procedures including field sampling methods, use of duplicate and blank samples, sample storage and transport procedures, ensuring Chain of Custody documentation and periodic third party verification or ensure that any outside party commissioned to undertake a water sampling programme on behalf of Perseus has the appropriate QA/QC procedures in place.

CAGL will ensure to send samples to a reputable analytical laboratory in Ghana.

6.4 DATA ENTRY, MANAGEMENT AND REPORTING

CAGL environmental department will enter laboratory results into a water quality-monitoring database in accordance to the Environmental Management Program. The database will be an excel-based system that helps in tabulating and graphing the results and compares them to Ghana EPA (EPA January 2001) and IFC Environmental, Health & Safety Guidelines – Mining (December 2007), Where applicable, World Health Organisation (WHO) standards would apply, especially for community drinking water supplies. Monitoring results will be interpreted and reported to the government through the existing monthly return forms to the EPA and also as part of CAGL's annual environmental report.

6.5 PROPOSED MONITORING PROGRAMMES

The proposed monitoring environments to that will be included in the monitoring programme are as following:

1. Meteorological Data
2. Surface Water Quality
3. Ground Water Quality
4. Sediment
5. Dust
6. Noise
7. Vibration
8. Ecological Environment
9. Tailings Storage Facility
10. Socio-economic Environment

6.6 METEOROLOGICAL DATA

6.6.1 Data Collection

Rainfall and temperature data was obtained from the nearest national climatologically station operated by the Meteorological Services Agency (MSA) at Dunkwa-on-Ofin located about 15km east of Ayanfuri. The evaporation data was obtained from the station from Bogoso about 30km south from Ayanfuri. The stations are considered as being close enough to the project area to provide relevant information.

Data obtained from these stations will be used for reference and comparative purposes.

6.6.2 Frequency

Climatic data from the national climatological stations at Dunkwa-on-Ofin and Bogoso will be collected on an annual basis.

6.7 SURFACE WATER QUALITY

6.7.1 Baseline Sampling

A comprehensive surface water quality monitoring programme was put in place in August 2008. A table of existing surface water monitoring locations used during the baseline data collection phase is provided in table 6.1 and Map 32.2.

6.7.2 Construction, Operations and Closure Monitoring

Surface water quality may impact significantly on the surface water environment, especially where downstream water users utilise water for drinking and domestic purposes. Surface water monitoring points that will be required during construction, operation and closure include downstream of pit discharge points, waste rock dumps and other stockpiles, the TSF, the treatment plant as well as locations around any other activity such as workshops and fuel bays. It is proposed that sampling downstream of pits and waste dumps is phased to align with mining development, operation and closure. Monitoring will continue for up to three years post closure.

Table 6.1: Surface Water Sampling Locations in the CAGL Project Area					
		Aug	Dec	April	July
Location ID	Description	2008	2008	2009	2009
		√			
PA3	Akesuoa River downstream of Nkutumso Village	√	√	√	-
PA4	Akesuoa River upstream of Nkutumso Village	√	√	√	√
PA7	Subin River downstream of Odumkrom Village	√	√	√	√
PA11	Asuafu River downstream of Nkonya Village	√	√	√	√
PA13	Drainage immediately downstream of Abenabena	√	√	√	√
PA15	Subin River at the railway crossing	√	√	√	√
PA16	Swamp area downstream of Chirawewa pit complex	√	√		√
PA17	Downstream Chirawewa on road to Dabiesem		√		√
PA19	Asuaa downstream Ayanfuri at culvert on N. Esuajah haul road		√	√	√
PA20	Culvert on Sefwi-Bekai road nr Odumkrom (EU sample point)		√	√	√
PA21	Pond on Fobinso haul road below HLP				√
PA23	Pond below Chirawewa waste dump		√		√
PA24 (As1)	Stream north of HLP nr Gyaaman but above HLP drainage		√		√
PA 25 (As2)	Drainage from swamp area to stream north of HLP		√		√
PA27 (new PA3	Sample relocated better reflect drainage from Proposed TSF area			√	√

6.7.3 Frequency

It is proposed that surface water samples be sent for analysis from all identified sites on a quarterly basis until the start of the project construction phase. Once construction starts, it is proposed that frequency of sampling increases between weekly, fortnightly, monthly and quarterly. Those sites with increased risk of exposure to adverse impacts of operations will be sampled more frequently than those with a low risk of exposure (Table 6.2). The sampling programme described below is in addition to daily and weekly sampling programmes for process plant control.

Field analyses will be undertaken for pH, conductivity, turbidity, TDS and dissolved oxygen on a weekly basis by CAGL environmental staff. Monthly suite parameters will be sent to an independent laboratory. The prime purpose of weekly sampling will be to determine if unknown changes are occurring that would need to be quickly rectified.

Table 6.2: Potential Future Surface Water Sampling Frequency	
Type of Site	**Sampling frequency**
Treatment Plant and Services Area	Weekly suite of field parameters Monthly suite of detailed parameters
FTSF	Weekly suite of field parameters
CTSF	Weekly suite of field parameters
Pits and Waste Dumps	Monthly suite of detailed parameters

6.7.4 Parameters

The following parameters are recommended for analysis at an independent laboratory.

- Surface water parameters downstream of the FTSF and Treatment Plant:
- Cyanide: Free, WAD and Total Cyanide (CN)
- Physico Chemical: pH, Dissolved Oxygen (DO), Conductivity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Apparent Colour, True Colour, Turbidity, Oil and Grease, Alkalinity and Hardness ($CaCO_3$)

- Nutrients and Other Chemical analysis: Sodium (Na), Potassium (K), Sulphate (S), Chloride (Cl), Nitrate (NO_{3-}), Nitrite (NO_{2-}), Phosphate (PO_4), Calcium (Ca), Magnesium (Mg), Chemical Oxygen Demand (COD), and Biological Oxygen Demand (BOD)
- Microbiological: Total Plate Count for Total Coliforms and Faecal Coliforms
- Metals (Total or Dissolved): Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Lead (Pb), Mercury (Hg), Chrome (Cr), Nickel (Ni), Arsenic (As), Cadmium (Cd), Aluminium (Al) and Selenium (Se)
- Surface water parameters downstream of pits and waste dumps:
- Physico Chemical: pH, Dissolved Oxygen (DO), Conductivity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Apparent Colour, True Colour, Turbidity, Alkalinity and Hardness (CaCO3)
- Nutrients and Other Chemical analysis: Sodium (Na), Potassium (K), Sulphate (S), Chloride (Cl), Nitrate (NO_{3-}), Nitrite (NO_{2-}), Phosphate (PO_4), Calcium (Ca) and Magnesium (Mg)
- Metals (Total or Dissolved): Iron (Fe), Manganese (Mn), Copper (Cu), Zink (Zn), Lead (Pb), Mercury (Hg), Chrome (Cr), Nickel (Ni), Arsenic (As), Cadmium (Cd), Aluminium (Al) and Selenium (Se)

For every batch of surface water samples, it is proposed that one field blank, one laboratory blank and one duplicate set of samples will be taken.

6.8 GROUNDWATER QUALITY

6.8.1.1 Village Boreholes

The boreholes at the five main villages will continue to be monitored on a quarterly schedule until such time as construction begins. Thereafter, it is proposed to monitor the boreholes on a monthly basis until construction is completed and the mine has been operating for one year. Thereafter, monitoring would be half-yearly.

6.8.1.2 FTSF Monitoring

Monitoring boreholes established downstream of the facility will be used to take water samples. Additional detail of FTSF monitoring is provided in section 6.15.

6.9 STREAM BOTTOM SEDIMENT

6.9.1 Baseline Sampling

Sediment samples were taken in September 2008 from the dewatered Abnabna pit. No elevated trace metal values were recorded.

6.9.2 Development, Operational and Closure Sampling

Sediment sampling will take place during the development, operational and closure phases. Of particular significance is the area downstream of the FTSF main embankment.

6.9.3 Frequency and Parameters

It is proposed that sediment is sampled on a biannual basis in the Fobin and Subin rivers at three of the sample point locations used in the aquatic ecology baseline survey.
Stream bottom sediment parameters to be analyzed as follows:

- Physico Chemical: pH and Conductivity
- Metals: Iron (Fe-Total), Manganese (Mn-Total), Copper (Cu-Total), Zinc (Zn-Total), Lead (Pb-Total), Mercury (Hg-Total), Chrome (Cr-Total), Nickel (Ni-Total), Arsenic (As-Total), Cadmium (Cd-Total), Aluminium (Al-Total) and Selenium (Se-Total)

6.10 DUST MONITORING

6.10.1 Baseline Sampling

As part of the baseline sampling, total suspended particulate (TSP) was measured for 48 hrs at three locations, in two villages and one forested location (Map 31.1).

6.10.2 Development, Operational and Closure Monitoring

Dust generated along the haul roads, and from pits, waste dumps and stockpiles may impact traffic and residents of nearby villages. In addition to periodic TSP sampling it is proposed to install a number of gravimetric dust samples at strategic locations in the Project area.

It is proposed that TSP and gravimetric dust sampling is undertaken during construction and continued throughout operations and closure at periodic intervals. When gravimetric dust monitoring is conducted due consideration will given to the following:

- The zone of influence, such as villages and other sensitive areas
- The dust generation potential of the activity
- The general wind direction in the Projects area of influence.

Not all sites will be monitored at the same time, as non-operational sites do not generate significant dust so monitoring frequency is therefore reduced. It is therefore proposed that dust monitoring is conducted as the activities develop but that Abnabna village and the area between Esuajah North and Ayanfuri village receive special attention.

6.10.3 Personnel Monitoring

When operations start, personal dust monitoring will be conducted on over a shift period (8 hours) on employees working in potentially dust exposed locations. This monitoring will be considered as part of the Occupational Health and Safety Management.

6.11 NOISE

6.11.1 Baseline Sampling

In order to characterize background noise levels of the Project area maximum noise levels were recorded during 24-hours periods at three sensitive locations that surround the area designated for the proposed project facilities. Two village locations (Abnabna and Ayanfuri) and one forested location were selected. Noise sampling points are shown in Map 31.1.

6.11.2 Location and Frequency

Noise monitoring will be undertaken during the development and operational phases. It is proposed that noise monitoring is conducted in Abnabna village and other area where deemed appropriate.

6.12 VIBRATION

6.12.1 Baseline Sampling

No vibration monitoring was conducted during the baseline phase.

6.12.2 Location and Frequency

Vibration and air blast monitoring will be required for each pit as it is developed and worked which along with the seismograph, blast design and charge records (e.g. hole depth, hole angles, rock type, stemming depth and type) shall be analysed by the blast foreman and a report issued for each blast conducted. This will assist in assessing how well the blast went and what improvement measures can be implemented.

Routine blast monitoring will be required at Abnabna village when blasting is undertaken at the Abnabna and AF-Gap pit complex.

6.13 ECOLOGICAL ENVIRONMENT

6.13.1 Baseline Sampling

Once off surveys were undertaken of the terrestrial fauna and flora and the freshwater environment during the baseline surveys.

6.13.2 Development, Operational and Closure Monitoring

It is not proposed that any surveys of terrestrial fauna and flora are to be undertaken during the development or operation phases.

Although post mining land uses are likely to be agriculturally oriented, a terrestrial fauna survey could be considered during the closure phase to assess habitat regeneration.

It is however proposed that the fresh water environment is sampled on a biannual basis for the first two years of operations. The freshwater environment provides a highly sensitive biological receptor for water quality and is considered to be a very useful monitoring tool.

6.13.3 Location and Frequency

Sampling points for the freshwater sampling have been selected downstream of significant infrastructure and are proposed in Table 6.3.

Table 6.3: Fresh water ecology sampling points

Basin	Frequency	Parameters
Fobin River sub-catchment (1)	Biannual	Qualitative and quantitative analysis of Phytoplankton, Macro-invertebrates and aquatic insects
Fobin River sub-catchment (2)	Biannual	
Subin River sub-catchment	Biannual	

6.14 EROSION AND SEDIMENT CONTROL

Erosion and sediment loss will be monitored during the development, operational and closure phases. Several accepted informal methods are as follows:

- Regular inspection of pit and waste dump operations and of surface run-off control structures
- Visual assessment of erosion as a preventative measure carried out on a routine basis, which will provide rapid evidence of where control measures need repair or implementation

- Sampling and analysis of run-off water quality and existing surface water for key parameters.

This programme will be integrated with the CAGL site-wide surface water quality monitoring.

6.15 MONITORING OF FTSF

As part of the operation of the facility, extensive operational monitoring will be undertaken. Complete details of the monitoring programme will be included in the operations manual that will be produced at the final design stage.

The proposed monitoring will fall into two basic types:

Short term operation monitoring - this includes items such as spigot off-take locations, whether pipe joints are leaking, thickness of deposited tails, etc., which are part of ensuring the facility is operating smoothly

Performance monitoring - this includes items such as checking monitoring bores for contamination, checking piezometric levels within the embankments, tailings level surveys and water flow measurements etc. which are used to monitor the performance of the facility and refine future embankment lift levels and final tailings extent and to ensure the project is meeting all its commitments in regard to a safe secure operation

6.15.1 Monitoring Bores

Four groundwater monitoring boreholes will be installed, downstream of the facility and on all saddle embankments to measure pore water pressure and pore water level.

6.15.2 Piezometers

Piezometers will be used on the downstream side of the main embankments in excess of 15 m and the entire facility will be audited by a suitably qualified geotechnical engineer to ensure that it is operating in a safe and efficient manner.

6.15.3 Quarterly Inspections

The tailings storage facility will ultimately have embankments in excess of 15 m and the entire facility will be regularly audited by a suitably qualified geotechnical engineer to ensure that it is operating in a safe and efficient manner.

6.16 RECLAMATION MONITORING

The success of rehabilitation will need to be monitored to demonstrate CAGL's commitment in this area to the government, community and other stakeholders, and to enable rehabilitation techniques to be continuously refined and improved.

Parameters that could be monitored include:

- Percentage ground cover and species composition of revegetated areas.
- Chemical/elemental analysis of vegetation on reclaimed areas.

6.17 POST CLOSURE MONITORING

Post closure monitoring of areas managed by CAGL would be to best practice standards, and rehabilitation success would be measured by the development of a self-sustaining state of rehabilitated areas compared with undisturbed communities

7.0 PROVISIONAL ENVIRONMENTAL MANAGEMENT PLAN

7.1 INTRODUCTION

This chapter of the EIS presents a general summary of the proposed Environmental and Social Monitoring Programme to be implemented by CAGL.

A detailed and specific programme shall be written prior to commencement of production. The social aspect of the programme shall be done in conjunction the Social Development Consultative Committee so that it has input from appropriate stakeholders.

In line with Best Practice, it is CAGL's aim to manage its operations so that undesirable (negative) environmental impacts of the Project during construction, operations and following closure are minimized (e.g. impacts on water and air quality) whilst positive impacts are maximized (e.g. employment and training opportunities for the locally available workforce and the development of sustainable programmes for the Project area).

7.2 CHARACTERISTICS OF PEMP

Typically, a PEMP gives consideration to the following subjects:

- Corporate Commitment and HSE Policies
- Environmental Management Structure
- Financial Allocations
- Project Overview
- Existing Natural Environment
- Existing Socio-Economic Environment
- Environmental Impacts and Mitigation Measures
- Environmental Action Plans
- Monitoring Programme
- Reclamation and Decommissioning
- Emergency Response Plan
- Auditing & Review
- Community Relations and Resettlement

7.3 PERSEUS MINING LIMITED CORPORATE POLICIES

7.3.1 Environment

Perseus Mining Limited (Perseus) regards environmental care as an integral part of its business and is committed to excellence in the management of environmental matters. We aim to minimize environmental impacts at every stage of work from planning, through exploration, development, mining, processing and decommissioning. Perseus, through its personnel will:

- Maintain a comprehensive Environmental Management System;
- Undertake consultation to ensure that community interests are considered;

- Comply with applicable laws, regulations and standards;
- Provide safeguards and contingency plans to mitigate potential impacts;
- Monitor all activities and strive to continually improve performance; and
- Promote environmental awareness amongst the workforce to increase understanding of environmental responsibilities.

All employees and contractors are responsible for upholding Perseus's standard of environmental management.

7.3.2 Community

The company maintains a policy of employment from the countries of operation and from local community of the individual projects. Most of the company's qualified professionals are from Ghana and Ivory Coast.

7.3.3 Health and Safety

The Company firmly believes that the health and safety of its employees and affected third parties is of prime importance in the successful pursuit of its business activities.

The Company has a basic commitment to conduct its operations in a manner that will prevent injuries to its employees and not put anybody's health at risk. In doing so it embraces the principle that a zero lost time injury frequency rate is achievable.

The Company firmly believes that the benefits to be gained from successful health and safety programmes are significant in both human and monetary terms, thus requiring high standards of Occupational Health and Safety to be pursued at all times and at all levels within the Company.

7.4 ENVIRONMENTAL MANAGEMENT SYSTEM

The Project will develop an Environmental Management System following the principles contained in ISO14001/ISO14004. The major elements of the Environmental Management System will be:

- Recognition that sound environmental management is essential to successfully operate the facility.
- Accountability of all staff for minimizing environmental risk and assuring compliance with regulatory requirements as well as corporate environmental objectives.
- Implementation of monitoring programs to provide early warning of any deficiency or unanticipated performance in environmental safeguards
- Training and orientation of employees in order to perform their jobs in compliance with sound environmental practices.
- Consideration of environmental factors to be included in all new or modified facilities and in the purchase of equipment and materials.
- An environmental incident reporting system will be established and reports prepared in a timely manner.
- Environmental response planning will be completed to provide the basis for response to environmental incidents, including spill prevention and counter measures plans, monitoring plans and mitigation plans.

- Periodic reviews will be conducted to verify environmental performance and to continuously strive towards improvement.
- Procedures are implemented to assure ongoing dialogue with government entities in connection with regulatory changes which may affect the operation.

7.5 ENVIRONMENTAL STAFFING

To facilitate environmental and social management practices CAGL will establish a Sustainability Department (see chart below). The Sustainability Manager (SM) shall report to the CAGL Resident Manager thereby ensuring that sustainability issues are assigned the appropriate priority and level of attention.

7.6 DEPARTMENTAL RESPONSIBILITIES

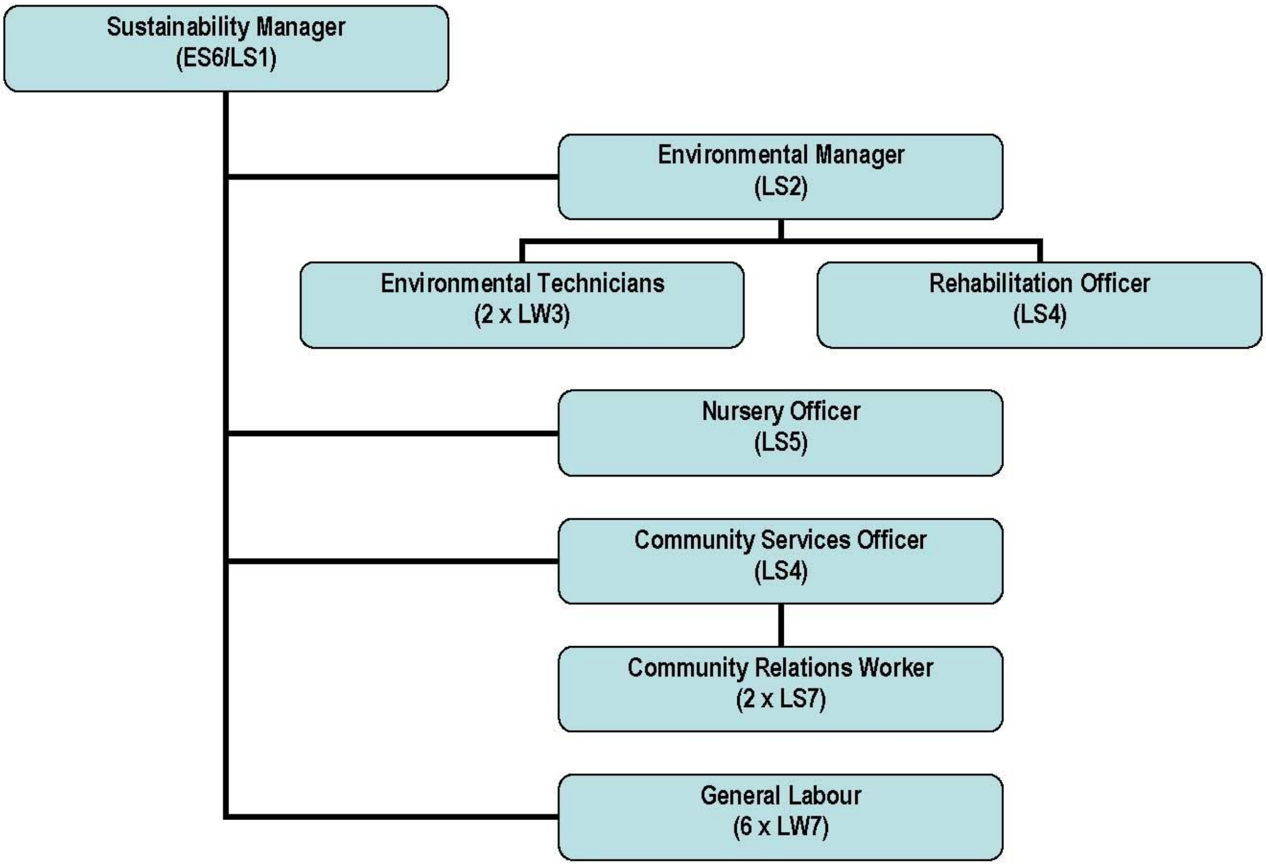
The Sustainability Department staff will manage Environment and Community Relations functions and will be controlled by a senior employee at the level of ES6. This department will be responsible for the following:

- Environmental monitoring,
- Rehabilitation,
- Forestry and
- Community relations and services.

The Department will be responsible for directing and maintaining all environmental monitoring and reclamation programmes/activities in the Project area and engaging regulators and stakeholders on related issues. This ensures specific environmental management responsibilities are allocated as appropriate and ensure the commitments stated in the environmental policy are achieved.

The community relations and community services will manage community management planning leading to the sustainable development of the mine within the community through joint initiatives that will see benefit and enrichment to the social fabric through understanding and open dialogue with the mine.

Specifically the mine will assist with joint programs that will focus on improved health, education, hygiene, and infrastructure. The forestry function will manage the growth of re-notification plant, establish a seedling farm and a market garden for mine staff food requirement. The forestry team will work hand in glove with the rehabilitation functions ensuring the clean sustainable return of the active mining areas to socially responsible land usage as jointly agreed with the long term land users. The total workforce of the Sustainability department has been estimated at 15 people.



7.7 PROJECT COMPONENTS

A complete project description is presented in Chapter 2 of this report and is illustrated in Maps 2.1 and 2.2. The Project will consist of construction, operation and decommissioning (including reclamation) phases of the following elements:

- Pits - Abnabna-AF Gap, Fobinso (Phase 1), Fetish and Esuajah North(Phase 2).
- Rock Waste Dumps - Abnabna-AF Gap, Fobinso, Fetish and Esuajah North.
- Flotation Tailing Storage Facility.
- Concentrate Tailings Storage Facility.
- Plant Site / Services Area.
- ROM Pad.
- Mine Roads.
- Asuafa Diversion channel.
- Water Storage Facility.
- Access Road.
- Sediment Control (Inc drains).
- Power line to Plant site.

7.8 WASTE, DISCHARGES AND EMISSIONS

A register of the waste, discharges and emissions that will arise from the proposed Project is provided in tables 7.1 to 7.3 below. These list both the routine discharges and emissions and those that may occur as a result of accidental occurrences. For ease of description and for completeness, the Project has been divided into specific locations where considered necessary.

Table 7.1: Potential Air Emissions During Operations

Location / Source	Description
Mining, including blasting	Dust, gaseous emissions, noise and vibration.
Waste Rock Dump	Dust raised by haulage and unloading, and from erosion of exposed surfaces. Noise and engine emissions from heavy equipment.
Haulage / transport	Noise and dust raised by mine surface vehicles on unsealed roads; emission from surface vehicle exhausts

Table 7.2: Potential Solid Wastes and Residues During Operations

Source / Location	Description
Mining	Waste rock transported to the waste rock dumps and/or rehandling when partially backfilling mined out pit
Mine and infrastructure facilities	All solid wastes, e.g. used tyres, oil filters, batteries, scrap metal and wood packaging, used metal containers (e.g. paints and solvents) to be properly stored.
Hydrocarbon wastes	Waste hydrocarbons will be moved to the fuel storage facility and removed from site by the facility operator.
General refuse	Office and chop kitchen waste will be taken to the managed landfill site.

Table 7.3: Potential Liquid Discharges During Operations

Source / Location		Description
Mining Operations	Haulage and waste rock disposal	Run-off from surface mine roads and dumps Leachate from dumps drains to the local environment
	Pit water	Water accumulating in the pits will be actively removed by pumping to settling ponds before being utilised for dust suppression. Excess water will be discharged to the environment provided laboratory analysis shows it meet EPA effluent discharge quality.
Heavy Vehicle Workshop	Waste oils/fuels	Waste will be stored on site in a tank and removed and disposed of by fuel supply contractor.
	Fuel delivery and storage	Run-off containing hydrocarbons will drain through oil/silt traps before reporting to the natural environment provided effluent quality is good for discharge.
Container office block, First aid station, Contractors yard, Ablution block	Surface drainage	Run-off containing suspended solids or oils drains through oil/silt traps will drain into sediment pond and then to watercourses.
	Sewage	Sewage disposed to septic tanks.
Transport of personnel, fuels, general supplies		Spillage of fuel and oil. Accidental spillage; rupture of storage tanks; potential release to local environment.

7.9 REGISTER OF ENVIRONMENTAL IMPACTS

The purpose of an EMP is to ensure that appropriate control and monitoring measures are in place to deal with all significant potential environmental impacts of a project. An impacts register therefore provides a focus for environmental management. The potential impacts of the proposed operations are summarised in table 7.4 below.

7.10 ENVIRONMENTAL STANDARDS AND QUALITY OBJECTIVES

In accordance with the Perseus's environmental policy, CAGL will manage its operations so as to minimise potential effects on the environment and to comply with all relevant legislation regarding the protection of the environment. This section sets out the environmental standards that CAGL is committed to achieving. These standards have been set in accordance with the following:

- All statutory requirements which are specific to CAGL

- Relevant Environmental Acts and Regulations (including LI 1652 *Environmental Assessment Regulations* 1999)
- Relevant Regulatory Agencies' environmental guidelines (including Ghana's Mining and Environmental Guidelines and Environmental Protection Agency guidelines for the quality of discharges into natural watercourses, environmental quality guidelines for ambient air and noise)
- Industry best practice.

7.11 MITIGATION AND ENVIRONMENTAL CONTROLS

CAGL is committed to limiting the impacts of the emissions/discharges identified in this EIS to ensure compliance with the standards and quality objectives. In order to achieve this aim, CAGL will implement mitigation and control measures as described in Chapter 5 of this document. Specific operational control procedures will be developed to ensure on-going application of the EMP principles throughout the life of the mine.

7.12 MONITORING

The current environmental monitoring programme will be modified to encompass all potential new or changed impacts as outlined in Chapter 6 of this document. This will include:

- Continuation of surface water monitoring at locations established during baseline data collection,
- Establishment of surface water quality monitoring stations at any settling ponds, regular monitoring of water accumulating in the pit and ensure levels meet the EPA criteria before discharge to the environment,
- Selective monitoring of trace elements within ore deposit,
- Maintenance of noise and dust monitoring programme during operations,
- Establishment of an operational blast monitoring regime,
- The community consultative monitoring program, which comprises informal and formal meetings of the community, will be maintained during the CAGL Project.

In accordance with EPA requirements, monthly monitoring returns will be submitted to the EPA on Form MO1.

7.13 OCCUPATIONAL HEALTH AND SAFETY

The principal aspects of the Health and Safety programme that CAGL will be implementing are:

- Training and education of all new employees and contractors at the site prior to commencing work, including use of personal protective clothing (PPE).
-
- An internal health and safety report prepared on a monthly basis, which reviews the data available for the previous month and provides recommendations for improvements;
- Application of appropriate occupational health and safety standards, such as World Bank Environment, Health and Safety Guidelines and WHO drinking water standards;
- CAGL will prepare a comprehensive Emergency Response Management Plan (ERMP), which will provide for emergencies such as fuel spill or fires. A Medical Evacuation Plan, which will be implemented in the event of an accident or medical emergency, will form part of the ERMP.

7.14 AUDIT AND REVIEW

Following implementation of the EMP, the Sustainability Manager will undertake internal reviews. The purpose of the reviews is to:

- Ensure that the EMP is being implemented appropriately.
- Identify corrective actions where appropriate.
- Assess the effectiveness of previous corrective measures.

Table 7.4: Summary Matrix of Potential Impacts During Operations

Nature of Impact	Environmental issues							
	Surface Water	Ground -water	Air Quality	Soil & Land use	Flora & Fauna	Local Community	Land-scape	Cultural Heritage
Air emissions								
Noise and dust from mining and blasting			✓	✓	✓	✓		
Dust from ore stockpile and waste rock dump			✓	✓	✓	✓		
Dust from haul roads, un-vegetated ground and vehicular movements			✓	✓	✓	✓		
Noise from haulage					✓	✓		
Emissions from vehicles			✓			✓		
Liquid effluents								
Pit de-watering	✓				✓	✓		
Potential seepage of water from the opens pit to groundwater and consequent implications for abstraction by local communities		✓				✓		
Run-off from waste dumps and stockpiles	✓				✓	✓		
Leakage/spillage of oils/fuels	✓	✓			✓	✓		
Run-off from site/haul roads	✓				✓	✓		
Sewage storage (septic tank) and disposal		✓				✓		
Accidental spillage of fuel, oil or chemicals during transport to and from CAGP	✓	✓			✓	✓		
Solid wastes								
Waste rock to dump	✓	✓	✓	✓	✓	✓	✓	✓
Disposal of used storage containers	✓	✓				✓		
Disposal of scrap, workshop wastes, used tyres, batteries etc.	✓	✓				✓		
Community								
Employment – direct and indirect				✓		✓		
Loss of income to farmers						✓		
Influx of population into area communities due to employment opportunities and potential infrastructure development				✓	✓	✓	✓	✓
Revenue increase by local employment						✓		
Increase in speculative farming				✓	✓	✓	✓	✓
Increase in galamsey activity	✓	✓		✓	✓	✓	✓	✓
Training opportunities						✓		
Others								
Change in topography (open pit, waste storage)	✓			✓	✓	✓	✓	
Visual						✓		
Land take for mining development				✓	✓	✓	✓	✓

Key: ✓ Potential impacts

7.15 ENVIRONMENTAL ACTION PLAN

CAGL will regularly review its environmental performance against its stated objectives, to determine whether the objectives are being met or whether improvements can be identified. Where a need for improvement is identified, the Environmental Action Plan (EAP) that is outlined below (Table 7.5) identifies required works and schedules to implement the improvement. Implementation of the CAGP Project will require the following specific actions to follow up on potential impacts and mitigation measures identified in this EIA, including:

- Implementation of mitigation measures, stipulated in Chapter 5 of this document.
- Implementation of a monitoring programme, stipulated in Chapter 6 of this document.
- Development of detailed EMP as specified in this chapter.

The implementation of the monitoring programme will be the responsibility of the Sustainability Manager.

7.16 RECLAMATION/DECOMMISSIONING

CAGL is required by legislation to implement a land rehabilitation programme and prepare a decommissioning plan as part of its overall environmental management strategy. In addition, when acquiring the Ayanfuri mining property, Perseus also acquired the rehabilitation liabilities of Stratsys Investments Ltd, which in turn had acquired such liabilities from AngloGold Ashanti (Ghana) Limited. Consequently, the Closure Rehabilitation Plan (CRP) will have to address the existing liabilities and those that would newly arise from the development and operation of the Project. Provisional reclamation and decommissioning plans are presented in detail in Chapters 8 and 9 of this EIS. Rehabilitation will be concurrent with operations to the extent practicable.

7.17 EMERGENCY RESPONSE PLAN

CAGL will develop an Emergency Response Plan containing procedures to provide the basis for the prevention of and response to environmental incidents. These will cover:

- Identification of the potential for uncontrolled or unintentional release situations;
- Understanding the environmental risk presented by these situations;
- Establishing preventative measures; and
- Preparation and implementation of effective notification and response systems.

Preparedness for accidents and emergencies is implemented in order to reduce risk of occurrence and to control/mitigate the environmental impacts associated with them if they should occur. The requirements will provide for regular reviews and for practice drills. The Emergency Response Plan also requires the Company to notify Governmental Departments and Agencies of any non-compliance to statutory requirements.

7.18 COMMUNITY RELATIONS AND RESETTLEMENT

The mining sector laws and regulations of Ghana require companies to resettle or relocate communities and/ or affected facilities that fall within their active mining areas. To ensure that this is done in compliance with the EPA's requirements on resettlement so that the company can operate in an environmentally and socially responsible manner CAGL will shortly initiate a full Resettlement Action Plan (RAP). This will take cognizance of international best practice. The Project will involve the relocation or resettlement of about 22 hamlets. This will be finally confirmed once the RAP has been completed. CAGL will implement any conditions set out in the RAP once it has been approved by the EPA. The RAP will establish a baseline data of all structures and Project Affected Persons (PAP's). It will identify the key socio-economic and cultural issues that must be addressed, the likely significant projects impacts and potential benefits.

7.18.1 Community Consultative Committee

CAGL understands and is committed to proactive community relations as a key principle in its day-to–day operations as well as for future development planning, as demonstrated in its Community Relations Policy (see introduction note). Many of these community relations will be managed through the proposed Social Development Consultative Committee. Some of the issues the Committee will discuss when they meet include but are not limited to:

- Current activities and mining progress
- Planned changes in mining operations
- Proposed exploration activities
- Development of partnerships with stakeholders for community development
- Proposals for company sponsored sustainable livelihood programmes; and
- Plans for company/community development projects and other assistance.

The Committee will continue to be the forum for discussion and decisions to be made by community leaders and the company on a range of community issues from addressing complaints to community assistance projects.

7.18.2 CAGL Relocation Committee

In parallel with the RAP, a CAGL Project Resettlement Committee (PPRC) will be formed to deal with issues arising out of the resettlement process and to ensure implementation of the EPA approved RAP. Amongst other things the PPRC would:

- Adopt and ensure adherence to the EPA approved RAP
- Develop and approve new site/s
- Develop and approve compensation rates and resettlement package
- Develop and approve structural design plans where applicable
- Resolve other outstanding issues.

The PPRC will comprise representation from the following:

- CAGL
- Hamlets community
- District Assembly
- District Town and Country Planning Office
- Traditional Authority
- EPA
- Mines Department
- Land Valuation Board.

To ensure that local people suffer a minimum of disturbance and continue to contribute to a sustainable local economy, the resettlement proposal will give due consideration to farm related issues. Indeed, CAGL does not intend to restrict the use of farms except in the areas directly used by the project.

7.18.3 CAGL - Community Relations and Assistance Programs

CAGL's Community Relations Policy makes a commitment to work with the community for its betterment. In recognition of the potentially significant impacts its operations can have on the local communities it is committed to ensuring that the legacy it leaves will contribute to an improvement in the socio-cultural and economic well being of the people. In recognition of the potential adverse impacts the Project might have on the local community CAGL is committed to the following measures to minimise or remove the negative effects on the local communities:

- Provide adequate and fair compensation for all farms and structures that might be lost or impacted upon as a result of the development;
- Continue to monitor local communities around the project area to ensure that they do not become adversely affected by the development;
- Employ local people and train those who need to develop the requisite skills wherever practicably possible;
- Develop specific and appropriate Sustainable Alternative Livelihood Projects (SALP) projects, where possible, to assist the local communities to develop their own income generating activities where they cannot be directly employed.
- Continue with regular consultation meetings to include Government and Traditional authorities to ensure that community development is carried out in conjunction with these bodies.

Table 7.5: Environmental Action Plan for CAGL Project

ACTIVITY/EFFECT	CONTROL/PROCESS
Pre-Project Phase	
Farm Compensation	CAGL to complete farm compensation policy and procedures (completed). CAGL to liaise with Project Consultative Committee. CAGL to identify farmers who need to be compensated (in progress). CAGL to pay compensation according to policy and involve District, Local Chiefs, Farmer's representative, Owners (in progress). CAGL to ensure appropriate records are maintained
Resettlement Process	CAGL to complete resettlement policy and procedures CAGL to prepare RAP. CAGL to liaise with Project Consultative Committee Local Consultative Committee, EPA, DCE, to review guidelines CAGL to discuss and negotiate resettlement with affected owners under consultation with DCE and Local Chiefs
Project Consultation Process	CAG with assistance from AC&E to prepare Public Forums with DCE, Local Chiefs, Farmer's representative, other stakeholders.
Other benefits to neighbouring settlements	CAGL to progress its policy for community assistance programmes in education, health, water supply and sanitation, infrastructure and agricultural assistance. Implement community relations and assistance programmes
Preparation of Draft EIS for EPA	CAGL to prepare Draft EIS for submission to EPA (this report)
Site Preparation Activities	
Demarcation of area to be cleared for project development	Sustainability Manager to co-ordinate with mining team according to mining schedule phases. Demarcation of areas to be cleared for project development according to EMS procedures and EMP and as per the mining schedule.
Clearing of vegetation	Clearing of vegetation will be a progressive process under internal close supervision in accordance with procedures and according to the mining schedule. Opportunities for recovery of commercial sized trees and for segregation of wood for community firewood will be evaluated at the time of the demarcation and clearing process. Clearing will be required for the haul roads and mining area.
Dust generated from site clearing activities	Implement dust suppression measures through the application of water in accordance with established procedures. This measure should be sufficient to prevent the generation of quantities of dust considered to be a nuisance.
Segregation of topsoil	Topsoil resources in the Project area will be stripped and recovered, as areas are required for the project. Materials to be stockpiled in a secure manner in accordance with established procedures. Topsoil will be recovered and reused or stockpiled according to established procedures. Topsoil from construction of the mining area will be used for rehabilitation according to requirements at the time of construction. Topsoil will be used for early revegetation requirements such as the stabilisation of embankments or structural earth works, and will be stored until areas become available for rehabilitation.
Soil erosion controls	CAGL will ensure that appropriate drainage control measures to minimise soil erosion are put in place during preparation of all areas of the site. Drainage control measures may include construction of settlement ponds, culverts, road cambers, drains, ditches, use of Vetiver, *etc.*
Public Safety - Security around the pit	Employment of local security personnel to prevent access to the mining area. Preventive signboards are placed to prevent access to the mining areas. Earth protective bunds to be constructed around the pit – at decommissioning.
Construction Phase	
Instructions to contractors	All CAGL contracts require that contractors understand and follow the CAGL environmental and safety policies and procedures.

	CAGL to ensure that environmental clauses become part of contract agreements. Such clauses will refer to, blasting techniques, blasting time information, road watering, solid and liquid waste management, haul road crossing management, clearing activities, topsoil management, water management, workers and public safety (as part of EMS implementation and procedures).
Construction of the Haul road	Process under CAGL supervision according to requirements of Site Preparation Activities. Important aspects to check are engineering design for river crossings and road drainage.
Dust generation during construction	CAGL to implement dust suppression measures through the application of water in accordance with established procedures. This measure should be sufficient to prevent the generation of quantities of dust considered to be a nuisance. CAGL to implement specific measures to prevent over-speeding of haul and service vehicles when driving through or near towns and villages on their way to the site as well as on the site itself. Speed limit sign boards are posted at appropriate locations and both CAGL drivers and contractors are obliged to comply with the speed limits along access roads and the CAGL mining lease in general.
Operation Phase	
Dust from excavation activities of the pit (and some limited blasting)	CAGL to implement the blasting control procedures currently being used and approved by the Mines Inspectorate for the limited blasting expected to be required. CAGL's to use modern blasting technologies, which enable good control of detonation sequencing and the quantities of blasting agent to be used, hence reducing the potential of fly rock and dust generation. The Company procedure controls blasting times and ensures that no blasting will be undertaken during extreme weather conditions (high winds). CAGL to monitor dust levels on surrounding environment through dust deposition monitoring (see Chapter 6).
Dust from haulage transportation of ore and waste	CAGL to use appropriate dust control/suppression measures including the use of water tankers to water the haul roads and on-site access roads to significantly reduce dust generation and associated nuisances. The number of times water will be applied daily will be in accordance with CAGL procedures and will vary according to weather conditions and the intensity of vehicle movements on particular roads. CAGL to monitor dust levels on surrounding environment through dust deposition monitoring (see Chapter 6).
Gaseous emissions and PM10 from diesel engines	CAGL to check equipment is well maintained.
Noise and vibrations from blasting	CAGL to use controlled blasting technology, which includes initiation of the blast holes through electronic detonators and establishment of a maximum instantaneous charge. CAGL to establish a safe blasting perimeter during blasting procedures. Blasting procedures and effects to be discussed publicly at meetings such as the Project Consultative Committee CAGL to monitor noise/vibrations at boundary of "safe blasting perimeter".
Noise from machinery	Ensure all heavy equipment and machines are equipped with standard mufflers. CAGL to monitor noise levels (see Chapter 6).
Public Safety - Security around the pit	CAGL to provide security personnel and to use preventive signboards to prevent access to the mine areas by non-authorised persons. CAGL to monitor effectiveness of this safety measure.
Management of run-off: All surface run-off water from exterior areas will be diverted away from the pit as required. Rainwater and groundwater (if any) will also be pumped out of the pit.	Mine water not required for dust suppression will be released in a controlled manner. Necessary earthworks will be undertaken to ensure effective drainage control and diversion around the perimeter of the pit and haul roads. Early revegetation of disturbed areas will be undertaken as much as practicable using topsoil segregated during the preparation phase. Water quality will be tested regularly and all mine water from the pit will be directed to one or more sediment management facilities where sediment loading

	will be reduced. CAGL to monitor water quality parameters (pH, TSS, conductivity) down stream of Project facilities (see Chapter 6).
Soil erosion from site.	CAGL to monitor erosion through visual inspections. CAGL to verify compliance to site preparation processes. CAGL to take appropriate corrective measures such as stabilisation with Vetiver grass, early revegetation and construction of settlement pond.
Land use and Social issues	CAGL to monitor success of compensation policy and resettlement process. CAGL to continue alternative livelihood projects. CAGL to continue dialogue and engagement of communities through formal and informal meetings.
Waste Management	CAGL to ensure implementation of waste management policy. CAGL to monitor implementation of waste management policy.
Rehabilitation / Closure Phase	
Rehabilitation Programme	CAGL to implement Closure Plan with the following general principles: Any hazardous material, equipment of contaminated soils will be safely disposed. Ensure that the Project Area is in a stable and safe condition. Rehabilitation of disturbed areas to an acceptable end land use for the benefit of neighbouring communities whenever practicable. Consideration of the post-closure socio-economic conditions in the neighbouring communities.
Consultation with Stakeholders	CAGL to liaise with Project Consultative Committee and relevant stakeholders (in particular the local communities) and obtain their input for the post mining land-use plan.
Rehabilitation of exposed slopes in pit	Rehabilitation activities to be undertaken where feasible and safe under CAGL management/control at closure.
Rehabilitation of waste storage area	Rehabilitation activities to start as soon as practicable, under CAGL management and control. Final landforms to conform where possible to surrounding hills and valleys. Topsoil to be re-handled from stockpiles and used to provide a growth medium on the oxide stockpiles in accordance with CAGL topsoil management and rehabilitation procedures. Proportion of mine waste will be used to backfill Pampe pit and contoured to create a useable landform.
Passive care	Monitoring of rehabilitation criteria (plant growth, soil erosion, stream water quality).
Site stability (sustainability)	Monitoring of rehabilitation criteria to declare after care status of rehabilitated site.

8.0 CLOSURE AND DECOMMISSIONING ASPECTS

8.1 INTRODUCTION

This chapter represents the first phase in the development of a Conceptual Closure Plan (CCP), which is to be produced as part of the EIS for the Central Ashanti Gold Project (the Project). It describes the basic principles that will be followed and is presented only as a form of intent and commitments by CAGL. It does not represent a formal Closure and Decommissioning Plan. Its objective is to demonstrate that CAGL is fully aware of its responsibilities and the degree of planning and inputs required to protect the local and regional environment of the Project area as represented by Phases 1 and 2.

CAGL is not required to submit a formal closure and decommissioning plan until two years before the closure of the Project. In practice, the earlier development of a CCP assists both the Company and the EPA in understanding what will be required, technically and financially, and that the environmental management practices during life-of-mine are consistent with the plans for mine closure and decommissioning.

8.2 CURRENT RECLAMATION/BONDING COMMITMENTS

In 2007 the EPA accepted the Ashanti Goldfields Company (AGC) 2004 cost estimate for the closure of the Ayanfuri mine. A reclamation security agreement was signed between the EPA and AngloGold Ashanti (AGA) on August 6 2007. Subsequently, Perseus Mining Limited, following its acquired interest in the Ayanfuri property through Stratsys Investment Limited, made a cash deposit of US$257,939 to a joint EPA/AGA account and presented the first Bank Guarantee for US$1,000,000 on August 15 2007. A second Bank Guarantee for US$500,000 was arranged in March 2008 and subsequently a third one for the same amount in July 2008. A new Reclamation Bonding Agreement will need to be negotiated due to the significant change in circumstances arising from the proposed project and new reclamation and closure plans will be necessary.

8.3 BASIC PRINCIPLES OF CLOSURE AND DECOMMISSIONING

CAGL will prepare a decommissioning plan as part of its full Environmental Management Plan that will be prepared in accordance with the requirements of its Mining Lease and the requirements of Ghana's Mining and Environmental Guidelines (1994). If the Project is extended beyond Phases 1 and 2, this CCP will be reviewed, modified and incorporated into the EIS required for the extension.

The decommissioning plan should have objectives compatible with those for the rehabilitation plan.

The following objectives are proposed:

- All structures will be disposed of according to the terms of the mining agreement;
- Safe disposal of hazardous material, equipment and contaminated soils and steel structures;
- Decontamination of process plant site;
- Ensure that the project area is in a safe condition;
- Rehabilitation of disturbed areas to an acceptable land use end whenever possible; and
- Consideration of the post-closure socio-economic conditions in the neighbouring communities.

8.4 PROPOSED SITE END-USE

At the end of the current planned mine life, the area covered by the various facilities will consist of open pits, waste dumps, process plant, tailings disposal and supporting facilities will be 998 ha (Table 8.1).

According to the closure and decommissioning objectives set out in section 8.3 the appropriate sites in the Project area will be rehabilitated to achieve a post-mining land use compatible with the prevailing rural conditions of the area.

8.5 GHANA MINING LEASE REQUIREMENTS

The Mining Leases granted by the Minerals Commission to new gold mines in Ghana (at least since the early 1990's) have contained a section relating to the disposal of company assets upon termination or expiration of the Mining Lease. Table 8.2 provides a typical example of the contents of such a section.

8.6 GHANA ENVIRONMENTAL GUIDELINES

The requirements of Ghana's Mining and Environmental Guidelines, 1994 in relation to mine closure and decommissioning are presented in table 8.3.

8.7 CAGL MINE CLOSURE STANDARDS

CAGL will specify Mine Closure Standards as part of its Environmental Management System. These standards define the requirements for mine closure planning at different stages of mine life in order to provide a firm basis for cost estimations and financial provisions for all activities associated with mine closure (Table 8.4).

The intent of this first phase of the CCP is that it should:

- Provide input into the Technical Feasibility Study and the Project Environmental Impact Statement;
- Fulfil the closure planning requirements of the Perseus Corporate Environmental Policy;
- Meet the standards required by accepted international mining practice; and
- Ensure compliance with appropriate leases, licences, regulations and guidelines in Ghana.

The CAGL standards for mine closure require consideration of the following issues:

- All legal requirements and other approval document commitments, tenement conditions and relevant third party agreements (likely future trends in legalisation should also be considered);
- All relevant government or industry guidelines that outline accepted industry practice;
- Completion criteria and set targets that, when achieved, will lead to relinquishment of ongoing responsibilities; and
- All engineering and technical aspects of closure, including earthworks and rehabilitation requirements, contaminated land, where relevant, and any likely future maintenance costs. Where relevant, options for the alternative methods of dealing with major issues should be included.

Other mine closure activities including, but not limited to:

- Employee retention and redundancy;
- Site security;

Table 8.1: Land Required for Mining, Processing and Support Facilities

Facility	CAGP Area (ha)	Previously Undisturbed Land (Greenfield)
PITS		
Abnabna	49.7	-
AF Gap		
North Esuajah	22.3	-
Fetish North Ramp	32.4	-
Fetish South		
Fobinso North	27.6	-
Fobinso South		
Total Pits	**132**	
Haul roads	12	12
WASTE DUMPS		
Abnabna/AF	57.5	
Fetish	102	
Fobinso North	50	
Esuajah North	97.3	
Total Waste Dumps	**306.8**	
CAGP FACILITIES (New)		
Flotation TSF	339.4	339.4
CIL TSF	13.7	13.7
Process Water Pond	2.5	2.5
Plant Site Area/MC Area	22.3	22.3
Substation	1.7	1.7
Eastern Mine Ore Piles	12	12
Miscellaneous	10	10
ROM Pad/ Magazine	118.7	118.7
Nkonya Access Road	2.6	2.6
Abnabna Road Diversion	14.3	14.3
Asuafa Diversion channel	14.7	14.7
Sediment Control (Inc drains)	4	4
Power line to plant site	8.8	8.8
Total New Facilities	**564.7**	**564.7**
Total	**1015.5**	**576.7**

Table 8.2: Closure Terms & Conditions for Assets on Termination/Expiration of Mining Lease

Section 29 – ASSETS UPON TERMINATION OR EXPIRATION

(a) Upon the termination or expiration of this Agreement, immovable assets of the Company in the Mining Area and all other appurtenances, pits, trenches and boreholes shall become the property of the Government without charge on the effective date of the termination or expiration.

(b) All materials, supplies, vehicles and other movable assets of the Company in the Mining Area which are fully depreciated for tax purposes shall become the property of the Government without charge on the effective date of termination or expiration. Any such property that is not then fully depreciated for tax purposes shall be offered for sale to the Government within sixty days from the effective date of such termination or expiration at the depreciated cost.

If the government shall not accept such offer within sixty days, the Company may sell, remove or otherwise dispose of all such property during a period of one hundred and eighty days after the expiration of such offer. All such property not sold, removed or otherwise disposed of shall become the property of the Government without charge.

(c) Notwithstanding the foregoing, the Secretary, may by notice to the Company require the removal or destruction of any assets of the Company in the Mining Area and if the Company does not remove or destroy such assets within a period of thirty days from the date of the Secretary's notice to that effect, the Secretary shall cause such removal or destruction at the expenses of the Company.

(d) The Company shall take all reasonable measures to ensure that all of the assets to be offered for sale to the Government or transferred to the Government in accordance with this Paragraph shall be maintained in substantially the same condition in which they were at the date of the termination or the date on which the Company reasonably knew that such termination would occur and any such assets shall not be disposed of, dismantled or destroyed except as specifically provided for in this Paragraph.

(e) Upon the termination or expiration of this Agreement, the Company shall leave the Mining Area and everything thereon in a good condition, having regard to the ecology, conservation, reclamation, environmental protection, drainage and safety provided however that the Company shall have no obligation in respect of areas where the Company has not undertaken any work or which have not been affected by the Company's operations. In the connection unless the Chief Inspector of Mines otherwise directs, the Company shall in accordance with good mining practice, fill up or fence and make safe all holes and excavations to the reasonable satisfaction of the Chief Inspector of Mines. In addition the Company shall take all reasonable measures to leave the surface of the Mining Area in usable condition and to restore all structures thereon not the property of the Company to their original condition. In the event that the Company fails to do so, the Secretary shall restore and make the Mining Area and everything there safe at the expense of the Company.

Source: Company (Confidential) Mining Lease

Table 8.3: Decommissioning Section of Mining and Mineral Processing Requirements for Environmental Impact Assessment (EIA)

Decommissioning

- The company shall prepare a conceptual Decommissioning Plan as part of the EIA or EAP.
- The Decommissioning Plan Shall:
  - Nominate the end use(s) of all lands affected by the mining project.
  - Nominate the end use(s) of all buildings, housing and other mine infrastructure.
  - Describe the fate of all fixed equipment.
  - Describe the steps required to make the area safe.
  - Describe how public access will be managed after mine closure.
  - Describe the type and duration of post decommissioning monitoring.

The company shall submit to EPC and the Mines Department, through the Minerals Commission, a detailed Decommissioning Plan, at least two years before the planned abandonment of the mining project. In the case of mine located in a forest/wildlife reserve(s) a copy of the plan should be submitted to the Forestry Commission.

The company shall honour all commitments made in the detailed Decommissioning Plan except where written permission is given by EPC in the light of new field evidence.

Source: Mining & Environmental Guidelines. Minerals Commission & Environmental Protection Council May, 1994.

Table 8.4: Planning of Closure and Decommissioning

Document	Stage of Mine Life	Accuracy Cost Estimates
Conceptual Closure Plan	Project feasibility, design and approval documentation	±30%
Working Closure Plan	Construction and operation until two years before closure	±20%
Final Closure Plan	Operation with two years mine life remaining	±10%
Post-closure Report	Lease relinquishment	Actual

- Employee and public safety;
- Contract termination costs;
- Reduction in value of store stock;
- Costs associated with agreements with stakeholders;
- Community consultation;
- Post-closure monitoring;
- On-going closure monitoring;
- On-going licensing requirements; and
- Management of employee and financial records and technical reports.

The degree to which each of these issues is examined is dependent on which Plan is being prepared. As this is the first phase of the CCP, many of the above points are yet to be finalised before the full CCP can be prepared.

The overall closure planning sequence that will be implemented by CAGL is presented in Figure 8.1.

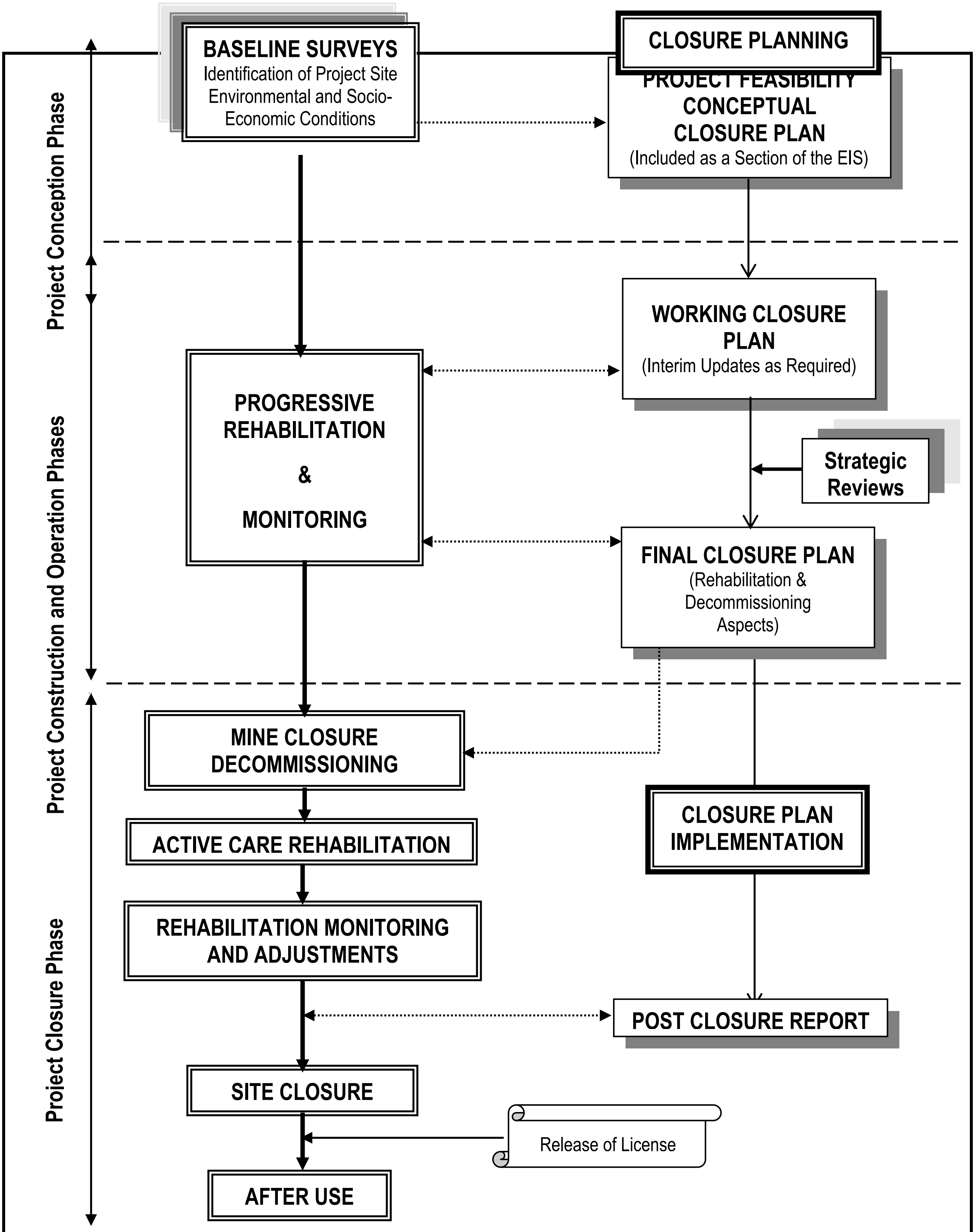


Figure 8.1: The Closure Planning Sequence

In addition to the physical facilities listed above, consideration will have to be given to:

- Surface and ground water management;
- Revegetation and land-use;
- Definitive post-closure monitoring programme;
- Socio-economic impact assessment of mine closure (employees);
- Socio-economic impact assessment of local communities;
- Notification to, and discussion with interested parties;
- Health and safety system;
- Emergency response system;
- Financial assurance mechanisms;
- Environmental monitoring and maintenance; and
- Post closure reporting.

Each of the above items will require individual consideration to develop the most acceptable closure/decommissioning option involving environmental, technical, socio-economic and cost factors. The considerations may be summarised as follows:

- Key issues – what are the significant issues that need to be addressed at closure?
- Performance criteria – what criteria should be used to show that decommissioning and closure will be accomplished effectively?
- Investigations and test work – is additional information and data required, and what programmes are required to further investigate these criteria?
- Closure options - what alternative are viable or achievable?
- Closure actions – what closure actions are recommended?
- Demonstration of performance – how can CAGL show that the closure actions will have met the proposed performance criteria?

From the above considerations a final closure plan would be prepared and submitted to the EPA for consideration and approval.

8.8 CLOSURE OBJECTIVES AND CRITERIA

The broad objectives for mine closure for the CAGL Project are that impacts of the operations should be managed and rehabilitated to a standard that minimises or negates restrictions on sequential land use and complies with the laws of the Republic of Ghana. In addition there should be no ongoing liability beyond relinquishment of tenements. These objectives are consistent with Perseus's Environmental Policy that states that it will "design, operate and decommission all facilities and associated infrastructure to avoid or mitigate adverse environmental impact, minimise associated long term financial liability and enhance social benefit".

With a currently planned operating life of 10 years and constantly increasing community expectations (both locally and internationally) it is considered to be essential that the closure objectives and standards aim to meet targets that are higher than the current minimum in order to reduce the risk of future non-compliance.

The selected closure objectives are tabulated below:

CLOSURE OBJECTIVES	
Legal Compliance	Meets current Ghanaian legislation and anticipates changes to Ghanaian legislative and community expectations over the next 10 years
Corporate Policy	Complies with policy
Risk of future non compliance	Low
Final land use	Sustainable agricultural industry

Ten criteria have been selected as the basis for meeting the closure objectives.

CLOSURE CRITERIA		
Community Involvement		Stakeholders will be team members and involved at all stages of the planning process by means of periodic formal meetings.
Socio Economic Impacts		The quality of life of all stakeholders, as measured by quality of living conditions, health services, general infrastructure and per capita income will be measurably higher than exist before commencement of operations, with the improvements to be self funding and sustainable at the completion of operations.
Water Resources		Impacts on surface and groundwater bodies have been identified and remediated during operating life to EPA satisfaction.
Soil Erosion		The suspended solids loading of run-off from site will be no higher than as is measured at control sites established up-slope of operations.
Revegetation		Establishment of sustainable agricultural systems.
Visual Amenity		Consideration will be given during the design stage.
Physical safety		Drill holes plugged, costeans backfilled, open voids bunded or fenced as required.
Stability	**Tailings Storage Facility**	Demonstrate that the containment structures have been designed to maintain integrity for a 100 year time frame.
	Waste Rock Dumps	Demonstrate that the final landform has been designed to maintain integrity for a 100 year time frame.
Residual Contamination		Allows establishment of agricultural systems and does not restrict public access to site.
Non-mining Waste Clean Up		All material to be made safe in situ or buried.

8.9 PRELIMINARY CLOSURE CONCEPTS

8.9.1 Mining of the Open Pits

The Project will result five pits of varying configuration. Four of the pits already exist from earlier mining (Abnabna, Fobinso, Fetish and Esuajah North. The fifth pit (AF Gap) is the result of a new discovery located between the Abnabna and Fetish pits. The pits are as follows:

1. The Abnabna and AF Gap pits will initially be mined separately but will eventually merge to form a single pit (Figures 2.1, 2.2 and 2.3).

2. The existing Fobinso South and North pits will, in approximate terms, be mined as Fobinso stage 1 and stage 2 respectively (Figure 2.4).

3. The Fetish pit (Figures 2.5 and 2.6) and Esuajah North (Figure 2.7) will be each be mined as single stage and distinct entities.

8.9.2 Waste Rock Disposal and Backfilling

Waste rock disposal and backfilling of existing and newly mined pits will be as follows:

1. The final Abnabna – AF Gap pit complex will not be backfilled. The waste from this pit will be placed between the pit and Abnabna village to reduce the impact of noise and lighting from pit and plant site operations. It will not exceed a height of 25 m.
2. The AF Gap Bund is a secondary waste rock disposal area that provides protection from the Abnabna stream in the event of a flood (Map 2.2). This dump is approximately 5m high.
3. The Fobinso "Ultimate" dump has the largest capacity of all and will be formed by staged backfilling of Phases 1 and 2 (Map 2.2). Consequently, no open pit will exist at Fobinso at closure.
4. The Fetish Main Dump backfills the existing Chirawewa Main pit (Map 2.2) then a small valley before abutting up to an existing rehabilitated waste dump.
5. The Fetish Backfill Dumps are designed to rehabilitate the area affected by the previous mining. The two South Bokitsi pits adjacent to the highway will be filled to 5m above natural surface to control drainage in the area. The second dump will fill in a small pit to the south
6. The Esuajah North Dump is built as into sections so as not to intrude into the existing valley between the pit and the northern edge of Ayanfuri village.

8.9.3 Reclamation of Open Pits

8.9.3.1 Pits not Backfilled

The Abnabna/AF Gap complex, Fetish and Esuajah North pits will remain as open pits and considering their final geometry and the pre-mining ground water conditions and the surface water drainage network, it is anticipated a pit lake will develop in each in the post-closure mine condition. The perimeter drains established upstream of each pit to prevent inflow of rainwater into the pits during operation will be modified to enable upstream runoff to flow into the pit. Using this method the pits a can be filled during one wet season. The possibility of converting them into sources of domestic and/or irrigation water for agriculture and/or fisheries development will be investigated.

Rehabilitation work will include include:

- Reshaping of pit perimeters to accord with the document "Revised Akoben Methodology – page 14." (See also Chapter 9, section 9.11.2) in this document.
- To ensure public safety is achieved the pits will be double bunded after the reshaping has been completed. Live vegetation fences in front of the bunds will planted as an additional safety barrier on reshaped perimeters.
- Installation of an emergency spillway.

Pit Reshaping

The perimeters of pits that will not be backfilled will be reshaped prior to closure according to the guidelines of the Revised Akoben Methodology – page 14". A schematic x-section of the final Abnabna/AF Gap pit depicting how its perimeter would be shaped is presented at the end of this chapter. The schematic shows the final production wall graded back from the base of complete oxidation within pit to the surrounding natural contour. The regarded perimeter would have benches 10m wide and 8m in height.

The reshaped perimeter berms and walls will be revegetated with a mixture of native and introduced species according to EPA requirements on such mixtures. The pit ramp will be double bunded and made safe from vehicle access, further the ramp will be scarified dressed with topsoil and seeded with stabilization vegetation.

8.9.3.2 Backfilled Pits

The backfilled Fobinso (27.6 ha) and Fetish (102 ha) pits will be rehabilitated in the same manner as for the newly created waste dumps.

8.9.4 Rehabilitation of Waste Dumps

The majority of the waste rock will have been end dumped at the angle of repose. The top surfaces will be flat to gently sloping. Due to the mining schedule the majority of the waste at the end of mine life will be fresh rock and this fresh rock will comprise the final surface before reclamation.

The waste dumps will vary from 25m high (Abnabna) to 70m high (Fetish). The slopes and will require final reshaping towards the end of waste dump life. Major reshaping will be concurrent with mining operations. The waste dump batters will be cut to slopes of 1V:3H and shaped to minimise concentration of surface runoff. Benches will be built at 5 – 6m, a lift height of ≤ 20m and slopes of the base lift battered between 20^o and 30^o. Provision will be made at closure for safe access to the dumps by future stakeholders having farm and/or agro-forestry rights on the rehabilitated dumps.

Surface runoff from the waste dump tops and the batters will be collected and directed of the waste dumps via rock fill drains. These drains will flow to diversion channels located at the base of the waste dumps and will report to sediment ponds prior to discharge to local watercourses. Water retaining berms will have been constructed on the crests of the waste dumps and on each bench.

It is planned to spread a layer of between 15cm and 50 cm thickness, comprised of subsoil and/or oxide waste and/or topsoil over the fresh rock forming the top and slope surface of the dumps. The exact composition of the layer will vary 1) depending upon the agreed after-mining land use and 2) the volume of topsoil salvaged during land clearance in the construction phase. Rehabilitation for forestry (plantation or return to natural conditions) will require less topsoil than areas whose final land use is intended for agriculture.

The type of vegetative cover will be decided by the selected land use as agreed in consultation with the Project Consultative Committee representing local stakeholders.

Because of the anticipated non-reactive nature of the waste and the absence of contaminant concentrations of trace metals, no special soil amendments will be required. Vegetation trials similar to those proposed for the tailings dam will be initiated when areas of waste dumps are no longer required.

8.9.5 Rehabilitation of Flotation Tailings Storage Facility

The Flotation Tailings Storage Facility (FTSF) will have a surface of approximately 339 ha. Decommissioning of this facility will start immediately after the last ore has been processed. At this stage, the final top surface of the FTSF will have a concave slope and form a basin in the centre and upper reaches of the valley with a spillway to discharge runoff to the adjacent drainage lines to the west of the process plant. The basin area can be returned to a wetland. The under drainage system can be fitted with airlocks to prevent entry of air into the base of the tailings stack at closure. Once the tailings

have drained and the flow from the under drainage pipes is significantly reduced the outfall pipes will be capped, sealed and buried. In the event of premature closure of the project the same closure approach can be adopted.
The decommissioning plan for the FSTF will form part of the Closure and Decommissioning Plan that will have to be submitted for approval by the EPA and the Mines Inspectorate.

Following the above closure procedures the surface of the tailings will be stabilised against erosion through the establishment of vegetation. This may, or may not, involve the spreading of topsoil or borrow material. It will be decided by the selected land use for the FTSF which, in turn, will be decided by 1) the physical and chemical properties of the tailings and 2) the agricultural and agro-forestry requirements requested by the Project Consultative Committee representing local stakeholders. The separation of process tailings into two separate disposal streams provides a means of ensuring that the flotation tailings will be benign and non-acid forming.

When the final embankment footprint is reached the downstream slope will be re-graded as required to control erosion. Slopes will be flattened in accordance with the waste dump rehabilitation strategy and benches will be formed at regular intervals so that the final landform is similar to the waste dumps.

8.9.6 Rehabilitation of CIL Tailings Storage Facility

The CIL Tailings Storage Facility (CTSF) is also valley type storage with containment embankments common to the FTSF and Process Water Pond adjacent to the process plant (Map 2.2).

The CTSF is a double HDPE lined facility with under drainage above the top liner and a leak detection system between the upper and lower liner. During operation the CTSF will be covered with water. Bird balls and netting will be deployed to prevent access to the surface. Tailings from the Carbon in Leach (CIL) plant will be discharged to the CTSF at approximately 40% solids with the expected weak acid dissociable cyanide (WADCN) content of 400 ppm and free cyanide (Free CN) of around 50.

At closure, the surface of the CTSF will be covered first with a geotextile, then with a layer of clean free draining sand, 1m thick (minimum), hydraulically placed over the geotextile. Water will then be withdrawn from the upper half of the sand layer to allow a HDPE liner to be placed over the sand. Additional sand will then be placed over the HDPE liner and soil placed over the sand.

8.9.7 Reclamation of Heap Leach Pads

Introduction

The heap leach pads (HLPs) that were created by Cluff/AGC as the ore treatment component of their mining operations are considered a possible future gold containing resource. CAGL still has to undertake a comprehensive evaluation of the economic potential of this resource. Because of this, the reprocessing of the HLPs does not form part of the current CAGL operating mine plan.

Description of HLPs

Location

There are five 5 pads corresponding to five 5 phases of the ore treatment period, that were designated as HLPs phases 1- 5 (hereinafter referred to as the pad). The western side of the pad is approximately 950m from the Ayanfuri road intersection. The northern section is conspicuous along the Nkotumso-Gyaaman road. The southern and eastern faces of the pad can also be accessed through the Fobinso-Abnabna haul road. It is approximately 3km along the road to Fobinso pit.

Shape and Size of the Pad
The planar area of the pad surveyed is approximately 133 ha. All the heaps assume a plateau-like shape and are benched in lifts of 15 – 20m. The surfaces of these pads are rough with heaps of oxide material. The perimeter along the motorable access is approximately 4km. The volume of material on the heap had all come from the oxide pits and it is estimated at over 30 million tonnes.

Present Status of the Pad
The heaps are spent. There has been natural colonization of ferns and brachiaria grass on and around the slopes. The phase 5 area was battered by AGC to an overall average slope of 18°. Various species of plants (Cassia spp.) were introduced in addition to brachiaria grass and vetiver barriers, which control primary erosion. Storm drains and silt traps were constructed to manage storm water and all attendant topographical features. However, the phases 1 – 4 with general slope angle of 70° have highly eroded faces with badland topography as a result of erosion and denudation with some natural vegetation around the small gullies.

Slope stability of the Pad
The 70° pad faces are generally unstable but to date (September 2010) only relatively small areas have slumped and there has not been a major failure that would impact on the surrounding environs. Nevertheless, the slopes are a source of erodible material.

AGC Proposed End Use
AGC proposed that the pad should be planted to agroforestry to attain a density of 1000 trees per hectare with more than 40% of indigenous species. The ultimate end was to create resource providing fuel wood and timber for local communities.

CAGL HLPs Reclamation
The CAGP is currently bonded by Perseus Mining Limited through cash and Bank Guarantee arrangements for USD 2,257,939 (section 9.9 above) to remediate previous owner environmental liabilities. The EPA will require CAGL to provide a new reclamation bond to cover the anticipated reclamation costs of the new Project (see section 9.11.5 below).

A formalised reclamation plan shall be developed within the first two years of operation (Ghana Mining and Environmental Guidelines 1994). This reclamation plan shall incorporate the reclamation requirements of the current bond into a single reclamation plan for the life-of-mine. Consequently, and because the resource potential of the HLPs still has to be determined, the reclamation plan presented in this EIS does not include a provision for the complete reclamation of the HLPs. Nevertheless, CAGL will undertake an evaluation of the current environmental status of the HLPs and take any remedial measures necessary to ensure that the HLPs are not impacting on local streams and communities.

8.9.8 Plant and Associated Buildings

The process plant, mine services area and administration buildings will cover a surface of approximately 18 ha. Process plant will remain operational after cessation of mining, that is, until final ore processing has completed. Concurrent with this activity, vendor-supplied facilities, such as fuel storage tanks, will be dismantled and removed from the site.

Typical terms of mining lease agreements in Ghana provide for the transfer of ownership of all immovable assets within the lease area to the government. Other movable assets that are not depreciated may be sold or removed, subject to first right of refusal by the government. Accordingly, all crushing, conveying and processing equipment and the plant buildings are to be ceded to the government. Therefore, it is envisaged that all buildings will stay on site in suitable conditions while processing equipment and structure will be dismantled and either sold on for use at another similar operation or treated as scrap materials.

Rehabilitation of process, workshops and chemical storage facilities will ensure that no area is contaminated with oils or other hazardous substances. Areas that have not been stripped but were compacted during operations will be scarified prior to re-vegetation. Stockpiled topsoil will be spread where it is required. All disturbed areas will then be re-vegetated by sowing or planting appropriate species to achieve the planned end use of the site.

8.9.9 Accommodation

The CAGL Senior Staff accommodation village will be left in a safe condition and ceded to the Government.

8.9.10 Roads

Roads within and around the plant area and most haul and access roads within the Project area that are not required for post closure activities will be rehabilitated. They will be scarified prior to re-vegetation and stockpiled topsoil will be spread only where required. The Company will discuss with Government and traditional authorities what other roads should be left in place for future public use.

8.9.11 Other Considerations

The final decommissioning plan will have to consider the various socio-economic impacts that can result from mine closure. At this stage of the project, any discussion on these aspects will be too theoretical and probably highly inaccurate. However, constant discussion and collaboration with the official and traditional authorities through the Project Consultative Committee will be undertaken by CAGL in order to find and propose solutions to address those impacts.

8.10 POST-CLOSURE MONITORING AND MAINTENANCE

Post-closure reclamation monitoring and maintenance will begin after completion of the reclamation work and will extend through the period of physical stabilisation. It is estimated that such monitoring will be for a minimum of three years or such time as necessary.

Surface and ground water sampling will continue on a quarterly basis through the post-reclamation period or more frequently if water test results prove it necessary. These results will be compared with baseline data collected during the Project's exploration phase and throughout the operational phase to ascertain current status and identify problem areas.

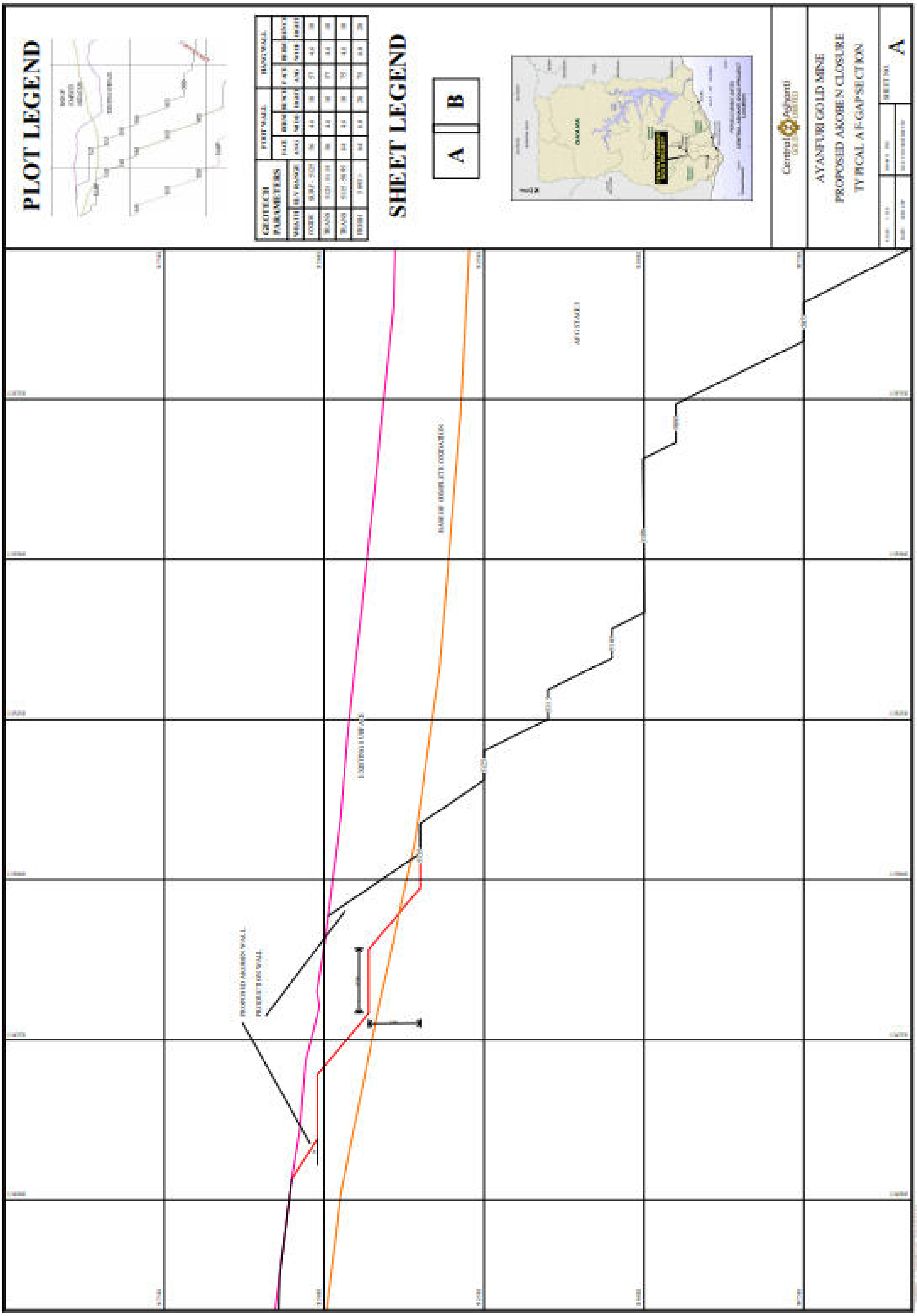
Periodic qualitative and quantitative monitoring of the re-vegetated areas and notation of observations will identify actual and potential problems that can be corrected with the maintenance program.

A qualified person on the staff of CAGL will conduct monitoring.

8.11 CLOSURE COSTS AND FINANCIAL ALLOCATIONS

CAGL will finance part of the rehabilitation and closure aspects of the project from its annual budget and operating costs. A detailed cash flow analysis of annual funds required will be provided when CAGL makes provision for a reclamation bond. Closure and reclamation costs are detailed in Chapter 9.0, section 9.11. Periodical reviews of reclamation costs developed through trials on the project areas during operations will be utilised to adjust the accrual rate as required.

Proposed Akoben Closure AF GAP x-section



9.0 CONCEPTUAL RECLAMATION PLAN

9.1 INTRODUCTION

Legislation in many countries today stipulates land reclamation as an integral part of a mine closure. Wherever feasible, land reclamation should be progressive during the life of the mine and not left until closure alone.

Reclamation requirements in Ghana are primarily governed by three documents:

- The Mining Lease issued to a company by the Minerals Commission (Table 9.1);
- Ghana Mining and Environmental Guidelines, Minerals Commission & Environmental Protection Council, May, 1994 (Table 9.2); and
- Environmental Assessment Regulations, L.I. 1652, 1999 (Table 9.3).

This chapter of the EIS sets out CAGL's reclamation objectives for the Project and provides a provisional Reclamation Plan is in accordance with the requirements stated in the above documents for the areas that will be disturbed by the development and operation of the Project. All aspects of the objectives and reclamation plan will be administered and implemented by CAGL.

In accordance with regulatory requirements, the reclamation plan documents serve, as the basis for on-going reclamation during project life, while the closure/decommissioning plan serves as a longer-term document but in which on-going and final reclamation plans will be linked. Indeed, mining projects can change noticeably between the beginning and the end of their operation. Therefore, the Reclamation Plan will be regularly reviewed according to the prevailing operational and environmental conditions at the time of review.

This chapter should be read in conjunction with Chapter 2, Project Description and Chapter 8, Closure and Decommissioning Aspects so as to avoid repetition.

CAGL will prepare and submit a revised Conceptual Closure Plan (CCP) and a Land Reclamation Plan (LRC) taking into account its current Bonding Agreement for the Project.

The Environmental Assessment Regulations, 1999 (LI 1652) - Section 23 include the requirement that funding for reclamation is made available in the form of a reclamation bond.

Table 9.1: Minerals Commission: Closure terms and conditions for Company assets on termination or expiration (of Lease)
Section 29 – ASSETS UPON TERMINATION OR EXPIRATION **(e)** Upon the termination or expiration of this Agreement, the Company shall *leave the Mining Area and everything thereon in a good condition, having regard to the ecology, conservation, reclamation, environmental protection, drainage and safety* provided however that the Company shall have no obligation in respect of areas where the Company has not undertaken any work or which have not been affected by the Company's operations. In the connection unless the Chief Inspector of Mines otherwise directs, the Company shall in accordance with good mining practice, fill up or fence and make safe all holes and excavations to the reasonable satisfaction of the Chief Inspector of Mines. In addition the Company shall take all reasonable measures to leave the surface of the Mining Area in usable condition and to restore all structures thereon not the property of the Company to their original condition. In the event that the Company fails to do so, the Secretary shall restore and make the Mining Area and everything there safe at the expense of the Company.
Source: Standard clause in Mining Lease

Table 9.2: Reclamation Sections from Mining and Mineral Processing Requirement for Environmental Impact Assessment (EIA)
Reclamation: The company shall prepare an initial Reclamation Plan as part of the EIA and EAP and execute the plan to achieve the following minimum standards: - The reclamation objective for restorable land will be to chemically and physically stabilise the land and leave it in a safe condition and return it to the same land capability as prior to mining. - The reclamation objective for non-restorable land will be to chemically and physically stabilise the land and leave it in a safe condition and encourage revegetation. The Reclamation Plan shall encompass all land on the concession to be disturbed by the company and any of its tributors. The Reclamation Plan shall: - Identify land which is restorable (such as the tops of waste dumps and land used for stockpiles) and land which is non restorable (such as deep open pits and the steep outer faces of waste dumps). - Identify the quantities of reclamation media required. - Identify the sources of reclamation media to meet the required quantities. - Identify applicable reclamation techniques. - Develop a planned approach to progressive reclamation as an integral part of the mine plan. - Commence reclamation as soon as possible after the commencement of operations. - Where practicable, undertake reclamation trials to refine techniques. A final (formalised) reclamation plan shall be developed within the first two Years of operation and submitted to the EPC, Mines Department and the Minerals Commission. In the case of a mine located in a forest/wildlife reserve(s) a copy of the reclamation plan shall be submitted to the Forestry Commission. - A final reclamation plan shall be developed within the last five years of mining operations planned ceases. - The company shall honour all commitments made in the reclamation plan except where written permission is given by EPC in the light of new field evidence. - Government reserves the right to request companies to post reclamation bonds. The company shall honour all commitments made in the detailed Decommissioning Plan except where written permission is given by EPC in the light of new field evidence.
Source: Ghana Mining and Environmental Guidelines. Prepared by Minerals Commission & Environmental Protection Council, May 1994.

Table 9.3: Reclamation Plan Requirement of L.I. 1652
Section 14 (4): An environmental impact statement for mining and other extractive industries shall include reclamation plans.
Source: Environmental Assessment Regulations, L.I. 1652, 1999.

9.2 RECLAMATION OBJECTIVES

Following international environmental guidelines as well as best practice, CAGL will establish a basic Rehabilitation Procedure which sets out general planning and development objectives for progressive reclamation and mine closure.

These objectives are:

- Provide a final land-use that considers the needs of the stakeholders;

- Provide landforms that blend with the natural topography;
- Provide a site both chemically and physically stable;
- Leave disturbed areas in a safe and stable condition;
- Ensure that potential long-term environmental liabilities associated with the closure of the site are minimized;
- Restore as much of the Mining Area to a sustainable land-use capability as is practicable; and
- Provide rehabilitated areas that contribute to the long-term sustainability of the local economy.

9.3 RECLAMATION PLANNING

The type of information that will be considered for the Reclamation Plan to be developed by CAGL is presented in table 9.4. The Plan will also incorporate erosion and sediment control plans. The detailed reclamation plan will address the reclamation of the various facilities listed section 9.5.

9.4 RECLAMATION PRINCIPLES

The basic principles of reclamation (also stated in the Rehabilitation Procedure) that will be followed by CAGL are:

- Progressively rehabilitate the site wherever possible;
- To the greatest extent possible, reshape the land so that it is stable, adequately and sensibly drained, and suitable for the end-land use and for re-vegetation;
- Recover, characterize, store, and reuse as much topsoil as possible;
- If topsoil is not adequate or if unsuitable, test alternative substrates such as overburden or oxide materials, and/or utilize agricultural soil amendment techniques;
- Identify and manage reactive waste rock so as to minimize long-term effects on the environment;
- Re-vegetate with local species as much as possible, or use species that have been proven to adapt to local environmental conditions; and
- Monitor and manage rehabilitated areas until the vegetation is self-sustaining and reclamation objectives have been met.

9.5 RECLAMATION OF FACILITIES

9.5.1 Reclamation Units

It is estimated that 998 ha of land will be utilised by the development and operation of the open pits, waste rock storage areas, tailings storage facilities, process plant, administration and other support facilities among others (Table 9.5 and Map 2.2).

9.5.2 Rehabilitation of the Various Units

Chapter 8 includes a description of closure concepts and a provisional rehabilitation plan for the open pits, waste rock storage areas, tailings storage facilities, process plant, administration and other support facilities among others.

Table 9.4: Provisional Contents of the CAGL Land Reclamation Plan (LRP)

1.0 INTRODUCTION
1.1 The Context of an LRP for the Project
1.2 Determination of Post-mining Land Use(s)

2.0 CAGL GOLD PROJECT: THE EXISTING SITUATION
2.1 Introduction
2.2 Available Data
- 2.2.1 The Physical Environment
- 2.2.2 The Biological (Flora/Fauna/Soils) Context
- 2.2.4 The Socio-Economic Context

2.3 The CAGP Mine Plan
- 2.3.1 Phased Mining Plans

2.4 Current Reclamation Plans at CAGP
- 2.4.1 Stated Reclamation Objectives
- 2.4.2 Current Status of the Reclamation Programme

2.5 Principal Areas of Concern
- 2.5.1 Introduction
- 2.5.2 Post-Mining Topography (Pit and Waste)
- 2.5.3 Water Quality
- 2.5.4 Erosion and Sedimentation
- 2.5.5 Plant Establishment and Management
- 2.5.6 Reclamation of Other Features
- 2.5.7 Company Resources

3.0 CAGL GOLD PROJECT: LAND RECLAMATION ACTION PLAN
3.1 Introduction
3.2 Development of the LRP
- 3.2.1 Data Collection and Interpretation
- 3.2.2 Mining Plans

3.3 Post-Mining Topography
- 3.3.1 Open Pit
- 3.3.2 Waste Storage Areas
- 3.3.3 Haul Road

3.4 Air Quality: Dust Control
3.5 Soil: Salvage and Re-Use
3.6 Waste Characterisation
- 3.6.1 Characterization
- 3.6.2 Prediction of Potential Impacts

3.7 Waste Storage Area Construction and Reclamation
- 3.7.1 Backfilling Plan
- 3.7.2 Re-grading of Waste Top
- 3.7.3 Sediment and Drainage Control
- 3.7.4 Surface Preparation for Revegetation
- 3.7.5 Final Close-Out Procedures

3.8 Water Quality Management
- 3.8.1 Sediment Control Plan
- 3.8.2 Control of Other Pollutants
- 3.8.3 Monitoring

3.9 Reclamation of Other Facilities and Features
- 3.9.1 Pit
- 3.9.2 Maintenance Yard
- 3.9.3 Other

3.10 Seed and Planting-Stock
3.11 Company Requirements for Planning, Implementation and Monitoring
- 3.11.1 Staffing
- 3.11.2 Technical Facilities
- 3.11.3 Monitoring

Table 9.5 Land Area Required Mining, Process and Support Facilities (Table 2.2 Repeat)

Facility	AGC Area (Ha)	Not in Project	CAGP Area (Ha)	Increase Brownfield	Decrease Brownfield	Greenfield
PITS						
Abnabna	8		49.7	29		
AF Gap						
Besem North	15	15				
Besem Gap (part of Esuajah North Dump)	5					
Besem Main (part of Esuajah North Dump)	5					
South Bokitsi West (Backfilled)	4				4	
South Bokitsi W. Extension (Backfilled)	4				4	
South Bokitsi East (Backfilled)	3				3	
South Bokitsi East Ext (Backfilled)	1				1	
Chirawa Main (Backfilled)	25				25	
Chirawa South	1	1				
Chirawa West (Backfilled)	10				10	
Chirawa East (Backfilled)	2				2	
North Esuajah	15		22.3	3		
South Esuajah	5	5				
Fetish Main (Backfilled & rehabilitated)	15	15				
Fetish	17.5		32.4	5.5		
Fobinso North (Backfilled)	7					
Fobinso South (Backfilled)	6.4		27.6		47	
Nkonya	5	5				
Total Pit	**154**	**41**	**132**	37.5	96	
HAUL ROADS	**16**	**16**	**12**			**12**
WASTE DUMPS						
Abnabna/AF	5		57.5			32
Besem North	5	5				
Chirawewa	11	11				
North Esuajah	18		97.3			48
South Esuajah	1	1				
Fetish Main (Rehabilitated)	6				25	
Fetish	15		102		45	74
Fobinso North	3.5		50			49.5
Fobinso South	3.5	3.5				
Nkonya	5	5				
Total Waste Dumps	73	25.5	306.8		70	203.5
Leach Pads	**133**	**133**				
CAGP FACILITIES (New)						
Flotation TSF			339.4			339.4
CIL TSF			13.7			13.7
Process Water Pond			2.5			2.5
Plant Site Area/MC Area			22.3			22.3
Substation			1.7			1.7
Eastern Mine Ore Piles			12			12
Miscellaneous			10			10
ROM Pad/ Magazine			118.7			118.7
Nkonya Access Road			2.6			2.6
Abnabna Road Diversion			14.3			14.3
Asuafa Diversion channel			14.7			14.7
Sediment Control (Inc drains)			4			4
Power line to plant site			8.8			8.8
Total New Facilities			**564.7**			**564.7**
Grand Total	**376**	**190**	**1016**	**38**	**166**	**780**

9.6 GENERAL LAND RECLAMATION METHODS

The following land reclamation and re-vegetation methods, soils management and conservation technologies will be under consideration for the restoration of reclamation units disturbed by mining operations.

9.6.1 Topsoil and overburden cover

The use of topsoil (and oxide or overburden cover as necessary) is a principal means of preparing reshaped land forms for vegetation establishment on disturbed areas. CAGL will develop a Topsoil Management Procedure, to recover as much topsoil as practicably possible from any area prior to its disturbance. Significant depths and quantities of recoverable topsoil materials exist on relatively flat

lying upland areas. Any recoverable topsoil will be stockpiled and protected in accordance with company guidelines for later re-handling and reuse.

The spreading of layers of local recovered topsoil (5 to 10 cm), containing natural seeds and growth medium, on to oxide or laterite materials to establish vegetation is a recognised reclamation technique. This technique has been shown to be successful in establishing sown seeds on disturbed areas and waste dumps. The Project reclamation programme will continue to utilize this technique as a valuable revegetation method. Its potential value will largely depend on the amount and quality of topsoil that can be conserved during development of the project.

9.6.2 Agricultural Soil Amendment Methods

If sufficient quantities of topsoil are unavailable, the use of agricultural soil amendment methods can be considered. These methods generally consist of adding suitable quantities of a substance (chemical or natural such as manure, compost, sludge, etc.), or topsoil substitutes (subsoil, overburden, mine oxide waste material) to increase fertility of the surface to be rehabilitated though the latter is limited in its effect.

9.6.3 Direct Establishment of Vegetation

The establishment of vegetation directly on reclamation units is the most effective and economical method of achieving the objectives of a reclamation programme. This technique is often not expensive and has been proved successful particularly in tropical areas. It also provides for greater long-term stability of the vegetative cover. Prior to establishment of any vegetation, reclamation units must be adequately reshaped and scarified if compacted during operations.

The Project will utilise information obtained from other mine reclamation programmes in Ghana for the efficacy of direct establishment methods for the waste storage areas and other disturbed areas at the mining site. Establishing fast growing nitrogen-fixing species will increase the organic matter and nitrogen content of the various substrates, as well controlling soil erosion, providing fuel wood, and for some species, edible fruit and medicinal products.

Species of both leguminous and timber species to be considered in the reclamation and revegetation programmes includes *Ceiba pentandra, Terminalia superba, Terminalia ivorensis, Triplochiton scleroxylon, Khaya ivorensis, Cedrela odorata, Tectona grandis, Gliricidia sepium, Acacia mangium* and *Leuceana leucocephala* among others. Other mining companies in Ghana have demonstrated that these species of trees can be successfully used in mine reclamation programmes.

9.6.4 EPA Species Planting Recommendations

The inclusion of a given percentage of native tree species in non-agricultural revegetation programmes is a stated objective of the EPA. CAGL will liaise with the EPA on the best means of meeting that objective.

9.6.5 Production of Plant Material

CAGL will establish a nursery for the production of plant materials. This will include the establishment of an area for the production of Vetiver grass (*Vetivera zizanioides*), used extensively for the purpose of slope erosion protection. Species to be cultivated at the Nursery are listed in table 9.6.

Seedlings of indigenous tree species and seeds of grasses and leguminous plants for ground cover as well as cash crops such as Cocoa (*Theobroma cacao*), Oil palm (*Elaeis guinneensis*), Pineapple and Sweet Apple will be purchased locally or from suppliers in nearby regions and from the Ministry of Food and Agriculture and the Forestry Commission.

Table 9.6: Plant species to be cultivated at the CAGL nursery	
Common Name	**Scientific Name**
Acacia	*Acacia mangium**
Cassia	*Cassia siamea*
Leucaena	*Leucaena leucocephala**
Neem	*Azadirachta indica*
Gliricidia	*Gliricidia sepium**
Wawa	*Triplochyton sclerexylon*+
Emire	*Terminalia ivorensis*+
Ofram	*Terminalia superba*+
Ceiba	*Ceiba pentandra*+
Mahogany	*Khaya ivorensis*+
Otie	*Pycnanthus angolensis*+
Nyankom	*Herritera utilis*+
Teak	*Tectona grandis*
Edinam	*Entandrophragma cylindricum*+
Essia	*Combretodendrom macrocarpus*+
Cedrella	*Cedrella odorata*
Flamboyant	*Delonix regia*
Okoro	*Albizia zygia**+
Asanfena	*Aningeria robusta*+
Note - * leguminous species	+ indigenous to West Africa (Ghana)

9.6.6 Establishment of Plant Material

Establishment of plant material on surfaces that have been adequately prepared for reclamation will be manually planted with nursery-raised seedlings or dispersion of seeds and cuttings.

9.6.7 Testing of Reclamation Techniques

The various reclamation species and manual techniques presented above are currently being utilised at various mine operations in southern Ghana. The programme will be under the supervision of the CAGL Sustainability Department.

9.6.8 Control of Erosion

Control of erosion is important during the life of mine. It is a key factor to achieve sustainable reclamation. A number of practices to ensure control of erosion are proposed as follows:

- Deforestation and land clearance will be limited to the strict minimum;
- Whenever possible, early revegetation of disturbed areas will be undertaken;
- Measures to protect the soil from water erosion will be carried out on a catchment basis;
- Drainage from external catchments will be controlled by diversion channels or appropriate holding structures;
- The length and gradient of structure slopes will be managed to be at a minimum. Long slopes will be provided with erosion control and water management structures (such as interception ditches, drop structures or other energy dissipation structures, sculpted areas and sediment control features);
- Use of erosion control materials on structures such as embankments and steep drainage channels, as necessary;

- Drainage structures designed for a 1:100 year storm event;
- Use of Vetiver and other grasses to control sheet and rill erosion;
- On roads, use of side drains, road camber, and drainage controls to ensure adequate drainage; and
- Visual assessment of erosion and analysis of run-off water quality will be a preventative measure carried out on a routine basis, which will provide rapid evidence of where control measures need repair or implementation.

9.7 POST-RECLAMATION MONITORING AND MAINTENANCE

Post-reclamation monitoring and maintenance will begin after completion of the reclamation work and will extend through the period of physical stabilisation. It is expected that such monitoring will be for a minimum of three years.

The reclamation programme will be concurrent with the mining operation wherever feasible, although for this relatively short-lived mining operation, the opportunities for concurrent reclamation will be limited. Information from current operations, in conjunction with the overall environmental monitoring programme during the same period, will enable the prospective length of the post-monitoring programme to be more accurately determined towards the end-of-mine life.

Surface and ground water sampling will continue on a quarterly basis through the post-reclamation period or more frequently if water test results prove it necessary. These results will be compared with baseline data collected at the beginning of the project to ascertain current status and identify problem areas. Periodic qualitative and quantitative monitoring of the revegetated areas and notation of observations will identify actual and potential problems that can be corrected with the maintenance programme. A qualified person on the staff of CAGL will conduct the monitoring.

Monitoring techniques will be selected from one or more of the following:

- Qualitative and quantitative analysis of vegetation cover and revegetation successes;
- Tissue analysis of selected plant species; and
- Analysis of re-vegetated soils and wastes.

9.8 MANAGEMENT OF THE RECLAMATION PROGRAMME

The management of the reclamation programme will be under the supervision of the Sustainability Manager.

9.9 SUMMARY OF AGC AND TAGIT RECLAMATION COSTS

The AGC Decommissioning Plan 2004 formed the basis for a Reclamation Bonding Agreement with the EPA (See Chapter 8, section 8.2). A listing of the individual reclamation items and estimated costs for each in the AGC plan has been assembled by CAGL (Appendix 9.10). In 2006, CAGL (then under the name of Stratsys Investments Limited) commissioned an independent audit by Tagit Consult (an Accra based consulting company) of the reclamation status and cost status of the CAGP. Reclamation and cost status reported by Tagit has also been included in Appendix 9.10.
A summary of the costs presented by AGC to complete reclamation of areas disturbed by mining activities and the Tagit assessment of remaining works to be completed is presented below. AGC estimated that there were 290 ha still requiring reclamation but Tagit revised this upwards to 381 ha[1], albeit at a lower cost.

[1] CAGL has estimated a total of 389 ha.

	AGC 2004						Tagit Consult 2006			
Item	Area (Ha)	Area To Be Completed (Ha)	Reveg.	Fencing	Batters	Estimated Total Cost	Area (Ha)	Estimated Total Cost	Estimated Completion Works %	Total Outstanding Liability
Pits	114	86	459,854	544,998	190,230	1,195,082	138	995,621	Variable	320,012
Dumps	90	66	197,986		46.942	244,928	66	234,802	Variable	46,961
HL Pads	133	133	121,583		221.583	343,165	133	343,65	Variable	343,165
Structures	39	5				24,764	44	164,946	Variable	8,114
Social projects						450,000		450,000	0	450,000
Totals		**290**				**2,257,939**	**381**	**2,188,534**		**1,168,252**

The above information is provided only to indicate the disturbed (brownfield) nature of parts of the Project area being redeveloped by CAGL.

9.10 REQUIRED REVISIONS TO AGC DECOMMISSIONING PLAN

9.10.1 General

The above AGC Plan is no longer considered valid two reasons. Firstly, the CAGP will redevelop and expand some areas in the plan. Some areas have, and are, being revaluated as potential mining resources. Secondly, the estimated costs are now almost six years old.

9.10.2 Effect of CAGP Changes

The development of the CAGL Project has changed the status of some of the pits and waste dumps scheduled for reclamation in the AGC plan. Some of these had not received any reclamation attention at all, others with reclamation already in progress in 2004 (but not completed) to be completed. The changes in the status of those as a result of the CAG Project are:

- The Abnabna, Fobinso, Fetish and Esuajah North pits are to be redeveloped and associated waste dumps expanded or relocated.
- The South Bokitsi and Chirawewa pit complexes are to backfilled as a result of redevelopment of the Fetish pit.
- Waste dumps of the Besem complex and the existing Esuajah North dump will be incorporated into the new Esuajah North dump.
- CAGL has not made a decision on the future status of the Esuajah South pit.
- The Ntwintwina pit and waste dump is land that has been relinquished to the Minerals Commission for the use of small-scale miners and is no longer part of the CAGL licensed areas
- The Dadieso pit and waste area is part of the planned CAGL exploration programme.
- Nkonya pit and waste dump is the only unaffected area of the CAGP.

A formalised reclamation plan shall be developed within the first two years of operation (Ghana Mining and Environmental Guidelines 1994). This reclamation plan shall incorporate the reclamation requirements of the current bond into a single reclamation plan and bond for the CAGL life-of-mine.

9.11 PROVISIONAL ESTIMATE OF RECLAMATION AND CLOSURE COSTS

9.11.1 Methodology

A scope of work for each major component of rehabilitation and reclamation work at site has been developed. Unit costs have been developed using the costs that have been incurred in the currently active reclamation programs at numerous mines in Ghana and extrapolating those costs to the CAGL Project. Costs have been estimated assuming that the costs will either be incurred during operations or incurred at the end of mine life.

9.11.2 Pit Backfilling Costs

The sequence of mining the pits has allowed for the placement of waste material in pits directly. This cost has been incorporated into the mining operating costs for the backfilling of the existing (brownfield) Fobinso South and Fobinso North pits. This will entail the placement 40M tonnes of waste at an extra haulage cost of $0.50/tonne for a total of USD $20,000,000 (Twenty million). Waste arising from the mining of the (brownfield) Fetish pit will be backfilled into the existing pits of the (brownfield) South Bokitsi pit complex and into the existing (brownfield) Chirawewa Main, East and West pits. The cost of backfilling the Chirawewa and related pits is approximately USD $17,000,000 (Seventeen million). Back filling of pits is expensive but has been selected as an effective alternative to building waste dumps due to the proximity of population, land use application dominating the area, the requirement for rehabilitation of previous mining activities and recognised preferred practise by stakeholders.

9.11.3 Outline of Reclamation Costs

The scope of work, costing and work up of major earthworks and revegetation costs are presented in the spreadsheet below (Table 9.7). A scope of work for each major component of rehabilitation and reclamation work at site has been developed. Unit costs have been developed using the costs that have been incurred in the currently active reclamation programs at numerous mines in Ghana and extrapolating those costs to the CAGL Project. Costs have been estimated assuming that the costs will either be incurred during operations or incurred at the end of mine life.

A calculation has been made for the cost of closure and reclamation for each year of mine life. For example, should operations cease at the end of the Development year, the cost of closure (removal of built facilities and reclamation of disturbed areas) is USD 6,054,465 (excluding costs of Management and Maintenance, Monitoring of Decommission). If no mining rehabilitation works are undertaken by the end of Year 10, the cumulative cost of closure in Year 11 (after mining has finished) would be USD 17,517,658. (excluding costs of Management and Maintenance, Monitoring of Decommission). The cost includes the cost for rehabilitating pits that will not be re-developed (i.e. Pits - Besem North, Chirawewa South, Esuajah South, Fetish Main, Nkonya; Waste dumps - Besem North, Chirawewa, Esuajah South, Fetish Main and Nkonya; and Heap Leach pads) which is estimated at USD 3.0 million. If, however, mining rehabilitation is progressed annually then the Year 11 expenditure is reduced to USD 12,865,735.

The reclamation, closure and decommissioning costs presented in table 9.7 do not include the costs associated with the current CAGL reclamation bond. Those costs will be revised in relation to the changed status of many of the facilities as a result of the development of the CAGP. The costs will be incorporated into those provided in table 9.7 when the reclamation binding arrangements are set with the EPA.

9.11.4 Calculation of Unit Reclamation Costs

At the request of the EPA, a costing has been prepared to explain the unit cost for the various revegetation items presented in table 9.7. The breakdown of the individual cost items used to arrive at a total unit cost item is presented in table 9.8.[2]

[2] Costs associated with use of large mobile equipment are incurred as part of mining cost, not reclamation. Cost of use of large equipment during reclamation is considered minimal being limited to final minor grading and surface preparation.

Table 9.8: Breakdown of Unit Costs for Task, Operations and Items in Table 9.7					
Task, Operations, Item	**Unit Costs/ year USD**	**No. Of Units/ year**	**Total Costs/ year**		
Establish erosion control vegetation (Vetiver)					
Unskilled (unit costs for gardeners)	7030	10	70,300		
Supervision & management (annual cost for supervisor)	21333	2	42,666		
Vehicle (operating costs only assumed fully owned)	2800	2	5,600		
Mobile equipment (owned equipment used to move materials part of annual opex)	1250	1	1,250		
Watering 3 months (as per indicated costs from Mining Contractor)	1700	3	5,100		
Vetiver grass grown in owners nursery, costs included in the operating costs					
Total			124,916		
Annual Coverage (based on other operations performance)	100	Ha/yr	**1,249**		per Ha
Establish initial nitrogen fixing vegetation					
Unskilled (unit costs for gardeners)	7030	10	70,300		
Supervision & management (annual cost for supervisor)	21333	2	42,666		
Vehicle (operating costs only assumed fully owned)	2800	2	5,600		
Mobile equipment (owned equipment used to move materials)	1250	1	1,250		
Watering 3 months (as per indicated costs from Mining Contractor)	1700	6	10,200		
Seedlings (2m x 2.5m seeding space for good coverage) USD each	2.5	2000	5,000		
Total			135,016		
Annual Coverage (based on other operations performance)	75	Ha/yr	**1,800**		per Ha
Establish final land use vegetation					
Unskilled (unit costs for gardeners)	7030	10	70,300		
Supervision & management (annual cost for supervisor)	21333	2	42,666		
Vehicle (operating costs only assumed fully owned)	2800	2	5,600		
Mobile equipment (owned equipment used to move materials)	1250	8	10,000		
Watering 3 months (as per indicated costs from Mining Contractor)	1700	6	10,200		
Seedlings (2m x 2.5m seeding space for good coverage) USD each	4.00	2000	8,000		
Total			146,766		
Annual Coverage (based on other operations performance)	60	Ha/yr	**2,446**		per Ha
Establish vegetation on pit benches					
Unskilled (unit costs for gardeners)	7030	10	70,300		
Supervision & management (annual cost for supervisor)	21333	2	42,666		
Vehicle (operating costs only assumed fully owned)	2800	2	5,600		
Mobile equipment (owned equipment used to move materials)	1250	8	10,000		
Watering 3 months (as per indicated costs from Mining Contractor)	1700	6	10,200		
Seedlings (2m x 2.5m seeding space for good coverage) USD each	4.50	2000	9,000		
Dozer works	1200	20	24,000		
Total			171,766		
Annual Coverage (based on other operations performance)	60	Ha/yr	**2,863**		per Ha

Table 9.8 Continued: Breakdown of Unit Costs for Task, Operations and Items in Table 9.7					
Establish thorn bush fences					
Unskilled (unit costs for gardeners)	7030	10	70,300		
Supervision & management (annual cost for supervisor)	21333	1	21,333		
Vehicle (operating costs only assumed fully owned)	2800	1	2,800		
mobile equipment (owned equipment used to move materials)	1250	1	1,250		
Watering 3 months (as per indicated costs from Mining Contractor)	1700	3	5,100		
Seedlings (0.7m x 1m for solid fence lines) USD each plant	0.50	13333	6,667		
			0		
Total			107,450		
Annual Coverage (based on other operations performance)	60	Ha/yr	**1,791**		per Ha
Truck topsoil/saprolite from stockpile, place and spread to a thickness of 250 mm					
Topsoil/saprolite win haul place (0.25m x 10000m2= volume placed)	0.25	10000	2.21	5525	
Spread topsoil/saprolite	950	1		950	
Total				**6475**	per Ha
Truck topsoil from stockpile, place and spread on pit benches to a thickness of 250 mm					
Topsoil/saprolite win haul place (0.25m x 10000m2= volume placed)	0.25	10000	2.21	5525	
Spread topsoil/saprolite (rate from Mining Contractors)	950	1		950	
Total				**6475**	per Ha
Truck topsoil from stockpile, place and spread on haul roads to a thickness of 125 mm	0.125	10000	2.21	2762.5	
Topsoil/saprolite win haul place (0.125m x 10000m2= volume placed)				237.5	
Total				**3000**	per Ha
Demolition and removal of surplus treatment plant structures, removal from site by others	$200,000	Allowance			
Removal of process plant concrete footings, and backfill	$120,000	Allowance			
Demolition and removal of mine workshops with removal from site by others	$10,000	Allowance			
Removal of mine workshop concrete footings and placement in designated dump	$5,000	Allowance			
Removal of "contaminated" soil to a depth of 300 mm					
Topsoil/saprolite win haul place (0.3m x 10000m2=volume)	0.3	10000	2.21	6630	
Disposal of contaminated soil (Placement in CTSF) guess as type of contamination will determine cost	3,000	5	0.215	3,225	
Total				**9855**	per Ha
Rip hard stands to a depth of 200 mm					
Grader ripping (rate per Ha to rip to 200mm)	1800	1.1		**1980**	per Ha
Final reshaping of waste dumps (or pit slopes exposed)					
Dozer shaping (based on Mining Contract indicated rates)	1200	2		2400	
Placement of fill (0.25m x 10000m2 = volume per Ha)	0.25	10000	2.21	5525	
Total				**7925**	per Ha

9.12 FINANCIAL ALLOCATIONS

CAGL will finance the majority of the rehabilitation and closure aspects of the project from the Company's annual budget and operating costs, since this is a relatively short-term project. A detailed cash flow analysis of annual funds required will be provided when CAGL makes provision for the alteration in its reclamation bond to reflect the new Project. Periodic reviews of reclamation costs developed through trials on the Project Areas during operations will be utilised to adjust the accrual rate as required.

Insert spreadsheet table 9.7

Table 9.7: Unit Reclamation Costs and Estimated Reclamation Costs Year 0 -11

Item	Land Area - hectares	Scope of Activity by Year			Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
Item	Land Area - hectares	Perimeter	Units	Development	1	2	3	4	5	6	7	8	9	10	11
Pits[1]		M	meters	5557			1778		1696						
Fobinso Back filled)	60	2315	Ha		60										
Abnabna-AF Gap	37	3242	Ha	37											
Fetish	23	1696	Ha						23						
Esuajah North	18	1778	Ha				18								
Pits[2] (not in project)															
Besem North	15								5	10					
Chirawewa South	1								1						
Esuajah South	5										5				
Nkonya	5										5				
Rock Waste Dumps[3]															
Fobinso	60		Ha				30	30							
Abnabna-AF Gap	37		Ha	30	7										
Fetish (Chirawewa & Bokitsi Pits Backfilled)	165		Ha						30	30	30	30	30	15	
Esuajah North	66		Ha				30	36							
Rock Waste Dumps[4] (not in project)															
Esuajah South	1								1						
Nkonya	5							5							
Besem North	5								5						
Heap Leach Pad	133										30	30	30	43	
Tailing Storage Facility[5]	332		Ha	292			40								
Plant Site / Services Area	18		Ha	18											
ROM Pad	113		Ha	113											
Mine Roads	12		Ha	6			6								
Asuafu Diversion channel	12		Ha	12											
Water Storage Facility	12		Ha	12											
Access Road	5		Ha	5											
Sediment Control (Inc drains)	2		Ha	1			1								
Power line to plant site	14		Ha	14											
Total			Ha	540	67	0	125	71	65	40	70	60	60	58	**0**

1. Based on perimeter at cessation of mining under current mine plan, includes partial backfilling
2. Based on perimeter of existing AGC pits that will not be re-developed
3. Base footprint on completion and taking into account backfilling of various pits
4. Base footprint of existing AGC waste dumps that will not be required
5. Based on perimeter at closure under current mine plan.

Estimation of Unit Costs – Re-vegetation

Estimated re-vegetation costs in southern Ghana

No.	Task, Operation or Item	Unit Cost USD	Unit of Size	Cost to Close if Closed at End of Period Development or Year 1 to 11											
				Development	1	2	3	4	5	6	7	8	9	10	**11**
1	Establish erosion control vegetation (Vetiver)	$1,250	Ha	$611,250	$83,750	$0	$133,750	$88,750	$45,000	$37,500	$75,000	$75,000	$75,000	$72,500	**$0**
2	Establish initial nitrogen fixing vegetation	$1,800	Ha	$880,200	$120,600	$0	$192,600	$127,800	$64,800	$54,000	$108,000	$108,000	$108,000	$104,400	**$0**
3	Establish final land use vegetation	$2,500	Ha	$1,222,500	$167,500	$0	$267,500	$177,500	$90,000	$75,000	$150,000	$150,000	$150,000	$145,000	**$0**
4	Establish vegetation on pit benches	$2,900	Ha	$21,460	$0	$0	$10,440	$0	$16,820	$5,800	$5,800	$0	$0	$0	**$0**
5	Establish thorn bush fences	$1,800	Ha	$10,003	$0	$0	$3,200	$0	$3,053	$0	$0	$0	$0	$0	**$0**
6	Expansion of nursery	$ 50,000	Lump sum	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	**$ 50,000**

Costs have been established according to current practices in Ghana

Estimation of Unit Costs – Earthworks

Estimated earthworks costs in southern Ghana

No.	Task, Operation or Item	Unit US$	Unit Size	Development	1	2	3	4	5	6	7	8	9	10	11
7	Truck topsoil/saprolite from stockpile, place and spread to a thickness of 250 mm	$6,500	Ha	$2,093,000	$435,500	$0	$650,000	$461,500	$234,000	$195,000	$390,000	$390,000	$390,000	$377,000	**$0**
8	Truck topsoil from stockpile, place and spread on pit benches to a thickness of 250 mm	$6,500	Ha	$200,052	$0	$0	$64,008	$0	$61,056	$0	$0	$0	$0	$0	**$0**
9	Truck topsoil from stockpile, place and spread on haul roads to a thickness of 125 mm	$3,000	Ha	$414,000	$0	$0	$21,000	$0	$0	$0	$0	$0	$0	$0	**$0**
10	Demolition and removal of surplus treatment plant structures, with removal from site by others	$200,000	Lump sum	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	**$200,000**
11	Removal of process plant concrete footings, and backfill	$120,000	Lump sum	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	**$120,000**
12	Demolition and removal of mine workshops with removal from site by others	$10,000	Lump sum	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	**$10,000**
13	Removal of mine workshop concrete footings and placement in designated dump	$5,000	Lump sum	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	**$5,000**
14	Removal of "contaminated" soil to a depth of 300 mm	$10,000	Ha	$30,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	**$150,000**
15	Rip hard stands to a depth of 200 mm	$2,000	Ha	$36,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	**$0**
16	Final reshaping of waste dumps (or pit slopes exposed)	$8,000	Ha	$536,000	$536,000	$0	$624,000	$568,000	$520,000	$320,000	$560,000	$480,000	$480,000	$464,000	**$0**

Details of unit costs:

a. Battering of waste is not a direct reclamation costs. These costs are included in the Perseus mining costs and are considered an integral part of the ore mining operation.

b. Costs for the construction of a nursery not included.

Item	Development	1	2	3	4	5	6	7	8	9	10	11
Yearly Cost for Closure at end of year before Mining rehab works	$6,054,465	$1,343,351	$2	$1,966,501	$1,423,554	$1,034,734	$687,306	$1,288,807	$1,203,008	$1,203,009	$1,162,910	**$150,011**
Cum Cost for Closure at End of year before Mining Rehab Works	$6,054,465	$7,397,816	$7,397,818	$9,364,319	$10,787,873	$11,822,607	$12,509,913	$13,798,720	$15,001,728	$16,204,737	$17,367,647	**$17,517,658**

Other Decommissioning and Closure Unit Costs

Unit No.	Task, Operation or Item	Unit Cost	Development	1	2	3	4	5	6	7	8	9	10	11
6	Mobilisation and Demobilisation	(included in Mining contract)												
7	Management and Maintenance	6%	$363,267.88	$439,680.94	$435,493.06	$545,107.14	$615,024.78	$675,014.81	$714,159.17	$772,641.59	$820,531.67	$841,618.61	$848,154.41	**$714,763.07**
8	Monitoring of Decommissioning	2%	$121,089.29	$146,560.31	$145,164.35	$181,702.38	$205,008.26	$225,004.94	$238,053.06	$257,547.20	$273,510.56	$280,539.54	$282,718.14	**$238,254.36**

Costs were established according to current practices in Ghana.

Item	Development	1	2	3	4	5	6	7	8	9	10	11
Mining rehabilitation costs included as part of Mining costs (as per the DFS)	$0	$69,800	$69,800	$139,600	$258,260	$34,900	$34,900	$314,100	$404,840	$851,560	$1,053,980	**$2,373,200**
Cumulative Mining Rehabilitation costs	$0	$69,800	$139,600	$279,200	$537,460	$572,360	$607,260	$921,360	$1,326,200	$2,177,760	$3,231,740	**$5,604,940**
	$6,054,465	$7,328,016	$7,258,218	$9,085,119	$10,250,413	$11,250,247	$11,902,653	$12,877,360	$13,675,528	$14,026,977	$14,135,907	**$11,912,718**
TOTAL COSTS TO CLOSE MINE AT YEAR END	**$6,538,822**	**$7,914,257**	**$7,838,875**	**$9,811,929**	**$11,070,446**	**$12,150,267**	**$12,854,865**	**$13,907,549**	**$14,769,570**	**$15,149,135**	**$15,266,779**	**$12,865,735**